PEFCR Fish for human consumption Pilot

Goal and scope description

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Abstract:

This is the Scope Document of the Product Environmental Footprint (PEF) Category Rules (PEFCR) – Seafood for human consumption.

It includes the description of the scope, unit of analysis and representative product.

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Nomenclature

LCA	Life Cycle Assessment
EF	Environmental Footprint
CF	Characterization Factor
BREF	Best Available Techniques Reference Document
BOM	Bill of materials
B2C	Business to Consumers
B2B	Business to Business
PEFCR Guide	This refers to the document “Guidance for the implementation of the EU PEF during the EF pilot phase - Version 4.0” [1]
ILCD	International Reference Life Cycle Data System
GHG	Greenhouse Gas
EPD	Environmental Product Declaration
EoL	End of Life
ELCD	European Life Cycle Database
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
ISO	International Standard Organization
PCF	Product Carbon Footprint
PCR	Product Category Rule
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rule
RP	Representative Product
SC	Steering Committee
TAB	Technical Advisory Board

1 Introduction

As a part of the development of Product Environmental Footprint Category Rules (PEFCR) for the application of the Product Environmental Footprint method on specific product categories within the EU this document describes the goal and scope for the development of a PEFCR for products from the fishery and aquaculture sector on the EU market. This project is referred to as the "PEF Fish pilot".

The of the PEF fish pilot is undertaken by a Technical Secretariat (TS) consisting of the following members:

- Norwegian Seafood Federation (FHL)
- Federation of European Aquaculture Producers (FEAP)
- European Feed Manufacturers' Federation (FEFAC)
- SINTEF Fisheries and aquaculture
- Marine Harvest ASA
- Norway Pelagic AS (Pelagia AS from 1st January 2015)
- Norway Seafoods AS
- Lucas perches
- Leroy fishcut
- Marine Harvest, VAP - Boulogne

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For a complete and precise explanation of the background and goals for the development of a PEFCR for fish and mollusk products, we recommend to look at the web pages presenting the European Commission's environmental policy and, more specifically, their policies on sustainable development and "Single market for green products initiative"[1]. The process of developing PEFCR is explained more in detail on their web pages for "PEF pilots"[2].

1.1 The PEF pilot

The European Commission is proposing EU-wide methods to measure the environmental performance of products and organisations, and encouraging Member States and the private sector to take them up. Today, companies willing to highlight the environmental performance of their products have to choose between several methods promoted by governments and private initiatives. Providing environmental

[1] Link to web page: http://ec.europa.eu/environment/eussd/smgp/index.htm
[2] Link to web page: http://ec.europa.eu/environment/eussd/smgp/pef_pilots.htm

information often comes with high costs of mapping the environmental performance and developing communication means. Also they face the distrust of consumers confused by too many labels with information that makes products difficult to compare.

The European Commission is proposing two methods to measure environmental performance throughout the lifecycle, the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF). They announced a three-year testing period to develop product- and sector-specific rules through a multi-stakeholder process, including provision for organisations with other methods to have them assessed as well. An open call for volunteers was published by the Commission, inviting companies, industrial and stakeholder organisations in the EU and beyond to participate in the development of product-group specific and sector-specific rules.

The Product Environmental Footprint methodology has been drafted by the European Commission's Joint Research Centre. The methodology is based on Life Cycle Assessment, thus basically covers the environmental impacts and point to improvement opportunities from the extraction of raw materials to the disposal of a product. The methodology was being developed building on the International Reference Life Cycle Data System (ILCD) Handbook as well as other existing methodological standards and guidance documents. PEFCRs aim at providing detailed technical guidance on how to conduct a product environmental footprint study for a specific product category. PEFCRs complement the general methodological guidance for environmental footprinting by providing further specification at the product level. They will increase reproducibility and consistency of product environmental footprint studies.

1.2 The EU seafood consumption[3]

The EU is a major global market for seafood products - 12.3 million tonne representing €52.2 billion in 2011. It is the first importer of seafood products, absorbing 24% of total world exchanges in value. Tuna, cod and salmon are the main species consumed in terms of volume. Seafood consumption per capita in the EU seems to have reached a plateau after a decade of dynamic growth. EU consumption per capita in 2011 was 24,5 kg [2].

Figure 1.1**Feil! Fant ikke referansekilden.** presents the development in the consumption seafood, compared to other food commodities, in the EU over a 15 year period.

[3] This chapter is based on the report "2014 Edition THE EU FISH MARKET" by European Market Observatory for Fisheries and Aquaculture Products (EUMFOA). Link to web page: https://ec.europa.eu/fisheries/market-observatory/monthly-highlights3

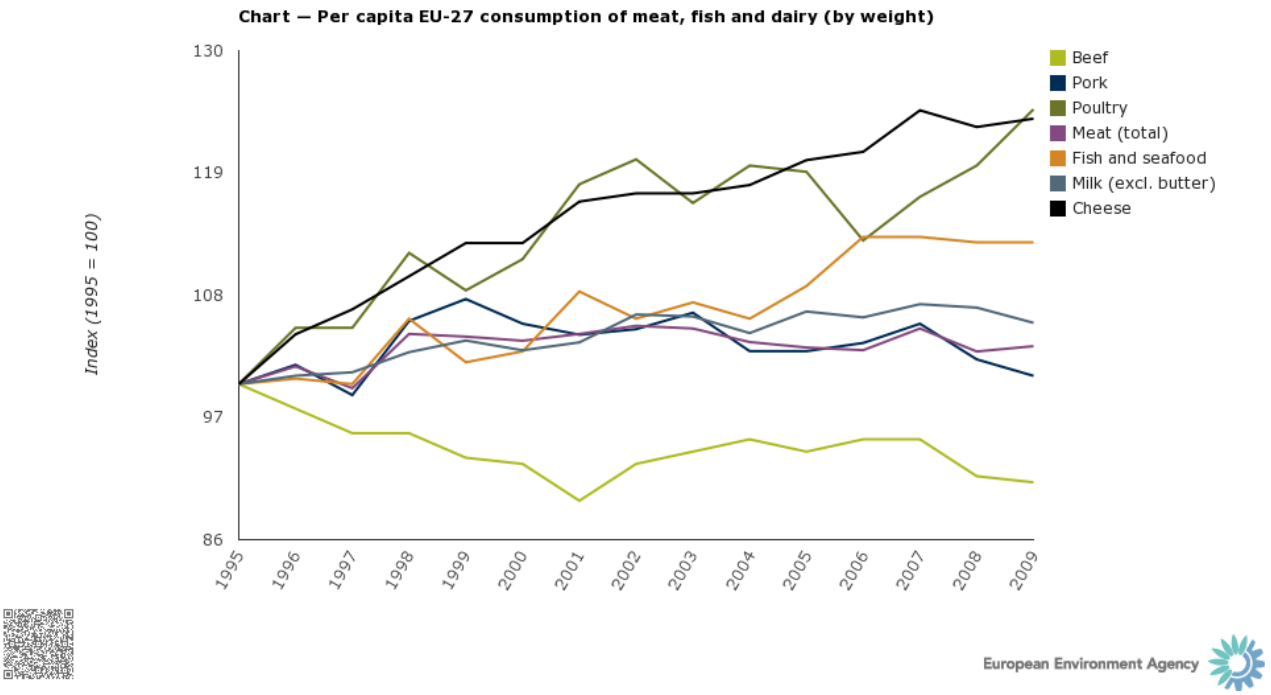


Figure 1.1 Line graph of changes over time in consumption per capita for poultry, cheese, fish and seafood, milk, meat, pork and beef (index: 1995 = 100)[4]

Seafood consumption varies a lot between Member States, where northern one are more focused on processed fish while southern ones favor fresh products and devote a larger part of household expenditure to fish. Central and Eastern European States are below the EU consumption average but register increases. Farmed products represent 24% of total EU consumption, where Norway and China are the main EU suppliers. Norway showed significant increases in volumes of seafood products exported to the EU – mainly salmon and cod. Intra-EU trade registered a volume of exchanges accounting to more than 5.1 million tonne (net weight). Almost 62% of the total apparent consumption of both captured and farmed products was covered by 13 species, these are presented in Table 1.1 [2].

[4] http://www.eea.europa.eu/data-and-maps/daviz/per-capita-eu-27-consumption-1#tab-chart_1

Table 1.1 Ranking of the most important species in per capita consumption in the EU in 2011 [2]

Main commercial species	Per capita (Kg)	% wild	%farmed
Tuna (canned)	2,14	100%	0%
Cod	1,96	98%	2%
Salmon	1,72	2%	98%
Pollack	1,64	100%	0%
Herring	1,18	100%	0%
Mussel	1,16	10%	90%
Hake	0,94	100%	0%
Mackerel	0,87	100%	0%
Pangasius	0,80	0%	100%
Tropical shrimps	0,75	46%	54%
Sardine	0,71	100%	0%
Squid	0,70	100%	0%
Scallop	0,58	87%	13%

Consumption studied in terms of commodity groups and supply balance in live weight equivalents (Table 1.2) provides a complimentary perspective and shows that "small pelagics" is also an important fish commodity, this being the sum of species such as herring, mackerel and sardines.

Table 1.2 Supply balance and apparent consumption in 2011 at EU level and by commodity group (live weight equivalent)[2]

Commodity group	Production (tonnes)		Import (tonnes)		Export (tonnes)		Apparent consumption (tonnes)			Per capita (kg)		
	Fishery	Aquaculture	Fishery	Aquaculture	Fishery	Aquaculture	Fishery	Aquaculture	Total	Fishery	Aquaculture	Total
Bivalves and other molluscs and aquatic invertebrates	244.268	627.392	307.054	147.656	6.291	6.962	545.031	768.085	1.313.116	1,08	1,53	2,61
Cephalopods	114.972	3	539.468	0	27.610	0	626.830	3	626.833	1,25	*less than 0,01*	1,25
Crustaceans	214.364	242	407.295	292.323	99.890	1.774	521.769	290.791	812.560	1,04	0,58	1,62
Flat fish	203.941	11.039	54.635	1.307	50.475	4	208.102	12.342	220.444	0,41	0,02	0,44
Freshwater fish	37.700	89.927	130.727	497.149	4.925	2.948	163.502	584.128	747.630	0,33	1,16	1,49
Groundfish	516.110	0	2.468.617	21.184	136.557	87	2.848.170	21.097	2.869.267	5,67	0,04	5,71
Miscellaneous aquatic products	34.137	55	317.719	0	9.006	0	342.850	55	342.905	0,68	*less than 0,01*	0,68
Other marine fish	512.132	148.432	576.016	30.775	165.074	6.024	923.074	173.183	1.096.257	1,84	0,34	2,18
Salmonids	8.437	357.497	72.709	764.749	38.083	66.815	43.064	1.055.431	1.098.494	0,09	2,10	2,19
Small pelagics	2.084.872	1	454.628	0	690.152	0	1.849.347	1	1.849.348	3,68	*less than 0,01*	3,68
Tuna and tuna-like species	340.160	5.060	1.298.329	1	294.130	421	1.344.360	4.640	1.349.000	2,68	0,01	2,68
Total	**4.311.093**	**1.239.648**	**6.627.198**	**1.755.143**	**1.522.192**	**85.035**	**9.416.099**	**2.909.756**	**12.325.855**	**18,74**	**5,79**	**24,53**

Figure 1.2**Feil! Fant ikke referansekilden.** presents more detail on which species constitute aquaculture production in the EU.

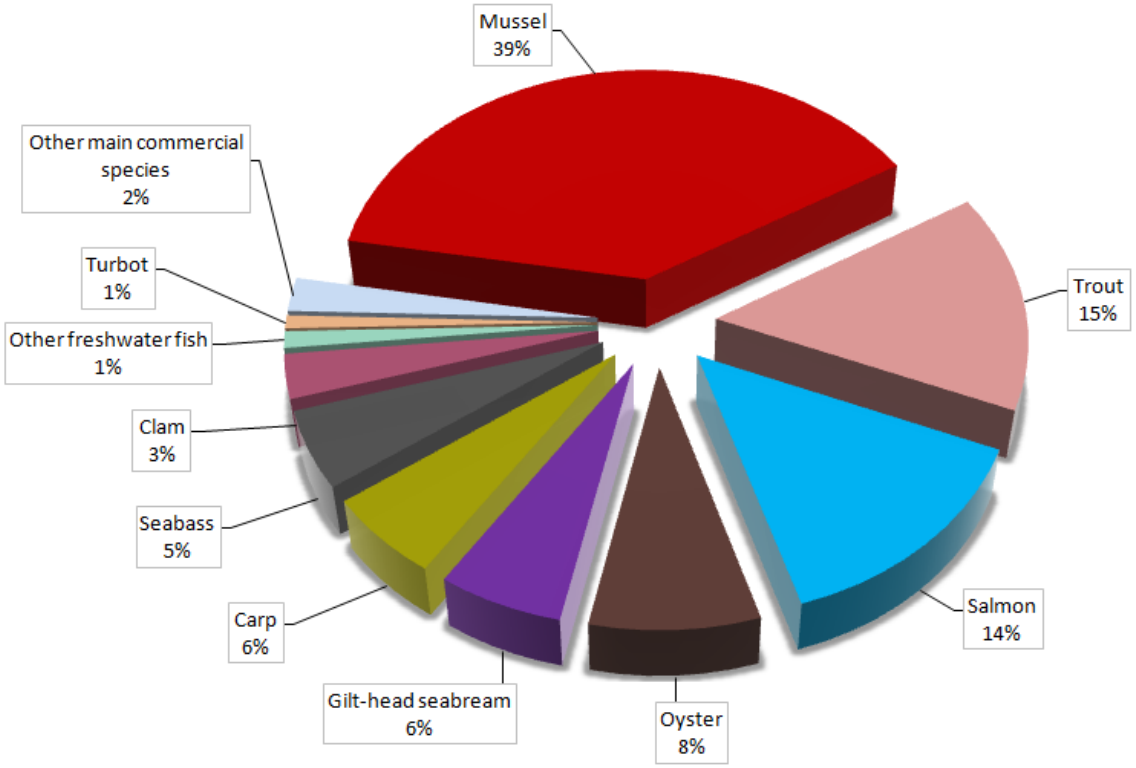


Figure 1.2 Composition of farmed products in the EU – by volume (2011) [2][5]

[5] Chart 47 from the report "2014 Edition THE EU FISH MARKET" by European Market Observatory for Fisheries and Aquaculture Products (EUMOFA). Link to web page: https://ec.europa.eu/fisheries/market-observatory/monthly-highlights3

The following table is a compilation of the data presented in Table 1.1 and Table 1.2. This table shows a more complete picture of the EU seafood consumption.

Table 1.3 Compilation of data on seafood consumption per capita.

Species	kg/capita	% of total	% wild	% farmed
Scallop	0,58	2	87	13
Mussel	1,16	5	10	90
other bivalves and invertebrates	0,87	4	41	59
Squid	0,70	3	100	0
Other cephalopods	0,55	2	100	0
Tropical shrimps	0,75	3	46	54
Other crustaceans	0,87	4	64	36
Flat fish	0,44	2	100	0
Pangasius	0,80	3	0	100
Other freshwater	0,69	3	22	78
Cod	1,96	8	98	2
Pollack	1,64	7	100	0
Hake	0,94	4	100	0
Other ground fish	1,17	5	100	0
Miscellaneous aquatic products	0,68	3	100	0
Other marine fish	2,18	9	84	16
Salmon	1,72	7	2	98
Other salmonids	0,47	2	4	96
Herring	1,18	5	100	0
Sardine	0,71	3	100	0
Mackerel	0,87	4	100	0
Other small pelagic	0,92	4	100	0
Tuna (canned)	2,14	9	100	0
Other tuna like	0,55	2	100	0
Totals	**24,5**	**100**		

1.3 Seafood production systems

1.3.1 Fishing technologies

Fishing technologies range from artisanal fisheries with relatively primitive lines and spears up to ocean-going ships that carry the most modern engines, hull designs and ICT systems that marine technologies can offer. These vessels can also process the fish on board and deliver products ready for consumption as they enter shore.

For the environmental assessment of fisheries, not only is the fishing gear a very important

environmental aspect but also how the vessel is operated and whether the vessel has on-board processing are strong influencing factors.

There are many ways of dividing fisheries into different groups but two of the most important are the pelagic and demersal fisheries.

- Pelagic fisheries target species that live in the pelagic zone, in the middle of the water body of oceans and lakes. These species typically live in schools.
- Demersal fisheries target species living close to the sea floor; a typical example is cod.

Further pelagic and demersal fishers can be divided into ocean-going fleets and coastal fleets, depending on what areas the vessel is equipped, designed and allowed to operate in.

The Fisheries and aquaculture department of the FAO provides the following categories of fishing gears[6] (the links leads to individual fact sheets on each gear). It is developed as an international Standard Statistical Classification of Fishing Gear (ISSCFG)[7].

- Surrounding nets (including purse seines)
- Seine nets (including beach seines and Boat, Scottish/Danish seines)
- Trawl nets (including Bottom: Beam, Otter and Pair trawls, and Midwater trawls: Otter and Pair trawls)
- Dredges
- Lift nets
- Falling gears (including cast nets)
- Gillnets and entangling nets (including set and drifting gillnets; trammel nets)
- Traps (including pots, stow or bag nets, fixed traps)
- Hooks and lines (including handlines, pole and lines, set or drifting longlines, trolling lines)
- Grappling and wounding gears (including harpoons, spears, arrows, etc.)
- Stupefying devices

The most important gears, based on their share of European fisheries, are the different types of surrounding nets, seine nets, trawls, gillnet and lines.

1.3.2 Aquaculture technologies

Aquaculture, the growing of aquatic animals and plants, covers a wide range of aquatic species and methodologies for their rearing. These can range from how the fish is kept under control, feeding, how the species are developed (e.g. selective breeding) and other techniques to enhance welfare, health, growth and productivity.

Figure 1.3 presents different aquaculture technologies.

For European aquaculture and environmental assessment, it is important to distinguish between the different production systems, broadly described as open and closed systems.

[6] Link to web page: http://www.fao.org/fishery/topic/1617/en
[7] Link to web page: http://www.fao.org/fishery/cwp/handbook/M/en

- Open systems use natural movement (sea) or water flow (river) to secure water exchange and thus benefit from natural energy flows; open systems generally have less control over emissions into the surrounding environment.
- Closed systems are usually land-based and manage water inflow and outflow; RAS systems can vary in the amount of water and waste treated but involve energy use for pumping; extensive pond culture also vary in water exchange but, through natural vegetation and flora, rarely have high nutrient emissions.

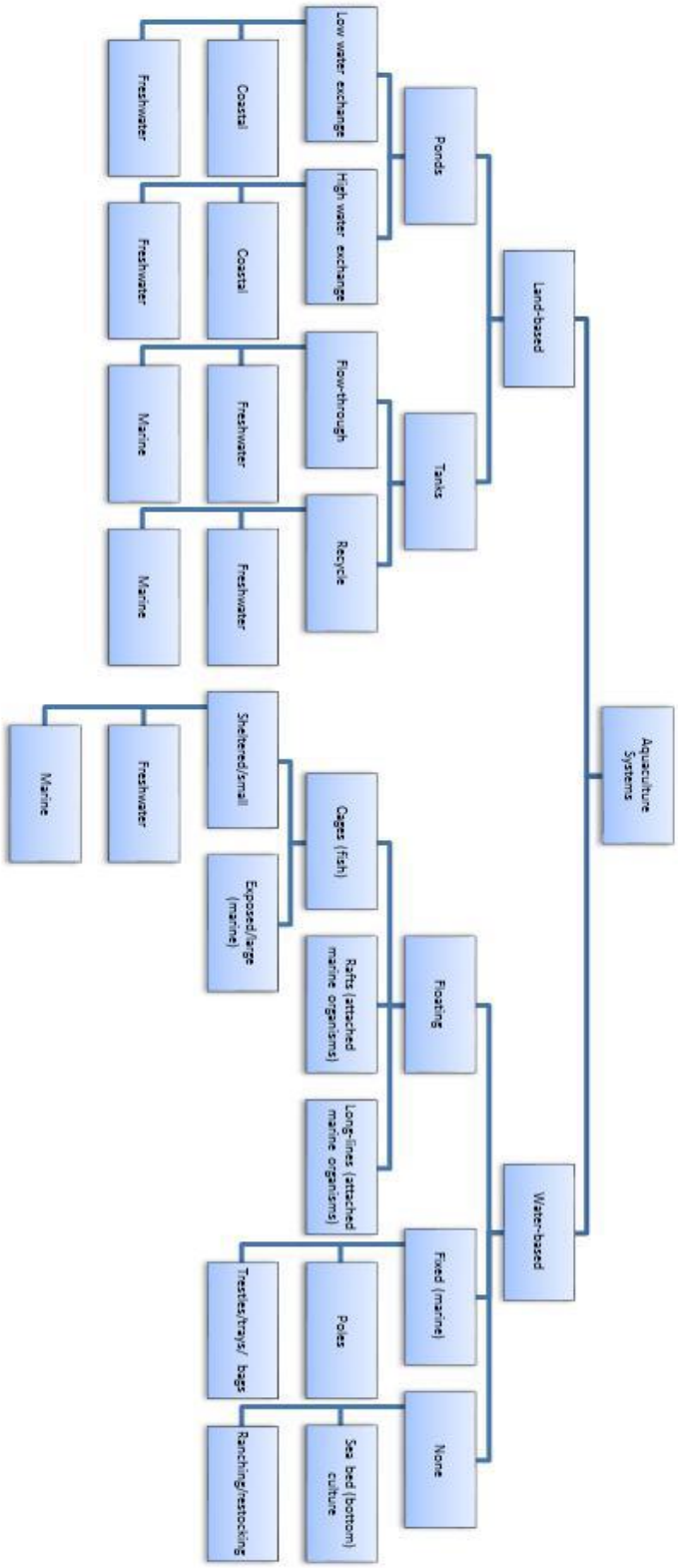


Figure 1.3 Aquaculture systems[8]

[8] http://www.europarl.europa.eu/RegData/etudes/STUD/2014/529084/IPOL_STU%282014%29529084_EN.pdf

1.4 Relationship with other pilots: Feed

Feed is known to be a major environmental aspect in the life cycle of aquaculture seafood products [3-13] . The fish for human consumption PEFCR will not cover the production of feed as this is covered by the PEFCR developed for "feed for food producing animals", led by FEFAC – the European Feed Manufacturers' Federation. This pilot will include feed for fish aquaculture as one of their representative products[9].

There are several reasons why feed production should be covered by its own PEFCR. One is to ensure future comparability between food products that are dependent on feed from the same sources, e.g., beef, farmed fish, chicken and pig. Another reason is the complexity of global feed production systems. Modern feed production includes numerous different ingredients, established and emerging ingredients. To cover all of these different ingredients and all of their potential environmental aspects, according to the PEF guide, will require a wide-ranging set of rules.

Allocation is one example of a methodical choice that has to be harmonised between the PEFCRs for food products. One practical example is how the use of byproducts from fisheries is treated once it is used in feed for aquaculture species. Also how trimmings from fish farming are treated when used in feed for agricultural meat production. It is estimated that as much as 20% of fishmeal and fish oil now come from offcuts and trimmings from fisheries and aquaculture.

2 Overview of existing PCRs and environmental studies

The PEFCR guide states that *"If, based on the results of this analysis, the existing PCR is completely in line with the PEF requirements, the existing PCR shall be used as PEFCR for the same product category, complementing it with any additional elements as appropriate (e.g. additional environmental information). If there are a number of deviations, then the Technical Secretariat shall document the major differences in a report to be uploaded in the EF virtual consultation Forum. The PEFCR development process will then adapt the existing PCR(s) and make the PCR(s) fully consistent with the PEF requirements and the requirements of this Guidance document"[1]*

From the documents identified and presented in the following chapter it does not already exist a PCR that is sufficiently in line with the PEF, that it can form the basis for a PEFCR for fish for human consumption. Two of the documents only include the carbon footprint, climate impacts, and thus not a complimentary set of impacts assessment and the third only cover a specific group of fish for human consumption products.

In addition to the existing standards for LCA and GHG assessment of consumer products as such, there are standards and guidelines that provide specifications for fish and seafood. These documents are sometimes developed and communicated within single countries, in the local language, or markets. The origin of these documents can be due to national legislation or business-to-business communication systems. The Environmental Product Declaration Systems, in particular, has produced a lot of rules and guidelines (different forms of PEFCRs) for assessment of different products around the world. However, it is difficult to find them, they are not very transparent and their quality is very uneven. The PEFCR Guide lists standards and guidelines that are relevant for the PEF in its chapter 1.3.2 [1].

[9] Link to web page with overview and info on other PEFCR developments: http://ec.europa.eu/environment/eussd/smgp/pef_pilots.htm

Table 2.1**Feil! Fant ikke referansekilden.** presents known and trusted documents containing guidelines for LCA-based assessment of fish and seafood products. **Feil! Fant ikke referansekilden.** Table 2.2 presents how these align to the PEF with regards to methodological requirements.

Table 2.1 documents providing guidance for LCA of fish and seafood products

Document	Type of document
BSI PAS 2050-2:2012 Assessment of life cycle greenhouse gas emissions[10].	This Publicly Available Specification (PAS), PAS 2050-2, contains requirements for the assessment of life cycle greenhouse gas (GHG) emissions specifically associated with seafood and other aquatic food products. The requirements are supplementary to those specified in PAS 2050:2011, which provides a generic method for assessing the life cycle GHG emissions of goods and services [14].
NS 9418:2013 Carbon footprint for seafood - Product category rules (CFP-PCR),	Developed by Standards Norway [15]. This is the only one published in Norwegian.
PRODUCT CATEGORY RULES ACCORDING TO ISO 14025:2006. PRODUCT GROUP: UN CPC 2124 FISH, OTHERWISE PREPARED OR PRESERVED; CAVIAR AND CAVIAR SUBSTITUTES[11]	This is a PCR document developed in the framework of the International EPD System, operating in accordance with ISO 14025:2006; 9001; 14001; 14040 and 14044. The International EPD® System is a system of voluntary environmental declarations applicable to any type of goods and services.

2.1 Alignment of PCRs and sectorial guidance documents against the PEF Guidelines and the Pilot

Both the supplementary requirements for the application of PAS 2050:2011 to seafood and other aquatic food products by British Standard Institute (BSI, 2012) and the NS 9418:2013 Carbon footprint for seafood - Product category rules (CFP-PCR), Developed by Standards Norway (SN, 2013) align well with the intension of the seafood PEFCR as they both are founded on the LCA methodology.

There are methodological differences and it is important to be aware that these two documents only treat climate impacts and not other environmental impacts. This is a fundamental difference to consider.

[10] Link to the BSI web page: http://shop.bsigroup.com/en/Browse-By-Subject/Environmental-Management-and-Sustainability/PAS-2050/PAS-2050-2/

[11] Link to web page with the PCR: http://www.environdec.com/en/PCR/Detail/?Pcr=9006#.VEiz8PmsWQA

Table 2.2 Alignment of identified PCRs with the PEF/ENVIFOOD (multiple pages)

Document	PEF / ENVIFOOD	BSI PAS 2050-2:2012 Assessment of life cycle greenhouse gas emissions.	NS 9418:2013 Carbon footprint for seafood - Product category rules (CFP-PCR)	EPD PCR PRODUCT GROUP: UN CPC 2124 FISH, OTHERWISE PREPARED OR PRESERVED; CAVIAR AND CAVIAR SUBSTITUTES
Scope	PEF: All kind of products ENVIFOOD: Food and drink products	Seafood and other aquatic food products derived from both wild capture and aquaculture production.	Seafood and other aquatic food products derived from both wild capture and aquaculture production.	Fish, otherwise prepared or preserved; caviar and caviar substitutes
System boundaries	The system boundary shall be defined following general supply-chain logic, including all stages from raw material extraction through processing, production, distribution, storage, use stage and end-of-life treatment of the product, as appropriate to the intended application of the study.	Cradle-to-gate. The rest of a products life cycle covered by PAS 2050. Capture fisheries: 1) Fishing, including preparation and transport to and from fishing fields 2) Landing and auctioning 3) Processing and storing 4) Transport and distribution including packing Aquaculture: 1) Capturing and/or cultivation of broodstock 2) Hatching and nurseries 3) Farming, harvesting & slaughtering 4) Processing and storing 5) Transport and distribution including packing	NS 9418 covers the value chain from production of feed ingredients up to retailer gate. For stages after retailer, it points to the use of ISO 14067.	Complete life cycle.
Functional unit	descriptive: - The function(s)/service(s) provided: “what” - The extent of the function or service: “how much” - The expected level of quality: “how well” - The duration/life time of the product: “how long”.	Point the requirements of PAS 2050:2011 5.9, but also provides recommendations/examples for the functional unit for seafood products. The functional unit shall be recorded to two significant figures. Where a product is commonly available on a variable unit size basis, the calculation of GHG emissions shall be proportional to the unit size (e.g. per kilogram or per litre of goods sold, or per month or year of a service provided).	1 kilogram of edible products.	The declared unit (DU) is 100 g of edible product plus the packaging weight . The reference flow shall be defined at the customer gate, at the shelf or the retailer or at the market place. Should covering liquids or preservatives are considered edible, their weight is intended to contribute to the declared Unit. Otherwise, only the seafood drained weight shall be considered.
Allocation	Hierarchy: 1.subdivision or system expansion by substitution; 2.based on a relevant underlying physical relationship; 3.based on some other relationship (including economic allocation).	Hierarchy of allocation a) Avoidance by dividing the unit processes to be allocated or expanding the product system b) Where neither of these approaches is practicable, the GHG emissions and removals arising from the process shall be allocated between the co-products in proportion to their mass (for some cases volume).	Allocation should be done based on the mass of the outputs, if allocation cannot be avoided by subdividing the production system or system expansion.	If allocation cannot be avoided by dividing the unit process into two or more sub-processes and collecting the environmental data related to these sub-processes, the priorities suggested by the ISO 14040 shall be considered.

Impacts categories and impact assessment method	• Climate Change • Ozone Depletion • Ecotoxicity for aquatic fresh water • Human Toxicity - cancer effects • Human Toxicity – non- cancer effects • Particulate Matter/Respiratory Inorganics • Ionising Radiation – human health effects • Photochemical Ozone Formation • Acidification • Eutrophication – terrestrial • Eutrophication – aquatic • Resource Depletion – water • Resource Depletion – mineral, fossil • Land Transformation Relevant potential environmental impacts of a product may go beyond the widely accepted life-cycle-based EF impact assessment models. It is important to consider these environmental impacts whenever feasible	Only climate impact	Only climate impact. Impact assessment method according to the IPPC 4th assessment report.	▪ Use of resources. Materials, energy and water ▪ Emission of greenhouse gases ▪ Emission of ozone-depleting gases ▪ Emission of acidifying gases ▪ Emissions of gases that contribute to the creation of ground level ozone ▪ Emission of substances to water contributing to oxygen depletion ▪ Waste generation ▪ State of fish stocks with reference to the species of interest, total world captures and data sources (e.g. FAO, ISSF) Impact assessment method and characterization factors as recommended by the EPD system[12].
Waste and end of life	waste flows arising from processes included in the system boundaries shall be modelled to the level of elementary flows. The waste treatment scenarios shall be based on current practice, technology and data.	Waste handling and processing must be included.		The potential environmental impact and benefit of recycling and waste treatment may be presented in the EPD, although only with a descriptive approach and no quantification
Normalization and weighting	The PEF guide states that following the two mandatory steps of classification and characterization, the environmental impact assessment may be complemented with normalization and weighting, which are recommended/optional steps.	Only include midpoint indicator.	Only include midpoint indicator.	Only include midpoint indicators.

[12] http://www.environdec.com/en/The-International-EPD-System/General-Programme-Instructions/

Communication		Points to other standard: Product Life Cycle Accounting and Reporting Standard by the GHG protocol.[13]	Points to the rules set by ISO 14067 and in adition requires that the products is described with its CPC and ISIC code.	Separate standards for use and communication of EPDs.
Cut-off rules	In the PEF guide cut-off is not allowed.	Point to PAS 2050:2011.	Emissions and process that contribute with less than 1% of the total carbon footprint can be excluded, but the sum of these cut offs can not sum to more than 10%.	LCI data for a minimum of 99 % of total inflows to the core module shall be included. Inflows not included in the LCA shall be documented in the EPD.
Land use change	The PEF guide requires GHG emissions from direct land use change to be allocated to goods/services for 20 years after the land use change occurs using the IPCC default values. For practical guidance on specific issues (e.g. in case previous land use is unknown), the application of PAS 2050:2011 is recommended	Climate impacts from land use changes must be included. Points to The requirements of PAS 2050:2011 5.6.	Climate impacts from land use change must be included according to ISO 14067	
Data		Data must cope with seasonal differences. Instruction on how sampling sizes should be evaluated.	Specifies where generic data can be used and where primary data should be used. Also provides guidance for data sampling. Specific guidance for electricity and fuels use.	Specifies for which processes primary data should be used. Specific guidance for electricity and fuels use.

[13] Link to GHG protocol web page: http://www.ghgprotocol.org/standards/product-standard

2.2 Relevant environmental assessment competence

Seafood production systems have been studied with LCA for the last decades. This body of assessment work covers many different goals and scopes. The environmental challenges that have been covered are often limited to only include energy use and climate impacts, but the range of environmental impacts included is expanding.

In recent years, new impact assessment methods have been developed to include biodiversity and stock bearing capacity. The assessments have not only compared seafood products with competing products from agriculture but have also compared different types of seafood products with each other. These have included products from different geographical origins and products produced with different fishing and aquaculture technologies. In addition, parameters such as fisheries and aquaculture regulations have formed part of the LCAs as well as the effects of how the production systems are operated.

There is an extensive body of scientific papers, book chapters and reports that include LCA and fish. E.g. using the search words "seafood + LCA" in two of the biggest search engines for scientific papers, ScienceDirect and Springer Link , returns 247 and 95 relevant hits.

Rather than a list of relevant projects, which would be without end, this section lists institutions and persons that have contributed to the main scientific work on seafood production systems and LCA during recent years. This list is not complete.

- Friederike Ziegler, SIK - Swedish Institute for Food and Biotechnology, Sustainable Food Production, Sweden.
- Peter Tyedmers, Dalhousie University, Halifax, Canada
- Patrik Henrikson, Leiden University[14].
- Erik Skontorp Hognes, SINTEF Fisheries and aquaculture.
- Ian Vázquez-Rowe, University of Santiago de Compostela, (now at Pontificia Universidad Católica del Perú)
- Rob Parker, University of Tasmania, Institute for Marine and Antarctic Studies, Hobart, Australia
- Ángel Avadí, Institut de Recherche pour le Développement (IRD), Centre de Recherche Halieutique Méditerranéenne et Tropicale, France
- A. Hospido, Chemical Engineering Department, Institute of Technology, University of Santiago de Compostela, Spain
- N. Pelletier, Global Ecologic Environmental Consulting and Management Services, Canada
- Jeroen Guinée, Leiden university.
- Wageningen University
- Jaime Zufía, Saioa Ramos and Begoña Pérez-Villarreal, AZTI (Spain):

[14] Link to more information and key personel: http://seatglobal.eu/partners/eu/leiden-university/

3 The scope of the PEFCR Fish for human consumption

3.1 Product scope and classification

The scope of the PEFCR Fish for human consumption is “fish and mollusk for human consumption” from marine fisheries and aquaculture. This includes fresh products and products that are solely fish and mollusk, and also preserved with techniques such as refrigeration, freezing, salting, brine, drying and smoking.

For products where seafood is only part of a manufactured product the seafood PEFCR can be used to cover the fish or mollusk part of the product, but the other ingredients and the preparation of manufactured products and will not be covered by this PEFCR.

The functionality of this product is to provide safe and nutritious food for human consumption.

The requests in the PEFCR guide will put constraints on the scope of the PEFCR as the screening analysis must cover the products that the PEFCR intend to cover. The species that this PEFCR cover, by being included in the representative product of the PEFCR and the representative product model, is presented in chapter 4.

With reference to the NACE/CPA classification, the “PEFCR fish for human consumption” will cover following classes:

- 03.0 Fish and other fishing products
    - 03.00 Fish and other fishing products
        - 03.00.1 Fish, live
            - 03.00.12 Live fish, marine, not farmed
            - 03.00.13 Live fish, freshwater, not farmed
            - 03.00.14 Live fish, marine, farmed
            - 03.00.15 Live fish, freshwater, farmed
        - 03.00.2 Fish, fresh or chilled
            - 03.00.21 Fresh or chilled fish, marine, not farmed
            - 03.00.22 Fresh or chilled fish, freshwater, not farmed
            - 03.00.23 Fresh or chilled fish, marine, farmed
            - 03.00.24 Fresh or chilled fish, freshwater, farmed
        - 03.00.4 Mollusks and other aquatic invertebrates, live, fresh or chilled
            -

In addition to these stages also the following classes under C Manufactured products 10.20 Processed and preserved fish, crustaceans and mollusks:

- 10.20.1 Fish, fresh, chilled or frozen
    - 10.20.11 Fish fillets and other fish meat (whether or not minced), fresh or chilled
    - 10.20.12 Fish livers and roes, fresh or chilled
    - 10.20.13 Fish, frozen
    - 10.20.14 Fish fillets, frozen
    - 10.20.15 Fish meat, (whether or not minced), frozen
    - 10.20.16 Fish livers and roes, frozen
- 10.20.2 Fish, otherwise prepared or preserved
    - 10.20.21 Fish fillets, dried, salted or in brine, but not smoked

- 10.20.22 Fish livers and roes dried, smoked, salted or in brine
- 10.20.23 Fish, dried, whether or not salted, or in brine
- 10.20.24 Fish, including fillets, smoked
- 10.20.25 Fish, otherwise prepared or preserved, except prepared fish dishes
- 10.20.26 Caviar and caviar substitutes

Products that are not covered:

- 03.00.3 Crustaceans, not frozen
  - 03.00.31 Crustaceans, not frozen, not farmed
  - 03.00.32 Crustaceans, not frozen, farmed
- 03.00.5 Pearls, unworked
- 03.00.6 Other aquatic plants, animals and their products
- 03.00.7 Support services to fishing and aquaculture
- 03.00.11 Live ornamental fish
- 10.8 Other food products
  - 10.85.1 Prepared meals and dishes,
    - 10.85.12 Prepared meals and dishes based on fish, crustaceans and mollusks

3.2 Functional Unit

The functional unit will be **"1 kg of edible seafood plus necessary packaging",** ensuring comparability with other food products and relevant for what most consumers and professional buyers actually consider when purchasing food.

Edible is defined as:

- For fish the meat, liver and roe
- For mollusk everything except the shell and parts that are not recommended to be eaten due to health risks.

What part of an fish that is edible is partly given by its physiology, and for that it exists databases on the percentage of meat, bone etc for specific species. Still it can be discussed what is edible, not all meat is fair to be assumed that is edible, e.g. some fishes have more and smaller bones than other. Still the PEFCR Fish for human consumption TS think that in the EU market it is a common understanding of what is fair to consider edible for a specific species. Already it exists established method to calculate from different products forms, e.g head on and gutted or fillet and back to the weight of round fish. This operation si done in all types of fisheries and aquaculture statistics and in toll declarations. E.g. FAO use such data and provide examples in their CWP Handbook of Fishery Statistical Standards[15], [16]

In case it shows that further clarification of what is fair to define as edible databases can be established, based on bilological facts and consensus building processes.

[15] Link to FAO web page on CONVERSION FACTORS: http://www.fao.org/fishery/cwp/handbook/I/en
[16] List of examples from FAO: http://www.fao.org/fishery/cwp/handbook/I/en

Other functional units could have been relevant and possible for study (e.g. nutritional value "1 kg of protein") however, seafood contains a range of different nutritive substances, such as proteins and different amino acids, various minerals, vitamins and fatty acids which make fish a valuable food item. Public health authorities, in general, recommend the population to eat more fish of as part of a balanced and differentiated diet. However, the concentrations of different nutritive substances may differ considerably - dependent on species, season and geography - without influencing the environmental footprint of the products.

In addition, EU legislation sets specific rules on information for consumers regarding the nutritional value of food in general. On this basis, it is suggested that the functional unit is not linked to any specific nutritive substance that is contained, in varying levels, in all kinds of seafood.

The PEFCR guide requires the following to be described for the functional unit:

- **What**: Seafood products for human consumption and the packaging needed to deliver 1 kg of the product to the final consumer.
- **How much**: 1 kg
- **How good**: The product should be appropriate for human consumption
- **How long**: For products where durability or shelf-life is established

The Envifood protocol [16] differs between its recommendation for the functional unit for B2B communication and B2C communication:

- "[B2C] Many materials and intermediate products are used in the supply chain of consumer goods. The final use and function of these are not always known at the point of sale for the operator selling its product. If a functional unit is common in B2B relationships (e.g. for the payment of intermediate products, fat content of milk may be used), this functional unit may also be used for the calculation of life cycle impacts. Otherwise the unit of analysis corresponds to the reference flow."

- "For B2C communication-related applications, the unit of analysis is the functional unit that should be in line with the requirements of the EU Regulation 1169/2011 on the provision of food information to consumers for nutrition declarations, as relevant. Hence, the functional unit should be expressed per weight or volume (i.e. 100 g or ml). In addition, it may be expressed otherwise (i.e. per portion, per consumption unit or per unit sold) as stated by the relevant PCRs."

3.3 System boundaries

This is how the Envifood protocol explains system boundaries: *"System boundaries are a set of criteria specifying which unit processes are part of a product system (ISO 14040:2006). The system boundary should as far as possible include all relevant life cycle stages and processes (EC, 2010). Cut-off criteria will determine how completely a system is assessed (i.e. which inputs will be taken into consideration in the assessment). According to ISO, using initial identification of inputs based on mass alone may lead to significant omissions, hence energy and environmental significance should also be used as cut-off criteria."* [16]

The system boundaries for the PEFCR Fish for human consumption will be from fishing and aquaculture and up to the stage where the fish is prepared and consumed. This system boundary is indicated in Figure 3.1**Feil! Fant ikke referansekilden.**.

The life cycle of fish products can be divided into (Figure 3.1**Feil! Fant ikke referansekilden.**):

- Feed manufacture (for aquaculture production)
- Aquaculture
- Fishing
- Processing: Conservation (e.g. freezing, drying and salting), gutting, filleting, mincing and other types of processing of the seafood.
- Distribution: Transport and storing from landing site to processing, retailer and final consumer
- Manufacturing of mixed food products. Similar to processing, but here mixing of fish and molluscs with other food products
- Retail: Display and storage
- Use: preparation and consumption
- Waste treatment.

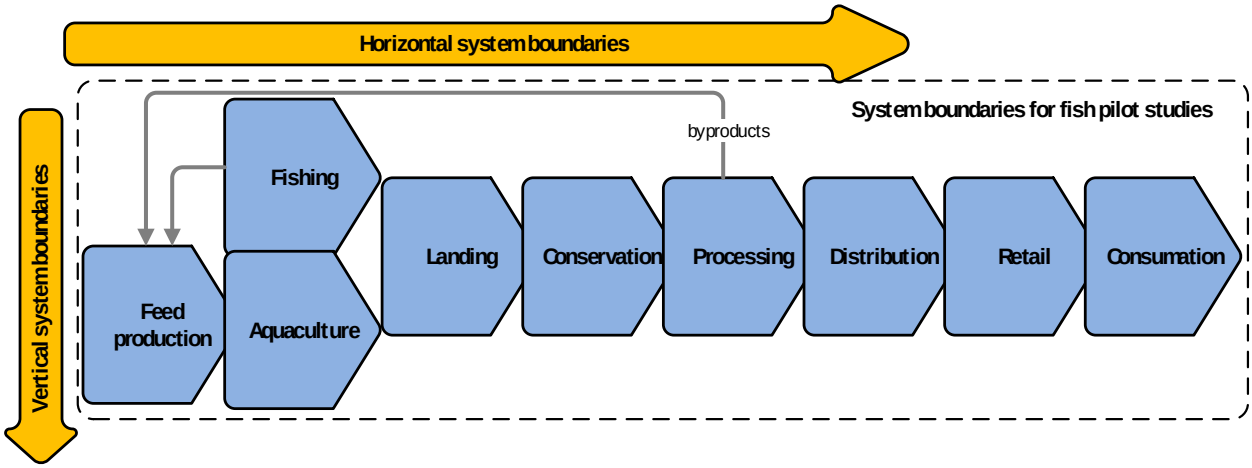


Figure 3.1 life stages and suggested system boundaries for PEFCR Fish for human consumption.

4 Representative product and model

The representative products for the PEFCR Fish for human consumption will be 1 kg of edible seafood at the EU market and the model for the representative product captures the different production technologies that supply the EU marked. This 1 kg will be a virtual (non-existing) product composed by products from the most important production methods that supply the EU seafood market. These shares are presented through the consumption data presented in chapter 1.2 and Figure 4.2.

Here seafood is considered as one type of product, all seafood deliver the same functionality, a meal, but produced with several different technologies. This is illustrated in Figure 4.1.

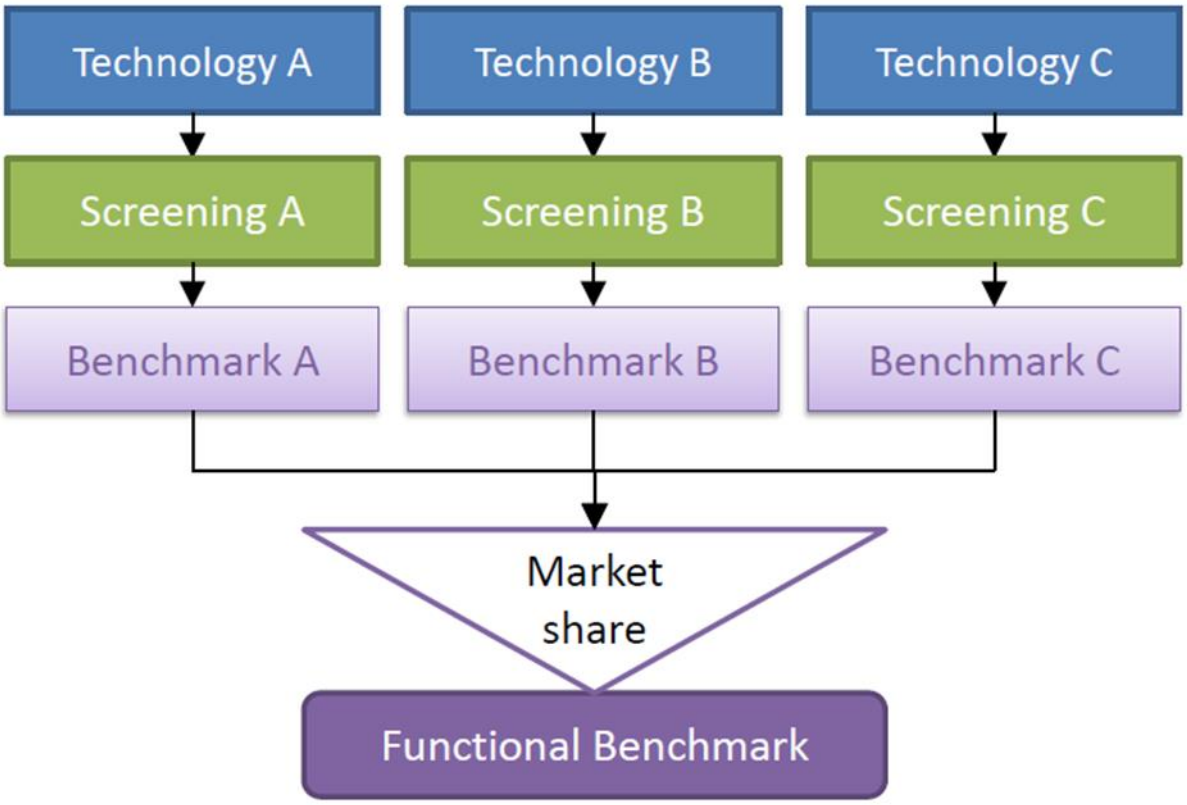


Figure 4.1 From webinar on representative products

The selection of the representative product is based on the goal of capturing important and fundamentally different production, processing and distribution technologies. This approach is chosen based on the experience from LCAs that show that the manner in which seafood is produced, processed and distributed is more important for which environmental impacts it causes than the individual species.

- One especially important exception from this is the direct impacts on fish stocks from fishing, in this case what species is fished is the only thing that matter

The following figure presents what technologies that will be assessed in the screening studies and the products that they cover. The representative product will be composed by the products and productions systems/technologies presented in this figure. The percentage in brackets indicate how much of the consumption per capita that product presents in the EU seafood consumption (see Table 1.3). In sum the representative product as indicated in Figure 4.2, with the connections established by the TS, cover more than 94% of the seafood consumed in the EU, measured per mass consumed per capita.

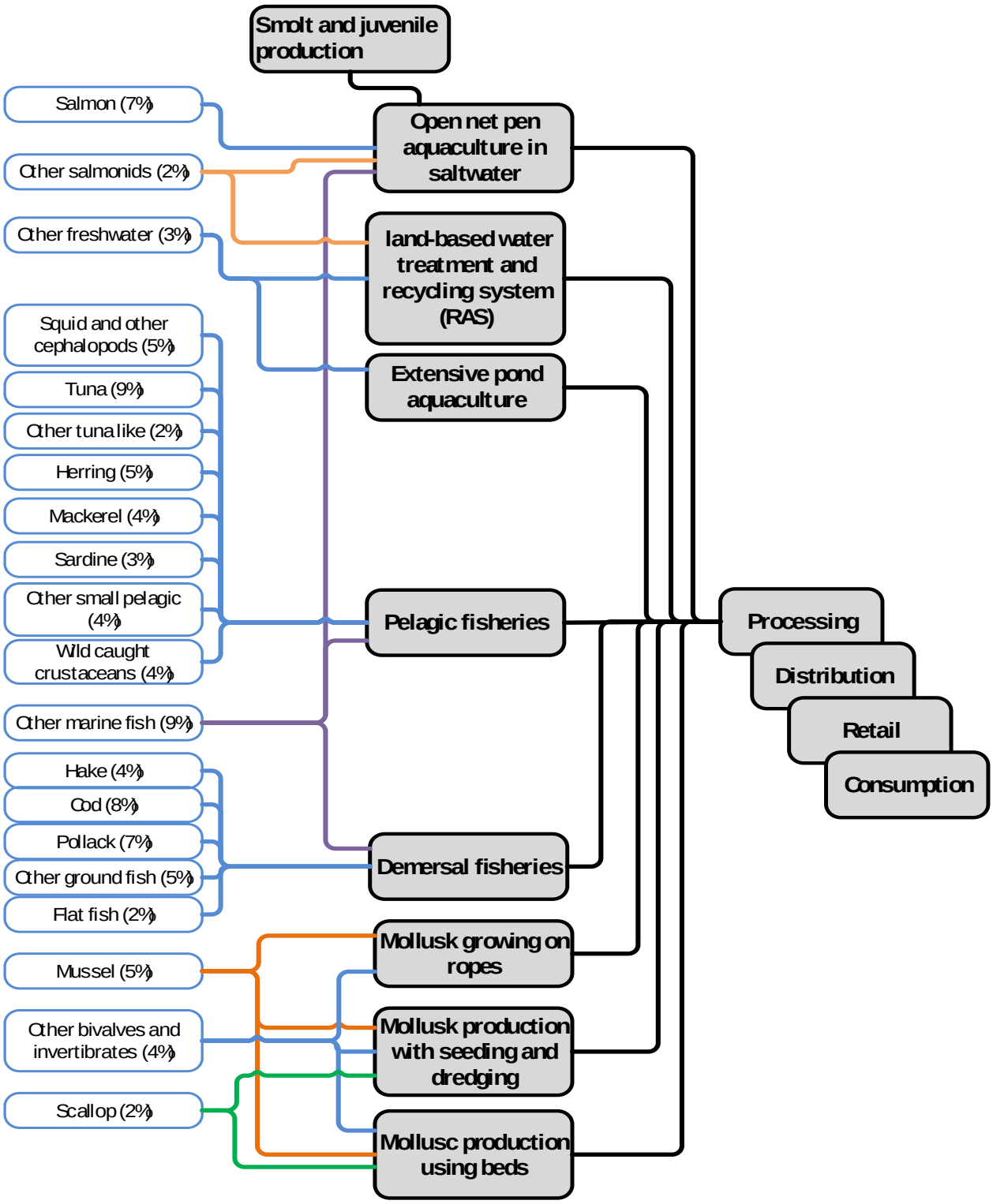
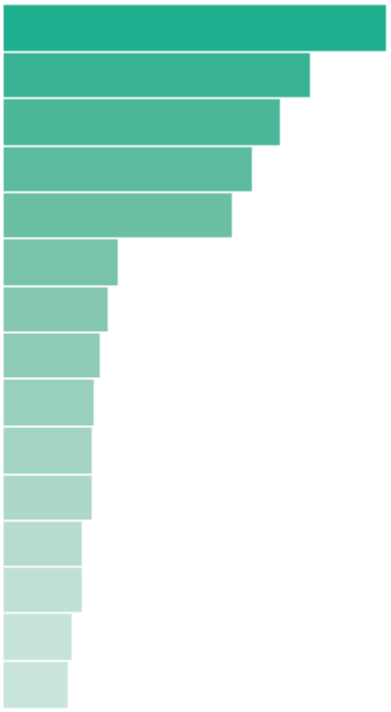


Figure 4.2: Products and production technologies covered by the representative product model. The percentages in this figure (they sum up to 94%) present each products share of the EU seafood consumption per capita, (see chapter 1.2 and Table 1.3).

When the data on seafood consumption is compared with EU fisheries landings we see that the main species are the same.

Table 4.1 The 15 main species caught by the European Union (2011) (volume in tonnes live weight and percentage of total) [17]

Herring	509 951	10.46%
Sprat	413 415	8.48%
Mackerel	376 333	7.72%
Sandeels	335 023	6.87%
Sardine	307 963	6.31%
Horse mackerel	159 756	3.28%
Cod	146 634	3.01%
Jack and horse mackerels	133 531	2.74%
Anchovy	126 115	2.59%
Round sardinella	123 600	2.53%
Skipjack tuna	121 056	2.48%
Yellowfin tuna	102 132	2.09%
Blue shark	100 270	2.06%
Hake	85 256	1.75%
Plaice	82 668	1.70%



4.1 Description of the model for PEF screening studies

Feil! Fant ikke referansekilden. presents a generic working map of seafood production systems, here important life cycle stages and energy and material inputs are mapped.

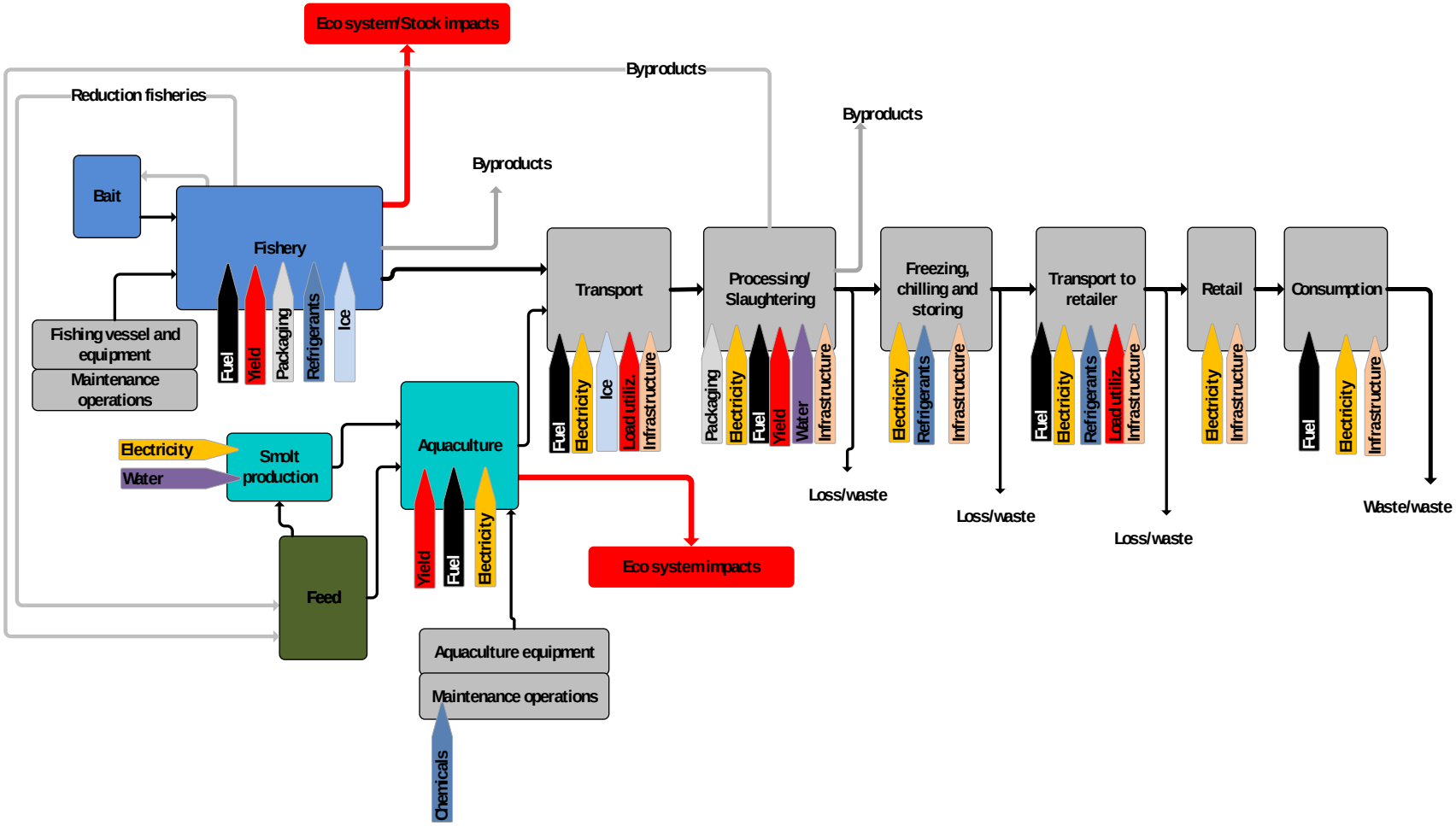


Figure 4.3 Flow sheet of a generic seafood production system with important mass and energy flows indicated

4.2 Bill of materials

Fish can be divided into different body segments, the following list providing non-exclusive examples, as there are numerous different ways to separate a fish:

- Head
- Guts
- Body - Fillets, Back loin, Belly loin
- Tail
- Fins
- Offal - e.g. Stomach, Liver...
- Eggs or Roe
- For mollusks, the body and the shell are the 2 main items.

Packaging materials are used in different parts of the process: two main types will be bulk packaging, used in the value chain from fishing to repacking, and retail/consumer packaging. Materials that are commonly used in the seafood industry for packaging are:

- Plastics: Extruded polystyrene (EPS), polypropylene boxes and polyethylene film.
- Wood: Boxes and pallets
- Paper and cardboard. Often cardboard with a plastic of wax film

4.3 Data strategy

It does not exist databases that contain LCI data on seafood production systems of high quality, and that cover the global seafood production system. That would be the whole world.
Data for the processes that are unique for seafood production systems, what one will often refer to as the foreground system, will be modelled using data from:-

- data gathered by members in the TS from previous LCAs of seafood productions systems
- official statistics
- literature: journal articles and scientific reports
- data collection from TS members and relevant producers

Data on the processes that underpin the seafood production system with e.g. materials, energy and infrastructure, what is often referred to as the background system, will be modelled using data from the latest version of the life cycle inventor database Ecoinvent.

The screening analysis will be performed in the LCA software Simapro.

4.4 Production (fishing and aquaculture) technologies

The list seafood production technologies that will be covered in the representative product and it model is presented in Figure 4.2. The following presents more details on these technologies and how they will be included in the representative product model.

4.4.1 Fishing technologies

According to the report "Facts and figures on the Common Fisheries Policy - Basic statistical data 2014 EDITION"[17] the EU fishing fleet, per February 2014, consists of more than 87 000 vessels. 16% of the catches in EU-28 is caught with trawl and the remaining 84% with conventional (non trawling gear).

To map and study environmental hot spots in fisheries , Norwegian fisheries will be used as a proxy. This will include data from:

- Demersal fisheries with trawl and conventional gears, e.g. coastal fisheries with jig and gillnets and autoliners.
- Pelagic fisheries with trawl and conventional fishing gears such as purse seins.

At this point it is not identified data on exactly how much is captured with each gear in Europe. That will be added as soon as good and complete data is identified. Figure 4.2 presents how the TS consider that species in the EU seafood consumption and production technologies are connected.

4.4.2 Aquaculture technologies

The aquaculture technologies that will be covered by the representative model is:

- Open net pen aquaculture in sea water will be modelled using data from Norwegian production of Atlantic salmon as a proxy
- Land based RAs systems will be modelled using data from literature and from Danish trout production as a proxy
- Freshwater pond aquaculture will be covered using data from literature and by data collection from Hungarian carp production.
- Growing, dredging and bedding of bivalves and invertebrates will be modelled using data from Norwegian mollusc production, data collection from French producers and literature data from LCAs of Spanish mussel production.

To address other species than the ones mentioned in this list, for the screening studies, sensitivity analysis can be performed for parameters that are known to be different for different species. One example will be feed efficiency and mortality in open net pen aquaculture of salmon and seabass.

Based on data in chapter 5.2 in the report "Facts and figures on the Common Fisheries Policy - Basic statistical data 2014 EDITION" [17] a table was produced showing aquaculture in Europe with Norwegian production included. This table has a rough assumption that all the Norwegian production is salmon, while a small share of it would be trout and mussels and an even smaller share would be other saltwater fishes. This table also show what percentage, of value and mass, the technologies included in the representative model cover. This is also based on the qualified assumption on what technologies that are used to produce the different species, explained in the comments field of the table.

Table 4.2 European aquaculture production with assumptions on technologies applied

Aquaculture production in Europe					
	1 000 EUR	% value	Tonne live weight	% mass	Comment
salmon	4 516 724	61 %	1 309 388	55 %	Assumed all Norwegian production was salmon
trout	499 904	7 %	185 539	8 %	
oyster	438 512	6 %	98 751	4 %	
mussel	428 773	6 %	492 413	21 %	
Gilt-head seabream	370 251	5 %	72 900	3 %	
seabass	369 812	5 %	67 809	3 %	
clam	171 597	2 %	37 028	2 %	
bluefin tuna	145 374	2 %			
carp	136 467	2 %	73 860	3 %	
turbot	70 949	1 %	10 799	0 %	
Other freshwater fish			13 989	1 %	
Total EU-28	3 598 955		1 254 106		
Norwegian aquaculture	3 764 608		1 138 797		
Total including Norway	7 363 563		2 392 903		
Aquaculture technology	**Value covered**		**Mass covered**		
	1 000 EUR	**% value**	**Tonne live weight**	**% mass**	**Comment**
Saltwater aquaculture with open net pen	5 256 787	71 %	1 450 097	61 %	Assumed that Salmon, Gilt-head seabream and Seabass is produced with open net pen aquaculture
Land based RAS systems	716 227	10 %	210 327	9 %	Assumed that Trout, Blue fin tuna, Turbot and "other freshwater fish" is produced in land based recycling systems
Freshwater pond aquaculture	136 467	2 %	73 860	3 %	Carp is produced in extensive pond aquaculture
Growing, dredging and bedding of bivalves and invertibrates	1 038 882	14 %	628 192	26 %	Oyster, Mussel and Clam are produced with theses methodes.

Feil! Ugyldig selvreferanse for bokmerke. presents the top ten species produced with aquaculture (in value and in mass) in the EU in 2011. Here Norwegian production is not included.

Table 4.3 Top 10 species in aquaculture in the EU (2011). On the left side in value and on the right side in tonne live weight [17].

	value	% value
Salmon	752 116	20.90%
Trout	499 904	13.89%
Oyster	438 512	12.18%
Mussel	428 773	11.91%
Gilt-head seabream	370 251	10.29%
Seabass	369 812	10.28%
Clam	171 597	4.77%
Bluefin tuna	145 374	4.04%
Carp	136 467	3.79%
Turbot	70 949	1.97%

	volume	% volume
Mussel	492 413	39.18%
Trout	185 539	14.76%
Salmon	170 591	13.57%
Oyster	98 751	7.86%
Carp	73 860	5.88%
Gilt-head seabream	72 900	5.80%
Seabass	67 809	5.40%
Clam	37 028	2.95%
Other freshwater fish	13 989	1.11%
Turbot	10 799	0.86%

4.5 Seafood processing

Processing such as gutting, filleting, refrigeration, freezing and drying will be included in the screening analysis.

4.6 Transport

Different transport and distribution methods will be included in the screenings studies: Ship and truck and fresh and frozen transport. Transport processes will be included using data from the LCIA database EcoInvent (latest version).

4.7 Packaging

Packaging materials will be included in the screening model with data from the LCIA database EcoInvent (latest version). The most common packaging material swill be included in the screening analysis, this encompass materials such as:

- Plastics: Extruded polystyrene (EPS), polypropylene boxes and polyethylene film.
- Wood: Boxes and pallets
- Paper and cardboard. Often cardboard with a plastic of wax film

For packaging materials that goes too energy or material recycling the end of life formula presented in chapter 3.7 of the PEFCR Guide [1] and in annex V of the PEF Guide [18] will be used.

4.8 Allocation, waste and end of life treatment

For processes with multiple outputs, allocation will be performed using mass allocation. For outputs that are not in any kind of way utilized the allocation will be set to zero. This is then considered to be waste. Mass allocation is option number two in the hierarchy of allocation models that they suggest

Allocation will be further discussed according to parallel discussions on this methodical choice in the cow model working group.

Here waste is defined as something that is not used, and by-product is defined as something that is somehow utilized. Thus what is waste end what is by-product is defined by what the producer actually choose to do with these resources. It is not possible to predefine what is what is what; it is up to the decision of those that generate the product/by-product/waste.

For the screening analysis it will clarified what is assumed to be utilized (considered a by-product) and what is considered not to be utilized (waste)

For outputs that go too energy or material recovery the end of life formula presented in chapter 3.7 of the PEFCR Guide [1] and in annex V of the PEF Guide [18] will be used.

The following presents examples of outputs from important processes in seafood production systems

Table 4.4 Outputs seafood production systems

Life cycle stage	Outputs
Fishing	- Bycatch, non targeted catch - Guts, blood etc from processing e.g. gutting, filleting, - products that does not have the required quality for intended use - Packaging materials and equipment
Aquaculture	- dead fish - escapes - products that does not have the required quality for intended use - Packaging materials and equipment - sludge
Processing	- Cut offs, blood, water with proteins, guts - Packaging materials - products that does not have the required quality for intended use

4.9 Capital goods

The pilots are required to include capital goods in the assessment process. For seafood, capital goods are items such as aquaculture equipment and facilities, fishing vessels and the infrastructure that the seafood industry relies on, harbors, roads, airports etc. Capital goods will be included in the screening analysis using the LCIA database EcoInvent (latest version).

4.10 Use

Most seafood LCAs have only included the life cycle up to the farm gate or landing site or to the retailer. Nonetheless, it is expected, for most food products, that the consumer's activities relative to buying and

preparing food is of great importance so as to consider the complete life cycle of the products. Nonetheless, there are several good reasons for not including this phase.

Firstly, variability is potentially unlimited since the single consumer's preferences are the key to purchase and preparation. Secondly is consideration that, at this stage of the life cycle, the seafood producers, sellers and retailers have limited capacity to influence the environmental impacts caused by the use of the product.

Chapter 6 in the Envifood protocol also treats how the 'use' phase of different food products can be included [16]

The retailer and consumer stages will be included with a case where the relevant parameters are defined based on the experience and competence of the pilot technical secretariat.

4.11 Benchmarking

The representative product and its model is chosen with respect of the goal of identifying environmental hotspots, to provide the necessary knowledge to evaluate the rules in the PEFCR.

With the inherent variation in the global seafood production systems that supply the European market it will not in any kind of way be possible to provide robust and responsible benchmarks for specific species. However the model can deliver benchmark in the form of extremities, but then for one and one technology pathway. Also for the species that are used as case examples in the screening benchmarks can be provided.

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