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FRENCH LCI PROJECT ON FISHERIES

METHODOLOGICAL REPORT

Constructing life cycle inventories for
key French fishery products

METHODOLOGICAL REPORT



In collaboration with:



ANOP
Association Nationale des
Organisations de Producteurs de la
pêche maritime et des cultures marines



Le pôle des produits aquatiques
BUREAU MAURIC
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S A . T H O . A N .

S E T E

plate-forme
d'innovation
nouvelles
vagues

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CONSEIL



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The many companies that provided answers to our questions

The boat owners and professional fishers who took part in the surveys

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Summary

French LCI Project on Fisheries

Over the last several years, the French fishing industry has sought to more sustainably exploit marine ecosystems. As part of this process, one goal is to improve understanding of the environmental impacts of fishing systems. Consequently, the fishing industry has become more and more interested in environmental analysis methods, including life cycle analysis (LCA). In tandem, the first phase of the AGRIBALYSE® programme (which was launched in 2011 by ADEME) resulted in a life cycle inventory (LCI) database for agricultural products. ADEME proposed including fishery products as part of the programme's second phase. The French LCI Project on Fisheries resulted from this proposal and the industry's existing interest in LCA methodology.

The project is jointly financed by ADEME and FFP. It has brought together 15 collaborators—researchers and fisheries professionals—whose efforts are coordinated by CNPMEM. The project's goal is two-fold. First, it aims to use the LCA approach to improve methodology for evaluating the environmental impact of fishing systems. Second, it seeks to build and make available LCI data on different French fishery products. The project will yield several deliverables:

- this methodological report
- a questionnaire (two versions: a paper version and an electronic version) with an associated user's guide
- a data entry tool with an associated user's guide
- LCI databases for several fishery products
- summary sheets presenting project results

The methodological report

Report objectives

This report describes and discusses the methodological choices made by project collaborators during the construction of the LCIs for different French fishery products. The goal is to ensure transparency and reproducibility. The report seeks to document the methods used, not to provide specific recommendations. Its intended audience is anyone who wishes to assess the quality of the data in the AGRIBALYSE® database and/or to build LCIs for fishery products.

Fishing systems studied

LCIs were built for 15 fishing systems considered to be representative of the diversity of French fisheries. Given the specific nature of fishing activities, these fishing systems were defined based on three facets: target species, fishing area, and type of fishing gear. They are therefore hereafter referred to as “triplets”. This approach made it possible to accurately represent a fisher's métier, in contrast to what would be obtained using an approach focused exclusively on target species. In this report, the term métier is defined as a fishing activity exercised to capture a certain group of target species using a single type of fishing gear in a given area during a given season. A métier is indicative of where and how boats work.

System boundaries

In the triplets examined by the project, the focus was on the phases from cradle to gate. Consequently, the end boundary for the LCI was the boat's return to port. The LCI took into account the consumption and emissions flows associated with boat construction and maintenance, fishing gear construction and maintenance, vessel operation (diesel, oil, etc.), and fish storage and transformation on the boat. All operations related to the unloading, auctioning, trade, distribution, and consumption of fishery products fell outside the scope of this study. The study's reference period was from 2011 to 2015.

Data collection and analysis

Data were collected directly from professional fishers. This task was accomplished using a questionnaire. There were two versions—one for use in the field and one for use online. Data were entered using a standardised data entry tool, to ensure data homogeneity across triplets. The LCIs were then built using Simapro® software and the ecoinvent® (v. 3) database.

Ensuring data quality

Data quality was evaluated at the level of the individual datum and at the level of the overall inventory, in accordance with AGRIBALYSE® programme standards. Additionally, one of the project collaborators, the consulting firm Cycleco, critically assessed the data. Finally, the professional fishers who contributed data to the project also examined data quality *a posteriori* to confirm that data entry and analysis were consistent.

Flow allocation

Like agricultural activity, fishing activity leads to several products. Whenever possible, systems were broken down to avoid flow allocation, which reduces precision. When such a breakdown was impossible, mass allocation was used to partition different flows among different co-products.

Abbreviations and acronyms

CEA	Eastern Central Atlantic
LCA	life cycle analysis
NEA	Northeast Atlantic
ANOP	French National Association of Producer Organisations (<i>Association Nationale des Organisations de Producteurs</i>)
CAD 22	Côtes d'Armor Development Agency (<i>Côtes d'Armor Développement</i>)
HCA	hierarchical cluster analysis
CGDD	French General Commission for Sustainable Development (<i>Commissariat Général au Développement Durable</i>)
CITPPM	French Confederation of Industries Treating the Products of Marine Fisheries and Aquaculture (<i>Confédération des Industries de Traitement des Produits des Pêches Maritimes et de l'aquaculture</i>)
CNP MEM	French National Committee for Maritime Fisheries and Fish Farming (<i>Comité National des Pêches Maritimes et des Elevages Marins</i>)
FAO	Food and Agriculture Organisation of the United Nations
FEDOPA	French Federation of Producer Organisations for Small-Scale Fisheries (<i>Fédération des Organisations de Producteurs de la Pêche Artisanale</i>)
FFP	French Interprofessional Organisation for Fishing (<i>France Filière Pêche</i>)
LCI	life cycle inventory
ILCD	International Reference Life Cycle Data System
INRA	French National Institute for Agricultural Research (<i>Institut National de Recherche Agronomique</i>)
IRD	French National Research Institute for Sustainable Development (<i>Institut de Recherche pour le Développement</i>)
MTES	French Ministry for the Ecological and Inclusive Transition (<i>Ministère de la Transition Ecologique et Solidaire</i>)
OPPAN	Producer Organisation for Noirmoutier Small-Scale Fisheries (<i>Organisation de Producteurs des Pêcheurs Artisans de Noirmoutier</i>)
MSY	maximum sustainable yield
UAPF	French Union of Fishing Boat Owners (<i>Union des Armateurs à la Pêche de France</i>)
UMR LEMAR	Joint Research Unit—Marine Environmental Science Laboratory
UMR MARBEC	Joint Research Unit for Marine Biodiversity, Exploitation, and Conservation
UMR SAS	Joint Research Unit for Soil, Agro-hydrosystems, and Spatial Modelling
VBA	Visual Basic for Applications

Introduction

Background

Across the globe, products from aquatic ecosystems are an important part of human diets. Worldwide consumption of such products continues to grow and, in 2016, it exceeded 20 kg/person/year for the first time [1]. The use of aquaculture is helping to meet these growing demands, given that landings have stagnated globally (~93,000,000 tonnes per year) and for France (~around 490,000 tonnes per year) [2]. Over the last several years, a major challenge in the fishing industry has been to combine the sustainable exploitation of marine ecosystems with effective and long-lasting socio-economic models. Consumers and activist groups are increasingly making clear that they expect such a shift, as are fishers and their representatives.

To improve the environmental sustainability of fishing systems, it is crucial to have methods for gauging performance. Among the diversity of methods available, life cycle analysis (LCA) is often used because it takes an integrative approach (impact transfers along the production chain and shifts among environmental impacts can be avoided) and it allows environmental impacts to be examined at local and global levels. Within the European Union, LCA is the methodological framework of choice when generating ecolabels for consumer products [3]. LCA can also be used to improve ecodesign practices and processes. Several years ago in France, ADEME launched the AGRIBALYSE® programme, which aims to generate life cycle inventory (LCI) databases for agricultural products [4]. After the programme's first phase (2011–2015) ended, ADEME recommended including fishery products in the programme's second phase.

In tandem, as a result of its commitment to increasing sustainability, the French fishing industry has become more and more interested in ecolabelling schemes and methods such as LCA. Over the longer term, consumers and EU legislators may start to demand the former. Furthermore, to reduce the environmental impacts of fishing practices, such impacts must first be better understood. Developing the LCA approach will allow industry stakeholders to participate in ecodesign processes as well as to quantify and utilise the resulting environmental advances. For these reasons, it is crucial for the French fishing industry to become actively involved in addressing these issues.

French LCI Project on Fisheries

The French LCI Project on Fisheries resulted from ADEME's recommendation to include fishery products in AGRIBALYSE®'s second phase and the fishing industry's interest in LCA methodology. The two-year project is led by CNPMEM and brings together 15 partners from professional organisations associated with the fishing industry (UAPF, CITPPM, ANOP, FEDOPA, SATHOAN), scientific institutions (INRA, IRD), and private consultants (Cycleco, XJ Conseil, Bureau Mauric, PFI Nouvelles Vagues). The project's representatives are CNPMEM and ADEME. Its focus is to characterise the environmental impacts of certain fishery products (fresh or frozen at landing) obtained using different fishing practices. There are two objectives. The first is to improve knowledge and evaluation methodologies related to the environmental impacts of fishery products using LCA as a starting point. The second is to generate and make available input data (i.e., reference values) for different production stages, which will ultimately be used in LCAs, and to develop calculation methods so that different fishing practices and fishery products can be evaluated. The aim is to provide users with transparent and "quality" data. Each user is then responsible for how to use the data. AGRIBALYSE® has positioned itself broadly as a database designed to support eco-design and environmental information. The project created LCIs for fifteen triplets, so-named because they are defined by three facets: target species, fishing area, and type of fishing gear used. The project's choice of triplets was determined, on the one hand, by the desire to fully represent French fishing practices and environmental constraints and, on the other hand, by technical, scientific, and bureaucratic constraints on data accessibility.

Report objectives

This report addresses the project's first objective. It describes the methodological choices made by project partners during the creation of the LCI databases for French fishery products. Constructing an LCI requires clearly describing triplets, functional units, and allocation decisions, among other factors. In addition to providing metadata for each LCI, this report ensures the transparency and reproducibility the approach. While it describes the methods used, the intent is not to provide recommendations. Its intended audience is anyone who wishes to assess the quality of the data in the AGRIBALYSE® database and/or to build LCIs for fishery products. The decision context refers to an "A" (micro-level decision support) situation, i.e. at the product or process level.

1. Study scope

1.1. Description of triplets

The French LCI Project on Fisheries examined 15 examples of French fishing systems. They were chosen based on several criteria. First, these systems were intended to be as representative as possible of the diverse practices used by French fishers and to highlight associated environmental constraints. Second, because data collection is a crucial part of building LCIs, there needed to be limited technical, scientific, and bureaucratic constraints on data accessibility for these fishing systems. Third, the systems needed to be of import to the French market, whether in terms of tonnage and/or economic value.

Different fishing strategies and methods exist in France and, indeed, across the world. A boat can fish all year or only during specific periods. Different gear can be used—during the same trip or during different trips over the course of the year. There can be one or more target species, which may or may not be caught alongside non-target species. A distinction can therefore be made between single-species fisheries, in which there is one target species, and multispecies fisheries, in which multiple species are retained. Finally, a boat may fish within several geographic areas over the course of the season.

Given that fishing activities display specificities, triplets were defined based on the following:

Target species—Fishing area—Fishing gear

This categorisation scheme is useful because it reflects practical realities in the fishing industry and corresponds to the notion of *métier*, which is comparable to the concept of the "regime" in agricultural systems. For example, when we talk about a gillnetter that mainly targets sole in the Bay of Biscay, it has a concrete meaning. If the LCI had been focused on "sole fishing in France", clarity would have been lost since sole can be caught via trammel net or trawl in the Bay of Biscay, eastern English Channel, or Mediterranean Sea, and different activity types can have different environmental impacts.

The triplets examined by the project are described in Table 1.

Species	Fishing area	Fishing gear	Fish state upon landing
Great Atlantic scallop (<i>Pecten maximus</i>)	Saint-Brieuc Bay	Dredge	Fresh—Whole, in shell
Gadidae Atlantic cod (<i>Gadus morhua</i>) Haddock (<i>Melanogrammus aeglefinus</i>) Whiting (<i>Merlangius merlangus</i>)	Celtic Sea	Bottom trawl	Fresh—Eviscerated
Atlantic herring (<i>Clupea harengus</i>)	Northeast Atlantic	Pelagic trawl	Frozen—Whole
Atlantic mackerel (<i>Scomber scombrus</i>)	Northeast Atlantic	Pelagic trawl	Frozen—Whole
Saithe (<i>Pollachius virens</i>)—Fresh	North Sea	Bottom trawl	Fresh—Eviscerated
Saithe (<i>Pollachius virens</i>)—Frozen	North Sea	Bottom trawl	Frozen—Fillet
European pilchard (<i>Sardina pilchardus</i>)	Eastern Central Atlantic	Seine	Fresh—Whole
European anchovy (<i>Engraulis encrasicolus</i>)	Eastern Central Atlantic	Seine	Fresh—Whole
European pilchard (<i>Sardina pilchardus</i>)	Bay of Biscay	Seine	Fresh—Whole
Common sole (<i>Solea solea</i>)	Bay of Biscay	Trammel net	Fresh—Eviscerated
Albacore tuna (<i>Thunnus alalunga</i>)	Northeast Atlantic	Pelagic trawl	Fresh—Whole
Atlantic bluefin tuna (<i>Thunnus thynnus</i>)	Mediterranean Sea	Seine	Live
Atlantic bluefin tuna (<i>Thunnus thynnus</i>)	Mediterranean Sea	Longline	Fresh—Whole
Yellowfin tuna (<i>Thunnus albacares</i>)	Eastern Central Atlantic	Seine	Frozen—Whole
Skipjack tuna (<i>Katsuwonus pelamis</i>)	Eastern Central Atlantic	Seine	Frozen—Whole

Table 1: List of triplets

The triplet **Great Atlantic scallop—Saint-Brieuc Bay—Dredge** refers to all boats practicing the métier of harvesting Great Atlantic scallops using dredges in Saint-Brieuc Bay. In this triplet, the scallop is the only species landed. As seen in Figure 1, boats harvest the Great Atlantic scallop from several production areas: the main scallop bed in Saint-Brieuc Bay, which opens around mid-November; the Perros-Guirec scallop bed; the open water zone; the Nerput scallop bed in the open waters near Saint-Cast-le-Guildo; and the so-called "slipper snail" zone to the south of Saint-Quay-Portrieux. Some of the boats surveyed occasionally use the beds near Saint-Malo and Granville, which fall under a different regulatory scheme. Because it was impossible to disentangle the activities of boats operating in Saint-Brieuc Bay versus near Saint Malo or Granville, activities in both locations were included in the analysis. These boats are based out of the ports of Erquy, Saint-Quay-Portrieux, or Paimpol.

In France, scallop fishing is highly regulated. The season opens in early October and closes in late March/early April, depending on the year and scallop bed. On average, beds can be accessed twice a week for 45-min periods [5]. There are daily quotas, which vary for different scallop beds. Great Atlantic scallops are harvested using two dredges, which must meet regulatory standards: maximum size is two metres [6], and ring diameters must exceed 97 millimetres [7]. The scallop's minimum legal size is 11 centimetres. Landed scallops are fresh, whole, and in their shells.

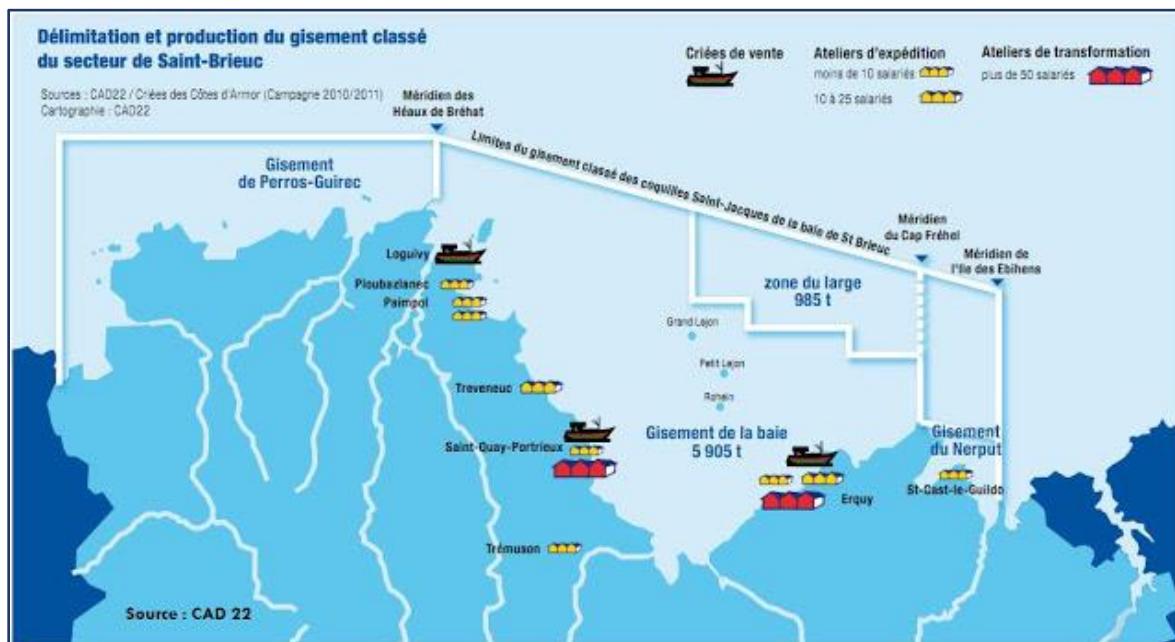


Figure 1: Map of protected production areas in Saint-Brieuc Bay (source: CAD 22)

The triplet **Gadidae—Celtic Sea—Bottom trawl** refers to all boats practicing the métier of harvesting Gadidae species (i.e., Atlantic cod, whiting, and haddock) using bottom trawls in the Celtic Sea. Because numerous species are captured (i.e., there is no one target species), this is a multispecies fishery. Indeed, boats practicing this métier catch Gadidae species (Atlantic cod, whiting, and haddock) as well as anglers, rays (e.g., the undulate ray, cuckoo ray, blonde ray), small shark species, or cuttlefish. Most trawlers are based out of ports in Brittany, such as Guilvinec or Paimpol and operate across the entire Celtic Sea, which corresponds to subareas VII e through k in FAO fishing area 27 (Figure 2). Trips typically last 10–15 days, and boats spent 200–300 days at sea per year, depending on the weather and season organisation. In the Celtic Sea, there are quotas and/or minimum legal sizes for certain species. Gadidae species are mainly caught with twin trawl systems; fish are fresh and eviscerated upon landing.

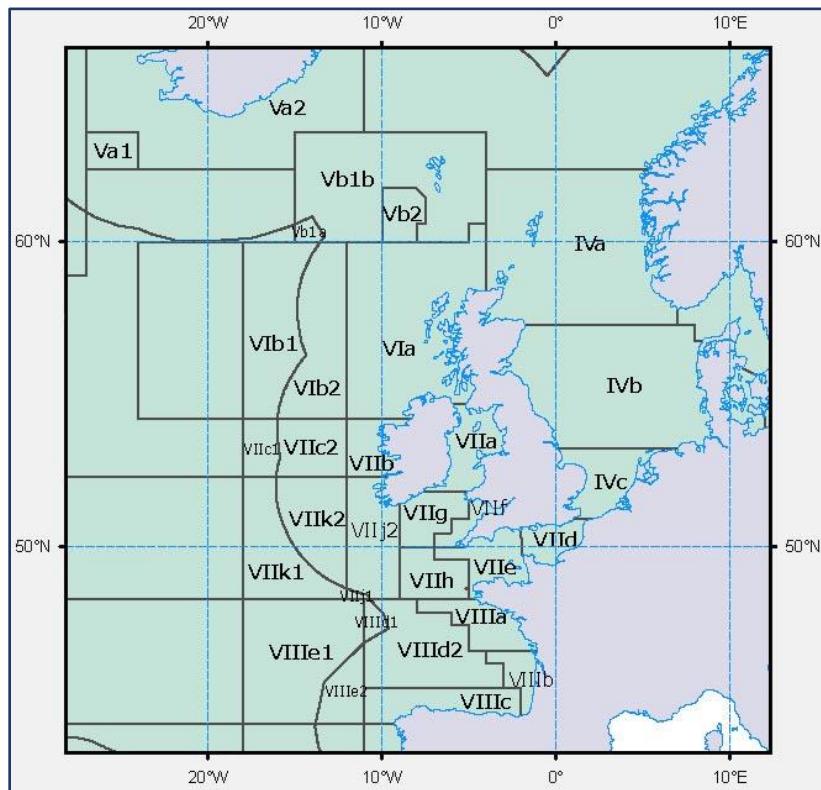


Figure 2: FAO fishing area 27 (source: FAO)

The triplets **Atlantic herring—Northeast Atlantic—Pelagic trawl** and **Atlantic mackerel—Northeast Atlantic—Pelagic trawl** refer to all boats practicing the métier of primarily harvesting small pelagic species, such as the Atlantic herring, Atlantic mackerel, Atlantic horse mackerel, blue whiting, and European pilchard using pelagic trawls in the Northeast Atlantic. They operate across the Northeast Atlantic, which corresponds to FAO fishing area 27 (Figure 2). They are based out of ports in the Netherlands (Ijmuiden, Scheveningen). Trips last around 15 days; the exact duration depends on how far boats must travel to access target fish stocks. On average, the boats spend 225 days at sea per year. Generally, over the course of a year, the first six months are dedicated to fishing for Atlantic mackerel from western Scotland to the Azores, as the species migrates. The Atlantic horse mackerel is also caught—the species becomes more and more abundant as the boats head south. During the second six months, boats focus on catching Atlantic herring and Atlantic mackerel in the North Sea and then fish the dense schools of Atlantic herring occurring in the eastern English Channel at the very end of the year. In European waters, both the Atlantic herring and the Atlantic mackerel are subject to quotas. Fish are caught using pelagic trawls. Upon landing, they are whole, frozen, wrapped in plastic, packaged in cardboard boxes, and organised in blocks.

The triplet **Saithe (fresh)—North Sea—Bottom trawl** refers to all boats practicing the métier of harvesting mainly saithe, but also blue ling, black scabbardfish, and European hake, using bottom trawls in the North Sea. They operate across the whole North Sea, which corresponds to subarea IV in FAO fishing area 27 (Figure 2). The boats are based out of the port of Boulogne-sur-Mer. Their trips last around 10 days, and they spend, on average, 250–280 days at sea per year. In the North Sea, there is a quota for saithe. Saithe are caught using bottom trawls. Upon landing, the fish are fresh and eviscerated.

The triplet **Saithe (frozen)—North Sea—Bottom trawl** refers to all boats practicing the métier of harvesting mainly saithe, but also Atlantic cod, European hake, and haddock, using bottom trawls in the North Sea. They operate across the whole North Sea, which corresponds to subarea IV in FAO fishing area 27 (Figure 2). The boats are based out of the port of Boulogne-sur-Mer. Their trips last around 10 days, and they spend, on average, 250–280 days at sea per year. In the North Sea, there is a quota for saithe. Saithe are caught using bottom trawls. Upon landing, the fish are frozen and in fillet form.

The triplets European pilchard—Eastern Central Atlantic—Seine and European anchovy—Eastern Central Atlantic—Seine refer to all boats practicing the métier of harvesting fish (see below) using a seine

in the open waters along the coast of Morocco. Even if the boats are not French, the project studied these triplets because their landed products are an important commodity for the French canning industry. The target species are mainly small pelagic fishes, such as the European pilchard, European anchovy, Atlantic mackerel, and Atlantic horse mackerel. Fishing primarily occurs in the open waters along the Moroccan coast, in subareas 1.1, 1.2, and 1.3 of FAO fishing area 34 (Figure 3). The boats are largely based out of the ports of Agadir, Kenitra, and Laayoune. They make day trips and spend 180–240 days at sea per year, on average. Fish are caught with seines; upon landing, they are fresh and whole.

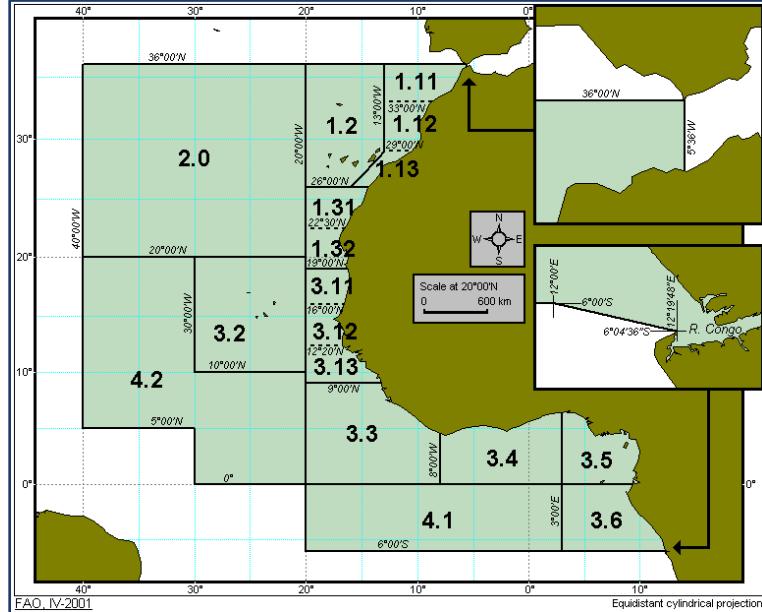


Figure 3: FAO fishing area 34 (source: FAO)

The triplet **European pilchard—Bay of Biscay—Seine** refers to all boats practicing the métier of harvesting mainly European pilchard, but also other types of bluefishes, such as Atlantic mackerel, Atlantic horse mackerel, or European anchovy, using seines in the Bay of Biscay. They operate in the open waters of the bay, which corresponds to subareas VIII a and b in FAO fishing area 27 (Figure 2). The boats are largely based out of the ports of Saint-Guénolé, Concarneau, and Douarnenez. Some are affiliated with Bayonne, and notably the port of Hendaye. They fish at night, making trips of around 8–10 hours. They spend 150–200 days at sea per year. There are no quotas for European pilchard in European waters. Caught with seines (a *bolinche* or a one-boat-operated purse seine), European pilchards are whole and fresh upon landing.

The triplet **Sole—Bay of Biscay—Trammel net** refers to all boats practicing the métier of harvesting sole and angler using trammel nets in the Bay of Biscay. Most of these boats also practice other métiers—they use single-layer gillnets to capture European seabass, pollack, European hake, gilthead seabream, or spider crabs. Additionally, some trap lobster or shrimp. They operate in the open waters along the coasts of the Bay of Biscay, which corresponds to subareas VIII a and b in FAO fishing area 27 (Figure 2). These gillnetters operate over the entire Bay of Biscay—off of Guilvinec, Lorient, Noirmoutier, La Rochelle, Arcachon, and Bayonne. They go out for day trips of approximately 10 hours and spend an average of 200 days at sea per year. Sole fishing is subject to different restrictions: there are quotas, and fishing moratoria may be imposed [8]. Caught with trammel nets, sole are fresh and eviscerated upon landing.

The triplet **Albacore tuna—Northeast Atlantic—Pelagic trawl** refers to all boats practicing the métier of harvesting albacore tuna using pelagic trawls in the Northeast Atlantic. In this métier, they may also end up capturing Atlantic bluefin tuna, swordfish, and Atlantic bonito. The boats operate over an extensive area, from Cape Finisterre through the Bay of Biscay to western Ireland. They are largely based out of the Saint Nazaire region. Some are also associated with Lorient, Guivinic, and the Bayonne region. The fishing season for albacore tuna is seasonal and runs from mid-July to late October. Trips last about 10 days, and boats spend an average of 200–300 days at sea per year. These boats may also practice other métiers, such as those involving bottom trawling, Norway lobster trawling, or pelagic trawling. The targets are small pelagic species such as the European anchovy or the European pilchard. Stocks of albacore tuna in the

Northeast Atlantic are considered to be sustainably harvested [9]; consequently, this fishery is not subject to regulatory constraints. Boats generally operate in pairs, utilising pair trawls (i.e., one trawl towed by two boats). Landed albacore tuna is whole and fresh.

The triplet **Atlantic bluefin tuna—Mediterranean Sea—Seine** refers to all boats practicing the métier of capturing Atlantic bluefin tuna using seines in the Mediterranean Sea. No other species are caught. Tuna seiners operate in the open waters off the Balearic Islands and Malta (Figure 4). They are based out of Sète, Agde, Marseilles, or Port-Vendres. Seine fishing for Atlantic bluefin tuna is strictly regulated. The eastern Atlantic-Mediterranean stock is subject to quotas; the commercial fishing season for tuna seiners is restricted to one month (late May to late June); and fish weighing less than 30 kg or measuring less than 115 cm cannot be caught [10]. All boats carry an observer who is responsible for ensuring that regulations are respected. Even though the fishing season lasts just one month, most boats reach their quotas after about 20 days at sea. Upon capture, tuna are transferred directly from the seines to cages (Figure 5). The cages are then dispatched to fish farms in Malta, Spain, Italy, and Croatia. Following a fattening period (which was not examined in this study), most of the tuna captured by French seiners end up on the Japanese sushi and sashimi market.

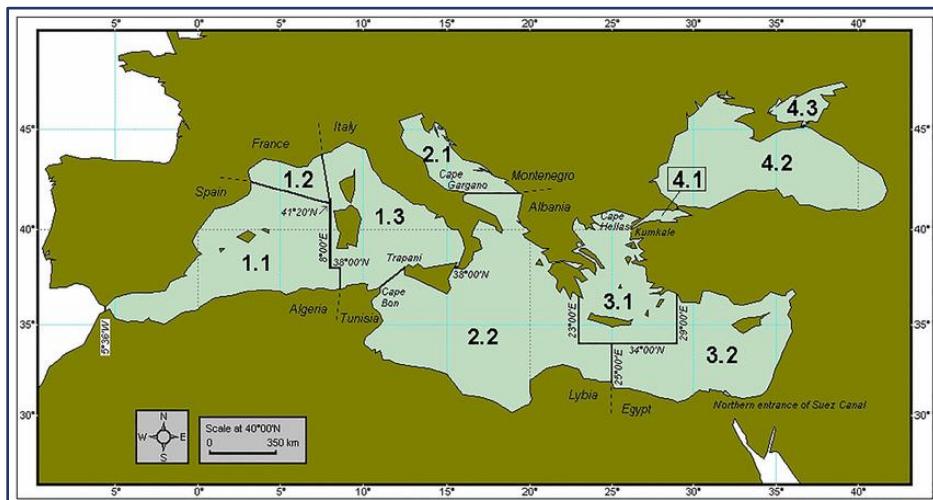


Figure 4: FAO fishing area 37—the Mediterranean Sea (source: FAO)

The triplet **Atlantic bluefin tuna—Mediterranean Sea—Longline** refers to all boats practicing the métier of harvesting Atlantic bluefin tuna using longlines in the Mediterranean Sea. They may also end up capturing other species, notably swordfish. Longliners are based out of ports along the entire Mediterranean coast and operate in the open waters along the French Mediterranean coastline (Figure 4). They go out at the end of the day, for trips lasting around 10 hours, and they spend an average of 30–70 days at sea per year. Like tuna seiners, longliners are also subject to quotas. In contrast to tuna seiners, longliners can fish all year long and capture fish weighing at least 8 kg or measuring more than 75 cm [10]. Caught using longlines, Atlantic bluefin tuna is whole and fresh upon landing.

The triplets **Yellowfin tuna—Eastern Central Atlantic—Seine** and **Skipjack tuna—Eastern Central Atlantic—Seine** refer to all boats practicing the métier of harvesting tropical tuna species using seines in the open waters along the coast of western Africa. The tuna seiners mainly catch yellowfin and skipjack but may also capture bigeye and albacore. They are primarily based out of Abidjan and operate in the open waters along the coast of western Africa. Boats spend an average of 280 days at sea per year. There are no regulations associated with skipjack fisheries, but there are quotas for albacore. Caught using purse seines, tuna are whole and frozen upon landing.

1.2. Functions of fishing systems

The primary function of fishing systems is to provide food, either to animals or humans. This function was the focus of the French LCI Project on Fisheries. It can be expressed as follows: "making available a certain quantity of fish in a certain form as the result of a fishing trip".

Fishing can serve other functions, such as maintaining the dynamics of coastal food webs or providing jobs on land and at sea. Such functions have socioeconomic importance; however, they were not considered in the study and were not allocated flows.

1.3. Functional unit

The functional unit chosen for this study was a kilogram of landed fish in a given form (e.g., fresh, frozen, eviscerated). It is clear from Table 1 that the form of the landed fish varies among triplets. However, within triplets, there is always a single form.

Because of the variability among triplets, the decision was made to convey the results using a standardised metric: the amount of consumable protein at landing. Consumable protein was defined as crude protein. To convert the study's functional unit to the standardised metric, two calculations were used. In the first calculation, the mass of landed fish in a given form (e.g., whole, eviscerated) was converted into the mass of consumable product (e.g., fillet or scallop "meat"). Conversions developed by IFREMER, ICCAT, and FROM Nord were used. In the second calculation, the mass of consumable product was converted into the mass of consumable protein using the values for protein content listed on ANSES' Ciqual website. The conversion factors and values for protein content are listed below in Table 2.

Triplet	Form upon landing	Conversion factor	Protein content	Additional comments
Great Atlantic scallop —Saint-Brieuc Bay—Dredge	Fresh—Whole, in shell	14.3%	17.9%	The "meat" represents 1/7 of the animal's mass
Gadidae —Celtic Sea—Bottom trawl	Fresh—Eviscerated	36.3%	18.1%	Means for the three Gadidae species
Atlantic herring —Northeast Atlantic—Pelagic trawl	Frozen—Whole	50.0%	17.7%	
Atlantic mackerel —Northeast Atlantic—Pelagic trawl	Frozen—Whole	52.1%	18.1%	
Saithe (fresh) —North Sea—Bottom trawl	Fresh—Eviscerated	46.7%	18.8%	
Saithe (frozen) —North Sea—Bottom trawl	Frozen—Fillet	100%	19.8%	The product is already in the form of a fillet
European pilchard —Eastern Central Atlantic—Seine	Fresh—Whole	50.0%	19.5%	
European anchovy —Eastern Central Atlantic—Seine	Fresh—Whole	50.0%	18.6%	
European pilchard —Bay of Biscay—Seine	Fresh—Whole	50.0%	19.5%	
Sole —Bay of Biscay—Trammel net	Fresh—Eviscerated	41.6%	18.0%	
Albacore tuna —Northeast Atlantic—Pelagic trawl	Fresh—Whole	59.9%	27.2%	
Atlantic bluefin tuna —Mediterranean Sea—Seine	Live	59.9%	23.3%	
Atlantic bluefin tuna —Mediterranean Sea—Longline	Fresh—Whole	59.9%	23.3%	
Yellowfin tuna —Eastern Central Atlantic—Seine	Frozen—Whole	59.9%	25.0%	
Skipjack tuna —Eastern Central Atlantic—Seine	Frozen—Whole	59.9%	22.0%	

Table 2: Conversation factors and protein content values used in the standardisation of the results

The case of the seine-caught Atlantic bluefin tuna from the Mediterranean is unique in terms of the functional unit. The tuna are not landed. Instead, they are placed in floating cages and then sent to fish farms in Malta, Spain, Italy, and Croatia to be fattened. One of these cages is shown below (Figure 5). For this triplet, the

functional unit is therefore a kilogram of product placed in a transport cage, and the system's end boundary was the placement of the animal in the cage.



Figure 5: Floating transport cage in the Mediterranean containing live Atlantic bluefin tuna (source: French Navy)

1.4. System boundaries

1.4.1. Approach and processes included

In accordance with AGRIBALYSE® programme principles, the key rule was to consider the system from cradle to gate. Here, this meant from the ship's cradle to its return with landed product (the moment just prior to unloading). Indeed, one of the project's objectives is to provide fundamental data that can be used by industry stakeholders located downstream from the fishing industry. As a result of this framing constraint, steps such as storage by fish auctioneers, the transformation of fish by stakeholders within the fish trade, product distribution, and product consumption were not considered by the project.

The systems studied did include all the infrastructure necessary to fishing practices, fishing operations, fish storage, and initial fish transformation (if it takes place on board). The system's end boundary was fish landing; the process of unloading the fish was not considered. More specifically, the following system components were studied:

- boat construction, maintenance, and end of life
- gear construction, maintenance, and end of life
- fishing activities: travel to fishing areas, fishing operations, fish sorting, fish cleaning, etc.
- initial fish transformation, if it takes place on board: deheading, evisceration, etc.
- storage, refrigeration, and/or freezing of fish on board

Illustrated below are some of the processes and flows that were included in the fishing systems studied (Figure 6). The complete list of the flows considered by the project is provided in Annex 1.

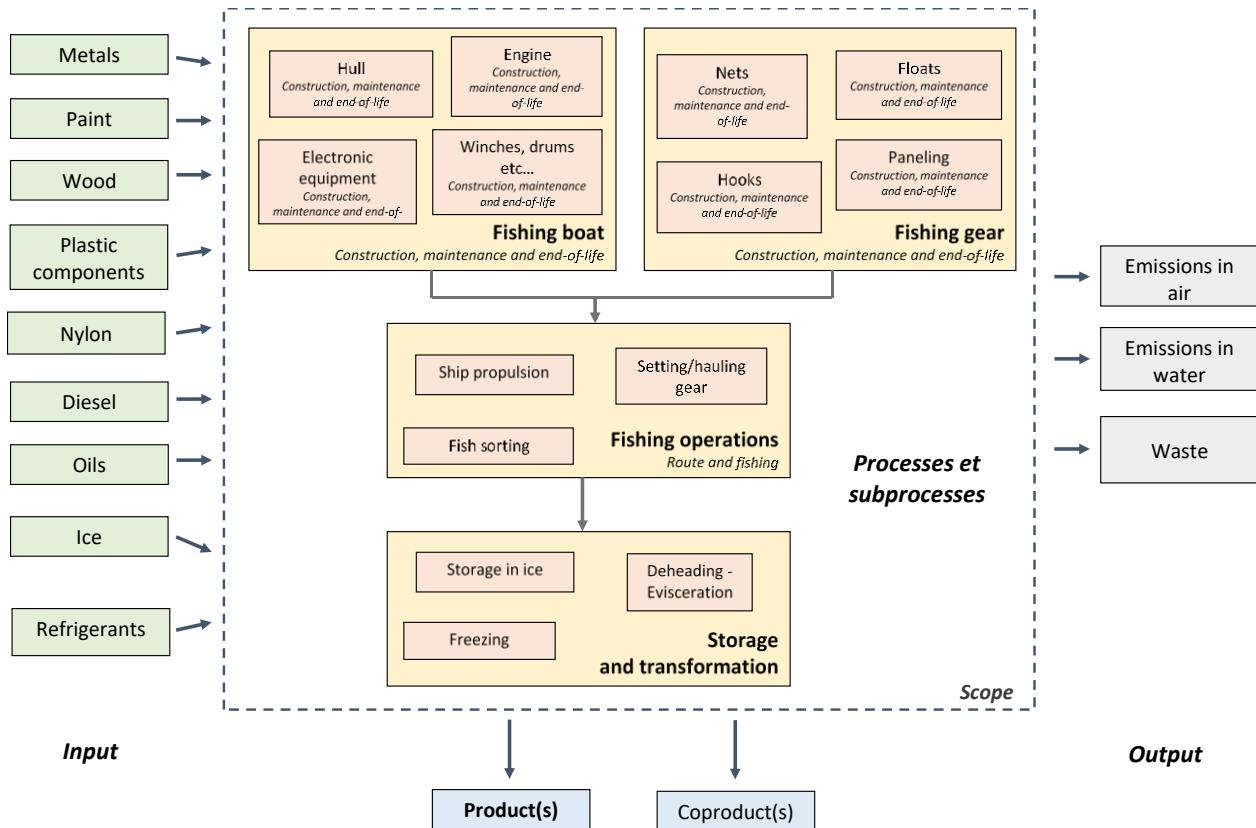


Figure 6: Diagram of study system processes

As mentioned above, for the Atlantic bluefin tuna—Mediterranean Sea—Seine triplet, in which fish are not landed but rather placed directly in floating cages, the system's end boundary was the moment at which the tuna are transferred from the seine to the cage.

When it comes to the boats and certain gear types, the length of time they are used by French boat owners does not necessarily reflect their total life span. Indeed, certain boats and gear types are resold, generally abroad. Because precise information is lacking on these later periods of usage and to avoid the slight overestimation of impacts, it was decided that total life span would be defined as the time spent by boats and gear in the possession of French boat owners.

Freshwater supplies were included in the system, provided that they contributed to fishing activities (e.g., cleaning). However, in most cases, freshwater supplies were used as part of the crew's daily life (e.g., for drinking, cooking, showering), which was not part of the study.

1.4.2. Criteria for exclusion and processes excluded

1.4.2.1. Criteria for exclusion

To help decide whether or not to include different processes associated with fishing activities, a 5% cut-off threshold ("cut-off criteria") was tested – for impacts. However, for the majority of fisheries, applying this threshold resulted in the inclusion of just three processes: the boat, the gear, and diesel consumption. Consequently, the decision was made to include all the processes mentioned above (oil, coolant, storage containers, waste, etc.), even though their effects appeared to be negligible.

1.4.2.2. Excluded processes

In this project, port-related activities and infrastructure were not included in the study systems. The variety of activities and infrastructure found in ports and the complexity of related issues would require a whole analysis by themselves. It would be necessary to collaborate with the relevant stakeholders (e.g., those involved in fish auctions/markets or the fish trade), who are different from the stakeholders who are directly involved in fishing. In particular, fish auctioneers produce ice that is supplied to certain fishing boats; the project could not take this ice into account, due to a lack of data.

Certain boats based out of French ports may end up landing their fishery products in foreign ports (e.g., Lochinver in Scotland; Table 3). Since the system's end boundary was fish landing, the transport of these products to France was not taken into account by the project.

To remain consistent with LCIs for agricultural systems [4], all of the flows associated with the crew's daily life (food, personal hygiene, etc.) were excluded from the system. Cleaning products, small consumables (e.g., knives, tools, lubricant), and equipment on the upperworks (bowgraces, cordage, etc.) were considered to have negligible impacts and were also excluded.

In this study, boat construction was modelled using an estimate of mass balance established by Bureau Mauric, a consulting firm. It has been shown that a simple estimate of mass balance does not include all the impacts associated with product construction because certain processes are omitted, such as the assembly of pieces, soldering, scrap generation, and energy usage.

Finally, carbon storage in the shells of great Atlantic scallops was not modelled in this study.

1.5. Representativeness of the data

1.5.1. Temporal representativeness

The reference year for the data is 2015 but the LCI database has been based on a weighted average of the last five years, 2011-2015. This period was chosen to ensure that the data were relatively recent and that they spanned several years. The goal was to obtain relatively robust results that had not been biased by an atypical year. The database was published in 2018. The difference between the publication year and the reference year was accounted for when the temporal representativeness of the inventories was evaluated.

1.5.2. Geographical representativeness

Geographical representativeness is related to the coverage of the fishing areas and the boats' ports of origin.

With regards to the fishing areas, during the project surveys, it was verified that the fishers were indeed operating exclusively within the fishing area associated with the triplet. This was not a problem because the fishing areas chosen actually reflect real areas of operation. With regards to the boats' ports of origin, one of the objectives of the data collection process was to survey boat owners affiliated with each of the ports identified for the triplet. For example, for the Sole—Bay of Biscay—Trammel net triplet, surveys were carried out at a dozen ports found along the Atlantic coast (e.g., in Le Guilvinec, Lorient, Le Croisic, Noirmoutier, La Rochelle, Arcachon, Pyla sur Mer, Capbreton, and Bayonne). Some boats do not land products in French ports. For these triplets, in accordance with LCA methodology, the geographical area specified on the inventories cannot be France, even if the boats are French. Instead, it must be the country in which the products are landed. This approach allows users that are interested in product distribution to utilise transportation models that fit with the landing area. The landing ports for the different triplets and the associated geographical areas are presented below (Table 3).

Triplet	Landing port(s)	Geographical area
Great Atlantic scallop—Saint-Brieuc Bay—Dredge	Erquy, Saint-Quay-Portrieux, Paimpol, etc.	France—FR
Gadidae—Celtic Sea—Bottom trawl	Le Guilvinec, Paimpol, etc.	France—FR
Atlantic herring—Northeast Atlantic—Pelagic trawl	Ijmuiden (NL), Scheveningen (NL)	Netherlands—NL
Atlantic mackerel—Northeast Atlantic—Pelagic trawl	Boulogne-sur-Mer (FR), Lochinver (GB), Hanstholm (DK)	Europe—EU
Saithe (fresh)—North Sea—Bottom trawl	Boulogne-sur-Mer	France—FR
European pilchard—Eastern Central Atlantic—Seine	Laayoune (MA), etc.	Morocco—MA
European anchovy—Eastern Central Atlantic—Seine	Agadir (MA), Kenitra (MA), etc.	Morocco—MA
European pilchard—Bay of Biscay—Seine	Saint-Guénolé, Concarneau, Hendaye, etc.	France—FR
Sole—Bay of Biscay—Trammel net	Lorient, Noirmoutier, La Rochelle, Arcachon, etc.	France—FR

Albacore tuna—Northeast Atlantic—Pelagic trawl	Saint-Nazaire, le Guilvinec, etc.	France—FR
Atlantic bluefin tuna—Mediterranean Sea—Seine	Not applicable	France—FR
Atlantic bluefin tuna—Mediterranean Sea—Longline	Sète, Grau d'Agde, Saint-Mandrier, etc.	France—FR
Yellowfin tuna—Eastern Central Atlantic—Seine	Abidjan (CI)	Ivory Coast—CI
Skipjack tuna—Eastern Central Atlantic—Seine	Abidjan (CI)	Ivory Coast—CI

Table 3: Landing ports and associated geographical areas for the triplets

1.5.3. Technological representativeness

Technological representativeness, or coverage, involves ensuring that the different fishing practices associated with the triplets are actually employed by the boats surveyed. For several triplets, the boats' fishing practices and strategies were fairly homogeneous. This is particularly true of the European pilchard—Bay of Biscay—Seine triplet: season organisation, days at sea, and gear are similar among boats. Indeed, most of the boats work together, namely to find shoals of fish. However, for some triplets, fishing practices and strategies are heterogeneous. This was notably the case for the Great Atlantic scallop—Saint-Brieuc Bay—Dredge triplet. Certain boats only harvest scallops from October to March and then spend the summer docked. Others continue fishing, with nets or traps, after the scallop season is over. Still others have another métier, such as trawling, which they practice at the same time as they are harvesting scallops. For these triplets, the decision was made to predetermine the categories of practices within the flotilla to ensure that boats from each category were surveyed (see § 2.2.1).

1.6. Data quality

In the French LCI Project on Fisheries, data quality was evaluated at the level of the raw individual datum as well as at the level of the overall inventory.

1.6.1. Quality of raw individual data

The raw individual data were the data collected by surveying professional fishers that were then entered using the data entry tool. Examples of such data are the monthly diesel consumption of a sole gillnetter operating in the Bay of Biscay or the number of blades used per year by a scallop dredger harvesting great Atlantic scallop in Saint-Brieuc Bay.

The quality of these data was evaluated using the data quality table in the AGRIBALYSE® methodological report [4], which is based on the pedigree matrix approach in ecoinvent® (v. 2.0) [11]. The pedigree matrix approach can be used to determine a confidence interval for the data and thus assess their quality. It relies on the classification of data into the following qualitative categories:

- publicly accessible and well-documented statistic (e.g., fishing pressure associated with maximum sustainable yield [MSY])
- statistic subject to restricted access or found in the scientific literature but still publicly accessible (e.g., detailed data from OBSMER)
- well-documented example case (e.g., detailed mass balance for a boat battery generated by the manufacturer)
- poorly documented example case (e.g., the approximate mass balance for the same battery)
- expert opinion (e.g., specialist painter providing an oral assessment of the mean amount of paint needed to cover a 24-m trawler)
- individual case or assessment (e.g., estimated gear life span provided by a boat owner/fisher)

More specifically, each of the categories described above is associated with a five-number vector (the pedigree matrix), which corresponds to an evaluation of the category based on five data quality indicators (see Table 4). A mathematical formula links the pedigree matrix to the base uncertainty associated with the data (equal to 1.05 in most cases). This formula can be used to calculate a quality score that corresponds to a 95% confidence interval for the type of data studied (see Table 4).

Data type	Base uncertainty	Pedigree matrix	Quality score
Publicly accessible and well-documented statistic	1.05	{1, 1, 1, 1, 1, na}	1.050
Statistic subject to restricted access	1.05	{2, 3, 2, 2, 2, na}	1.108
Well-documented example case	1.05	{1, 2, 1, 1, 1, na}	1.054
Poorly documented example case	1.05	{2, 3, 2, 3, 2, na}	1.109
Expert opinion	1.05	{3, 3, 2, 1, 2, na}	1.140
Individual case or assessment	1.05	{4, 4, 2, 1, 2, na}	1.245

Table 4: Quality scores for different data types (source: AGRIBALYSE® [4])

	1	2	3	4	5	Notes
Reliability	Verified data based on measurements	Verified data based on assumptions or non-verified data based on measurements	Non-verified data partially based on expert opinion	Expert opinion	Estimate	Verified data = official statistics, public reports Non-verified data = personal communication shared by fax, letter, or email
Completeness	Representative data collected from all the study sites for the triplet over the reference period	Representative data collected from more than 50% of the study sites for the triplet over the reference period	Representative data from just a few of the study sites for the triplet or from more than 50% of the study sites but over a shorter period than the reference period	Representative data from a single study site or a few study sites but over a shorter period than the reference period	Representativeness of data is unknown, or data come from a small number of sites and a short period of time	The scope of the reference period depends on the procedures/technologies studied
Temporal representativeness	Data collected fewer than 3 years ago	Data collected fewer than 6 years ago	Data collected fewer than 10 years ago	Data collected fewer than 15 years ago	Age of data unknown or data collected more than 15 years ago	
Geographical representativeness	Data from the study area	Average of data from a larger area that contains the study area	Data from a different geographical area that displays production conditions similar to those of the study area	Data collected from a different geographical area that displays slightly different production conditions than those of the study area	Origin of data is unknown, or data come from a geographical area that is distinct from the study area	
Technological representativeness	Data from companies, procedures, or materials that are part of the study system	Data from procedures and materials that are part of the study system and from companies that are not part of the study system	Data from procedures and materials that are part of the study system but that were produced using different technologies	Data from procedures and materials similar to those included in the study system	Data from procedures similar to those included in the study system but that were obtained in the laboratory, OR data produced using different technologies	
Sample size	> 100, continuous measurements, range is representative	> 20	> 10, aggregated data taken from environmental reports	≥ 3	Unknown	If possible, sample size must systematically be ascertained

Table 5: Pedigree matrix from the AGRIBALYSE® methodological report [4]

1.6.2. Whole inventory quality

As for prior projects in the AGRIBALYSE® programme, in this project, the quality of each inventory was evaluated according to International Reference Life Cycle Data System (ILCD) standards [12], using the following six criteria:

- technological representativeness
- geographical representativeness
- temporal representativeness
- comprehensiveness—completeness
- precision—uncertainty
- relevance of methodology

Inventories were assigned a score for these criteria that ranged from 1 ("very good") to 5 ("insufficient" or "unknown"). When a criterion could not be evaluated, a score of 0 ("not applicable") was assigned. The overall score was calculated in accordance with ILCD specifications. An inventory is considered to be of "good quality" if its score is less than 1.6, of "intermediate quality" if its score ranges between 1.6 and 3 (inclusive), and of "estimate" quality if it is greater than 3.

To ensure that the evaluation process was consistent, each criterion from the AGRIBALYSE® methodological report and the ILCD specifications was adapted to reflect the specificities intrinsic to fisheries.

- **Technological representativeness:** are the fishing practices of the boat(s) representative of all the practices associated with the triplet?
 - 1—very good: all the fishing practices associated with the triplet are carried out by the boat(s)
 - 2—good: most of the fishing practices associated with the triplet are carried out by the boat(s)
 - 3—sufficient: most of the fishing practices associated with the triplet are not necessarily carried out by the boat(s)
 - 4—somewhat insufficient: only some of the fishing practices associated with the triplet are carried out by the boat(s)
 - 5—insufficient: only one of the fishing practices associated with the triplet is carried out by the boat(s)
 - 5—unknown: the representativeness of fishing practices is unknown
 - 0—not applicable: this criterion is not applicable for the boat(s)
- **Geographical representativeness:** are the fishing areas and port(s) of origin for the boat(s) representative of the fishing areas and ports associated with the triplet?
 - 1—very good: fishing areas and port(s) of origin for the boat(s) are more than 95% representative of the fishing areas and ports associated with the triplet
 - 2—good: fishing areas and port(s) of origin for the boat(s) are more than 85% representative of the fishing areas and ports associated with the triplet
 - 3—sufficient: fishing areas and port(s) of origin for the boat(s) are more than 75% representative of the fishing areas and ports associated with the triplet
 - 4—somewhat insufficient: fishing areas and port(s) of origin for the boat(s) are more than 50% representative of the fishing areas and ports associated with the triplet
 - 5—insufficient: fishing areas and port(s) of origin for the boat(s) are less than 50% representative of the fishing areas and ports associated with the triplet
 - 5—unknown: geographical representativeness is unknown
 - 0—not applicable: this criterion is not applicable for the boat(s)
- **Temporal representativeness:** do the data for the boat(s) represent the whole reference period (2011–2015)?
 - 1—very good: the data represent the five years of the reference period
 - 2—good: the data represent at least three years of the reference period, with few changes in practices occurring therein
 - 3—sufficient: the data represent at least two years of the reference period, with few changes in practices occurring therein
 - 4—somewhat insufficient: the data represent two or three years of the reference period, with major changes in practices occurring therein

5—insufficient: the data represent just one year of the reference period
5—unknown: temporal representativeness is unknown
0—not applicable: this criterion is not applicable for the boat(s)

- **Comprehensiveness—Completeness:** are data available for all the flows and inputs mentioned in the questionnaire and data entry tool?
 - 1—very good: data are present for all the flows and inputs
 - 2—good: data are missing for several inputs of minor importance
 - 3—sufficient: data are missing for a few major inputs
 - 4—somewhat insufficient: data are missing for several major inputs
 - 5—insufficient: data are missing for many major inputs
 - 5—unknown: the completeness of the data on flows and inputs is unknown
 - 0—not applicable: this criterion is not applicable for the boat(s)
- **Precision—Uncertainty:** is variability sufficiently low across all the data for the boat(s)?
 - 1—very good: the standard deviation for the whole dataset is less than 7%
 - 2—good: the standard deviation for the whole dataset is less than 10%
 - 3—sufficient: the standard deviation for the whole dataset is less than 15%
 - 4—somewhat insufficient: the standard deviation for the whole dataset is less than 25%
 - 5—insufficient: the standard deviation for the whole dataset is greater than 25%
 - 5—unknown: the degree of variability in the data is unknown
 - 0—not applicable: this criterion is not applicable for the boat(s)In contrast to the other criteria, the scoring scale for "Precision—Uncertainty" was not taken from the AGRIBALYSE® methodological report. Rather, it was inspired by the approach of the MEANS platform [13].
- **Relevance of methodology:** the methodological approach was identical for all the project's inventories. Its relevance was considered to be "good" (score of 2) because system boundaries and calculations were adapted for fisheries.

1.7. Critical review

A critical review of this study was carried out by the consulting firm Cycleco. The full report resulting from this review is available in Annex 8.

2. Inventory

2.1. Project tools

Several tools were crucial in constructing the inventories. Such standardised tools ensure that inventories are homogeneous and comparable.

- Methodological choices were collaboratively made (system boundaries, functional unit, etc.). They are described in detail in Part 1 of this methodological report.
- To conduct surveys, a questionnaire was used. There were two versions—one for use in the field and one for use online. A user's guide was developed for the questionnaire and is provided in Annex 2. It is intended for future potential users; it describes each question and explains certain technical terms.
- A data entry tool was created to help standardise the entry of individual data; to gauge data quality; and to automatically calculate intermediate annual flows (e.g., litres of diesel consumed per kilogram of landed product). A user's guide was also developed for the data entry tool and is provided in Annex 3.
- Simapro® software and the ecoinvent® database (v. 3) [14] made it possible to calculate background flows (upstream and/or indirect).

2.2. Data collection

There were several phases of data collection. First, when necessary, a classification scheme was established for the fishery. This approach ensured that the boats surveyed provided a representative sample of the flotilla population associated with the triplet. Second, data were collected from professional fishers in the field or online using the appropriate version of the questionnaire. Third, the data were entered in a standardised and homogeneous way for all the triplets.

2.2.1. Classification scheme

One of the main objectives during data collection was to survey a sample of boats that was representative of the flotilla population associated with the triplet. Indeed, for some of the triplets, boat number was too great for all the boats to be surveyed. This was the case for the Great Atlantic scallop—Saint-Brieuc Bay—Dredge triplet (~200 boats), the Gadidae—Celtic Sea—Bottom trawl triplet (~100 boats), and the Sole—Bay of Biscay—Trammel net triplet (~300 boats). In addition to being numerous, boats in these systems display heterogeneous characteristics and practices. For these reasons, it was necessary to determine the different categories of boats present in each of these systems before initiating the surveys: it was crucial to ensure that data were collected from a representative sample.

The classification scheme involved assigning the boats to several distinct categories. It relied on two sets of data, which were relatively easy to obtain:

- boat technical specifications—length, engine power, tonnage, age, and hull material
- indicators of boat activities—tonnage and value of landed target species, the proportional contribution of target species to total tonnage, and the number of days at sea per year

These data were obtained from the relevant producer organisations (POs):

- Cobrenord and Les Pêcheurs de Bretagne for the Great Atlantic scallop—Saint-Brieuc Bay—Dredge triplet
- Les Pêcheurs de Bretagne for the Gadidae—Celtic Sea—Bottom trawl triplet
- FROM Sud-Ouest, OPPAN, Pêcheurs d'Aquitaine, and Les Pêcheurs de Bretagne for the Sole—Bay of Biscay—Trammel net triplet

The statistical approach used was hierarchical cluster analysis (HCA), which was implemented in R [15] using the FactoMineR package [16].

An example of the classification results is provided in Annex 6. The relevance of the categories obtained was then verified via discussions with fisheries experts associated with each of the POs contacted.

2.2.2. Questionnaire

Surveys were carried out using a questionnaire. There were two versions—one for use in the field and one for use online. The field version was a Word document, and the online version was an Excel spreadsheet. They contained the exact same questions. They comprised two large sections. The first focused on boat technical specifications, such as length, tonnage, age, maintenance history, and engine power. This information allowed Bureau Mauric, a consulting firm and project partner, to establish the boat's mass balance (see § 2.2.3.2). The second focused on the boat's fishing activities—season organisation, diesel or oil consumption, gear type, and fish storage. The user's guide for the questionnaire is provided in Annex 2.

2.2.3. Data collection procedure

2.2.3.1. Collecting data from boat owners

Most of the data used to construct the LCIs were obtained directly from boat owners. The type of data collection strategy depended on the triplet. The triplets fell into three general categories.

- There were "field" triplets: Great Atlantic scallop—Saint-Brieuc Bay—Dredge, Gadidae—Celtic Sea—Bottom trawl, European pilchard—Bay of Biscay—Seine, Sole—Bay of Biscay—Trammel net, Albacore tuna—Northeast Atlantic—Pelagic trawl, Atlantic bluefin tuna—Mediterranean Sea—Seine, and Atlantic bluefin tuna—Mediterranean Sea—Longline.
- There were triplets with small numbers of boat owners: Saithe (fresh)—North Sea—Bottom trawl, Saithe (frozen)—North Sea—Bottom trawl, Atlantic herring—Northeast Atlantic—Pelagic trawl, Atlantic mackerel—Northeast Atlantic—Pelagic trawl, Yellowfin tuna—Eastern Central Atlantic—Seine, and Skipjack tuna—Eastern Central Atlantic—Seine.
- There were "Moroccan" triplets: European pilchard—Eastern Central Atlantic—Seine and European anchovy—Eastern Central Atlantic—Seine.

The goal was to survey 30 boats from each triplet, boat number permitting. Below are the numbers of boats surveyed per triplet (Table 6). Overall, more than 150 boats were surveyed, and data from 132 of those boats were included in the analyses.

Triplet	Total number of boats	Classification scheme	Number of boats surveyed
Great Atlantic scallop—Saint-Brieuc Bay—Dredge	Around 200	Yes	19
Gadidae—Celtic Sea—Bottom trawl	Around 100	Yes	33
Atlantic herring—Northeast Atlantic—Pelagic trawl	2	No	2
Atlantic mackerel—Northeast Atlantic—Pelagic trawl			
Saithe (fresh)—North Sea—Bottom trawl	4	No	4
Saithe (frozen)—North Sea—Bottom trawl	2	No	2
European pilchard—Eastern Central Atlantic—Seine	Unknown	No	2
European anchovy—Eastern Central Atlantic—Seine	Unknown	No	6
European pilchard—Bay of Biscay—Seine	Around 30	No	13
Sole—Bay of Biscay—Trammel net	Around 300	Yes	11
Albacore tuna—Northeast Atlantic—Pelagic trawl	Around 40	No	16
Atlantic bluefin tuna—Mediterranean Sea—Seine	Around 20	No	7
Atlantic bluefin tuna—Mediterranean Sea—Longline	Around 100	No	13
Yellowfin tuna—Eastern Central Atlantic—Seine	9	No	4
Skipjack tuna—Eastern Central Atlantic—Seine			

Table 6: Number of boats surveyed per triplet as part of the French LCI Project on Fisheries

2.2.3.1.1. "Field" triplets

Most of the data for the "field" triplets was collected by Gautier Méheust, an UAPF hire specifically tasked with this work. For each triplet, contact information for the boats was obtained from the relevant POs. Méheust scheduled interviews with boat owners by phone and asked them to bring some key documents to the meeting (boating license, boat registration, and trim and stability booklet). Before each meeting, the local office of the departmental committee of fisheries, responsible for the given study area, was informed that a data collection official would be coming by. Project partners considered that this step was crucial to avoiding any misunderstandings in the field. The interviews, which lasted 30 minutes on average, largely took place at the ports, either on the docks or on the moored boat. Following the meeting, a confidentiality agreement was signed by the boat owner and project partners. For the three triplets for which classification schemes were created (see § 2.2.1), the data collection official surveyed boats in each category, to ensure there was no overrepresentation or underrepresentation.

2.2.3.1.2. Triplets with small numbers of boat owners

In certain triplets, there are small numbers of boat owners associated with the fisheries, which allows special relationships to be established with companies. Depending on the triplet, one or more preliminary meetings were held before data collection took place. The goal of these meetings was to inform boat owners about the project's objectives, to reassure them that their data would be kept confidential, and to refine the survey questions to better capture the characteristics and practices of their boats. Following these meetings, the boat owners filled out and returned the electronic questionnaire.

2.2.3.1.3. "Moroccan" triplets

For these triplets, two survey phases took place on the ground in Morocco, at the ports of Agadir, Kenitra, and Laayoune. With the approval of Moroccan authorities, project partner Xavier Joly met with and interviewed around a dozen boat owners. While the sample size seems small, it is important to note that these fisheries are very homogeneous, in terms of both boat characteristics and fishing practices. Joly also got in touch with a shipyard and an engine manufacturer to round out the data collected from the boat owners.

2.2.3.2. Complementary data

Certain data were not obtained from boat owners, either because they did not know the information desired or because the information they had lacked the requisite level of precision.

The mass balances for the boats (hull, structure, wheelhouse, gantry, etc.) were established by Bureau Mauric, a consulting firm and project partner. The procedure involved using models based on the general characteristics of the boats (length, width, depth, tonnage, etc.). Precise production data (tonnage and value) for the reference period (2011–2015) were obtained from the POs of the boats surveyed. Quantifying boat maintenance can be difficult for boat owners, so a boat painting company was contacted to gather information on the type and average quantity of paint applied to boat hulls. Other industry stakeholders, such as fish auctioneers and fishing cooperatives, were also contacted to obtain answers to highly specific questions (e.g., about fish boxes, storage sacs for great Atlantic scallops, the mass balance of isothermal containers). Finally, certain data were taken straight from scientific publications or specialised internet sites. All the sources for the project's data are provided in Annex 4.

2.2.4. Data entry

2.2.4.1. Data entry tool

Once the data had been collected, they were entered using a data entry tool made up of an Excel spreadsheet employing Visual Basic for Applications (VBA) modules. Thanks to this tool, the entry of raw individual data was standardised across triplets. The data could then be used directly to construct LCIs utilising SimaPro® software. The user can also preliminarily process the data using a VBA script. It is possible to determine yearly, allocated flows that are adjusted for the quantity of the landings. The way in which the data entry tool works is described in the user guide, which is available in Annex 3.

2.2.4.2. Missing data

When a datum was missing, the mean for the triplet was used.

When the datum related to life span or duration of usage, it was not possible to use the triplet mean. Consequently, generalised mean values were employed. The specific approach is summarised below (Table 7).

Process	First choice	Second choice
Boat	Triplet mean	35 years
Engine		10 years
Electronics		10 years
Extinguisher		20 years
Isothermal tub		40 years
Fish box		5 years
Braided lead rope		3 years

Table 7: Values to replace missing data on life span/duration of usage

When data on life span or duration of usage were missing, the following procedure was used. If the age of the component under consideration (boat, engine, etc.) was greater than that represented by the substitution value (first or second choice), then this age was rounded up to the nearest ten to arrive at a life span/duration of usage.

2.3. Data processing and LCI construction

Once the data had been entered, two processing steps took place:

- Using the data entry tool, data were preliminarily processed to obtain annual flows
- LCIs were constructed using SimaPro® software.

2.3.1. Preliminary data processing

The raw individual data for each boat were preliminarily processed using the data entry tool. The preliminary processing can be carried out automatically using the tool (see Annex 3). The results are annual, allocated flows (of consumables, quantities of materials, etc.) that are adjusted for the quantity of landings. It is thus possible to identify potential data entry errors and carry out an initial interpretation of the data. These results are complementary to the LCI results. Certain major flows that were simple to interpret emerged from the preliminary processing (e.g., diesel consumption per tonne of landings) and were presented without further analysis when the project's results were shared with the public.

2.3.2. Life cycle inventory construction with SimaPro®

2.3.2.1. Construction of individual inventories

To construct the LCIs, the raw individual data (i.e., without preliminary processing) were entered as processes in SimaPro®. There are several tabs associated with process entry:

- The "Documentation" tab contains the metadata for the process (e.g., name, quality, author). These metadata respect AGRIBALYSE® formatting. The biological indicator of stock state is found here (see § 2.4).
- The "Input/output" tab is where all the process's input and output flows are inventoried. For example, the process "Diesel combustion in marine engines" has diesel as an input and gases and particulates as outputs.
- The "Parameters" tab is where it is possible to save variables that are used multiple times within the "Input/output" tab.
- The "System description" was not used in the context of the project.

For each boat surveyed, a "Fishing activity" process was created. It comprised all the subprocesses used to generate a certain quantity of product. The subprocesses were as follows:

- A "Boat" subprocess was created for each boat. This subprocess involves the boat's mass balance (construction, maintenance, and end of life).
- A "Fuel combustion" subprocess (input and emissions)

- Two "Oil" subprocesses, one for motor oil and one for hydraulic oil (inputs and treatment of used oils)
- A "Gear" subprocess was created for each type of gear encountered. This subprocess involves the gear's mass balance (construction, maintenance, and end of life).
- There were also subprocesses related to product storage, the generation of cold storage conditions, and water usage, among other factors.

All the processes and subprocesses that were used to construct the inventories are described in Annex 4. The codes used in SimaPro® to designate certain processes (species, fishing area, etc.) are provided in Annex 5. It is important to note that, to avoid making data entry overly repetitive, only species associated with significant tonnage were entered in SimaPro®. A cumulative threshold of 95% was used: once that threshold was surpassed, the remaining species with low tonnages were placed together in the "Various" group. As soon as it became possible, parameterisation was used to construct the inventories in SimaPro®. The goal was to facilitate and speed up data entry. Indeed, several variables were used in different spots in each subprocess. By parameterising these variables, the user only needs to enter them once.

The data treatment procedure, from data collection to LCI construction, is described below (Figure 7).

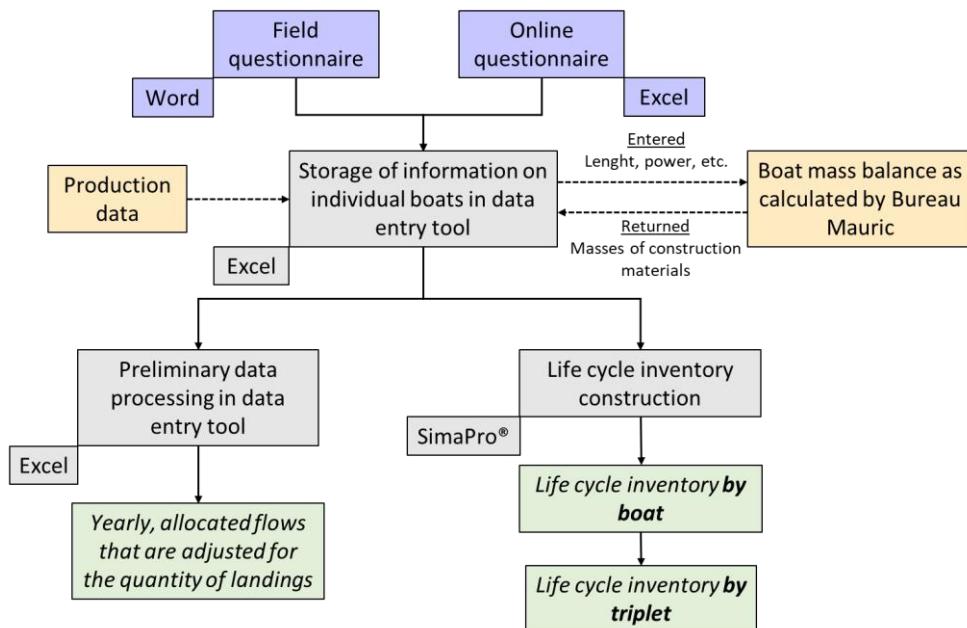


Figure 7: Diagram illustrating the data treatment procedure, from data collection to LCI construction

2.3.2.2. Constructing average inventories for each triplet

Once the individual inventories had been established for each boat, an average inventory was created for each triplet. These inventories were built as "Units" processes in SimaPro®. Consequently, as for the boat inventories, the triplet inventories compiled information on different inputs and outputs (the triplet's hypothetical average boat, mean fuel consumption, gear, waste, etc). These flows were estimated using the weighted means associated with product production. Data from boats with greater quantities of landed product were more heavily weighted. Annex 7 describes inventory construction, from the individual data to the average inventory per triplet.

2.3.2.3. Methodological choices

When constructing inventories in SimaPro®, it is necessary to make various methodological choices. First, when it was possible, processes were chosen from ecoinvent® v. 3. Also, whenever possible, the "Allocation, recycled content—system", or "Alloc Rec, S", format was chosen for these ecoinvent® processes. When something is designated as "Allocation, recycled content", it means that if a material used in the process is the product of recycling, only material recycling operations are allocated to the process. The creation of new materials (e.g., extraction of raw materials, transformation) is not allocated to the process. In SimaPro®, system models combine all the Unit processes involved in the process of interest. This approach stands in

contrast to single Unit processes, which contain only the main subprocesses involved. The benefit of using a system model is that LCIs can be calculated more quickly. In some cases, the appropriate process was not available in ecoinvent® v. 3. As a result, the necessary processes were created using scientific publications, documented example cases, or expert opinions. Emissions released directly into the environment (e.g., carbon dioxide, fine particles, paint fumes) were designated in SimaPro® and identified with a Chemistry Abstracts Service (CAS) number. The waste produced by fishers was treated as a mixture of plastics, with a density rounded to 0.2 [17]. Finally, it was estimated that 30% of the refrigerant used would end up leaking out as fumes [18].

Annex 4 describes all the processes created, the methodological choices made (e.g., densities, compositions), and the sources employed.

2.4. Evaluation of the biological impacts of fishing

2.4.1. Introduction

Since the early 2000s, many studies have used LCAs to quantify the environmental impacts of fishery products [19] [20] [21]. For most of these impacts (climate change, resource depletion, etc), the methodology is the same. However, because fishing is an activity that involves harvesting resources from the natural environment, it entails specific additional impacts. Fishing has direct effects on the sustainability of fish stocks, on marine habitats, and on the equilibrium of marine ecosystems. To ensure LCA completeness, several researchers have underscored that it is important to include biological impacts alongside more "traditional" impacts [22] [23]. Even if a standard methodological approach remains to be developed, more and more studies are creating indicators that allow LCAs to account for biological impacts [24] [25] [26] [22] [27].

No new indicators were created over the course of the French LCI Project on Fisheries. The goals were as follows: to identify fishing's biological impacts of interest, to review existing indicators, and, ultimately, to apply one or more of these indicators to our triplets, depending on their usefulness. To this end, as part of her internship project, Marion Debasly put together a review of the different methods and indicators described in the literature. She also conducted a simple critical review of the indicators. In tandem, three meetings with scientists and professionals with expertise in the field were organised to carry out an in-depth assessment of the indicators. This combined work resulted in an initial literature review and the application of a specific indicator to the triplets.

2.4.2. The biological impacts of fishing

Fishing is an activity that involves resource harvesting. It thus has several types of effects on ecosystems. First, fishing exploits fish stocks and therefore affects their sustainability. Second, fishing gear can alter certain marine habitats, notably the ocean or sea bed. Third, fishing can broadly disrupt marine ecosystems by modifying equilibria within tropic webs. It also affects marine biodiversity.

Project partners agreed that the following four categories of impacts should be evaluated:

- impacts on fish **stocks** resulting from resource harvesting
- impacts on marine **habitats** and notably the ocean or sea bed by fishing gear
- impacts on **general ecosystem functions** via the disruption of food web equilibria
- impacts on marine **biodiversity**

Also evaluated were impacts related to **waste** generation, which are two-faceted. First, there are impacts related to the harvesting of fish stocks because certain individuals are discarded. This impact falls into the first category, which is related to stock exploitation. Second, there are impacts resulting from the fate of discarded fish, which are thrown back. Such fish can have a positive or negative effect on the benthic ecosystems in which they end up [28] or can serve as food for birds, marine mammals, or benthic species such as the Norway lobster or the common whelk [29] [30]. However, despite the above research, the biological impacts of discarded fish remain poorly characterised. No descriptions of characterisation methods were found in the literature.

2.4.3. Requirements for indicators

The impacts described above can be evaluated using various methods or indicators. Project partners felt that indicators needed to meet certain requirements if they were to be included in an LCA of fishery products. These standards are specified here.

Indicators needed to be compatible with the LCA framework and, notably, be related to the amount of landed fish. It was even better if they shared the study's functional unit. It was also important for indicators to represent real environmental effects and not to simply convey status. Indicators needed to be applicable to the triplets as defined in the study (i.e., target species—fishing area—fishing gear). Finally, they had to have a solid scientific foundation (positive assessments, multiple citations, etc), and their calculations needed to utilise data that are relatively easy to obtain.

2.4.4. Review of biological indicators described in the literature

For each of the impact categories described above, several indicators have been described in the literature. They were assessed as part of the French LCI Project on Fisheries.

2.4.4.1. Impact on fish stocks

This category focuses on the impacts of fishing that are related to the **depletion of stocks** of target species. During discussions among project partners, several requirements were identified for indicators of impacts in this category. First, it was crucial for the indicator to incorporate the concept of maximum sustainable yield (MSY) in its calculation. MSY is an indicator in and of itself that is the basis for many fishery management measures deployed by various organisations (e.g., CIEM, ICCAT, CTOI). It is defined as "the largest amount of biomass that can be removed over the immediate and long term from fish stock(s) under prevailing environmental conditions without affecting reproduction" [31]. Second, it became clear that there are two schools of thought when it comes to evaluating impacts on fish stocks. The first, which shares similarities with the LCA framework, starts considering impacts from the moment a fish is removed from the stock. The second, which is informed by management measures, only begins considering impacts from the moment the stock is overfished (from an MSY perspective). Although it can be challenging to reconcile these two approaches, the project searched for a single indicator that encompassed both. Furthermore, it seemed important to account for the biomass harvested by a boat or group of boats from the stock, in order to convey its relative significance given available resources (again from an MSY perspective). Finally, the indicator needed to account for impacts on all the species caught, meaning not just on the stock of the target species but also on the stock of secondary species and discarded fish.

Several promising indicators were identified in the literature and assessed by project partners. In particular, the focus was on OF and OB, which were developed by Emanuelson *et al.* (2014) [26] and on I_{BNR}, which was developed by Hélias *et al.* (2014) [32].

The indicator that the project ultimately decided to use was strongly based on both Emanuelson's and Hélias's work and quantifies the pressure exerted by a boat or group of boats on the different stocks exploited. It is calculated as follows:

$$I_{Stocks} = \frac{\sum_j^J m_{j,v} \cdot CF_j + m_{rejects} \cdot CF_{rejects}}{\sum_j^J m_{j,t}}$$

Where

- $m_{j,v}$ = the boat's landed mass of species j (target or secondary) in live mass (v)
- $m_{discards}$ = the mean mass of discarded fish in the fishing area and métier under consideration (OBSMER data)
- $m_{j,t}$ = the landed mass of species j in transformed mass (t); this term makes it possible to convert the result into the study's functional unit.
- CF_j = the characterisation factor for fish of species j (target or secondary) landed by the boat:

$$\begin{cases} CF_j = OF \cdot \frac{1}{B} = \left(\frac{F}{F_{MSY}} - 1 \right) \cdot \frac{1}{B} & \text{if } F > F_{MSY}, \text{ then the stock is overfished} \\ CF_j = 0 & \text{if } F \leq F_{MSY}, \text{ then the stock is underfished or sustainably fished} \end{cases}$$

Where

- OF = the indicator developed by Emanuelson *et al.* (2014) [26]

- F = the actual fishing pressure on the stock of species j
- F_{MSY} = the fishing pressure at MSY for the stock of species j
- B = the current biomass of the stock of species j
- $CF_{discards}$ = the average characterisation factor for discarded fish in the fishing area under consideration. This factor is equivalent to the average characterisation factor for the corresponding FAO fishing area (calculated by Arnaud Hélias).

The indicator I_{Stocks} can be calculated for a single boat or for a group of boats.

In line with the LCA framework, I_{Stocks} can be broken down into an inventory datum (amount of each species harvested) that is multiplied by a characterisation factor (CF). This characterisation factor corresponds to the OF indicator developed by Emanuelson *et al.* (2014) [26] but is corrected using the inverse of stock biomass; the objective is to understand the significance of the amount of fish being harvested by the boat or group of boats relative to available biomass. When a stock was considered to be underfished or sustainably fished, the choice was made to set the characterisation factor to zero. This approach fits with a fishery management perspective but stands in opposition to the LCA perspective, which considers impacts from the moment a fish is caught (see above). Furthermore, it is necessary to set the characterisation factor to zero to avoid a situation in which a highly harvested stock that is also underfished or sustainably fished (= high negative value) leads to the aggregated I_{Stocks} indicator underestimating the impacts associated with an overfished stock experiencing a low harvesting intensity (negative values could even result).

The I_{Stocks} indicator accounts for all removals of fish from stocks, whether the fish are landed (target or secondary) or discarded. The indicator is composed of two parts. The first part concerns the J species that are landed by the boat or group of boats. It corresponds to the average of the characterisation factors weighted by the mass harvested from each stock. Weighting makes it possible to account for differences in harvesting levels. The second part represents the impacts associated with discarded fish. Because precise data are lacking on fish discard levels for individual boats, the decision was made to use a mean mass of discarded fish as well as an average characterisation factor for the fishing system and area under consideration. The mass of discarded fish was estimated using information from the OBSMER programme. OBSMER has collected observational data that can be used to determine the percentage of discarded fish for each métier practiced by French fishers. Because the exact composition of the mass of discarded fish is unknown (for individual boats and groups of boats alike) and in order to limit sources of bias as much as possible, a characterisation factor corresponding to a "typical" fish for the relevant FAO fishing area was used (e.g., zone 27—Northeast Atlantic). Although this approach lacks precision, the project's partners all felt that it was the best available solution at present.

In the numerator is the landed mass of species j , which corresponds to the live mass of the species (prior to any transformation such as evisceration, deheading, etc). It represents the effective mass removed from the stock. However, the landed mass of species j in transformed mass also appears in the equation because the indicator must be expressed in the study's functional unit: tonnes of landed product, accounting for transformation.

The values of F , F_{MSY} , and B come from organisations that evaluate fish stocks, such as the CIEM, ICCAT, and CECAF.

It is important to note that, for some stocks, no precise value is available for F or F_{MSY} . That said, in a certain number of these cases (such as that of the great Atlantic scallop in Saint-Brieuc Bay), available assessments indicate that the stock is not overfished, even if precise numbers are unavailable. This finding suggests that the ratio of F to F_{MSY} is less than 1 and that the characterisation factor is equal to 0. Consequently, in some cases, it is possible to calculate the characterisation factor even when a precise estimate for F/F_{MSY} is lacking.

Initially, the plan was to use the CF established by Arnaud Helias based on FAO data if F , F_{MSY} , and/or B were unavailable for a given species j , and CF_j could therefore not be calculated. However, project partners felt that Helias's CFs were not precise enough because they were based on data for the whole FAO fishing areas (e.g., sole from the stock in the Bay of Biscay has the same CF as sole from the stock in the eastern English Channel). The new plan then became to apply the formula exclusively to stocks for which the CFs could be calculated from robust assessments and to indicate on each graph that the result is only valid for a certain percentage (in tonnes) of the catch.

Finally, this indicator may be updated when Arnaud Hélias's next publication comes out. The latter was the basis for the discussions surrounding this indicator.

2.4.4.2. Impacts on marine habitats

This category includes the impacts of fishing on **marine habitats**. The indicators described in the literature focus exclusively on how fishing gear such as the bottom trawl or dredge impact benthic habitats on the ocean or sea bed.

At present, many indicators simply calculate the area swept by fishing gear [24] [19]. However, the indicator developed as part of the Bentthis project [33] goes further and also accounts for the gear's depth of penetration into the ocean or sea bed. Work by Langlois *et al.* (2015) [34] proposes associating an estimate of the area swept with an estimate of the resilience of the affected benthic communities.

However, following discussions among project partners and with experts, based on current knowledge, there is no indicator at present that could be used to fully characterise impacts on the ocean or sea bed. To do so would require accounting for the area swept, penetration depth, sweep frequency, ocean or sea bed characteristics, and the resilience of benthic communities. As a result, the decision was made not to employ any indicator of impacts on marine habitats in the project database. However, it should be noted that research on this topic is ongoing (for example, CIEM has begun studying this issue) and that the publication of new discoveries may change the project's current perspective.

2.4.4.3. Impacts on trophic webs

This category of impacts includes impacts related to the **imbalance in trophic webs** resulting from the removal of biological resources from the ecosystems being exploited.

At present, most of the indicators developed are based on the PPR index [35], which can be used to calculate the amount of primary productivity needed to produce a certain mass of harvested fish. The L index, which was developed by Libralato *et al.* (2008) [36] proposes the opposite approach: it quantifies the loss of secondary productivity resulting from the capture of a species belonging to a lower trophic level. In the opinion of the project's partners and the experts consulted, a major issue with these two indicators is that they cannot be used to truly assess disequilibrium in trophic webs. For example, the question arises: for the PPR or L indices, are the impacts the same if fishing occurs at a single trophic level (e.g., targeted fishing of bluefishes) or at multiple levels (e.g., multiple species caught using bottom trawls)?

As in the case of habitat impacts, research focused on how to best assess disequilibrium in trophic webs is still underway. In the opinion of the project's partners and the experts consulted, there is currently no indicator that would allow this category of impacts to be evaluated in a satisfactory manner. As a result, the decision was made not to employ any indicator of impacts on trophic web disequilibrium in the project database.

2.4.4.4. Impacts on biodiversity

Fishing has impacts on marine **biodiversity** because it affects the abundance and variety of species and habitats making up exploited ecosystems. At present, there are very few indicators that can be used to evaluate the impacts of fishing on marine biodiversity.

In LCAs of agricultural systems or freshwater systems, the indicator used to assess biodiversity impacts is the fraction of affected species per m² per year; no distinction is made based on species type or status (i.e., whether or not species are endangered). Several questions have been raised in regard to this approach, notably:

- Underlying these methods is the idea of a "natural" state of reference, whose definition is problematic. That said, it has been underscored that LCAs are always carried out with the aim of comparing two production systems. The change that is observed (improvement or degradation) is the focus, rather than the quantification of the absolute impacts on biodiversity.
- Here, the goal of the LCA is to express impacts in terms of kilogram of landed fish, and reservations were expressed about the ability to associate impacts related to biodiversity loss in marine ecosystems with specific fishing activities.

Research on such biodiversity-related issues is currently being carried out in the context of the Marine Strategy Framework Directive (MSFD), the UNEP/SETAC initiative, and CIEM research [37].

Although there is a consensus that it is important to account for the impacts of fishing on biodiversity when conducting LCAs, those participating in project discussions have highlighted that there is currently no indicator in the literature that is compatible with the LCA framework.

2.4.5. Conclusion

Based on diverse research and various discussions with experts, an indicator for expressing fishing's impacts on exploited fish stocks was finally chosen and applied to the project's triplets. Other categories of impacts (i.e., on habitats, ecosystems, and biodiversity) were discussed, but the current state of knowledge remains limited. No indicators that satisfactorily express these impacts could be found in the literature. The project's partners do note, however, that there is extensive research underway that is exploring these issues. In the coming years, new indicators may be described that will allow assessments of these impacts to be incorporated into LCAs of fishery products.

2.5. Flow allocation

In LCAs, flow allocation involves partitioning the environmental impacts associated with the consumption of a given input (e.g., diesel) among the different products and co-products that are generated using the input. Depending on the production objective, several key partitioning approaches exist, including (but not limited to) physical allocation (mass, density, etc.), economic allocation, and biophysical allocation.

2.5.1. Fishing products and co-products

Like agricultural systems, fishing systems generate several products. This is not systematically the case, but it is generally true. In the French LCI Project on Fisheries, a distinction was made between main products (i.e., part of the triplet's definition) and co-products.

2.5.1.1. General case

Practically speaking, the main product (i.e., the product of the triplet) is the product that is sought by professional fishers practicing a specific métier. In contrast, co-products may vary in nature. A co-product is any product that is caught, landed, and utilised at the same time as the main product, using the same gear and during the same fishing trip. A product caught during a different period of the season using the same or different gear could also be a co-product.

2.5.1.2. Multispecies fisheries

In multispecies fisheries, a fisher captures several species without any single one being targeted or dominant. In this project, the triplet Gadidae—Celtic Sea—Bottom trawl is an example of a multispecies fishery. In addition to catching the three Gadidae species, trawlers may also capture anglers, megrims, or different ray species, among other fishes. In that triplet, no one product is considered to be the main product.

2.5.2. Flow allocation

The project's guidelines for allocating flows were based on the recommendations laid out by the AGRIBALYSE® programme and comply with ISO 14040 standards [38]. The guidelines for allocating flows are listed below in order of priority:

1. Avoid allocation whenever possible

This goal can be achieved by becoming as familiar as possible with the triplets and by excluding other activities that generate co-products. For example, in the Sole—Bay of Biscay—Trammel net triplet, instead of placing the boat's diesel consumption in the process "annual fishing activity", because the boat uses the trammel net and the trawl successively, the data should be placed in the process "trammel netting activity".

2. Mass allocation

Two allocation approaches were considered in the context of this project: mass allocation and economic allocation. Mass allocation is tied to one of the fisher's main objectives, which is to land the maximum amount of fish possible. This allocation approach is fairly consistent with the strategy of multispecies fisheries, where fishing efforts are spread across several different species. Economic allocation is tied to another objective of professional fishers, which is to target the most marketable products. This allocation approach is fairly consistent with a very targeted fishing strategy that focuses on a single species because of its economic value and where the fisher does not financially depend on capturing secondary species. In the context of this project, this economic objective was considered to play a secondary role. Furthermore, a significant

challenge with this allocation approach is that the sale price, and thus the impacts, of fishery products varies tremendously within and among years. Consequently, the decision was made to use the mass allocation approach. Below is a hypothetical example of mass allocation and, for comparison's sake, economic allocation (Figure 8).

Impacts were exclusively allocated to the products landed by fishers. A fishery's discards (i.e., non-landed products) could not be quantified in a precise way; consequently, no impacts were allocated to them in the course of the project.

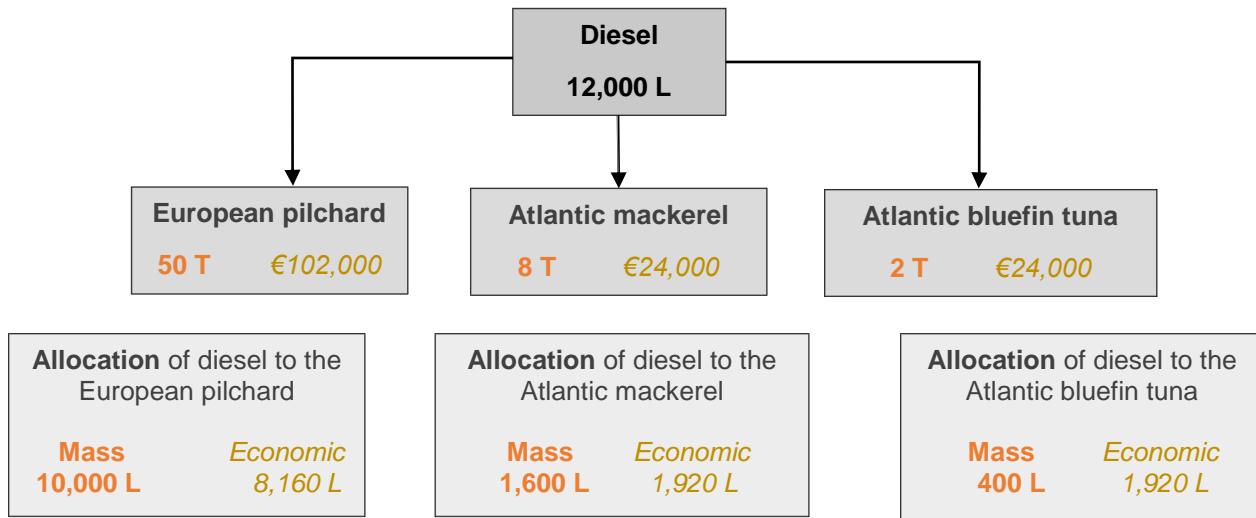


Figure 8: Hypothetical example showing mass allocation (and economic allocation) of diesel consumption to three fishery products

The idea of allocating fishing time was suggested as a way of allocating boat-related impacts. This recommendation was rooted in the idea that a boat's impacts are more proportional to the time spent at sea than to the amount of landed product. Although this allocation approach was ultimately not adopted, it could be revisited in the future.

2.5.3. Allocations among and within fishing activities

When allocation was found to be necessary, it was carried out in two steps. The first step involved allocating flows among the different métiers practiced by a given fisher. The second step involved allocating flows among the different products captured during the practice of a given métier.

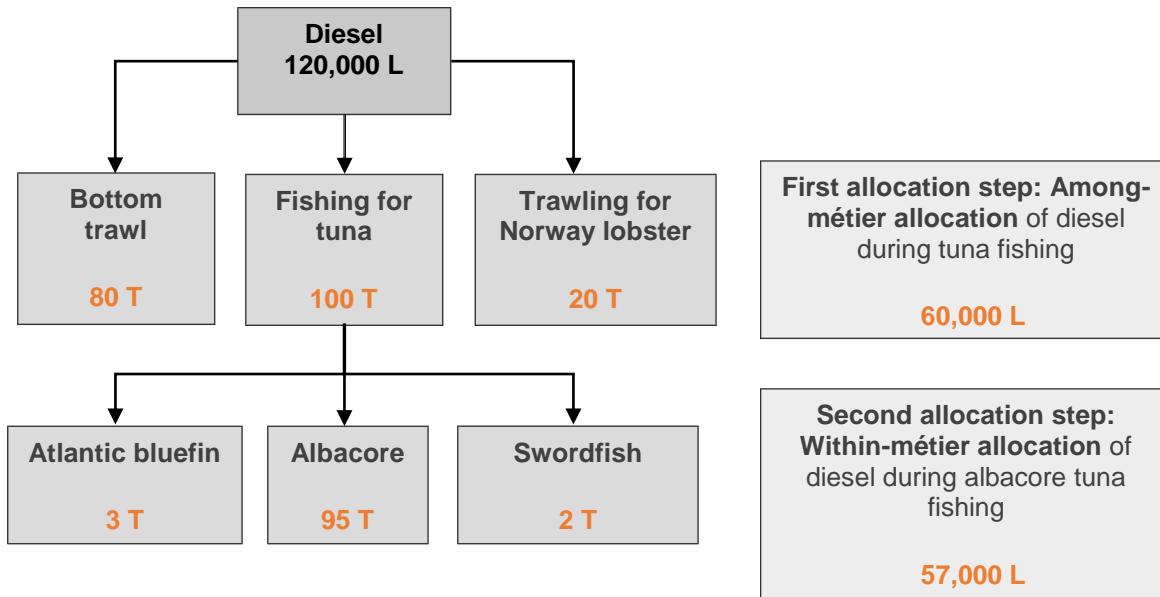


Figure 9: Hypothetical example illustrating the two-step process used to allocate diesel consumption during albacore tuna production

Conclusion

This methodological report describes the approach used and choices involved in constructing LCIs for different French fishery products. While it describes the methods used, the intent is not to provide recommendations. The target audience is anyone who wishes to assess the quality of the data in the AGRIBALYSE® database and/or to construct LCIs for fishery products.

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Terminology

Ecolabelling	Ecolabelling conveys information to consumers about the environmental impacts associated with the creation of a product or a good
Boat mass balance	Complete inventory of the materials making up a fishing boat
Bolinche	Regional French term for a seine
Bottom trawl	Cone-shaped net that is opened using boards and that is towed along the sea floor by a fishing boat
Pelagic trawl	Cone-shaped net that is towed midwater (i.e., no contact with sea floor) by a fishing boat
Pair trawl	A single trawl towed by two fishing boats
Twin trawls	Two trawls towed by the same fishing boat
Dredge	Type of fishing gear that consists of a metal mouth frame to which is attached a holding bag composed of metal rings/mesh and a blade for raking the sediment
Output	Element exiting the production system; it can be a pollutant, form of waste, etc. (e.g., CO ₂)
Lowering a trawl	Action of putting a trawl into the water
Flow	Input or output that crosses the production system's boundaries
Input	Element entering the production system; an input can be a commodity, source of energy, etc. (e.g., fuel)
Life cycle inventory	Complete assessment of the inputs and outputs of a production system that results in the creation of a product or service; building a life cycle inventory is the first step in carrying out a life cycle analysis
Fishing trip	Here, a fishing trip is defining as a given trip made by a fishing boat for the purpose of fishing in the open sea; depending on specific fishing practices, a fishing trip can last a few hours or several weeks
Knot	A unit of speed used in maritime navigation; a knot is equivalent to one nautical mile per hour, or 1,852 kilometres per hour
Longline	Type of fishing gear consisting of a mainline to which hooks are attached; when the target is Atlantic bluefin tuna, the longline is kept in open water by the presence of floats
Process	In LCAs, a process is a component of a production system that is associated with different inputs and outputs; the construction of a fishing boat is an example of a process
Fishing quota	The total amount of fish that can be caught for a given stock, a quantity that is determined by the relevant fishing authority (e.g., European Union, ICCAT, or IOTC); quotas can be established at different levels, from that of the individual boat to that of the world (the term total allowable catch, or TAC, is used)
Seine	A rectangular net deployed in open water to encircle shoals of fish
Stock	The exploitable proportion of a population of a given species found in a given area
Hauling back a trawl	Action of pulling a trawl out of the water and back on board the boat

Annexes

Annex 1: Processes and flows examined

This annex describes all the processes, subprocesses, and unit flows that were examined as part of the project.

Process	Subprocess	Quantified flow
Boat construction, maintenance, and end of life	Materials used to build the boat	Steel
		Stainless steel
		Aluminium
		Composite
		Wood
		Concrete
		Epoxy/plywood
		Polyethylene
		Insulation
	Electrical equipment and electronics	Electrical panels and transformers
		Electronic navigation equipment
		Anodes
		Electrical cables
		Batteries
	Boat propulsion system	Heat motor
		Electric motor
		Pump
		Propellers
	Paint	Erodible antifouling
		Semi-erodible antifouling
		Hard matrix antifouling
		Silicone-based antifouling
		Polyurethane-based paint
		Chlorinated rubber paint
	Fire suppression	CO ₂
		Powder
		Water additive
		Halon
		FM-200®
	Miscellaneous	Life rafts
	Operating fluids	Diesel
		Gas
		Motor oil
		Hydraulic oil
		Freshwater
		Refrigerants
	Waste	Waste generated
		Waste brought up with catch
	Bait	European pilchard
		Atlantic mackerel
		Gurnard
		Squid
Gear construction, use, maintenance, and end of life	Metal components of gear	Steel
		Stainless steel
		Galvanised steel
		Aluminium
		Iron
		Lead
		Cast iron
		Bronze
		Copper
	Plastic components of gear	Polyester
		PVC
		Nylon
		Polyurethane
		Polyethylene

		Polypropylene
		Polystyrene
		Rubber
		Oak
		Elm
		Ash
		Beech
		Acacia
		Fir
		Spruce
		Pine
		Cedar
		Paint
		Nylon
		Lubricant
Construction, use, maintenance, and end of life of fish storage and preservation equipment	Metal components of equipment	Steel
		Stainless steel
		Galvanised steel
		Aluminium
		Iron
		Lead
		Cast iron
		Bronze
		Copper
		Polyester
Packaging units for fresh fish	Plastic components of equipment	PVC
		Nylon
		Polyurethane
		Polyethylene
		Polypropylene
		Polystyrene
		Rubber
		Polyester
		PVC
		Nylon
Packaging of frozen fish	Materials used in the manufacture of packaging units	Polyurethane
		Polyethylene
		Polypropylene
		Polystyrene
		Rubber
		Stainless steel
Initial transformation	Packaging used	Aluminium
		Plastic film
		Polystyrene
		Cardboard
		Plastic film
		Polystyrene
		Cardboard
		Organic waste discarded

Annex 2: User's guide for the questionnaire

Questionnaire objectives and format

The goal of the questionnaire was to gather data on the consumption and emissions patterns associated with the fishing activities of specific métiers/triplets for the reference period (2011–2015). Two major issues were studied:

- Boat construction, maintenance, and end of life
- Fishing activity, from a boat's departure from port to its return with landed product

The questionnaire was therefore composed of two parts. The first part focuses on the boat's technical features. These data could then be fed into models yielding estimates of the energy and amounts of materials (e.g., steel, wood) used to build the boat. The second part focuses on first-hand data on the consumption and emissions patterns associated with the boat's fishing activity.

Below, the objective of each question is explained, and some technical terms are described.

Boat technical features

1. What type of boat do you use?

We were expecting a response such as gillnetter, polyvalent trawler, pot vessel, or seiner (etc.). It is a response that is very métier specific, although some boat owners focus on hull characteristics (e.g., materials used, length) instead.

2. What is the boat's length overall (LOA)?

3. What is the boat's moulded breadth (or midship beam or maximum width)?

Distances between the boat's extremities.

4. What is the ship's depth (distance from the main deck to the bottom of the hold)?

5. What is the boat's draught when fully loaded?

The depth is the vertical distance from the main deck to the bottom of the hold. It is equivalent to the sum of the draught, which encompasses the part of the boat that is submerged, and the freeboard, which encompasses the part of the boat that is above the waterline.

6. What is the displacement and draught of the boat in the following situations: upon departure for a fishing trip (situation 1), upon departure from the fishing grounds (situation 2), upon return to port with a full load (situation 3), and upon return to port empty (situation 4)?

This information is available in the boat's trim and stability booklet.

7. What is the boat's gross tonnage?

A boat's gross tonnage is its total interior volume. It is generally expressed in register tons for small boats and in UMS tonnage for boats longer than 24 m. There is no direct way to convert between register tons and UMS tonnage, but the following relationships are generally accepted:

- 200 UMS units are equal to 100 register tons
- 500 UMS units are equal to 200 register tons
- 3,000 UMS units are equal to 1,600 register tons

8. What is the name and address of the boat's builder? How was the boat delivered to you?

Here, the goal is to collect information about the boat's construction site, delivery distance, and delivery method, as well as the energy mix used in the country of construction.

9. In what year was the boat first launched? What is your estimate of the boat's life span in years? Do you know what will happen to the boat at the end of its life?

10. What is the boat primarily made of (steel/aluminium/wood/composite)? If there are several main materials, could you provide an approximate percentage of each?

11. What type of paint was used on the hull?

Knowing the type of paint used makes it possible to evaluate the toxic compounds released into the environment.

12. What type of paint was used on the superstructures?

13. Could you describe your boat's engine?

The goal is to collect as many details as possible (e.g., brand, motor type, power, age/life span). They can then be used to estimate the amounts of different materials needed to build the engine. Its life span is a key part of determining how well the money that has been invested has been recouped.

- 14. Do you have an electric generator or just alternators? If so, what is its power?**
- 15. How often is the boat careened? Who carries it out?**
- 16. How often is regular paint applied? Antifouling paint? On these occasions, how much paint is used? (see Question 10)**
- 17. What electronic equipment (e.g., radar, sonar, AIS, VHF radio) is the boat equipped with? How often is such equipment replaced?**

The aim is to evaluate the overall environmental impact of the electronics used on board the boat.

- 18. What is the number of crew members required by law?**
- 19. How many bunks does the boat have?**
- 20. Are there showers on board? If so, how many?**
- 21. Are there toilet facilities on board? If so, how many?**

These data are used to estimate the quantity of waste produced during fishing trips that is related to the crew's daily life and to characterise the boat's infrastructure. The responses also provide information about the quality of life on board.

22. What fire suppression system does the boat have in place?

Boats have centralised tank systems (CO₂), fire extinguishers (powder or CO₂), or both.

- 23. What is the associated volume/quantity of fire suppressants (e.g., powder, CO₂)?**
- 24. How often is the system tested/maintained?**

Normally once a year, according to regulations.

Fishing activity

While the technical features of a boat are fairly fixed (e.g., the boat's length overall does not change over time), its fishing activities can vary from year to year. The study was interested in data from the period from 2011 to 2015. It is important to begin this part of the questionnaire by conveying this information to the person being surveyed. For each question, the goal is to capture the average for the reference period or, if that is unavailable, the numbers for one or several notable years.

Furthermore, annual flows for a given boat can be 100% associated with a given triplet (e.g., a boat that exclusively fishes for Atlantic mackerel in the Northeast Atlantic). However, more often, they are partitioned among the triplet's métier and other métiers (e.g., a boat that dredges great Atlantic scallops and Venus clams from October to April and then traps lobster the rest of the year). In the latter case, to limit the need to allocate joint flows among several métiers, it is important to collect information that is focused as much as possible on the processes of interest.

Let's take the example of a fisher who collects great Atlantic scallops and Venus clams in the winter. If we are given a monthly estimate of diesel consumption, it will be difficult to determine what proportion is attributable exclusively to the harvest of great Atlantic scallops. Consequently, it will have to be allocated between the two production systems (mass, value, etc., depending on the chosen allocation approach).

25. Could you describe a typical fishing season for you?

The aim of this question is to get a sense of how the fishing season plays out for the boat.

- There are métiers that are practiced all year.

For example:

- 1st fishing period—sole caught via trammel net from January to April
- 2nd fishing period—mullet caught via trammel net from May to July
- etc.
- For each métier, the number of trips per week, per month, and per period should be obtained.

This information becomes very important. It is possible that the survey will yield consumption/emissions data that are associated with different units of time (as mentioned above, the ideal unit of time is the triplet-specific fishing trip). For example, diesel consumption may be expressed per trip, hydraulic oil consumption may be expressed per month, and ice consumption may be expressed per week. It is therefore crucial to

standardise all these forms of consumption—most commonly by converting them to annual metrics—so that they can be associated with annual fish landing data. Given that the trip is the smallest temporal denominator used, it is necessary to know the number of trips per week/month/period/year, at the very least. Having these data for the triplet's métier is obviously essential, but it is also helpful to have them for other métiers practiced by the boat. It makes it possible to verify certain estimates by cross-checking consumption by trip and by year (invoiced). It is sometimes necessary to determine pro-rata rates for the different estimates.

- For each métier, the following information is collected per trip:
 - Time spent at sea: in hours for small-scale fishing, in days or weeks for larger-scale fishing
 - How the fishing trip proceeds: departure time, time to set up nets, duration of trawling session, rest phases, fishing speed, etc.
 - Areas fished (estimates of distance covered)

The idea is to state the initial question simply: "Could you describe your fishing season?" and then ask more specific questions over the course of the discussion.

It is also helpful to ask the person being surveyed if, during the reference period (i.e., here, between 2011 and 2015), there were any years with atypical conditions (e.g., climate, lack of certain fish species, spoilage).

26. What is the proportion of turnover associated with each métier you practice?

These data can facilitate the allocation of consumption to the triplet/métier depending on fish volume (mass allocation) and value (economic allocation).

27. Which species do you capture? Provide the most comprehensive list possible.

The goal is to have as complete a list as possible of species that the fisher brings on board, including both landed and discarded fish.

28. For each species, or at least for the target species, what quantity of fish did you land per year between 2011 and 2015? If you do not know the precise quantities of fish that you landed, would you mind us obtaining the information from your PO?

Fishers may be unable to provide accurate estimates in response to this question. In such cases, ask for approximate figures and get their permission to acquire more detailed information from their POs. If you wish to do the latter, make sure that the permission slip at the end of the questionnaire is signed!

29. Could you provide an estimate of the quantity of fish discarded for each species (or the proportion of discards relative to landings)?

Note: this question may be a sensitive one. Obtaining a proportion of discards relative to landings should be fine.

30. What is your mean fuel consumption?

Expressed per trip, ideally. If not, expressed per week, month, or year.

- 31. What is your consumption of motor oil, transmission fluid, and propeller lubricant?**
- 32. What is your mean consumption of hydraulic oil?**
- 33. What is your mean consumption of freshwater? How do you use this freshwater (cooking/drinking aside)?**
- 34. Where is the ice produced? What is your mean consumption of ice?**
- 35. What refrigerant is used in your cold-storage system? Does it have to be refilled? If so, about what quantity is added?**

Depending on the situation, the answer may be expressed per fishing trip, per week, per year, etc. It is for this reason that it is crucial to know the number of trips made (see above).

**36. How much waste is generated when you go out to sea (liquid/solid, organic/non-organic)?
How much waste is picked up in your nets/trawls? What is done with this waste?**

Here, it is important to distinguish between the waste generated by the boat itself and the waste brought up with catch (via net/trawl). If possible, it is good to obtain separate values (e.g., a 30-L bag of each).

37. What gear do you use to capture the triplet's target species? Could you describe it?

The goal is to obtain the maximum amount of information possible on gear type, number, and technical features (e.g., headline length, netting, final mass). We have been in contact with gear manufacturers, who

have helped us calculate the quantities of the different materials used to construct gear based on its characteristics. However, to double-check these estimates, we found it helpful to obtain the boat owner's opinion on the mass of the different materials making up the gear (a rough estimate sufficed). It is also important to gather information on gear maintenance (e.g., frequency, type), life span, replacement frequency, and fate at the end of life.

38. What equipment found on board the boat is dedicated to gear operation? Could you describe it?

The goal is to gather as many details as possible on the equipment used to operate gear, including, but not limited to, type (e.g., winches, reels), number, age and/or life span, and maintenance history. If possible, it is also important to obtain estimated mass of the different materials involved.

39. How is the fish stored? Is there a fish hold? If so, what is its capacity?

On small boats, fish may be stored right on the main deck.

- 40. Does the boat have fish preservation equipment on board (e.g., ice maker, freezer)? If so, what is the mass of the equipment's main materials? What is the equipment's life span and fate at the end of life?**
- 41. What type of containers are the fish stored in (e.g., trays, boxes)? How many of these containers are brought on board? How long do these containers last?**
- 42. Do you use cardboard or plastic packaging? If so, how much?**

This question is notably asking about the plastic wrap that is placed between the ice and the product.

43. What quantity of each species is stored in each container/packaging unit? What quantity of ice/ice water is used?

A packaging unit is an example of a container used to store fish, like trays, bins, etc. The aim of the question is to determine the relationship between the quantity of fish and the quantity of ice.

44. For the target species, in what form are fish typically stored (e.g., deheaded, eviscerated, whole)? What is the fate of the organic waste resulting from fish transformation?

Using the above information, we determine the ratio between transformed mass and live mass that can be used to determine the quantity of organic waste produced.

Annex 3: User guide for the data entry tool

Objective

The data entry tool developed for the French LCI Project on Fisheries has two aims: to allow data to be entered in a standardised fashion and to facilitate the calculation of certain indices from the data. It was designed to deal with environmental data on the activities of fishing boats. It is intended for use by anyone who wishes to build LCIs or carry out LCAs related to fishing activities.

General usage

The data entry tool is a macro-enabled Excel workbook. It is made up of 10 spreadsheets; data is entered in 7 of the sheets. These data describe fishing activities by boats and represent information gathered from professional fishers.

It allows the standardised entry of data for the different subprocesses tied to a boat's fishing activities (Figure 10):

- boat: construction, maintenance, and end of life
- gear: construction, maintenance, and end of life
- fishing operations: diesel consumption, production, etc.
- fish transformation and preservation

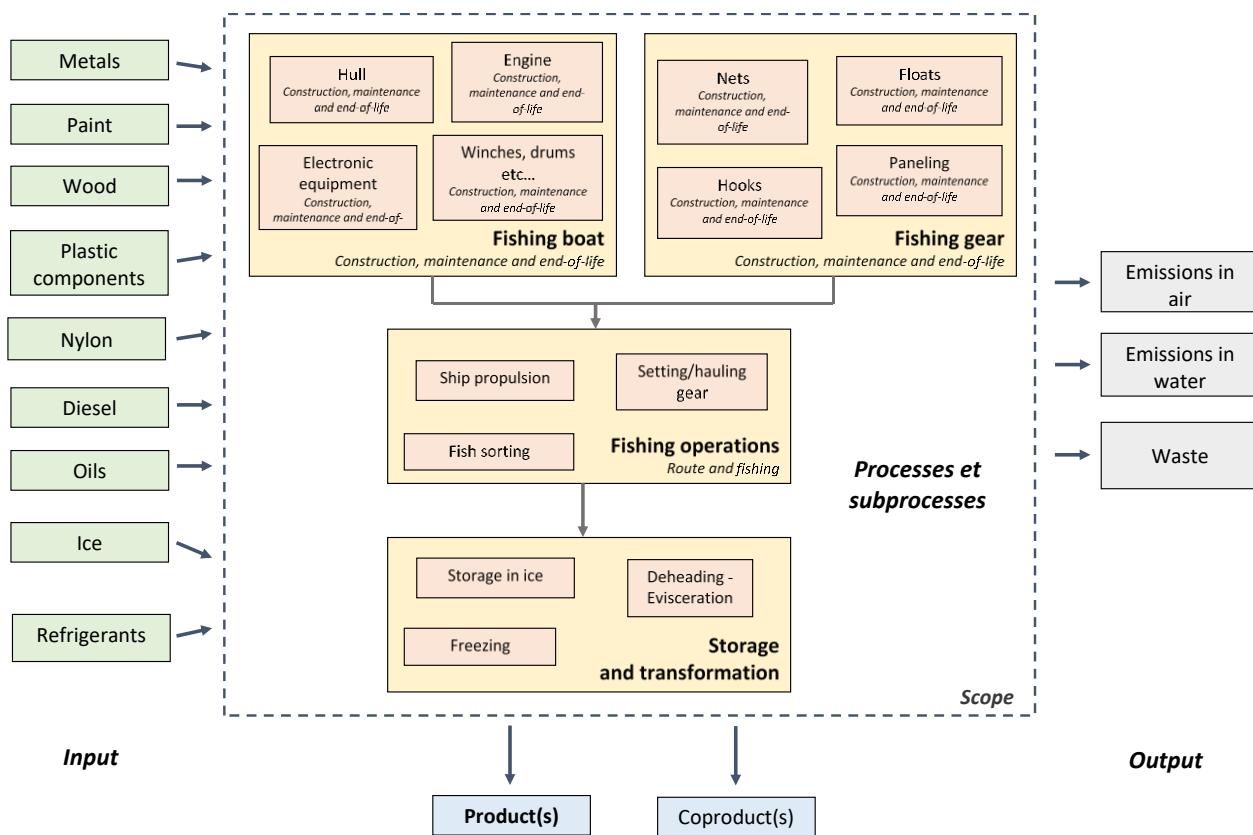


Figure 10: Subprocesses associated with a boat's fishing activities

The data collected are focused on the consumption of different fluids (e.g., diesel, water, oil), the different quantities of materials used (e.g., steel making up boat, nylon composing nets), and the amounts of waste produced.

The person entering the data can indicate the quality of each piece of data as well as the quality of the entire inventory (see Data quality).

The data entry tool was developed taking into account the project's methodology and its triplet approach (target species—fishing area—fishing gear). Consequently, it was designed to focus on a single target species. The results are therefore expressed in terms of landed tonnes of the target species. It was also

designed to focus on the data for a single boat. That said, it is possible to enter the average values obtained for several boats (see #2—Information).

Once the data have been entered, a VBA function can be run (see VBA script). This function calculates standardised results that are expressed in terms of landed tonnes of the target species. The output appears in the last two spreadsheets of the workbook.

Page-by-page guide

The data entry tool is a workbook composed of 10 spreadsheets. Data are entered in seven of the sheets. The output appears on two other sheets. Finally, one sheet contains a legend for the workbook's colour-coding scheme.

Opening and initialising the workbook

When the workbook is opened, the user receives an initialisation request. Initialisation involves:

- saving the workbook in a format in which macros are enabled
- indicating the métier or triplet (target species—fishing area—fishing gear) for which the user wishes to conduct the LCA
- indicating the allocation type (mass or economic) that the user wishes to use in the LCA

Sometimes it is necessary to activate the content to launch the initialisation process.

#1—User's guide

This spreadsheet provides a colour-coded guide to workbook use (see Colour codes).

#2—Information

First, this spreadsheet allows the user to enter specific pieces of information about the boat from which the data were collected. There is the option to provide information for several boats. The user must also indicate the allocation type (mass or economic). Second, the user can evaluate the overall quality of the inventory based on ILCD standards (see Data quality).

#3—Boat Information for Bureau Mauric

On this spreadsheet, the user enters information on the technical features of the boat in question. These features are the basis for determining the boat's mass balance, a task carried out by Bureau Mauric, a consulting firm, as part of the project.

#4—Boat

This spreadsheet contains the results of the boat's mass balance. It also repeats certain information that appears in spreadsheet #3, namely information related to the painting regime and fire suppression system.

#5—Description of the fishing season

In this spreadsheet, the user describes the boat's fishing season (e.g., métier[s] practiced, fishing areas visited, number of fishing trips). The goal is to identify, over the year, the number of months, weeks, fishing trips, and days dedicated to the métier of interest. This information makes it possible to calculate annual rates of consumption.

#6—Fishing activities

The first table on this spreadsheet repeats the description of the fishing season provided in spreadsheet #5. The second table allows the user to inventory all the types of the consumption/production (diesel, motor oil, water, waste, etc.) related to the boat's operation. If applicable, information about bait amounts can be entered in the third table. Finally, the fourth table compiles information related to production, namely the tonnage and value of each of the products landed during the year.

#7—Fishing gear

The first table on this spreadsheet allows the user to enter information about the mass balance, maintenance, and life span of each key component of the setting/hauling gear (e.g., winches, reels, net hauler) used in the métier of interest. In the project, this component of the mass balance was accounted for in the boat's overall mass balance. In the second table, the user can similarly enter information about the mass balance, maintenance history, and life span of each piece of gear used in the métier of interest.

#8—Preservation and transformation

The first table in this spreadsheet allows the user to enter information about the mass balance, maintenance, and life span of each piece of storage equipment used in the métier of interest (e.g., ice maker, freezer). The second table contains information about the packaging units in which fish are stored (e.g., fish boxes, isothermal containers, trays). The user can create the mass balance for each unit and also enter unit life span, the number of units used, and the amount of packaging ultimately consumed (e.g., plastic film, cardboard). In the third table, information can be entered regarding the amount of packaging used for each frozen packaging unit. Finally, the last table focuses on initial product transformation (e.g., evisceration, deheading). An estimate can thus be obtained of the amount of waste generated from differently transformed products (e.g., whole, eviscerated).

#9—Reference flows per process

This spreadsheet is a compilation of the results expressed in annual terms, which have been allocated to processes (e.g., boat, gear) using the VBA script. The results are also expressed in terms of landed tonnes of product. The spreadsheet only appears once the user launches the VBA script.

#10—Aggregated reference flows

This spreadsheet is a compilation of the results expressed in annual terms, which have been allocated in an aggregated manner using the VBA script. For example, the steel that was used to create the boat and the gear is aggregated into a single flow: "steel". The results are also expressed in terms of landed tonnes of product. The spreadsheet only appears once the user launches the VBA script.

VBA script

Several VBA modules are included in the data entry tool. They can be accessed via the "Developer" tab and the "Visual Basic" box. In addition to managing workbook initialisation and formatting, the main function of these modules is to carry out a preliminary analysis of the data.

This preliminary analysis involves several steps. First, all the consumption data that have been entered are expressed in annual terms. For example, diesel consumption per fishing trip is converted into diesel consumption per year using the information entered in the table focused on the fishing season. Second, the consumption data are allocated as necessary. If the user wishes to allocate a datum, an interface opens up. It asks the user to select the different products, in addition to the main product, to which the datum should be allocated. The user can choose between mass or economic allocation on spreadsheet #2. Third, all the consumption data (now expressed in annual terms and allocated) are divided by the amount of main product that is landed per year. The final output is the annual, allocated flow that is expressed per tonne of landed product.

The macro can be run using the "Perform preliminary analysis" button, which is located under the "Home" tab and "Preliminary data analysis" option. Another approach is to run the "Launch annualization" macro, which can be found under the "Developer" tag and the "Macro" button. Once the preliminary analysis has been run, the results appear in spreadsheets #9 and #10.

Data allocation

When the workbook has been initialised, the user is asked to indicate the desired form of allocation: mass or economic.

For each datum or process entered, the user can indicate if allocations should be directed towards products other than the main product. If the option "Yes" is chosen in the "Allocation" box, an interface will open up when the preliminary analysis is triggered. The user can then choose the products towards which data or processes are allocated.

The data or processes in question are as follows:

- the "Boat" process in spreadsheet #4
- consumption of fluids during fishing operations (e.g., diesel, oil, water) in spreadsheet #6
- the processes associated with the different setting/hauling gear in spreadsheet #7
- the processes associated with the different fishing gear in spreadsheet #7
- the processes associated with the different fish preservation equipment in spreadsheet #8
- the processes associated with the different packaging units in spreadsheet #8

Data quality

The data entry tool makes it possible to evaluate data quality at two different levels.

First, the quality of individual data can be evaluated (e.g., diesel consumption, quantity of steel used). In accordance with the standards established by the AGRIBALYSE® programme, the ecoinvent® pedigree matrix approach was used [11]. In this approach, data are assigned to a score category (Table 8), which are ranked from greater to lesser quality (i.e., from publicly available statistics to estimates). Each data type corresponds to a combination of scores forming a matrix, the pedigree matrix. Each score (values range from 1 to 5) reflects a criterion of quality. There are six such criteria: reliability, completeness, temporal representativeness, geographical representativeness, technological representativeness, and sample size.

Data type	Base uncertainty	Pedigree matrix	Quality score
Publicly accessible and well-documented statistic	1.05	{1, 1, 1, 1, 1, na}	1.050
Statistic subject to restricted access	1.05	{2, 3, 2, 2, 2, na}	1.108
Well-documented example case	1.05	{1, 2, 1, 1, 1, na}	1.054
Poorly documented example case	1.05	{2, 3, 2, 3, 2, na}	1.109
Expert opinion	1.05	{3, 3, 2, 1, 2, na}	1.140
Individual case or assessment	1.05	{4, 4, 2, 1, 2, na}	1.245

Table 8: Quality scores for different data types [4]

Using base uncertainty and the appropriate pedigree matrix, a quality score is calculated for each data type. This score indicates the variability associated with a given datum. As data quality declines, the value of this indicator increases.

Second, data quality can be evaluated at the level of the overall inventory. In accordance with ILCD standards, there are six criteria that are evaluated on a scale of 1 ("very good") to 5 ("insufficient" or "unknown"). When a criterion cannot be evaluated, a score of 0 ("not applicable") is assigned. The overall score is calculated in accordance with ILCD specifications. An inventory is considered to be of "high quality" if its score is less than or equal to 1.6, of "basic quality" if its score is between 1.6 and 3 (inclusive), and of "estimate" quality if its score is greater than 3.

To ensure that the evaluation process was consistent, each criterion from the AGRIBALYSE® methodological report and the ILCD specifications was adapted to reflect the specificities intrinsic to fisheries (see § 1.6.2).

Miscellaneous

Colour codes

The following colour-coding system was used to facilitate data entry.

Type of case	Colour code	Examples - Comments
Non-modifiable question/unit		The fuel consumption question is non-modifiable. The length of the boat (in meters) is a non-modifiable unit.
Question/unit can be modified by the user		Since the type and number of materials making up the gear may vary, this question can be modified by the user. One or more materials can be added. Fuel consumption can be expressed per fishing trip, week, or year: this unit can therefore be modified by the user.
Data entered by the user	Yellow	Most of the information is to be provided by the user. In some cases, the format is multiple choice.
Calculated datum	Pink	Certain values are calculated based on responses to earlier questions.
Cell to be left empty	Grey	

This colour-coding system is described in spreadsheet #1 of the workbook.

Life span

Life span data are very important in life cycle analyses. For this reason, the user is required to enter data on life spans, even if only estimates are available.

Minimum—maximum

If the user has access to minima and maxima for the data, it is possible to enter this information in the workbook.

Line modification

If a user needs to add, delete, or modify a line, the following procedure can be employed:

- In the Excel workbook—
 - o Modify the line concerned in the tab of interest (e.g., boat)
 - o Trigger the appearance of the output spreadsheets by running the preliminary analysis
 - o Modify the lines in question in the output spreadsheets (#9 and #10)
- In the VBA script—
 - o In the "Cell name" module, modify all the cell references changed following the addition:
 - in the modified input spreadsheet
 - in the output spreadsheets
 - o In the "Flow annualization" module, rectify the cell references as follows:
 - in the macro associated with the modified spreadsheet
 - in the "Aggregation" macro at the end of the module

References cited

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Annex 4: Process selection and creation, methodological choices, and data sources

This annex contains descriptions of all the processes used to construct the inventories in SimaPro®. Most of the processes came out of the ecoinvent® v. 3 database. Others, however, were created based on scientific publications, documented example cases, or expert opinion (in bold in the tables).

The description of the processes starts with the most general process (average process for a given fishery product) and then branches off into more specific processes (e.g., process for modelling the polyethylene used to build a storage container).

Mean inventory for a given product

The subprocesses used to construct the average inventory for a given product, ABC, are described below (Table 9).

Process Name	Species, fishing area, gear, average, at landing/FR U		
Source	Average activity weighted by X boats surveyed for this fishery		
Functional unit	X tonnes of landed product		
Inventory quality	Variable depending on the fishery		
Additional comments	In italics: processes used if necessary In bold: processes created (see below)		
Inputs	Waste treatment	Direct emissions	Comments
Water	<i>Water, well, in ground, FR</i>		Water is not treated
Boat	Average boat ABC/FR U		Treatment accounted for in the process created (see below)
Diesel	Diesel combustion in marine engines/FR U		Treatment accounted for in the process created (see below)
Motor oil	Lubricating oil {RER} production Alloc Rec, S	Waste mineral oil {Europe without Switzerland} market for waste mineral oil Alloc Rec, S	No distinction made between motor oil and hydraulic oil
Hydraulic oil	Lubricating oil {RER} production Alloc Rec, S	Waste mineral oil {Europe without Switzerland} market for waste mineral oil Alloc Rec, S	No distinction made between motor oil and hydraulic oil
Refrigerant	<i>Refrigerant R134a {RER} production Alloc Rec, S</i>	<i>Used refrigerant R134a {GLO} market for Alloc Rec, S</i>	
Bait	Sardine bait, for long lining/FR U		Treatment accounted for in the process created (see below)
Skiff	Skiff for tuna fishing/FR U		Treatment accounted for in the process created (see below)
Gear	Dredge frame, BS Brieuc/FR U Pelagic trawl, 114 m/FR U Etc.		Several different gear types; treatment accounted for in the process created (see below)
Ice maker	Ice-making machine, 4 tonnes/day, for fishing ship/FR U		Treatment accounted for in the process created (see below)
Compressor	Refrigerant compressor, for fishing ship/FR U		Treatment accounted for in the process created (see below)
Flash freezer	Freezing oven, 12 tonnes/day, for fishing ship/FR U		Treatment accounted for in the process created (see below)
Isothermal tub	Isothermal box for fish storage, 300 L/FR U Etc.		Several sizes of isothermal tubs; treatment accounted for in the process created (see below)
Fish box	Fish box, volume 20 L, capacity 15 kg/FR U		Several different box types; treatment accounted for in the process created (see below)

<i>Storage sac</i>	Great Scallop storage bag, BS Brieuc/FR U			Treatment accounted for in the process created (see below)
<i>Plastic film</i>	Packaging film, low density polyethylene {RER} production Alloc Rec, S	Waste polyethylene {Europe—Switzerland excluded} market for waste polyethylene Alloc Rec, S		
<i>Waste produced</i>		Waste plastic, mixture {Europe—Switzerland excluded} market for waste plastic Alloc Rec, S		Waste products incorporated in various plastics

Table 9: Subprocesses used to build the average process for a given fishery

Average boat

The subprocesses used to build an average boat used to harvest fishery product ABC are described below (Table 10).

Process Name	Average boat ABC/FR U			
Source	Average boat determined by weighting the X boats surveyed for this fishery			
Functional unit	Component use over a year			
Inventory quality	2.3 (basic quality)			
Additional comments	In bold: processes created (see below)			
Inputs		Waste treatment	Direct emissions	Comments
Steel	Steel, low-alloyed, hot rolled {RER} production Alloc Def, S	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, U		
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, U		
Aluminium	Aluminium, wrought alloy {GLO} aluminium ingot, primary, to market Alloc Rec, S	Aluminium (waste treatment) {GLO} recycling of aluminium Alloc Rec, U		
Composite	Glass fibre reinforced plastic, polyester resin, hand lay-up {RER} production Alloc Rec, S	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, U		
Wood	Cleft timber, measured as dry mass {RoW} hardwood forestry, oak, sustainable forest management Alloc Rec, S		Carbon dioxide, biogenic & Correction flow for delayed emission of biogenic carbon dioxide	Emission of fixed carbon + correction for life span (ILCD standards)
Exotic wood (deck)	Roundwood, azobe from sustainable forest management, under bark {RoW} hardwood forestry, azobe, sustainable forest management Alloc Rec, S		Carbon dioxide, biogenic & Correction flow for delayed emission of biogenic carbon dioxide	Emission of fixed carbon + correction for life span (ILCD standards); unit changed from m ³ to kg using the density conversion of 1000 kg/m ³
Concrete	Concrete, normal {RoW} market for Alloc Rec, S	Waste concrete {Europe without Switzerland} market for waste concrete Alloc Rec, U		Unit changed from m ³ to kg via the density conversion of 2400 kg/m ³
Epoxy/plywood	Plywood, for outdoor use {RER} production Alloc Rec, S		Carbon dioxide, biogenic & Correction flow for delayed emission of biogenic carbon dioxide	Emission of fixed carbon + correction for life span (ILCD standards); unit changed from m ³ to kg using the density conversion of 600 kg/m ³

Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S		
Insulation	Rock wool {GLO} market for Alloc Rec, U	Waste mineral wool {Europe without Switzerland} market for waste mineral wool Alloc Rec, S		See methodological choices concerning different proportions of each insulation type
	Glass wool mat {RoW} production Alloc Rec, S			
Life rafts	Synthetic rubber {RER} production Alloc Rec, S	Waste rubber, unspecified {Europe without Switzerland} market for waste rubber, unspecified Alloc Rec, S		
Electrical panels and transformers	Electronics, for control units {RER} production Alloc Rec, S	Electronics scrap from control units {RER} treatment of Alloc Rec, S		
Electronic navigation equipment	Electronics, for control units {RER} production Alloc Rec, S	Electronics scrap from control units {RER} treatment of Alloc Rec, S		
Anodes	Zinc anode for fishing ship/FR U			Treatment accounted for in the process created (see below)
Electrical cables	Cable, unspecified {GLO} production Alloc Rec, S	Used cable {GLO} treatment of Alloc Rec, S		
Batteries	Lead acid battery/FR U			Treatment accounted for in the process created (see below)
Heat motor	Heat engine for fishing ship/FR U			Treatment accounted for in the process created (see below)
Electric motor	Electric motor for fishing ship/FR U			Treatment accounted for in the process created (see below)
Pump	Pump, 40W {RoW} production Alloc Rec, U Edited			Treatment accounted for in the process created (see below)
Propellers	Bronze {RoW} production Alloc Rec, S	95% - Copper in car shredder residue {GLO} market for Alloc Rec, S		See methodological choices concerning different proportions in the bronze
		5% - Scrap tin sheet {GLO} market for Alloc Rec, S		
CO2	Carbon dioxide, liquid {RER} market for Alloc Rec, S		Carbon dioxide	Carbon dioxide released into air
Powder	Zeolite, powder {RER} production Alloc Rec, S	Waste zeolite {RoW} treatment of, inert material landfill Alloc Rec, S		
Water additive	Water, deionised, from tap water, at user {Europe without Switzerland} water production, deionised, from tap water, at user Alloc Rec, S			Water additive is not treated; see methodological choices for different proportions
	Foaming agent {GLO} production Alloc Rec, S			

Table 10: Subprocesses used to build an average boat for a given fishery

Fishing gear

The following tables describe the subprocesses defined for the construction of the gear used in the different fisheries.

Process Name	Seine, 350-70 m/FR U
Source	Interviews with fishers

Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine used to catch European pilchard in the Bay of Biscay						
Inputs							
		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	1600	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Polyester resin, unsaturated {RER} production Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	700	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}
Outputs							
		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	1600	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	700	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}

Table 11: Subprocesses used to construct a 350-m seine

Process Name	Seine, 400-80 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine used to catch European pilchard in the Bay of Biscay						
Inputs							
		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	2300	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Polyester resin, unsaturated {RER} production Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	800	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	250	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}
Outputs							
		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	2300	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	800	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	250	kg			1.14	{3,3,2,1,2,na}

Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}
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Table 12: Subprocesses used to construct a 400-m seine

Process Name	Bottompair trawl, 75 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Bottompair trawl, 75 m of headline, used by trawlers in the North Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Polyethylene, high density, granulate {RER} production Alloc Rec, S	5500	kg			1.14	{3,3,2,1,2,na}
FLOATS	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	380	kg			1.14	{3,3,2,1,2,na}
Puddening	Synthetic rubber {RER} production Alloc Rec, S	3800	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	9893	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	5500	kg			1.14	{3,3,2,1,2,na}
FLOATS	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	380	kg			1.14	{3,3,2,1,2,na}
Puddening	Waste rubber, unspecified {Europe without Switzerland} market for waste rubber, unspecified Alloc Rec, S	3800	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	9893	kg			1.14	{3,3,2,1,2,na}

Table 13: Subprocesses used to construct a 75-m twin trawling system

Process Name	Twin bottom trawl, 22 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Twin bottom trawling system, 22 m of headline, used by trawlers in the Celtic Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Polyethylene, high density, granulate {RER} production Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}
FLOATS	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	40	kg			1.14	{3,3,2,1,2,na}
Puddening	Synthetic rubber {RER} production Alloc Rec, S	1200	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	3568	kg			1.14	{3,3,2,1,2,na}
Paneling	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	1300	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	300	kg			1.14	{3,3,2,1,2,na}
FLOATS	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	40	kg			1.14	{3,3,2,1,2,na}

Puddening	Waste rubber, unspecified {Europe without Switzerland} market for waste rubber, unspecified Alloc Rec, S	1200	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	3568	kg			1.14	{3,3,2,1,2,na}
Paneling	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	1300	kg			1.14	{3,3,2,1,2,na}

Table 14: Subprocesses used to construct a 22-m twin trawling system

Process Name	Twin bottom trawl, 32 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Twin bottom trawling system, 32 m of headline, used by trawlers in the Celtic Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Polyethylene, high density, granulate {RER} production Alloc Rec, S	450	kg			1.14	{3,3,2,1,2,na}
FLOATS	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	320	kg			1.14	{3,3,2,1,2,na}
Puddening	Synthetic rubber {RER} production Alloc Rec, S	2000	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	5091	kg			1.14	{3,3,2,1,2,na}
Paneling	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	1800	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	450	kg			1.14	{3,3,2,1,2,na}
FLOATS	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	320	kg			1.14	{3,3,2,1,2,na}
Puddening	Waste rubber, unspecified {Europe without Switzerland} market for waste rubber, unspecified Alloc Rec, S	2000	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	5091	kg			1.14	{3,3,2,1,2,na}
Paneling	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	1800	kg			1.14	{3,3,2,1,2,na}

Table 15: Subprocesses used to construct a 32-m twin trawling system

Process Name	Regular bottom trawl, 63 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Simple trawler, 63 m of headline						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Polyethylene, high density, granulate {RER} production Alloc Rec, S	5000	kg			1.14	{3,3,2,1,2,na}
FLOATS	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	350	kg			1.14	{3,3,2,1,2,na}
Puddening	Synthetic rubber {RER} production Alloc Rec, S	3500	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	5934	kg			1.14	{3,3,2,1,2,na}

Paneling	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	5000	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Trawler and cordage	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	5000	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	350	kg			1.14	{3,3,2,1,2,na}
Puddening	Waste rubber, unspecified {Europe without Switzerland} market for waste rubber, unspecified Alloc Rec, S	3500	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	5934	kg			1.14	{3,3,2,1,2,na}
Paneling	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	5000	kg			1.14	{3,3,2,1,2,na}

Table 16: Subprocesses used to construct a 63-m simple bottom trawl

Process Name	Pelagic trawl, 114 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Pelagic trawl 114 m long used to catch albacore tuna						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	550	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	1500	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Chromium steel pipe {GLO} production Alloc Rec, S	100	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	912	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	550	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	1500	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	100	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	912	kg			1.14	{3,3,2,1,2,na}

Table 17: Subprocesses used to construct a 114-m pelagic trawl

Process Name	Pelagic trawl, 133 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	133-m pelagic trawl is used to catch albacore tuna						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix

Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	650	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	2200	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Chromium steel pipe {GLO} production Alloc Rec, S	130	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	984	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	650	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	2200	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	130	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	984	kg			1.14	{3,3,2,1,2,na}

Table 18: Subprocesses used to construct a 133-m pelagic trawl

Process Name	Pelagic trawl, 151 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	151-m pelagic trawl used to catch albacore tuna						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	700	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	2500	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Chromium steel pipe {GLO} production Alloc Rec, S	150	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	984	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	700	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	11.2	kg			1.14	{3,3,2,1,2,na}
Lead ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	2500	kg			1.14	{3,3,2,1,2,na}
Stainless steel ballast	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	150	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	984	kg			1.14	{3,3,2,1,2,na}

Table 19: Subprocesses used to construct a 151-m pelagic trawl

Process Name	Dredge frame, BS Brieuc/FR U
Source	Foundry manufactures dredges in Côtes-d'Armor (Forge Marine Du Cap [Erquy])
Functional unit	One piece of gear

Inventory quality	2.3						
Additional comments	Frame of shellfish dredge is 2 m long						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel, low-alloyed, hot rolled {RER} production Alloc Def, S	200	kg	100	250		{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	200	kg	100	250		{3,3,2,1,2,na}

Table 20: Subprocesses used to construct the frame of a 2-m shellfish dredge

Process Name	Dredge teeth, BS Brieuc/FR U						
Source	Foundry manufactures dredges in Côtes-d'Armor (Forge Marine Du Cap [Erquy])						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Cutting bars on 2-m shellfish dredge						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel, low-alloyed, hot rolled {RER} production Alloc Def, S	20	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	20	kg			1.14	{3,3,2,1,2,na}

Table 21: Subprocesses used to construct the cutting bars of a 2-m shellfish dredge

Process Name	Dredge rings, BS Brieuc/FR U						
Source	Foundry manufactures dredges in Côtes-d'Armor (Forge Marine Du Cap [Erquy])						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Rings on a 2-m shellfish dredge						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel, low-alloyed, hot rolled {RER} production Alloc Def, S	120	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	120	kg			1.14	{3,3,2,1,2,na}

Table 22: Subprocesses used to construct the rings of a 2-m shellfish dredge

Process Name	Trammel net, 50 m-100 mm/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Trammel net used by gillnetters in the Bay of Biscay						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix

Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	1.5	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Polypropylene, granulate {RER} production Alloc Rec, S	2.2	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, S	7	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	1.5	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Waste polyethylene/polypropylene product {Europe without Switzerland} treatment of waste polyethylene/polypropylene product, collection for final disposal Alloc Rec, S	2.2	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	7	kg			1.14	{3,3,2,1,2,na}

Table 23: Subprocesses used to construct a 50-m trammel net with 100-mm netting

Process Name	Trammel net, 50 m-120 mm/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Trammel net used by gillnetters in the Bay of Biscay						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	1.2	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Polypropylene, granulate {RER} production Alloc Rec, S	2.2	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, S	7	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	1.2	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Waste polyethylene/polypropylene product {Europe without Switzerland} treatment of waste polyethylene/polypropylene product, collection for final disposal Alloc Rec, S	2.2	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	7	kg			1.14	{3,3,2,1,2,na}

Table 24: Subprocesses used to construct a 50-m trammel net with 120-mm netting

Process Name	Trammel net, 100m-100mm/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Trammel net used by gillnetters in the Bay of Biscay						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	3	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Polypropylene, granulate {RER} production Alloc Rec, S	4.5	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, S	14	kg			1.14	{3,3,2,1,2,na}

Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	3	kg			1.14	{3,3,2,1,2,na}
Floating cordage	Waste polyethylene/polypropylene product {Europe without Switzerland} treatment of waste polyethylene/polypropylene product, collection for final disposal Alloc Rec, S	4.5	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	14	kg			1.14	{3,3,2,1,2,na}

Table 25: Subprocesses used to construct a 100-m trammel net with 100-mm netting

Process Name	Hook for long lining/FR U						
Source	FAO website						
Functional unit	One piece of gear						
Inventory quality	3						
Additional comments	Hook and line for longline fishing in the Mediterranean Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Float (one float for seven hooks)	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	1.14	kg			1.054	{1,2,1,1,1,na}
Ballast (one ballast for seven hooks)	Lead {GLO} primary lead production from concentrate Alloc Rec, S	143	g			1.054	{1,2,1,1,1,na}
Intermediary buoy rope (one for seven hooks)	Polyethylene, high density, granulate {RER} production Alloc Rec, S	54.9	g			1.054	{1,2,1,1,1,na}
Mainline	Nylon 6-6 {RER} production Alloc Rec, S	330	g			1.054	{1,2,1,1,1,na}
Intermediary rope	Nylon 6-6 {RER} production Alloc Rec, S	8.8	g			1.054	{1,2,1,1,1,na}
Secondary line	Polyethylene, high density, granulate {RER} production Alloc Rec, S	156	g			1.054	{1,2,1,1,1,na}
Gangion	Nylon 6-6 {RER} production Alloc Rec, S	4.4	g			1.054	{1,2,1,1,1,na}
Longline clip	Chromium steel pipe {GLO} production Alloc Rec, S	100	g			1.054	{1,2,1,1,1,na}
Hook	Chromium steel pipe {GLO} production Alloc Rec, S	10	g			1.054	{1,2,1,1,1,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Float (one float for seven hooks)	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	1.14	kg			1.054	{1,2,1,1,1,na}
Ballast (one ballast for seven hooks)	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	143	g			1.054	{1,2,1,1,1,na}
Intermediary buoy rope (one for seven hooks)	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	54.9	g			1.054	{1,2,1,1,1,na}
Mainline	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	330	g			1.054	{1,2,1,1,1,na}
Intermediary rope	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	8.8	g			1.054	{1,2,1,1,1,na}
Secondary line	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	156	g			1.054	{1,2,1,1,1,na}
Gangion	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	4.4	g			1.054	{1,2,1,1,1,na}
Longline clip	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	100	g			1.054	{1,2,1,1,1,na}

Hook	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	10	g			1.054	{1,2,1,1,1,na}
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Table 26: Subprocesses used to construct a hook and line

Process Name	Seine, 1500-190 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine for capturing Atlantic bluefin tuna in the Mediterranean Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	15	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	4	ton			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	2	ton			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	4	ton			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	15	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	4	ton			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	2	ton			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	4	ton			1.14	{3,3,2,1,2,na}

Table 27: Subprocesses used to construct a 1500-m seine

Process Name	Seine, 1850-200 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine for capturing Atlantic bluefin tuna in the Mediterranean Sea						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	18	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	5	ton			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	2.5	ton			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	5.5	ton			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	18	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	5	ton			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	2.5	ton			1.14	{3,3,2,1,2,na}

Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	5.5	ton			1.14	{3,3,2,1,2,na}
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Table 28: Subprocesses used to construct a 1850-m seine

Process Name	Seine, 1600-220 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine for capturing tropical tuna species						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	58	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	11	ton			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	5	ton			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	18	ton			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	58	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	11	ton			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	5	ton			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	18	ton			1.14	{3,3,2,1,2,na}

Table 29: Subprocesses used to construct a 1600-m seine

Process Name	Seine, 1800-250 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine for capturing tropical tuna species						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RER} production Alloc Rec, S	70	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	15	ton			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RER} production Alloc Rec, S	9	ton			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S	20	ton			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	70	ton			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	15	ton			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {Europe without Switzerland} market for waste plastic, mixture Alloc Rec, S	9	ton			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	20	ton			1.14	{3,3,2,1,2,na}

Table 30: Subprocesses used to construct a 1800-m seine

Process Name	Seine, 600-60 m/FR U						
Source	Interviews with fishers						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	Seine for catching small pelagic species in Morocco						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Nylon 6-6 {RoW} production Alloc Rec, S	3600	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Polyester resin, unsaturated {RoW} production Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead {GLO} primary lead production from concentrate Alloc Rec, U	1200	kg			1.14	{3,3,2,1,2,na}
Floats	Ethylene vinyl acetate copolymer {RoW} production Alloc Rec, S	400	kg			1.14	{3,3,2,1,2,na}
Cables	Steel, low-alloyed, hot rolled {RoW} production Alloc Rec, S	850	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Nylon net	Waste plastic, mixture {RoW} market for waste plastic, mixture Alloc Rec, S	3600	kg			1.14	{3,3,2,1,2,na}
Polyester cordage	Waste plastic, mixture {RoW} market for waste plastic, mixture Alloc Rec, S	200	kg			1.14	{3,3,2,1,2,na}
Ballast	Lead in car shredder residue {RoW} treatment of, municipal incineration Alloc Rec, S	1200	kg			1.14	{3,3,2,1,2,na}
Floats	Waste plastic, mixture {RoW} market for waste plastic, mixture Alloc Rec, S	400	kg			1.14	{3,3,2,1,2,na}
Cables	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	850	kg			1.14	{3,3,2,1,2,na}

Table 31: Subprocesses used to construct a 600-m seine

Secondary processes

The tables below describe the subprocesses associated with various secondary processes (e.g., storage containers, heat motor, ice maker).

Process Name	Zinc anode for fishing boat/FR U						
Source	MME Group (http://www.mme-group.com/fileadmin/user_upload/Documenten/Downloads/EN/MME-Group-Anode-Booklet.pdf).						
Functional unit	One kilogram						
Inventory quality	2.4						
Additional comments	No process available for treating cadmium						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Zinc	Zinc {RoW} primary production from concentrate Alloc Rec, S	0.6525	kg	0.43	0.875		{1,2,1,1,1,na}
Aluminium	Aluminium, wrought alloy {GLO} aluminium ingot, primary, to market Alloc Rec, S	0.3	kg	0.1	0.5		{1,2,1,1,1,na}
Cadmium	Cadmium {RoW} cadmium production, primary Alloc Rec, S	0.0475	kg	0.025	0.07		{1,2,1,1,1,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Zinc	Zinc in car shredder residue {RoW} market for zinc in car shredder residue Alloc Rec, S	0.6525	kg	0.43	0.875		{1,2,1,1,1,na}

Aluminium	Aluminium (waste treatment) {GLO} recycling of aluminium Alloc Rec, S	0.3	kg	0.1	0.5		{1,2,1,1,1,na}
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Table 32: Subprocesses used to construct a zinc anode

Process Name	European pilchard bait, for long lining/FR U						
Source	Expert opinion of a fish trader in Sète						
Functional unit	One kilogram						
Inventory quality	2.5						
Additional comments	Hypothesis based on the expert opinion of the fish trader: half of the landed European pilchard comes from the Mediterranean Sea (fresh, no transport, polystyrene container), proxy used: "European pilchard from the Bay of Biscay"; the other half comes from the Atlantic Ocean (Morocco) (frozen, around 1000 km of transport in refrigerated convoy, packaged in cardboard). Also according to the fish trader, the packaging accounts for 1/10th of the total mass.						
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Fresh European pilchard from the Mediterranean Sea	0.45	kg			1.14	{3,3,2,1,2,na}	
Polystyrene container	0.05	kg			1.14	{3,3,2,1,2,na}	
Frozen European pilchard from the Atlantic Ocean	0.45	kg			1.14	{3,3,2,1,2,na}	
Cardboard packaging	0.05	kg			1.14	{3,3,2,1,2,na}	
Refrigerated transport	450	kg/km			1.14	{3,3,2,1,2,na}	
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polystyrene	0.05	kg			1.14	{3,3,2,1,2,na}	
Cardboard	0.05	kg			1.14	{3,3,2,1,2,na}	

Table 33: Subprocesses used in the process associated with longline bait (for European pilchard)

Process Name	Isothermal box for fish storage, 300 L/FR U						
Source	Technical specialist at S2M						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	The foam insulation represents 25% of the total mass						
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Insulating polyurethane foam	8.75	kg			1.14	{3,3,2,1,2,na}	
Polyethylene	26.25	kg			1.14	{3,3,2,1,2,na}	
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	

Insulating polyurethane foam	Waste polyurethane foam {RoW} market for waste polyurethane foam Alloc Rec, S	8.75	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	26.25	kg			1.14	{3,3,2,1,2,na}

Table 34: Subprocesses used to construct a 300-L isothermal tub

Process Name	Isothermal tub for fish storage, 1000 L/FR U						
Source	Technical specialist at S2M						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	The foam insulation represents 25% of the total mass						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Polyurethane, rigid foam {RER} production Alloc Def, U	27.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	82.5	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Waste polyurethane foam {RoW} market for waste polyurethane foam Alloc Rec, S	27.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	82.5	kg			1.14	{3,3,2,1,2,na}

Table 35: Subprocesses used to construct a 1000-L isothermal tub

Process Name	Isothermal box for fish storage, 1200 L/FR U						
Source	Technical specialist at S2M						
Functional unit	One piece of gear						
Inventory quality	2.3						
Additional comments	The foam insulation represents 25% of the total mass						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Polyurethane, rigid foam {RER} production Alloc Def, U	32.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	97.5	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Waste polyurethane foam {RoW} market for waste polyurethane foam Alloc Rec, S	32.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	97.5	kg			1.14	{3,3,2,1,2,na}

Table 36: Subprocesses used to construct a 1200-L isothermal tub

Process Name	Isothermal tub for fish storage, 1400 L/FR U
Source	Technical specialist at S2M
Functional unit	One piece of gear

Inventory quality	2.3						
Additional comments	The foam insulation represents 25% of the total mass						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Polyurethane, rigid foam {RER} production Alloc Def, U	37.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	112.5	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Waste polyurethane foam {RoW} market for waste polyurethane foam Alloc Rec, S	37.5	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	112.5	kg			1.14	{3,3,2,1,2,na}

Table 37: Subprocesses used to construct a 1400-L isothermal tub

Process Name	Isothermal tub for fish storage, 2000 L/FR U						
Source	Technical specialist at S2M						
Functional unit	One component						
Inventory quality	2.3						
Additional comments	The foam insulation represents 25% of the total mass						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Polyurethane, rigid foam {RER} production Alloc Def, U	53.75	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	161.25	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Insulating polyurethane foam	Waste polyurethane foam {RoW} market for waste polyurethane foam Alloc Rec, S	53.75	kg			1.14	{3,3,2,1,2,na}
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	161.25	kg			1.14	{3,3,2,1,2,na}

Table 38: Subprocesses used to construct a 2000-L isothermal tub

Process Name	Lead acid battery/FR U						
Source	Permrudee <i>et al.</i> (2013) - Life cycle assessment of lead acid battery. Case study for Thailand.						
Functional unit	4.70 kilograms						
Inventory quality	3.4						
Additional comments	Datum used comes from car battery. The treatment process of the battery is inspired from an ecoinvent process. Its subprocesses were modified from "Default" to "Recycled content" to fit project requirements.						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
PbSb 2.5%	Antimony {RoW} production Alloc Rec, S	0.092925	g			1.054	{1,2,1,1,1,na}
	Lead {GLO} primary lead production from concentrate Alloc Rec, S	3.624075	g			1.054	{1,2,1,1,1,na}
Pure lead	Lead {GLO} primary lead production from concentrate Alloc Rec, S	6.317	g			1.054	{1,2,1,1,1,na}
Acid	Sulfuric acid {RER} production Alloc Rec, S	804	g			1.054	{1,2,1,1,1,na}

Deionised water	Water, deionised, from tap water, at user {Europe without Switzerland} water production, deionised, from tap water, at user Alloc Rec, S	862.35	g			1.054	{1,2,1,1,1,na}
Other chemical products	Chemical, organic {GLO} production Alloc Rec, S	51	g			1.054	{1,2,1,1,1,na}
Insulation	Glass wool mat {RoW} production Alloc Rec, S	375	g			1.054	{1,2,1,1,1,na}
PbSb 3.2%	Antimony {RoW} production Alloc Rec, S	35.616	g			1.054	{1,2,1,1,1,na}
	Lead {GLO} primary lead production from concentrate Alloc Rec, S	1077.384	g			1.054	{1,2,1,1,1,na}
	Polypropylene, granulate {RER} production Alloc Rec, S	1043	g			1.054	{1,2,1,1,1,na}
Acid 50%	Sulfuric acid {RER} production Alloc Rec, S	1.865	g			1.054	{1,2,1,1,1,na}
Paper pulp	Sulfate pulp {RER} production, unbleached Alloc Rec, S	63	g			1.054	{1,2,1,1,1,na}
Plastic film	Ethylvinylacetate, foil {RER} production Alloc Rec, S	2	g			1.054	{1,2,1,1,1,na}
Cardboard	Carton board box production, with offset printing {RoW} carton board box production service, with offset printing Alloc Rec, S	336	g			1.054	{1,2,1,1,1,na}
Iron longline clip	Cast iron {RER} production Alloc Rec, S	35	g			1.054	{1,2,1,1,1,na}
Electricity	Electricity, high voltage {FR} production mix Alloc Rec, S	5.13	kWh			1.054	{1,2,1,1,1,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Battery	Scrap lead acid battery {RER} treatment of, remelting Alloc Def, S	4696.249	g			1.054	{1,2,1,1,1,na}

Table 39: Subprocesses used to construct a battery

Process Name	Satellite buoy, for tuna fishing on FADs/FR U					
Source	Marine Instruments (http://www.marineinstruments.es/tuna-fishing/buoys-m3i-blue/?lang=en).					
Functional unit	One unit					
Inventory quality	2.9					
Additional comments	Hypothesis: 1/3 of total mass is structure, 2/3 is battery					
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Polypropylene	2.3	kg			1.245	{4,4,2,1,2,na}
Battery	4.6	kg			1.245	{4,4,2,1,2,na}
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Polypropylene	2.3	kg			1.245	{4,4,2,1,2,na}
Battery	4.6	kg			1.245	{4,4,2,1,2,na}

Table 40: Subprocesses used to construct a satellite buoy for a fish aggregating device

Process Name	Fish box, volume 20 L, capacity 15 kg/FR U
Source	Technical specialist responsible for the Lorient fish auction
Functional unit	One unit
Inventory quality	1.9
Additional comments	

Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Polyethylene	Polyethylene, high density, granulate {RER} production Alloc Rec, S	1.6	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	1.6	kg			1.14	{3,3,2,1,2,na}

Table 41: Subprocesses used to construct a 20-L storage container

Process Name	Fish box, volume 40 L, capacity 25 kg/FR U						
Source	Technical specialist responsible for the Lorient fish auction						
Functional unit	One unit						
Inventory quality	1.9						
Additional comments							
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polyethylene	2.6	kg			1.14	{3,3,2,1,2,na}	
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polyethylene	2.6	kg			1.14	{3,3,2,1,2,na}	

Table 42: Subprocesses used to construct a 40-L storage container

Process Name	Fish box, volume 60 L, capacity 37 kg/FR U						
Source	Technical specialist responsible for the Lorient fish auction						
Functional unit	One unit						
Inventory quality	1.9						
Additional comments							
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polyethylene	3.8	kg			1.14	{3,3,2,1,2,na}	
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polyethylene	3.8	kg			1.14	{3,3,2,1,2,na}	

Table 43: Subprocesses used to construct a 60-L storage container

Process Name	Fish box, volume 75 L, capacity 50 kg/FR U						
Source	Technical specialist responsible for the Lorient fish auction						
Functional unit	One unit						
Inventory quality	1.9						
Additional comments							
Inputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	
Polyethylene	4.5	kg			1.14	{3,3,2,1,2,na}	
Outputs	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix	

Polyethylene	Waste polyethylene {Europe without Switzerland} market for waste polyethylene Alloc Rec, S	4.5	kg			1.14	{3,3,2,1,2,na}
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Table 44: Subprocesses used to construct a 75-L storage container

Process Name	Diesel combustion in marine engines/FR U	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Source	Anchoveta-SC project (https://anchoveta-sc.wikispaces.com/).						
Functional unit	One kilogram						
Inventory quality	2.6						
Additional comments	Angel Avadi's work on the Anchoveta Project (LCA on the Peruvian anchoveta) and the EMEP/EEA Air Pollutant Emission Inventory Guidebook						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Diesel	Diesel {Europe without Switzerland} market for Alloc Rec, S	1	kg			1.0006	
Emissions released into air		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Arsenic	Arsenic	0.00000004	kg			1.915541	
Benzene, hexachloro-	Benzene, hexachloro-	0.00000008	kg			1.0006	
Cadmium	Cadmium	0.00000001	kg			1.915541	
Carbon dioxide, fossil	Carbon dioxide, fossil	3.17	kg			1.040811	
Carbon monoxide, fossil	Carbon monoxide, fossil	0.0074	kg			1.915541	
Chromium	Chromium	0.00000005	kg			1.915541	
Copper	Copper	0.00000088	kg			1.915541	
Lead	Lead	0.00000013	kg			1.915541	
Mercury	Mercury	0.00000003	kg			1.915541	
Nickel	Nickel	0.000001	kg			1.915541	
Nitrogen oxides	Nitrogen oxides	0.0785	kg			1.040811	
NMVOC	NMVOC, non-methane volatile organic compounds, unspecified origin	0.0028	kg			1.040811	
Particulates, < 2.5 um	Particulates, < 2.5 um	0.0014	kg			1.349859	
Particulates, > 2.5 um and < 10 um	Particulates, > 2.5 um, and < 10um	0.0015	kg			1.040811	
Polychlorinated biphenyls	Polychlorinated biphenyls	0.000038	kg			1.0006	
Selenium	Selenium	0.0000001	kg			1.915541	
Sulfur dioxide	Sulfur dioxide	0.03	kg			1.0006	
Sulfur oxides	Sulfur oxides	0.02	kg			1.0006	
Zinc	Zinc	0.0000012	kg			1.915541	

Table 45: Subprocesses used to model the combustion of diesel in a marine engine

Process Name	Refrigerant compressor, for fishing boat/FR U	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Source	Supplier of compressors for French fishing boats (Johnson Controls)						
Functional unit	One unit						
Inventory quality	2.6						
Additional comments	30 kg—initial charge of refrigerant						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	550	kg			1.14	{3,3,2,1,2,na}

Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	550	kg			1.14	{3,3,2,1,2,na}

Table 46: Subprocesses used to construct a refrigerator compressor

Process Name	Freezing oven, 12 tonnes/day, for fishing boat/FR U						
Source	Expert opinion of boat owner						
Functional unit	One unit						
Inventory quality	2.6						
Additional comments							
Inputs							
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	1500	kg			1.245	{4,4,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	1500	kg			1.245	{4,4,2,1,2,na}

Table 47: Subprocesses used to construct a flash freezer

Process Name	Ice-making machine, 4 tonnes/day, for fishing boat/FR U						
Source	French manufacturer of ice makers, Geneglace (https://aircool.ru/files/tex_info_katalogi/TEXDOC/geneglace/pac_f100_sw.pdf)						
Functional unit	One unit						
Inventory quality	2.6						
Additional comments	Interpolated estimate obtained using the values for two ice makers that produce 2.7 tonnes of ice/day (resp. 5.5), weigh 700 kg (resp. 1200), and contain an initial charge of 50 kg of refrigerant						
Inputs							
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	932	kg			1.109	{2,3,2,3,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	932	kg			1.109	{2,3,2,3,2,na}

Table 48: Subprocesses used to construct an ice maker producing 4 tonnes of ice per day

Process Name	Heat engine for fishing ship/FR U						
Source	Anchoveta-SC project (https://anchoveta-sc.wikispaces.com/).						
Functional unit	One tonne						
Inventory quality	2.6						
Additional comments	Angel Avadi's work on the Achoveta Project (LCA on the Peruvian achoveta)						
Inputs							
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	340	kg			1.14	{3,3,2,1,2,na}
Iron	Cast iron {RER} production Alloc Rec, S	650	kg			1.14	{3,3,2,1,2,na}
Aluminium	Aluminium, wrought alloy {GLO} aluminium ingot, primary, to market Alloc Rec, S	10	kg			1.14	{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix

Stainless steel and iron	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	990	kg			1.14	{3,3,2,1,2,na}
Aluminium	Aluminium (waste treatment) {GLO} recycling of aluminium Alloc Rec, S	10	kg			1.14	{3,3,2,1,2,na}

Table 49: Subprocesses used to construct a heat motor for a fishing boat

Process Name	Electric motor for fishing ship/FR U						
Source	Anchoveta-SC project (https://anchoveta-sc.wikispaces.com/).						
Functional unit	One tonne						
Inventory quality	2.6						
Additional comments	Angel Avadi's work on the Achoveta Project (LCA on the Peruvian achoveta)						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Chromium steel pipe {GLO} production Alloc Rec, S	400	kg	370	430		{3,3,2,1,2,na}
Electrical cables	Cable, unspecified {GLO} production Alloc Rec, S	305	kg	270	340		{3,3,2,1,2,na}
Aluminium	Aluminium, wrought alloy {GLO} aluminium ingot, primary, to market Alloc Rec, S	245	kg	240	250		{3,3,2,1,2,na}
Plastic	Polyvinylchloride, suspension polymerised {RER} polyvinylchloride production, suspension polymerisation Alloc Rec, S	50	kg	40	60		{3,3,2,1,2,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Stainless steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S	400	kg	370	430		{3,3,2,1,2,na}
Electrical cables	Used cable {GLO} treatment of Alloc Rec, S	305	kg	270	340		{3,3,2,1,2,na}
Aluminium	Aluminium (waste treatment) {GLO} recycling of aluminium Alloc Rec, S	10	kg	240	250		{3,3,2,1,2,na}
Plastic	Waste polyvinylchloride {Europe without Switzerland} market for waste polyvinylchloride Alloc Rec, S	50	kg	40	60		{3,3,2,1,2,na}

Table 50: Subprocesses used to construct an electric motor for a fishing boat

Process Name	Antifouling paint/FR U						
Source	Fouling <i>et al.</i> (1952) - Characteristics of antifouling coatings.						
Functional unit	One kilogram						
Inventory quality	4.2						
Additional comments	Old publication from 1952. Hypothesis: 2/3 of the paint is degraded (therefore, 2/3 of emissions are released there), the other 1/3 is treated on land during careening (Hospido & Tyedmers, 2005). No contamination of water by rosin observed: use of "paraffin" as a proxy						
Inputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Rosin	Rosin size, for paper production {RER} production Alloc Rec, S	0.34	kg	0.28	0.4		{1,1,1,1,1,na}
Paraffin	Paraffin {RER} production Alloc Rec, S	0.3	kg	0.24	0.36		{1,1,1,1,1,na}
Copper oxide	Copper oxide {RER} production Alloc Rec, S	0.32	kg	0.28	0.36		{1,1,1,1,1,na}
Magnesium silicate	Sodium silicate, without water, in 37% solution state {RER} sodium silicate production, furnace liquor, product in 37% solution state Alloc Rec, S	0.04	kg	0	0.08		{1,1,1,1,1,na}
Water contamination		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Rosin	Paraffins	0.227	kg	0.187	0.267		{1,1,1,1,1,na}
Paraffin	Paraffins	0.2	kg	0.16	0.24		{1,1,1,1,1,na}
Copper oxide	Copper oxide	0.213	kg	0.187	0.24		{1,1,1,1,1,na}

Magnesium silicate	Silicate particles	0.027	kg	0	0.053		{1,1,1,1,1,na}
Outputs		Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
Paint waste	Waste paint {Europe without Switzerland} market for waste paint Alloc Rec, S	0.333	kg				{1,1,1,1,1,na}

Table 51: Subprocesses used to model the life cycle of antifouling paint

Process Name	Pump, 40 W {RoW} production Alloc Rec, U Edited
Source	Pump, 40 W {RoW} production Alloc Rec, U. ecoinvent® v. 3.3 database
Functional unit	2.426 kilograms
Inventory quality	Unknown
Additional comments	Functional unit changed to "kilogram" Pump end of life was modelled

Table 52: Subprocesses used to construct a pump

Process Name	Great Scallop storage bag, BS Brieuc/FR U					
Source	Sac manufacturer in Côtes d'Armor (Erquy Maritime Cooperative)					
Functional unit	One unit					
Inventory quality	2.3					
Additional comments						
Inputs						
Polypropylene	Big Bag 1t, polypropylene, production/FR U					
	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
	0.03	kg			1.14	{3,3,2,1,2,na}
Outputs						
Polypropylene	Waste polyethylene/polypropylene product {Europe without Switzerland} treatment of waste polyethylene/polypropylene product, collection for final disposal Alloc Rec, S					
	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
	0.03	kg			1.14	{3,3,2,1,2,na}

Table 53: Subprocesses used to construct a storage sac for Great Atlantic scallops

Process Name	Skiff for tuna fishing/FR U					
Source	Expert opinion of fishers operating tuna seiners					
Functional unit	One unit					
Inventory quality	2.6					
Additional comments	Skiff molded using steel					
Inputs						
Steel	Steel, low-alloyed, hot rolled {RER} production Alloc Rec, S					
	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
	35	ton			1.245	{4,4,2,1,2,na}
Outputs						
Steel	Steel and iron (waste treatment) {GLO} recycling of steel and iron Alloc Rec, S					
	Mean	Unit	Min	Max	Standard deviation	Pedigree matrix
	35	ton			1.245	{4,4,2,1,2,na}

Table 54: Subprocesses used to construct a skiff

Various methodological choices

The following tables describe the different methodological choices made during the construction of the project's inventories.

Input	Density	Source
Exotic wood	1000 kg/m ³	Information used in the ecoinvent® process: Roundwood, azobe from sustainably managed forests, under bark {RoW} hardwood forestry systems, azobe, sustainable forest management Alloc Rec, S
Concrete	2400 kg/m ³	http://ressources.batipratic.com/wp-content/uploads/2015/01/Calcul-poids-Materiaux.pdf
Plywood	600 kg/m ³	http://www.lecontreplaque.com/proprietes-physiques-du-contreplaque
Diesel	842 kg/m ³	Nurun Nabi, Md. et al., (2012). A comparative study of the number and mass of fine particles emitted with diesel fuel and marine gas oil (MGO), Atmospheric Environment, 57: 22-28. https://doi.org/10.1016/j.atmosenv.2012.04.039
Motor oil	881 kg/m ³	Average of a fully synthetic motor oil (Mobil 0W-40) and a mineral engine oil (Mobil Super 1000x4 20W-50). https://www.mobility.com
Hydraulic oil	885 kg/m ³	Kassfeldta, E. & Daved, G., (1997). Environmentally adapted hydraulic oil, Elsevier Science, 207: 41-45. https://doi.org/10.1016/S0043-1648(96)07466-2
R404a	1045 kg/m ³	http://climalife.dehon.fr/uploads/assets/catalogue/fr/climalife-2008-fr-21.pdf

Table 55: Densities applied during inventory construction

Input	Proportion	Source
Copper	95%	
Tin	5%	Information used in the ecoinvent® process: Bronze {RoW} production Alloc Rec, S

Table 56: Proportion of copper and tin in the bronze examined during inventory construction

Input	L < 12 m	12 m < L < 24 m	L > 24 m	Source
Mineral wool	98%	93%	80%	Bureau Mauric
Fibreglass	2%	7%	20%	

Table 57: Proportion of two insulation types (mineral wool and fibreglass) depending on boat size

Input	Proportion	Source
Water	97%	http://www.chemguard.com/fire-suppression/catalog/foam-concentrates/aqueous-film-forming-foam-afff/c303.aspx
Aqueous film-forming foam concentrates (AFFF)	3%	

Table 58: Proportion of water and AFFF in the AFFF foam extinguishers examined during inventory construction

Annex 5: Codes used in SimaPro®

This annex lists the codes used to describe the processes built in SimaPro®.

Table 59 provides the codes used to indicate landed species.

French common name	English common name	Scientific name	FAO code	SimaPro® code
Albacore	Yellowfin tuna	<i>Thunnus albacares</i>	YFT	Yellowfin Tuna
Alose feinte	Twaite Shad	<i>Alosa fallax</i>	TSD	Twaite Shad
Anchois	European anchovy	<i>Engraulis encrasiculus</i>	ANE	European Anchovy
Araignée de mer	Spinous spider crab	<i>Maja squinado</i>	SCR	Spinous Spider Crab
Balistes	Triggerfishes, Durgons nei	<i>Balistidae</i>	TRI	Triggerfishes, Durgons nei
Bar européen	European bass	<i>Dicentrarchus labrax</i>	BSS	European Bass
Bar tacheté	Spotted seabass	<i>Dicentrarchus punctatus</i>	SPU	Spotted Seabass
Barbue	Brill	<i>Scophthalmus rhombus</i>	BLL	Brill
Baudroie commune	Monkfish	<i>Lophius piscatorius</i>	MON	Monkfish
Baudroie rousse	Blackbelled angler	<i>Lophius budegassa</i>	ANK	Blackbelled Angler
Baudroies nca	Monkfishes nei	<i>Lophius spp.</i>	MNZ	Monkfishes
Béryx nca	Alfonsinos nei	<i>Beryx spp</i>	RED	Alfonsinos
Bonite à dos rayé (Pélamide)	Atlantic bonito	<i>Sarda sarda</i>	BON	Atlantic Bonito
Bouquet commun	Common prawn	<i>Palaemon serratus</i>	CPR	Common Prawn
Brosme	Cusk	<i>Brosme brosme</i>	USK	Cusk
Calmars côtiers nca	Squids nei	<i>Loliginidae, Ommastrephidae</i>	SQU	Squids nei
Cardine franche	Megrim	<i>Lepidorhombus whiffiagonis</i>	MEG	Megrim
Céphalodopodes autres	Cephalopods nei	<i>Cephalopoda</i>	CEP	Cephalopods nei
Céteau	Wedge sole	<i>Dicologlossa cuneata</i>	CET	Wedge Sole
Chinchard à queue jaune	Mediterranean horse mackerel	<i>Trachurus mediterraneus</i>	HMM	Mediterranean Horse Mackerel
Chinchard commun	Atlantic horse mackerel	<i>Trachurus trachurus</i>	HOM	Atlantic Horse Mackerel
Congre	European conger	<i>Conger conger</i>	COE	European Conger
Coquille Saint-Jacques	Great Atlantic scallop	<i>Pecten maximus</i>	SCE	Great Scallop
Dorade grise	Black seabream	<i>Spondyliosoma cantharus</i>	SPC	Black Seabream
Dorade royale	Gilthead seabream	<i>Sparus aurata</i>	SBG	Gilthead Seabream
Eglefin	Haddock	<i>Melanogrammus aeglefinus</i>	HAD	Haddock
Émissoles nca	Smooth hounds nei	<i>Mustelus spp.</i>	SDV	Smooth Hounds nei
Encornets rouges nca	Shortfin squids nei	<i>Illex spp.</i>	ILL	Shortfin Squids nei
Espadon	Swordfish	<i>Xiphias gladius</i>	SWO	Swordfish
Étrille commune	Velvet swimming crab	<i>Necora puber</i>	LIO	Velvet Swimming Crab
Flet d'Europe	European flounder	<i>Platichthys flesus</i>	FLE	European Flounder
Flétan noir	Black halibut	<i>Reinhardtius hippoglossoides</i>	GHL	Black Halipus
Gadidés	Gadidae	/	/	Gadidae
Gadiformes nca	Gadiformes nei	<i>Gadiformes</i>	GAD	Gadiformes nei

Grande vive	Greater weever	<i>Trachinus draco</i>	WEG	Greater Weever
Grenadier de roche	Roundnose grenadier	<i>Coryphaenoides rupestris</i>	RNG	Roundnose Grenadier
Grondin gris	Grey gurnard	<i>Chelidonichthys gurnardus</i>	GUG	Grey Gurnard
Grondin perlon	Tub gurnard	<i>Chelidonichthys lucerna</i>	GUU	Tub Gurnard
Grondin rouge	Red gurnard	<i>Chelidonichthys cuculus</i>	GUR	Red Gurnard
Hareng	Atlantic herring	<i>Clupea harengus</i>	HER	Atlantic Herring
Hareng de l'Atlantique	Atlantic herring	<i>Clupea harengus</i>	HER	Atlantic Herring
Homard européen	European lobster	<i>Homarus Gammarus</i>	LBE	European Lobster
Langouste rose	Pink spiny lobster	<i>Palinurus mauritanicus</i>	PSL	Pink Spiny Lobster
Langoustine	Norway Lobster	<i>Nephrops norvegicus</i>	NEP	Norway Lobster
Lieu jaune	Pollack	<i>Pollachius pollachius</i>	POL	Pollack
Lieu noir	Saithe	<i>Pollachius virens</i>	POK	Saithe
Limande sole	Lemon sole	<i>Microstomus kitt</i>	LEM	Lemon Sole
Lingue bleue	Blue ling	<i>Molva dypterygia</i>	BLI	Blue Ling
Lingue espagnole	Spanish ling	<i>Molva macrophthalma</i>	BVM	Spanish Ling
Lingue franche	Ling	<i>Molva molva</i>	LIN	Ling
Listao/Bonite à ventre rayé	Skipjack tuna	<i>Katsuwonus pelamis</i>	SKJ	Skipjack Tuna
Maigre	Meagre	<i>Argyrosomus regius</i>	MGR	Meagre
Maquereau commun	Atlantic mackerel	<i>Scomber scombrus</i>	MAC	Atlantic Mackerel
Maquereau espagnol	Chub mackerel	<i>Scomber japonicus</i>	MAS	Chub Mackerel
Marbré commun	Sand steenbras	<i>Lithognathus mormyrus</i>	SSB	Sand Steenbras
Merlan	Whiting	<i>Merlangius merlangus</i>	WHG	Whiting
Merlu européen	European hake	<i>Merluccius merluccius</i>	HKE	European Hake
Moro commun	Common mora	<i>Mora moro</i>	RIB	Common Mora
Morue de l'Atlantique	Atlantic cod	<i>Gadus morhua</i>	COD	Atlantic Cod
Mulet doré	Golden grey mullet	<i>Liza aurata</i>	MGA	Golden Grey Mullet
Mulet lippu	Thicklip grey mullet	<i>Chelon labrosus</i>	MLR	Thicklip Grey Mullet
Mulet porc	Thinlip grey mullet	<i>Liza ramada</i>	MGC	Thinlip Grey Mullet
Ombrine bronze	Canary drum	<i>Umbrina canariensis</i>	UCA	Canary Drum
Patudo	Bigeye tuna	<i>Thunnus obesus</i>	BET	Big Eye Tuna
Peau bleue	Blue shark	<i>Prionace glauca</i>	BSH	Blue Shark
Petite roussette	Lesser spotted dogfish	<i>Scyliorhinus canicular</i>	SYC	Lesser Spotted Dogfish
Phycis de fond	Greater forkbeard	<i>Phycis blennoides</i>	GFB	Greater Forkbeard
Plie cynoglosse	Witch flounder	<i>Glyptocephalus cynoglossus</i>	WIT	Witch Flounder
Plie d'Europe	European plaice	<i>Pleuronectes platessa</i>	PLE	European Plaice
Pocheteaux et raies raja nca	Raja Rays nei	<i>Raja spp.</i>	SKA	Raja Rays nei
Poulpes	Octopuses nei	<i>Octopodidae</i>	OCT	Octopuses nei
Raie bouclée	Maiden Ray	<i>Raja clavata</i>	RJC	Maiden Ray
Raie chardon	Shagreen ray	<i>Raja fullonica</i>	RJF	Shagreen Ray
Raie circulaire	Sandy ray	<i>Leucoraja circularis</i>	RJI	Sandy Ray
Raie douce	Spotted ray	<i>Raja montagui</i>	RJM	Spotted Ray
Raie fleurie	Cuckoo ray	<i>Leucoraja naevus</i>	RJN	Cuckoo Ray

Raie lisse	Blonde ray	<i>Raja brachyura</i>	RJM	Blonde Ray
Raie mélée	Small-eyed ray	<i>Raja microocellata</i>	RJE	Small-eyed Ray
Raies nca	Skates and rays nei	Rajiformes	SRX	Skates and Rays nei
Requin griset	Bluntnose sixgill shark	<i>Hexanchus griseus</i>	SBL	Bluntnose Sixgill Shark
Requin-hâ	Tope shark	<i>Galeorhinus galeus</i>	GAG	Tope Shark
Rouget barbet	Red mullet	<i>Mullus barbatus</i>	MUT	Red Mullet
Rouget de roche	Striped red mullet	<i>Mullus surmuletus</i>	MUR	Striped Red Mullet
Roussette	Nursehound	<i>Scyliorhinus stellaris</i>	SYT	Nursehound
Sabre noir	Black scabbardfish	<i>Aphanopus carbo</i>	BSF	Black Scabbardfish
Saint Pierre	John Dory	<i>Zeus faber</i>	JOD	John Dory
Sar à tête noire	Common two-banded seabream	<i>Diplodus vulgaris</i>	CTB	Common Two-banded Seabream
Sar commun	White seabream	<i>Diplodus sargus</i>	SWA	White Seabream
Sardine	European pilchard	<i>Sardina pilchardus</i>	PIL	European Pilchard
Saupe	Salema	<i>Sarpa salpa</i>	SLN	Salema
Sébaste chèvre	Blackbelly rosefish	<i>Helicolenus dactylopterus</i>	BRF	Blackbelly Rosefish
Sébastes de l'Atlantique nca	Atlantic redfishes nei	Sebastes spp.	RED	Atlantic Redfishes nei
Seiche	Cuttlefish nei	Sepiidae		Cuttlefish nei
Seiche commune	Common cuttlefish	<i>Sepia officinalis</i>	CTC	Common Cuttlefish
Sole commune	Common sole	<i>Solea solea</i>	SOL	Common Sole
Sole du Sénégal	Senegalese sole	<i>Solea senegalensis</i>	OAL	Senegalese Sole
Sole-pôle	Sand sole	<i>Pegusa lascaris</i>	SOS	Sand Sole
Sprat	European sprat	<i>Sprattus sprattus</i>	SPR	European Sprat
Squale nca	Dogfish sharks nei	Squalidae	DGX	Dogfish Sharks nei
Squale-chagrin de l'Atlantique	Leafscale gulper shark	<i>Centrophorus squamosus</i>	GUQ	Leafscale Gulper Shark
Tacaud commun	Pouting	<i>Trisopterus luscus</i>	BIB	Pouting
Thon germon	Albacore tuna	<i>Thunnus alalunga</i>	ALB	Albacore
Thon rouge	Atlantic bluefin tuna	<i>Thunnus thynnus</i>	BFT	Bluefin Tuna
Torpille marbrée	Marbled electric ray	<i>Torpedo marmorata</i>	TTR	Marbled Electric Ray
Tourteau	Edible crab	<i>Cancer pagurus</i>	CRE	Edible Crab
Turbot	Turbot	<i>Scophthalmus maximus</i>	TUR	Turbot
Vieille commune	Ballan wrasse	<i>Labrus bergylta</i>	USB	Ballan Wrasse

Table 59: Codes used to indicate landed species

Table 60 provides the codes used to indicate the fishing areas studied.

Fishing area in French	Fishing area in English	Code
Atlantique Centre-Est	Eastern Central Atlantic	ECA
Atlantique Nord-Est	Northeast Atlantic	NEA
Baie de Saint-Brieuc	Saint-Brieuc Bay	BSBrieuc
Golfe de Gascogne	Bay of Biscay	BBiscay
Méditerranée	Mediterranean Sea	MedSea
Mer Celtique	Celtic Sea	CelticSea
Mer du Nord	North Sea	NorthSea

Table 60: Codes used to indicate the fishing areas studied

Table 61 provides the codes used to indicate the fishing gear studied.

Fishing gear in French	Fishing gear in English - Code
Bolinche	Seine
Chalut de fond	Bottom trawl
Chalut pélagique	Pelagic trawl
Drague	Dredge
Filet trémail	Trammel net
Palangre	Longline
Senne	Seine

Table 61: Codes used to indicate the fishing gear studied

Table 62 provides the names of the triplets and products as used in SimaPro®.

Triplet name	Triplet name in SimaPro®	Name of average boat in SimaPro®	Name of average product in SimaPro®
Great Atlantic scallop—Saint-Brieuc Bay—Dredge	Great Scallop - BSBrieuc - Dredge	Average boat SCE/FR U	Great Scallop, BSBrieuc, Dredge, average, at landing/FR U
Gadidae—Celtic Sea—Bottom trawl	Gadidae - CelticSea - Benthic Trawl	Average boat GAD/FR U	Gadidae, CelticSea, Bottom Trawl, average, at landing/FR U
Atlantic herring—Northeast Atlantic—Pelagic trawl	Atlantic Herring - NEA - Pelagic Trawl	Average boat HER/NL U	Atlantic Herring, NEA, Pelagic Trawl, average, at landing/NL U
Atlantic mackerel—Northeast Atlantic—Pelagic trawl	Atlantic Mackerel - NEA - Pelagic Trawl	Average boat MAC/NL U	Atlantic Mackerel, NEA, Pelagic Trawl, average, at landing/NL U
Saithe (fresh)—North Sea—Bottom trawl	Fresh Saithe - NorthSea - Benthic Trawl	Average boat POK-FRE/UE U	Saithe, NorthSea, Bottom Trawl, average, fresh, at landing/EU U
Saithe (frozen)—North Sea—Bottom trawl	Frozen Saithe - NorthSea - Benthic Trawl	Average boat POK-FRO/UE U	Saithe, NorthSea, Bottom Trawl, average, frozen, at landing/FR U
European pilchard—Eastern Central Atlantic—Seine	European Pilchard - ECA - Seine	Average boat PIL-ECA-S/MA U	European Pilchard, ECA, Seine, average, at landing/MA U
European anchovy—Eastern Central Atlantic—Seine	European Anchovy - ECA - Seine	Average boat ANC-ECA/MA U	European Anchovy, ECA, Seine, average, at landing/MA U
European pilchard—Bay of Biscay—Seine	European Pilchard - BBiscay - Seine	Average boat PIL-BB/FR U	European pilchard, BBiscay, Seine, average, at landing/FR U
Sole—Bay of Biscay—Trammel net	Common Sole - BBiscay - Trammel net	Average boat SOL/FR U	Common Sole, BBiscay, Trammel Net, average, at landing/FR U
Albacore tuna—Northeast Atlantic—Pelagic trawl	Albacore - NEA - Pelagic Trawl	Average boat ALB/FR U	Albacore, NEA, Pelagic trawl, average, at landing/FR U
Atlantic bluefin tuna—Mediterranean Sea—Seine	Bluefin Tuna - MedSea - Seine	Average boat BFT-S/FR U	Bluefin Tuna, MedSea, Seine, average, at cage gate/FR U
Atlantic bluefin tuna—Mediterranean Sea—Longline	Bluefin Tuna - MedSea - Longline	Average boat BFT-LL/FR U	Bluefin Tuna, MedSea, Longline, average, at landing/FR U
Yellowfin tuna—Eastern Central Atlantic—Seine	Yellowfin Tuna - ECA - Seine	Average boat YFT/CI U	Yellowfin Tuna, ECA, Seine, average, at landing/CI U
Skipjack tuna—Eastern Central Atlantic—Seine	Skipjack Tuna - ECA - Seine	Average boat SKJ/CI U	Skipjack Tuna, ECA, Seine, average, at landing/CI U

Table 62: Names of triplets and main processes built in SimaPro®

Annex 6: Example classification of a fishing boat flotilla

This annex presents an example of the classification scheme used to define a sample that was representative of a whole study flotilla. Here, as an example, we illustrate the methodology using the flotilla of great Atlantic scallop harvesters in Saint-Brieuc Bay.

In the classification scheme, boats are assigned to several distinct categories. It relies on two sets of data, which are relatively easy to obtain from producer organisations:

- boat technical specifications, such as length, engine power, tonnage, age, and hull material
- indicators of boat activities, such as the tonnage and value of landed study species, the proportional contribution of study species to total tonnage, and the number of days at sea per year

The statistical approach used was hierarchical cluster analysis (HCA), implemented in R [15] using the FactoMineR package [16].

The results of this classification process are presented below (Figure 11). It shows that there are three main groups of boats:

- Group 1 (in black) contains small and old boats, which land limited numbers of tonnes of great Atlantic scallop. They are heavily focused on scallop harvesting and go out to sea only rarely.
- Group 2 (in red) contains boats of intermediate size and power; they are newer and are not heavily focused on scallops.
- Group 3 (in green) contains new, rather large boats that go out to sea frequently and that land many tonnes.

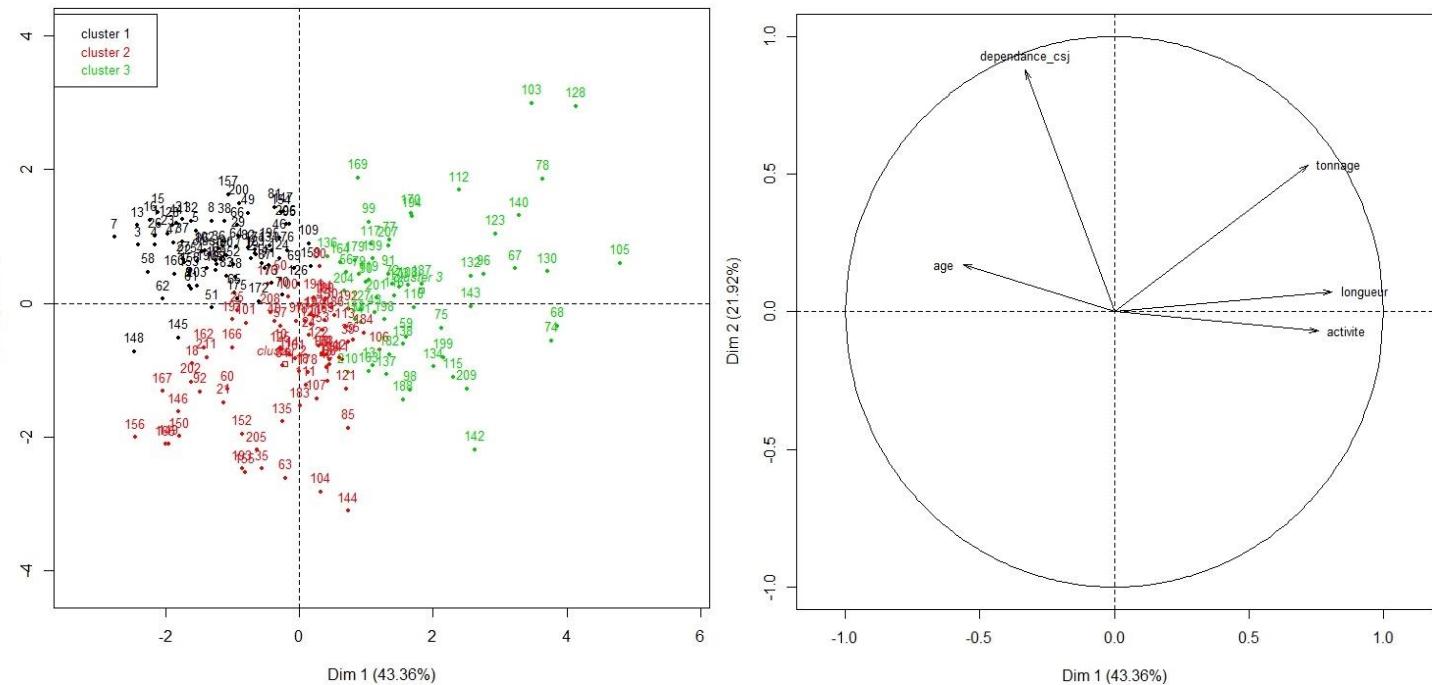


Figure 11: Example of the flotilla classification methodology (the Great Atlantic scallop—Saint-Brieuc Bay—Dredge triplet was used as an illustration)

This classification scheme informed the survey procedure since it was important to obtain information from boats representative of the flotilla.

Annex 7: Procedure for building average inventories

This annex describes how average inventories were built using the survey data collected from individual boats.

The general approach was to calculate an average for each process (e.g., boat, fuel consumption), which was weighted by production for each boat. In other words, more weight was accorded to boats landing greater quantities of the target products.

The following figures break down the calculations used to determine the main process (i.e., for the average product) and each major subprocess category (e.g., boats, fluids, gear).

The colour code used on the figures is as follows:

- blue = mean datum
- orange = individual datum
- grey = other datum

Below is the branching pattern for the main process (Figure 12), which corresponds to the average fishing activity carried out by the boats of each fishery studied. The major subprocesses are those associated with the boats, consumption of fuel and other fluids, gear, and equipment for fish storage and preservation.

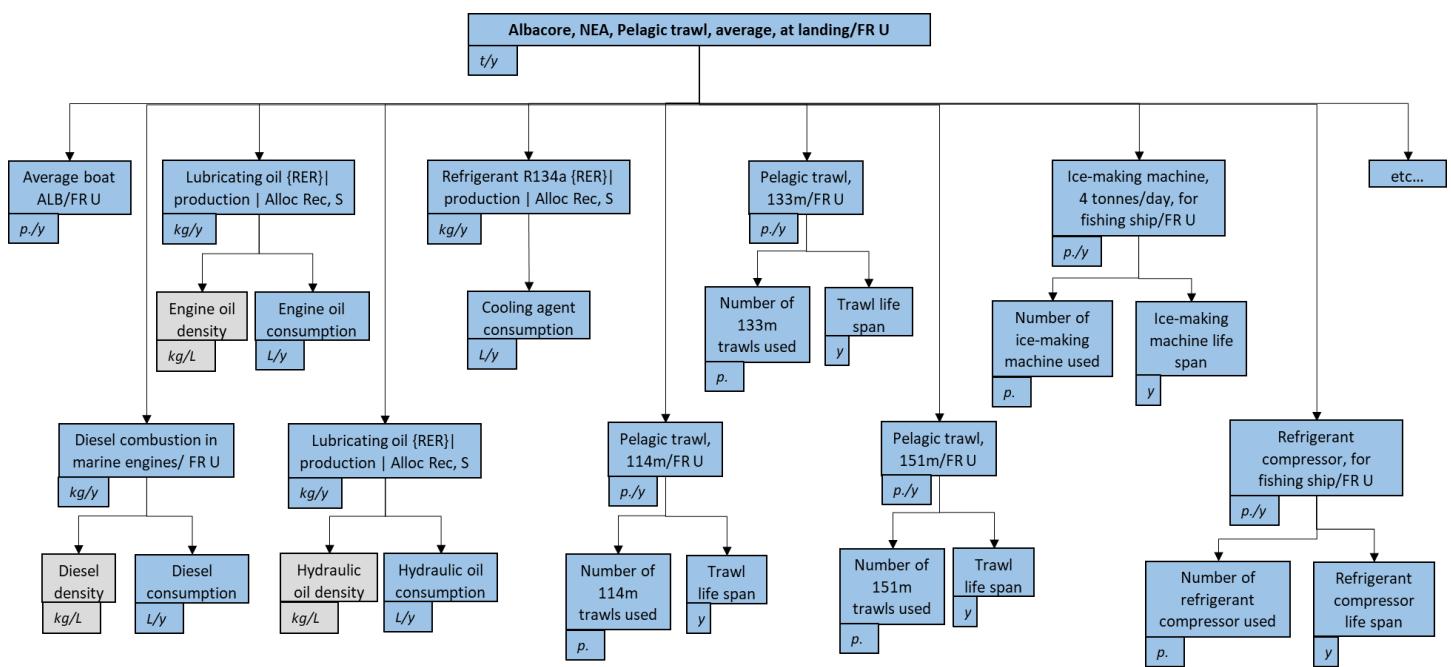
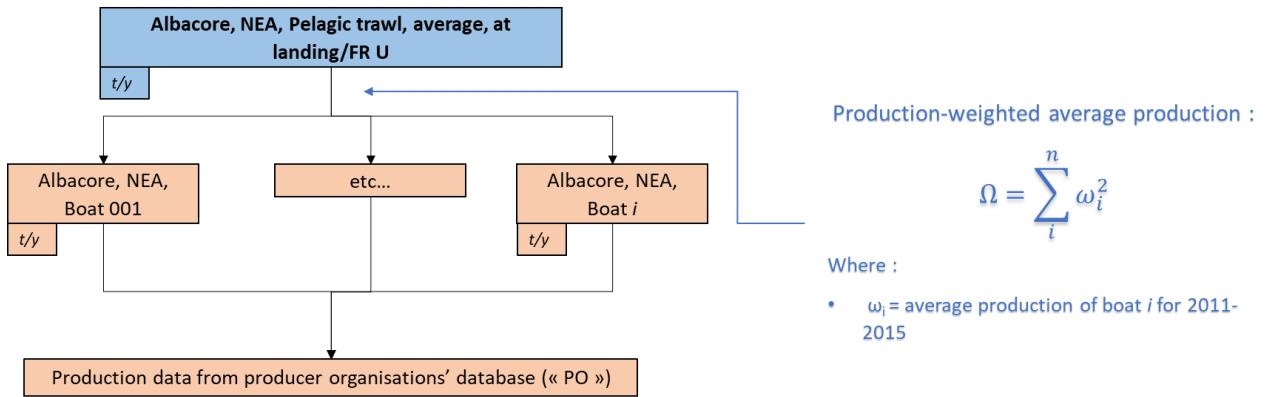


Figure 12: Branching pattern of the main process corresponding to average boat activity for each fishery studied (here, the fishery is albacore tuna in the northeast Atlantic)

Below is a description of the calculations used to determine average production (the reference value) for each fishery studied (Figure 13).



Production-weighted average production :

$$\Omega = \sum_i^n \omega_i^2$$

Where :

- ω_i = average production of boat i for 2011-2015

Figure 13: Calculating the average production for each fishery studied (here, it is average production for albacore tuna in the northeast Atlantic)

Below is a description of the calculations used to define an average boat for each fishery studied (Figure 14).

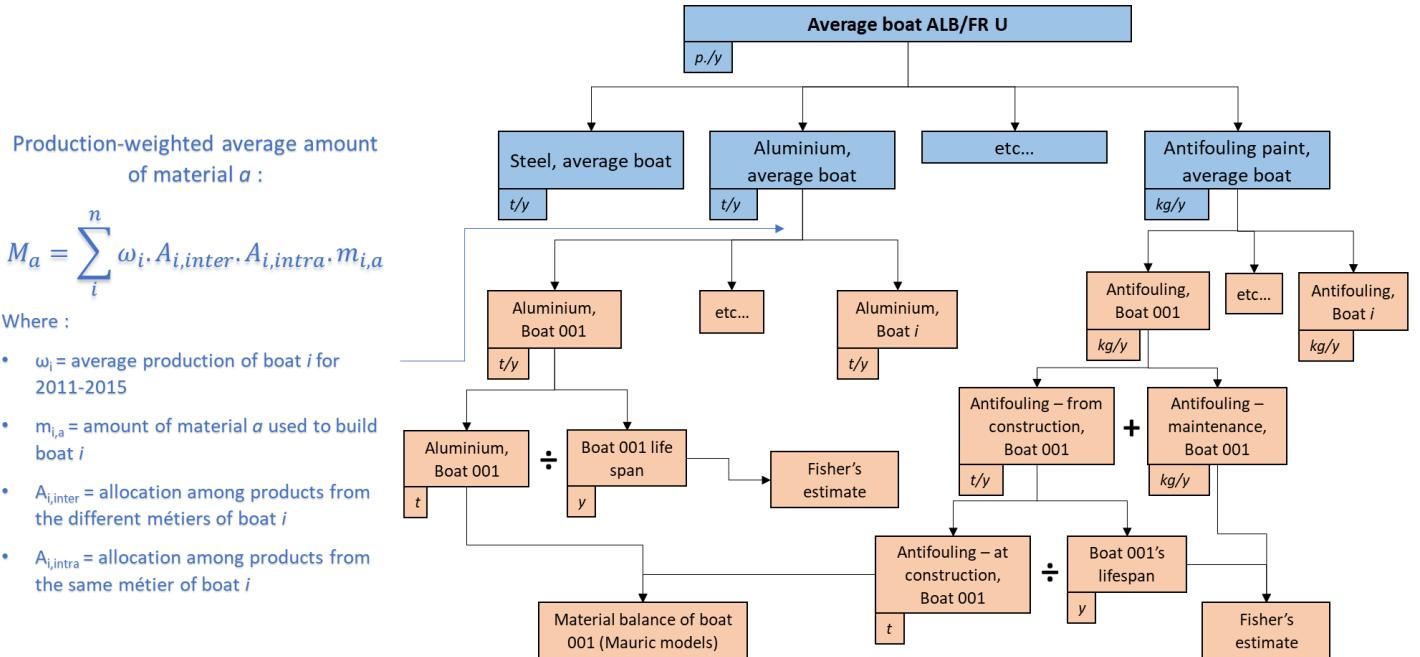


Figure 14: Defining the average boat for each fishery studied (here, it is the average boat used to capture albacore tuna in the northeast Atlantic)

Below is a description of the calculations used to determine mean consumption (Figure 15). This approach can be used to estimate consumption of the following materials:

- fuel (L)
- oil (L)
- water (L)
- refrigerant (kg)
- salt (kg)
- bait (kg)
- cardboard packaging (kg)
- plastic film (kg)
- waste (kg)

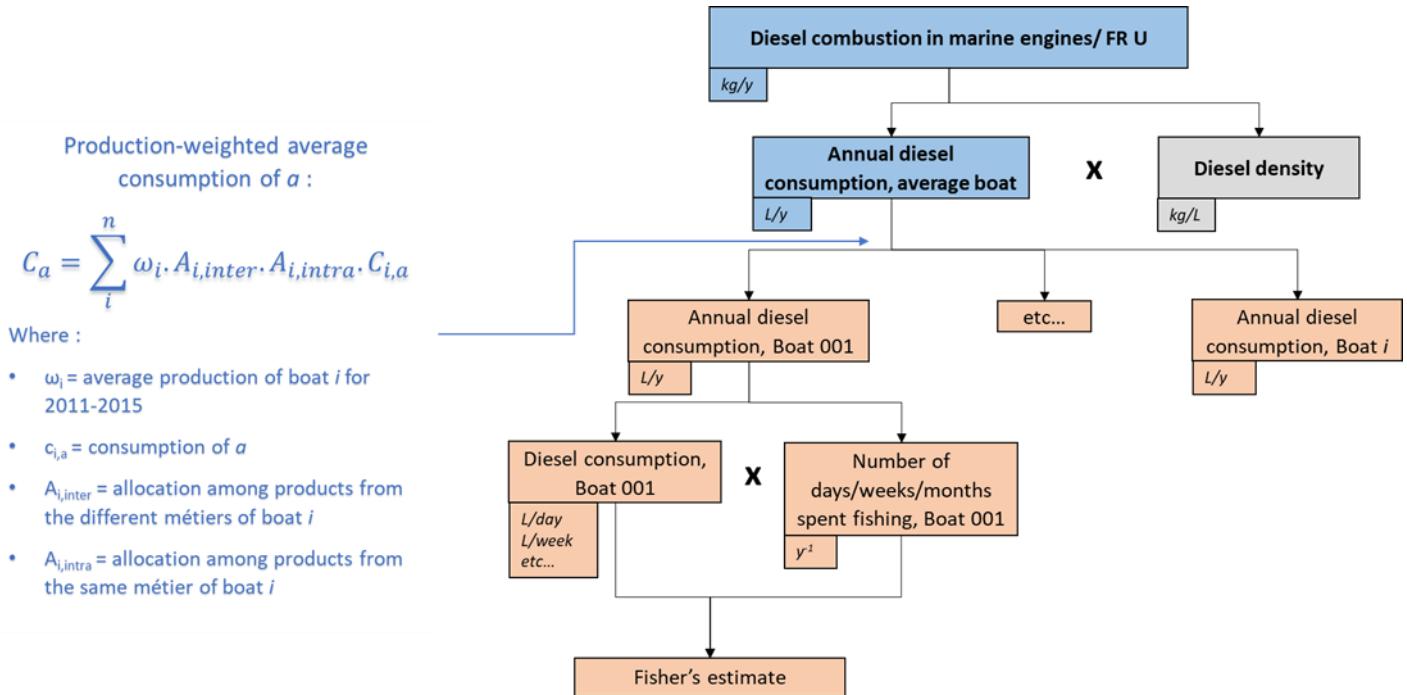


Figure 15: Calculating average consumption values for each fishery studied (here, it is the mean diesel consumption associated with the capture of albacore tuna in the northeast Atlantic)

Below is a description of the calculations used to define the average gear for each fishery studied (Figure 16). This approach can be used to characterise the following gear:

- trawls
 - dredges
 - seines
 - trammel nets
 - longlines

Production-weighted average number
of gear a used :

- ω_i = average production of boat i for 2011-2015
 - $g_{i,a}$ = number of gear a used for fishing by boat i
 - $A_{i,\text{inter}}$ = allocation among products from the different métiers of boat i
 - $A_{i,\text{intra}}$ = allocation among products from the same métier of boat i

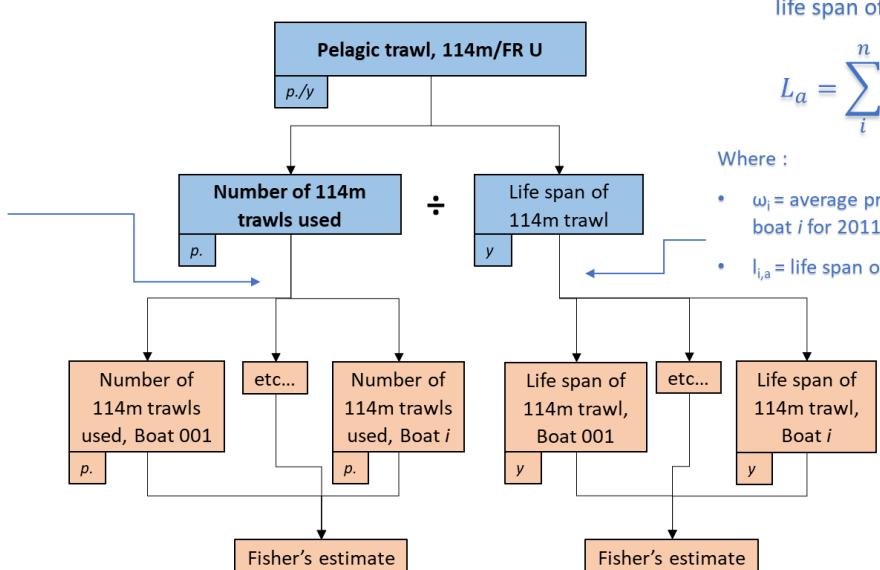


Figure 16: Defining the average gear for each fishery studied (here, it is the mean number and life span of 114-m pelagic trawls used to capture albacore tuna in the northeast Atlantic)

Below is a description of the calculations used to define the average fish storage and preservation equipment for each fishery studied (Figure 17). This approach can be used to characterise the following equipment:

- ice maker
- refrigerator compressor
- storage containers and sacs
- flash freezer
- skiff

Production-weighted average number of equipment a used :

$$E_a = \sum_i^n \omega_i \cdot A_{i,\text{inter}} \cdot A_{i,\text{intra}} \cdot e_{i,a}$$

Where :

- ω_i = average production of boat i for 2011-2015
- $e_{i,a}$ = number of pieces of equipment a used for fishing by boat i
- $A_{i,\text{inter}}$ = allocation among products from the different métiers of boat i
- $A_{i,\text{intra}}$ = allocation among products from the same métier of boat i

Production-weighted average lifespan of equipment a :

$$L_a = \sum_i^n \omega_i \cdot l_{i,a}$$

Where :

- ω_i = average production of boat i for 2011-2015
- $l_{i,a}$ = life span of equipment a

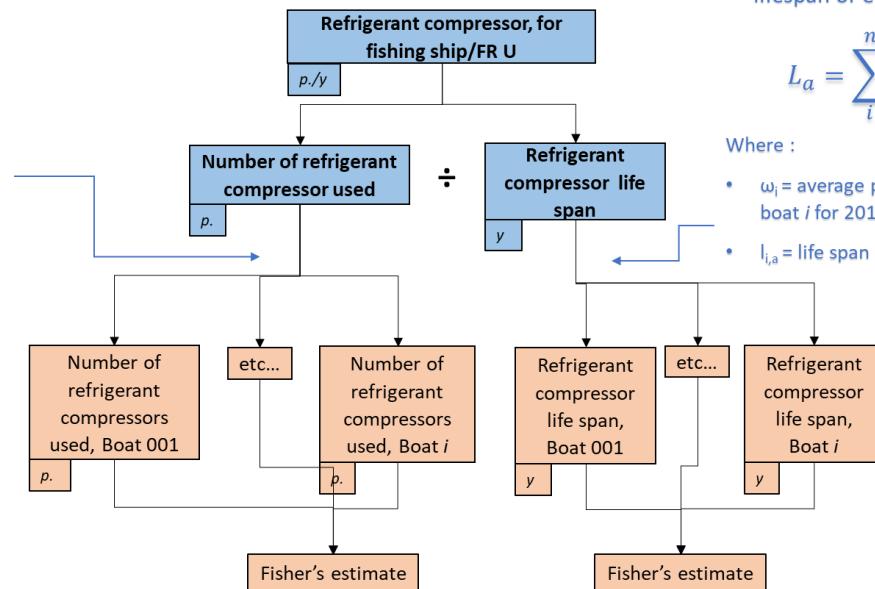


Figure 17: Defining the average equipment for each fishery studied (here, it is the mean number and life span of refrigerator compressors used in association with the capture of albacore tuna in the northeast Atlantic)

Annex 8: Critical review

This annex comprises the critical review of the LCIs that was generated as part of the French LCI Project on Fisheries. It was carried out by Jérôme Payet of the consulting firm Cycleco.

Rapport de revue des inventaires du projet ICV pêche

Date de finalisation de la revue : 31 mars 2019

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Distribution des inventaires :

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ADEME



Agence de l'Environnement
et de la Maîtrise de l'Energie

Validation de la conformité

Les 15 inventaires du cycle de vie développés dans le cadre du projet ICV pêche ainsi que les 367 inventaires d'arrière-plan développés pour permettre la modélisation des activités de pêche, des bateaux et des engins de pêches sont clairement documentés. Le niveau de détail de la modélisation est particulièrement appuyé et un effort très important a été mis en œuvre pour collecter des données spécifiques précises en lien direct avec les activités de ce secteur industriel.

Les inventaires du cycle de vie ont été modélisés à l'aide de données d'activité collectées sur le terrain, de données issues de la littérature et de données statistiques.

La base de données ecoinvent et le logiciel Simapro ont été utilisés pour modéliser les données.

La modélisation de type U (unit process) permet de décrire de façon détaillée et transparente l'ensemble des processus contributeurs.

La qualité des données est très satisfaisante et a été évaluée avec la pedigree matrix adaptée pour les besoins d'Agribalyse.

La revue s'est déroulée sous la forme d'un accompagnement du projet et d'une évaluation finale des ICV ayant requis trois étapes de modifications successives.

Le format attendu est le format ILCD avec une conformité aux règles du standard ISO 14040-44.

Le rapport final et le rapport de revue devront être mis à disposition des utilisateurs des ICV.

Sur la base des éléments communiqués durant le processus de revue critique, les éléments suivants sont établis :

Conformité au standard ISO 14040 & 14044	Les données sont conformes aux exigences du standard ISO 14040 et ISO 14044.
Conformité au format "ILCD"	Les jeux de données présentent une conformité partielle au format ILCD "Entry level".
Date, lieu, signature	Dr Jérôme PAYET 31 mars 2019 Ambérieu en Bugey (France)  18, avenue Roger Salengro 01500 AMBÉRIEU-EN-BUGEY - France Tél. 04 37 86 07 12 - www.cycleco.eu 

Contexte

Le projet ICV pêche a permis l'élaboration de 15 inventaires de cycle de vie de produits de la pêche.

Ces 15 inventaires sont construits à partir de la modélisation de 367 inventaires d'arrière-plan concernant les bateaux, les engins de pêche et les activités de pêche.

Les 367 inventaires sont construits de façon désagrégée (inventaires de type U, "Unit processes" et font appel à des procédés d'arrière-plan issus de la base de données ecoinvent).

Le logiciel Simapro a été utilisé pour modéliser les données. Néanmoins, la revue critique s'est basée strictement sur la documentation disponible hors du logiciel Simapro.

Les données d'activité ont été collectées auprès des professionnels de la filière. Les données d'émissions directes sont issues de publications antérieures ou d'extrapolations basées sur des modélisations.

La construction des inventaires a suivi trois étapes : 1/ collecte des données auprès des professionnels (questionnaire) ; 2/ traitement des données (tableur Excel) ; 3/ intégration des données dans le logiciel Simapro avec ajout des émissions directes.

Triplets couverts par ICV pêche :

Espèce(s) ciblée(s)	Zone de pêche	Engin de pêche	Code
Coquille Saint-Jacques	Baie de Saint-Brieuc	Drague	Coquille SJ – St-Brieuc
Gadidés (cabillaud, merlan, églefin)	Mer Celtique	Chalut de fond	Gadidés – mer Celtique
Hareng	Atlantique Nord-Est	Chalut pélagique	Hareng – Maquereau
Maquereau	Atlantique Nord-Est	Chalut pélagique	
Lieu noir (frais)	Mer du Nord	Chalut de fond	Lieu noir – frais
Lieu noir (congelé)	Mer du Nord	Chalut de fond	Lieu noir – congelé
Sardine	Golfe de Gascogne	Bolinche	Sardine – GG
Sardine	Atlantique Centre-Est	Senne	Sardine – ACE
Anchois	Atlantique Centre-Est	Senne	Anchois – ACE
Sole	Golfe de Gascogne	Filet trémail	Sole – GG
Germon	Atlantique Nord-Est	Chalut pélagique	Germon – ANE
Thon rouge	Méditerranée	Senne	Thon rouge - Palangre
Thon rouge	Méditerranée	Palangre	Thon rouge – Senne
Albacore	Atlantique Centre-Est	Senne	Thon trop. – ACE
Listao	Atlantique Centre-Est	Senne	

Objectifs et organisation de la revue

La revue des inventaires de cycle de vie est faite afin de valider la conformité avec les exigences du standard ISO 14040-44 et du format ILCD entry level.

Rappel des éléments concernant la conformité d'inventaires au handbook ILCD

1- Pour pouvoir revendiquer la conformité au ILCD handbook, l'inventaire du cycle de vie doit avoir été développé dans le respect des exigences spécifiées dans le document " International Reference Life Cycle Data System (ILCD) Handbook - Specific guide for life cycle inventory data sets" et complété par les informations décrites dans le "International Reference Life Cycle Data System (ILCD) Handbook - Detailed guidance for Life cycle assessment".

2- Dans le cas présent, la revue de conformité s'applique à un ICV dans une "Situation A", et la conformité doit couvrir 5 aspects généraux : qualité des données ; méthode ; nomenclature ; review et documentation.

3- Une conformité partielle peut être communiquée si les 5 aspects ci-dessus sont satisfait en partie seulement. Dans ce cas il doit être clairement mentionné que la conformité complète n'est pas satisfaite.

4- Concernant la qualité des données, le niveau de qualité doit être spécifié dans chacun des jeux de données comme "haute qualité, qualité basique, ou données estimées".

5- La version du document "International Reference Life Cycle Data System (ILCD) Handbook - Detailed guidance for Life cycle assessment" doit être identifiée en lien avec le dataset concerné.

6- Si une nouvelle version d'un composant de l'ILCD handbook est publiée, la nouvelle version remplace l'ancienne et les exigences de l'ancienne version ne peuvent être appliquées que dans un délai de 9 mois après la publication.

Si une revue critique est réalisée, le reviewer doit confirmer la conformité aux dispositions mentionnées dans les documents de l'ILCD handbook et la conformité avec les dispositions mentionnées dans le standard ISO 14040-44.

Du fait de l'organisation du processus de revue critique, l'amélioration des ICV est également réalisée en parallèle avec la revue critique. Diverses modifications des ICV ont ainsi eu lieu durant le processus de revue critique. La principale modification concerne les hypothèses retenues dans le cadre de la modélisation des bateaux. Ces modifications ont permis de renforcer les résultats présentés dans cette étude.

Procédure de la revue critique

- 1- Identification des fichiers source
- 2- Description du cadre de la vérification et des documents afférents
- 3- Identification des hypothèses de travail et des modèles mathématiques utilisés
- 4- Vérification de la procédure de construction des ICV
- 5- Contrôle des flux intermédiaires entrants et sortants : nom, unité, quantité
- 6- Contrôle des flux élémentaires entrants et sortants : nom, unité, quantité
- 7- Vérification du report des informations : identification des fichiers, format, détail

Documentation analysée dans le cadre de la revue

Rapport méthodologique

Tables Excel

Extraction Simapro (export CSV)

Limites de la revue critique

La revue critique se concentre sur les fichiers mis à disposition sous forme de documents Word, Excel et PDF. La revue critique ne se base pas sur les données présentées par le logiciel Simapro. En effet, selon le type de licence, la version du logiciel et la version de la base de données d'arrière-plan, les résultats et les informations présentés peuvent être différents.

Cadre général de la revue critique

Les éléments majeurs de la revue critique sont ceux définis dans la cadre de l'ILCD à savoir :

Elément de conformité	Exigence
Format	Utiliser le format ILCD
Documentation	Spécifier les besoins de documentation à minima Se référer aux critères ISO
Nomenclature	Nomenclature conforme à l'ILCD Possibilité d'utiliser certains flux élémentaires agrégés
Qualité des données	Pas d'exigence de qualité des données Mais nécessité de documenter les données et de renseigner les critères de qualité de l'ISO
Méthode	Conformité au standard ISO 14040-44 La conformité à la méthode ILCD n'est pas requise Documenter les modalités d'application des allocations/substitutions
Revue	Le reviewer doit être enregistré dans le fichier "Reviewers' registry" de la European Platform for LCA ; Le reviewer doit avoir des compétences dans le secteur concerné et dans la méthodologie ACV ; Le reviewer externe doit être indépendant tel que décrit dans le standard ISO ; OU Le reviewer interne doit être indépendant tel que décrit dans le standard ISO. Dans les deux cas, un rapport d'expertise séparé est nécessaire (le template ILCD et le champ des exigences minimum de documentation doivent être produits dans le dataset). La revue au niveau des processus unitaires peut ne pas être exigée ou communiquée selon les exigences de qualité des données.

Synthèse de la couverture des champs obligatoires dans ILCD

Vérification des champs obligatoires des métadonnées de l'ILCD :

Section	Mandatory	Reviewer comments
Activity description		<i>Process identifier is not a UUID</i>
Activity Name	yes	<i>Name should be adapted based on ILCD requirements</i>
Type	yes	<i>Reported as unit process</i>
General Comment	yes	<i>Only in Excel and Simapro not in ILCD format</i>
Included Activities Start	yes	<i>OK</i>
Included Activities End	yes	<i>OK</i>
Geography		
Shortname	yes	<i>Reported in the process name but not in the corresponding field</i>
Comment	yes	<i>Not available</i>
Technology		
Technology level	yes	<i>OK</i>
Comment	yes	<i>Not available</i>
Time Period	yes	<i>OK</i>
Start of Period	yes	<i>OK</i>
End of Period	yes	<i>OK</i>
Data Valid For Entire Period	yes	<i>OK</i>
Comment	yes	<i>OK</i>
Section	Mandatory	Reviewer comments
Representativeness		
Sampling Procedure	yes	<i>Not available at dataset level</i>
Extrapolations	yes	<i>Not available at dataset level</i>
Review		
Type of review	yes	<i>OK</i>
Scope of review	yes	<i>Need to be restated in the report.</i>
Method of review	yes	<i>Need to be restated in the report.</i>
Data quality indicator	yes	<i>OK</i>
Reviewer name and institution	yes	<i>OK</i>
Data Entry By		
Person	yes	<i>OK</i>

Data Generation And Publication		
Person		<i>OK</i>
Published Source	yes	<i>OK</i>

Eléments obligatoires de l'élaboration des jeux de données

I. DEFINITION DES OBJECTIFS

I-1- Définition des objectifs

- Application prévue : il serait souhaitable de préciser ce point dans le rapport général. La phrase "L'objectif est de mettre à disposition des utilisateurs des données transparentes et « de qualité ». Chaque utilisateur est responsable ensuite sur la manière d'utiliser les données. Agribalyse s'est positionné de manière large comme des données pour soutenir l'écoconception et l'information environnementale" peut être ajoutée au rapport final.
- Limites de l'étude : les limites de chacun des inventaires pourraient être exposées plus précisément. Le fait d'avoir des spécificités de limite d'inventaire dans chaque dataset pourrait être mieux décrit.
- Raison de l'étude : il serait souhaitable de préciser ce point dans le rapport général.
- Public cible : le public cible n'est pas mentionné.
- Type d'audience : il semble qu'il s'agisse d'une utilisation B2B sans que ce soit précisé dans le rapport.
- Mise en œuvre de comparaisons : d'un côté le développement de chaque jeu de données n'est pas élaboré dans un cadre de comparaison, d'un autre côté les premiers résultats obtenus font l'objet d'une communication comparant les résultats des impacts des ICV.
- Mandataire : Préciser dans le rapport final qu'il s'agit d'un partenariat CNPM-ADEME.

I-2- Description du contexte de décision

Le contexte de décision est un élément clé du cadre ILCD mais il n'est pas clairement explicité dans le rapport général. Au regard des éléments présentés dans le rapport général, il semble que le contexte de décision se réfère à une situation "A" (micro level decision support), c'est à dire au niveau du produit ou du processus. Les conséquences de décisions sont de portée limitée.

La phrase suivante peut être ajoutée au contexte de décision. " Contexte de décision: le contexte de décision se réfère à une situation "A" (micro level decision support), c'est à dire au niveau du produit ou du processus."

II. DEFINITION DU CHAMP DE L'ETUDE

II-1- Cohérence des méthodes, hypothèses et données

- Cohérence des hypothèses et des méthodes : les méthodes de construction des inventaires et les hypothèses utilisées sont bien documentées et clairement présentées dans l'export Simapro.
- Cohérence des données : le fait d'utiliser une seule et unique base d'arrière-plan donne une grande cohérence aux datasets.

- Gestion des incohérences : un effort est fait pour rendre la cohérence des flux élémentaires avec l'ILCD. Néanmoins le fait de spécifier l'UUID des flux élémentaires et des unités améliorerait la cohérence afin d'assurer la bonne lecture des flux d'émissions, des quantités et des compartiments correspondants.

II-2- Reproductibilité

- Documentation pour la reproducibilité : les ICV sont très bien documentés et organisés de façon à satisfaire totalement l'exigence de reproducibilité.

- Informations confidentielles : les informations confidentielles concernent le bilan matière des bateaux et les données individuelles des pêcheurs. Le fait de les agréger à l'échelle des triplets tout en utilisant des inventaires unitaires permet à la fois de garantir la confidentialité tout en préservant la transparence.

II-3- Fonction, unité fonctionnelle et flux de référence

- Identification du système : le système est clairement décrit dans les exports Excel de chacun des inventaires.
- Identification de la fonction et de l'unité fonctionnelle : fonctions et unité fonctionnelles sont clairement décrites.
- Méthode de mesure : l'élaboration des jeux de données a été faite sans mettre en œuvre de méthode de mesure.

II-4- Modélisation des inventaires et disposition pour la situation A

Bien que ce ne soit pas mentionné dans le rapport, il apparaît que les jeux de données sont développés pour une situation A de l'ILCD, les dispositions correspondantes évoquées dans l'ILCD servent de références pour la revue.

Concernant le modèle ICV et les allocations, le choix s'est judicieusement porté sur une approche attributionnelle, et les règles d'allocation appliquées pour les multifonctionnalités sont celles du standard ISO 14040-44 et de l'ILCD.

Il semble que le recyclage soit modélisé en cohérence avec l'ILCD, cependant le manque de détail de la documentation sur ce point ne permet pas d'appréhender l'influence du recyclage sur les résultats de l'évaluation.

II-5- Frontières du système et limite de cut off

- Champ de l'étude : il est bien présenté dans le rapport général.
- Processus inclus dans le système : la liste des processus inclus dans le système est trop générale et le fait qu'elle peut varier d'un jeu de données à l'autre rend la lecture plus complexe. La présentation aurait pu être faite avec une liste de processus par jeu de données.
- Flux traversant les frontières du système : ils sont bien renseignés à travers les différents documents Excel produits.

- Diagramme de présentation des frontières du système : le diagramme est compréhensible mais aurait gagné à donner plus de détail par jeu de données.
- Liste des exclusions (manquant comme par exemple les processus de transformation des matériaux).
- Système de compensation des impacts : Il n'y a pas de système de compensation des impacts.
- Critère de cut off quantitatif : il n'est pas mentionné dans le rapport. Il aurait fallu l'estimer et l'expliquer dans le rapport.

II-6- Définir le cadre de l'évaluation des impacts

(non concerné)

II-7- Représentativité technologique

- Technologies pour le système de premier plan (données spécifiques) et d'arrière-plan (technologie moyenne du marché).
- Qualité de la représentativité technologique (technologie spécifique) : bon. La validité technologique gagnerait en qualité si la représentativité statistique de la technologie était spécifiée pour chacune des données en comparaison avec l'ensemble de l'activité pour la zone géographique et la réalité temporelle considérée.

II-8 - Représentativité géographique

- Premier plan : données spécifiques au site ou producteur sauf cas particuliers liés à l'exigence de qualité des données.
- Arrière-plan : moyenne de marché.
- Qualité de la représentativité géographique : bon. La géographie de validité des données devrait être reprécisée au-delà du titre dans chacun des jeux de données ainsi qu'il est demandé dans l'élaboration des métadonnées au format ILCD.

II-9- Représentativité temporelle

- Qualité de la représentativité : l'année de référence des jeux de données n'est pas claire. Il semble que l'année de référence soit l'année de collecte des données. Ceci devrait être reprécisé à l'échelle du jeu de données. Il faudrait ainsi préciser dans le rapport que l'année de référence est 2015 et que les calculs des données d'activité soient réalisés sur la base d'une moyenne pondérée des 5 dernières années.
- Variabilité saisonnière : les modalités de prise en compte d'une variabilité saisonnière sont clairement expliquées.
- Moyenne pondérée sur plusieurs années : le fait de moyenner l'année de référence sur 5 années afin d'absorber les variations annuelles est bien expliqué et pertinent.

II-10- Identification des besoins de revue critique

- Identification du type de review et du reviewer en lien avec le "reviewer qualification".

II-11- Planification du reporting

- Mentionner le type de rapport nécessaire pour satisfaire les objectifs à atteindre. Dataset, dataset+report, ILCD LCI dataset devraient être utilisés pour le reporting.
- Niveau de rapport : il serait souhaitable d'indiquer explicitement le public ciblé par le rapport : interne, externe, public.

III. ANALYSE DE L'INVENTAIRE DU CYCLE DE VIE - COLLECTE DES DONNEES, MODELISATION DE SYSTEME, CALCUL DES RESULTATS

III-1- Identification des processus dans la modélisation attributionnelle : identifier et décrire les processus pertinents en cohérence avec les frontières du système

NON FAIT

III-2- Planification de la collecte des données

- Identifier les données spécifiques nécessaires à la réalisation des ICV. Ce travail a eu lieu en amont et a été poursuivi de façon itérative tout au long du projet en fonction des informations recueillies auprès des pêcheurs et des organisations de pêche.
- Identifier les données moyennes : lorsqu'il s'avérait que des données faisaient l'objet d'une variété importante d'une année sur l'autre, des données sur plusieurs années ont été recherchées afin de pouvoir calculer une moyenne interannuelle.
- Identifier les données génériques : les données génériques, également appelées données secondaires, ont été sélectionnées strictement dans la base de données ecoinvent ce qui renforce la cohérence des données.

III-3- Décrire ce que représentent les processus unitaires

Le choix des processus unitaires est directement lié aux données disponibles dans la base de données ecoinvent 3. Cependant, lorsque des proxy ont été retenus pour se substituer à des données non disponibles dans la base, il aurait été souhaitable de discuter ces choix et d'en décrire les limites en termes de conséquences sur le calcul des impacts.

Que ce soit en ce qui concerne les processus de production (ex cordage polyester approximé par de la résine polyester) ou les processus de fin de vie (lest en plomb approximé par Lead in car shredder residue {RoW} | treatment of, municipal incinération | Alloc Rec, S), il n'y a pas eu d'évaluation de l'influence possible du choix de la proxy sur le résultat final. On peut supposer que les conséquences sont mineures mais pour l'affirmer il aurait fallut faire une étude hotspot. Cette étude pourra être mise en œuvre lors de la révision des données.

III-4- Type de flux entrants et sortants à collecter

Les flux entrants et sortants sont issus des échanges avec les pêcheurs, avec les organisations de pêche, de la collecte de données d'articles scientifiques, ainsi que des hypothèses décrites dans le rapport.

III-5- Quantité de référence du flux de référence

Les quantités de référence des flux de référence sont généralement directement issues de la collecte des données avec les pêcheurs ou de moyennes statistiques permettant de renforcer la validité des données.

III-6- Représentativité au regard des conditions opérationnelles

L'intégralité des éléments nécessaires à la réalisation des inventaires est prise en compte dans la modélisation. Les produits (poissons) sont modélisés sur une partie de cycle de vie (cradle to gate) mais leurs éléments constitutifs (bateaux, engins de pêche) sont modélisés sur leur cycle de vie complet.

III-7- Passage de données brutes au processus d'inventaire unitaire

Seuls les calculs d'ICV des bateaux ont requis de passer de données brutes à des processus unitaires pour le calcul de l'impact d'un bateau moyen par activité de pêche. Ceci était apparemment nécessaire pour des raisons de confidentialité, cependant, les données finales résultent d'une agrégation d'éléments très divers et l'inventaire en résultant est difficile à interpréter. Les inventaires intermédiaires ne sont pas disponibles et cela peut susciter des doutes pour l'utilisateur de ces inventaires. Il est préférable dans cette situation de rediscuter de la confidentialité des ICV afin de pouvoir communiquer également les ICV intermédiaires.

III-8- Contrôle qualité intermédiaire

La réalisation de la complétude permettant de combler les manques de données avec des estimations de qualité acceptable, et la gestion de processus unitaires ne pouvant être complétée le contrôle de validité des données a été suivi de façon itérative tout au long du projet. Par exemple, l'analyse des ICV détaillés des bateaux (avant agrégation) a permis de détecter des biais important introduit par certain bateaux (coquille saint jacques sole, thon rouge palangre). Ces anomalies ne sont plus visibles après agrégation et peut influencer de façon importante les résultats. Concernant l'importance relative des bateaux dans l'impact total, il est très variable. L'ICV thon rouge méditerranée senne indique un impact des bateaux par kg de Thon >20% pour le changement climatique et >40% pour l'eutrophisation. De plus seuls les matériaux ont été pris en compte et toutes les transformations (soudure, transport, découpe, pertes, etc) sont exclues du système alors qu'elles sont susceptibles doubler les impacts. Il sera souhaitable lors de futurs mises à jour des données de rediscuter de la confidentialité des ICV afin de pouvoir communiquer également les ICV intermédiaires.

III-9- Emissions des indicateurs mesurés et groupes de flux élémentaires

Les émissions prises en compte concernent l'ensemble des catégories d'impact de l'ILCD. Néanmoins, au regard des flux intermédiaires décrits entrants (ex. : peinture antifouling) et de la comparaison avec les flux élémentaires sortants (ex. : solvants émis dans l'air lors de l'application des peintures), il semble que des flux élémentaires aient été omis, soit durant la phase d'utilisation (y compris maintenance), soit durant la phase de fin de vie. Une analyse de sensibilité aurait pu être réalisée sur ce point.

III-10- Emissions des composés ioniques

Aucune émission directe de composé ionique n'est identifiée dans les systèmes considérés.

III-11- Emissions de particules dans l'air

Les émissions de particules dans l'air ont été estimées à partir de publications et correspondent à des approximations. Une analyse de sensibilité aurait pu être réalisée pour refléter l'influence de l'incertitude de cette approximation sur l'évaluation de l'impact sur la santé humaine.

III-12- Flux élémentaires ressource

Les flux élémentaires ressource ont été identifiés et quantifiés pour être inclus dans les inventaires.

III-13- Modélisation des déchets et des dépôts de fin de vie des produits

Ce critère n'est pas vérifiable pour les bateaux ou les engins de pêche et n'est pas concerné par les poissons.

III-14- Nommage et autres conventions

La nomenclature des flux intermédiaires n'est pas sujette à des contraintes spécifiques. La nomenclature des flux élémentaires n'est pas précisée. Il y a une volonté de conformité à la nomenclature ILCD mais un manque de rigueur quant au choix de la version retenue pour le contrôle de cette conformité. Pour les futures mises à jour de la base de données, il est suggéré de tester qu'aucun flux potentiellement impactant ne soit exclu de l'analyse du fait de la correspondance des nomenclature.

Pour les futures mises à jour de la base de données, il est préconisé de sélectionner une version de la nomenclature ILCD (ex. EF_2.0), d'y faire explicitement référence dans le rapport final, et d'en extraire la liste des compartiments environnementaux, des sous compartiments et des substances considérées avec leur UUID, et de ne mentionner comme émission directe de flux élémentaires que les émissions listées dans cette nomenclature avec les compartiments et sous compartiments correspondants et l'UUID qui correspond. Par exemple je ne retrouve pas quelle nomenclature ILCD Thomas a utilisé pour sélectionner le nom "Copper oxide" par exemple.

III-15- Sélection des données secondaires

Les données secondaires sont intégralement issues de la base de données ecoinvent 3 et correspondent à la meilleure correspondance concernant ces flux.

III-16- Modélisation du système

Les éléments concernant la modélisation du système sont bien pris en compte. Il s'agit en particulier de la modélisation de l'intégralité du système, de l'utilisation de données consistantes et de l'utilisation de données de qualité suffisante pour combler les manques de données.

III-17- Eviter l'allocation par subdivision des processus

Les allocations ont été appliquées conformément aux exigences de l'ILCD et du standard ISO 14040-44. En premier lieu, chaque fois que possible, les allocations ont été évitées par subdivisions du processus. Des subdivisions partielles ou virtuelles n'ont pas été nécessaires.

III-18- Résoudre les multifonctionnalités par l'allocation

La gestion des multifonctionnalités a été systématiquement appliquée dans les ICV, soit pour la modélisation des activités de pêche, l'attribution des impacts des bateaux, ou celle des engins de pêche. Ce partage a été fait en priorité avec la différentiation des processus puis sur la base de co-

fonctions par répartition des inventaires aux différentes fonctions. Pour les bateaux, la clé de répartition est le temps de pêche. Pour les répartitions entre espèces, la clé de répartition est la masse de poisson pêchée. L'utilisation de données permettant une modélisation sur la base de la fraction protéique et sur la base de la valeur économique a permis de réaliser une analyse de sensibilité sur les différentes modalités d'allocation.

L'application de l'allocation pour l'attribution du bénéfice à la fin de vie aurait pu être décrite de façon plus complète dans le rapport. En effet, la documentation ne permet pas de connaître les détails de la modélisation (bateaux et engins de pêche).

Lors des versions ultérieures, il conviendra de vérifier que les allocations y compris pour le recyclage et la fin de vie soient explicites. Le PEF Guidance issu de l'ILCD et les données EF compliantes demandent d'appliquer la "Circular Footprint Formula CFF" dans l'élaboration des ICV.

III-19- Calculer les résultats d'inventaires

La procédure de calcul des inventaires est appliquée de façon consistante sur la base de la méthode Agribalyse.

IV. EVALUATION DES IMPACTS

Cette étape n'est pas prise en compte dans la documentation remise lors de l'expertise. Elle n'est pas couverte par la revue d'expert. Ni la classification, ni la caractérisation, ni la normalisation, ni la pondération ne sont prises en compte dans la revue critique.

De même il n'a pas été possible de valider l'exhaustivité de la quantification des impacts du fait des écarts possibles de nomenclature des flux élémentaires et des compartiments environnementaux.

V. INTERPRETATION

V-1- Identification des enjeux significatifs

Le travail prend en compte l'identification des enjeux significatifs. Néanmoins, une analyse plus poussée aurait permis de garantir l'exhaustivité de cette identification. Ceci aurait pu être fait par une revue à postériori de publications par exemple.

V-2- Vérification de la complétude

La complétude des données semble cohérente mais n'a pas pu être validée du fait de l'absence de règles de cut off explicites dans le rapport final.

V-3- Vérification de la sensibilité aux paramètres clés, aux inventaires unitaires clés, aux hypothèses de modélisation, aux choix de modélisation

Les paramètres importants, comme l'allocation par exemple, ont pu faire l'objet d'une analyse de sensibilité. En revanche, certains paramètres - comme la fraction de carbone biogénique dans le bois, les impacts à la fin de vie, ou encore la toxicité de certaines émissions durant la vie des bateaux - n'ont pas été testés.

V-4- Contrôle de consistance

Le contrôle de consistance a porté sur la qualité des données d'inventaire et s'est avéré très satisfaisant. Il n'a pas porté sur le choix des méthodes d'impact et des calculs des impacts. Concernant l'évaluation des impacts, aucune inconsistance identifiée n'est reportée dans le rapport final.

VI. PRINCIPES DU REPORTING

VI-1- Rapport complet et non biaisé

Le rapport est complet et non biaisé. Certain aspects méthodologiques auraient pu faire l'objet de descriptions plus poussées, comme la modélisation de la fin de vie des bateaux par exemple.

VI-2- Utilisation des unités internationales

Le rapport utilise les unités internationales.

VI-3- Reproductibilité et public cible

Le rapport et les données publiques sont très détaillés et permettent un haut niveau de reproducibilité. Le choix de modéliser les systèmes avec des données unitaires (type U) renforce grandement la transparence. Seules les données de modélisation des bateaux manquent de transparence du fait, semble-t-il, des contraintes de confidentialité.

VI-4- Trois niveaux de reporting

Du fait du non usage du format ILCD, les trois niveaux de reporting ne sont pas satisfaits.

VI-5- Format du rapport principal

Le rapport principal est en format PDF. La base de données en format Simapro est disponible. Les données unitaires sont également produites en format Excel.

Commentaires généraux

Changer "at landing" par "Before landing". Ce point devra être corrigé lors de la prochaine révision.

Problèmes copié/collé comme "Routes needed for transport from manufacturer place to farm and from farm to disposal place of the waste are balanced in the utilised transport modules."

Ecoinvent 3.0.3.

Données 2011 avec révision 2016.

Total de 371 ICV modélisés.

Trois processus (2 LCI of pumps 40W and plywood production, for outdoor use RER) semblent directement issus d'ecoinvent mais ont des process identifiers de l'INRA Rennes. Dès lors qu'il s'agit d'une simple conversion d'unité, il convient de le préciser dans le rapport final.

Les delayed CO₂ émissions sont comptabilisées.

La quantité de CO₂ par tonne de bois semble excessive pour plywood et exotic wood. Ce point devra être clarifié et si possible corrigé.

L'interprétation montre que les résultats sont très dépendants du périmètre de l'étude, il est dès lors important que la présentation des résultats dans un cadre comparatif rappelle systématiquement les différences de périmètre des études qui peuvent générer une différence de performances environnementales.

L'absence de format et le fait que les informations sont dispersées (présentes dans plusieurs fichiers) en ce qui concerne les données de modélisation (ou centralisées dans un fichier commun pour les métadonnées) rend l'analyse des ICV complexe.

Nomenclature des flux de produits : les noms ne sont pas conformes aux exigences ILCD.

Nomenclature des flux élémentaires : la conformité avec la nomenclature ILCD impose de définir le compartiment d'émission, l'UUID du flux et l'unité de quantification du flux dans le cadre de la nomenclature.

Les flux élémentaires d'émission d'ions issus des métaux ne sont pas comptabilisés.

Commentaires spécifiques

Modification des ICV des bateaux :

Limites de communication des résultats avec des comparaisons par kg de produit pêché ou par kg de protéine mais pour des produits ayant des périmètres différents.

Analyse conformité ILCD : recommandations et exigences

1- Le nommage des processus doit suivre la structure suivante : <"Base name"; "Treatment, standard, routes"; "mix and location type"; "quantitative flow properties">. Les autres informations comme le pays ou la région représentative, ou l'année de référence ne doivent pas faire partie du nom de processus mais doivent être documentés dans les champs correspondants. Par ailleurs, lorsque le nom du processus d'un dataset est associé à un seul flux de référence, le nom du processus doit être strictement identique à celui du flux de référence.

2- Il est recommandé d'utiliser la virgule comme séparateur dans le nom complet.

3- Obligatoire pour un public technique : veiller à ce que le "base name" soit un descripteur général du flux.

4- Obligatoire pour un public technique : "treatment, standard, route" doit présenter les informations qualitatives concernant le flux de produit, en particulier le type de traitement, la norme de référence concernant le produit ou le processus, le mode de production.

5- Obligatoire pour un public technique : les "mix and location type" se réfèrent à la moyenne pondérée des géographies et des technologies des différents systèmes de production.

6- Obligatoire pour un public technique : "quantitative flow properties" doit explicitement présenter les caractéristiques quantitatives du flux comme le contenu énergétique par unité, la composition, etc.

ILCD Review report for "ICV pêche" Life Cycle Inventories

Report on ILCD general review reporting items

REVIEW REPORTING	
General information	
Data set name	
Data set UUID and version number	UUID: Dataset version: 01.00.000
Data set locator (e.g. Permanent URI, URL, contact point, or database name and version, etc.)	Agribalyse
Data set owner	ADEME
Review commissioner(s)	Cycleco
Reviewer name(s) and affiliation(s), contact	Dr J. Payet, Cycleco
Review type applied	Independent external review
Date of review completion (DD/MM/YYYY)	31/03/2019
Reviewed against / Compliance system name	ILCD Data Network - Entry-level requirements

Reviewer assessment:			
Aspect	Y e s	No	Comments
Quality compliance (aspects of ISO 14040 & 14044) fulfilled (see table 2)	X		Good overall data quality.
Method compliance (as in ISO 14040 & 14044) fulfilled and documented in data set	X		Method used fully documented in the report.
Nomenclature compliance (see table 3) fulfilled	X		Nomenclature cannot be checked.
Documentation compliance (see table 3) fulfilled	X		Most of entry-level requirements fulfilled.
Review compliance (Independent external review OR independent internal review + review report) fulfilled	X		LCI dataset had been subjected to independent external review to check the validity of technical data and to confirm the ILCD compliance.
Overall compliance with ISO 14040 & 14044	X		Data found to be compliant with ISO 14040 and ISO 14044 requirements.
Overall compliance with "Compliance system"	X		The datasets are partially compliant with ILCD entry-level requirements.
Date, location, reviewer signature	31st March 2019, Ambérieu en Bugey, France Dr Jérôme PAYET		

Specific/detailed review reporting items for LCI data set: Quality compliance (ISO 14040 & 14044). Please note that for aggregated LCI result data sets, this includes key processes in the background system.

ITEMS	Comments
Time-related coverage/representativeness: “age of data and the minimum length of time over which data should be collected” “qualitative assessment of the degree to which the data set reflects the true population of interest”	Very good
Geographical coverage/representativeness: “geographical area from which data for unit processes should be collected to satisfy the goal of the study” “qualitative assessment of the degree to which the data set reflects the true population of interest”	Very good
Technology coverage/representativeness: “specific technology or technology mix” “qualitative assessment of the degree to which the data set reflects the true population of interest”	Very good
Precision: “measure of the variability of the data values for each data expressed (e.g. variance)”	Good. Variance is not measured currently. Data go through a rigorous quality control based on a series of checks (mass, energy) as well as comparison with other similar processes (“horizontal checking”) to check for data outliers.
Completeness: “percentage of flow that is measured or estimated”; assessed on level of process	Good. All relevant flows quantified. Coverage of at least 95% of mass and energy of the input and output.
Consistency: “qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis”	Good. The entire LCI modelling and calculation for this dataset were governed by the same methodology and conducted using the same software and database system.
Sources of the data; Appropriateness of use primary/secondary data source	Very good
Uncertainty of the information (e.g. data, models and assumptions).	Unknown

ITEMS	Comments
	An assessment of the uncertainty was not conducted. No errors in the primary data are suspected. Models and assumptions have been subjected to the internal review and are hence deemed valid.
Others	<p>Overall data quality rating (DQR) assessed conservatively using expert judgment by the reviewer based on knowledge and available qualitative information, as follows:</p> <p>The DQR are not quantified in the Life Cycle Inventories.</p>

Specific/detailed review reporting items for LCI data set: Nomenclature and Documentation

ITEMs	Comments
Nomenclature	
Correctness and consistency of applied nomenclature (Preferred use of ILCD flows etc.; Correct nomenclature of other flows; Exclusion of not permissible waste flows, sum indicator elementary flows etc.)	The modelling of the Life Cycle Inventories in Simapro version 8 did not allow the control of the nomenclature.
Documentation	
Appropriateness of documentation (see Document "Documentation of LCA data sets")	The documentation appears appropriate and complete. It comprehensively presents the content of the dataset for the 3 types of meta-data (process information, modelling and validation and administrative information). It enables a fair appraisal of the dataset.
Appropriateness / correctness of documentation form (ILCD Format)	The ILCD format is not used.

Documents de référence pour la revue

ISO 14040: 2006. Management Environnemental - Analyse du Cycle de Vie - Principe et Cadre. Date: 2006-07; Edition 2.

ISO 14044 : 2006. Management Environnemental - Analyse du Cycle de Vie - Exigence et lignes directrices. Date: 2006-07; Edition 1.

Fazio S. (2016) Review schemes and reviewers selection criteria in the Life Cycle Data Network framework, and at global level; EUR 28277 EN doi: 10.2788/573305 - European Commission 2016.

European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference life Cycle Data System (ILCD) Data Network - Compliance rules and entry-level requirements. Version 1.1, 2012. EUR 24380 EN. Luxembourg. Publications Office of the European Union; 2012.

European Commission - Joint Research Center - Institute for and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - Specific guide for life cycle inventory data sets. First edition march 2010. EUR 24709 EN. Luxembourg. Publications Office of the European Union; 2010.

European Commission - Joint Research Center - Institute for and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - Reviewer qualification for Life Cycle Inventory data sets. First edition March 2010. EUR 24379 EN. Luxembourg. Publications Office of the European Union; 2010.

European Commission - Joint Research Center - Institute for and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - Review schemes for Life Cycle Assessment. First Edition March 2010. EUR 24710 EN. Luxembourg. Publications Office of the European Union; 2010.

European Commission - Joint Research Center - Institute for and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed Guidance. First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union; 2010.

European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - Nomenclature and other conventions. First edition 2010. EUR 24384 EN. Luxembourg. Publications Office of the European Union; 2010.

Annexe 1 : Liste des échanges lors du processus de revue

- Les allocations répartissant les impacts par espèce pour les bateaux, matériel pêche, consommation, sont-elles appliquées sur les quantités de poisson pêché par saison ou par an. Si c'est par an je ne m'explique pas que

Quand les données le permettaient, on a été au plus près du système, donc sur la saison de pêche qui nous intéressait (saison de germon par exemple). Mais, lorsque le professionnel ne pouvait me donner qu'une consommation de gazole par an par exemple, on a été obligé d'allouer sur les différents métiers pratiques (chalut de fond en plus de la saison au germon par exemple). Je crois que tu as oublié la fin de ta question.

Comment sera assurée la confidentialité des inventaires des bateaux?

Dans la version qui sera publiée sur la base de données Agribalyse, seuls les processus « average » et les processus accessoires tels que machine à glace, caisse à poissons etc. seront disponibles. De telle manière qu'aucun bateau individuel ne sera accessible. Je t'ai envoyé la version de travail pour que tu puisses voir comment on avait construit les inventaires.

As-tu une source à mentionner pour les quantités de carbone de 3,94 kg CO2 / kg exotic wood et les 2,96 kg CO2 / kg plywood qui semblent optimistes?

J'ai repris les informations mentionnées dans le processus : « Roundwood, azobe from sustainable forest management, under bark {RoW}| hardwood forestry, azobe, sustainable forest management | Alloc Rec, S »

Il est étonnant de voir de la glace produite à partir d'eau de mer, peux-tu le confirmer?

Oui, je confirme. En fait, ils utilisent des machines à glace avec osmoseurs pour transformer l'eau de mer en eau douce.

Peux-tu définir "écart relatif" dans précision incertitude?

Un écart-type exprimé en pourcentage de la moyenne. ETR (%) = ET/moyenne *100

Pour le Pax vobis (gadidé) la représentativité techno est "très bonne" pourtant les gadidés ne représentent que 8% de ces captures, pourrais-tu m'éclaircir sur ce point?

Idéalement, il faudrait que je repasse sur chaque navire individuel et que j'adapte ces notes. Cela étant, comme ces inventaires individuels ne sont pas voués à être publiés (ce n'est qu'une version de travail), je ne sais pas si cela serait très pertinent d'y passer beaucoup de temps. Les notes pour les inventaires « average » sont, elles, à jour.

Toujours pour le Pax vobis, il n'y a pas d'emballage (caisse), est-ce une réalité ou une limite de la saisie de données?

Non, c'est bien une réalité. Pour ce navire et pour quelques autres, le poisson est directement stocké dans de la glace en vrac dans la cale.

Le Rangiroa est pris en compte dans les gadidés (a priori 25% de ses prises) mais seules les langoustines, le thon et la seiche sont mentionnés dans les saisons. Y a-t-il une confusion avec un autre bateau?

Ce n'est pas très clair dans la description de la saison. Quand j'écris « Langoustine – poisson en mer Celtique », je fais référence aux gadidés. J'ai modifié pour plus de clarté.

Annexe 2 : Report des échanges de questions durant le processus de review

Partie méthode	Commentaires	Traitement
Objectif ICV	Page 1 : "Comment réaliser un ICV de produits de la pêche française?" et page 7 ""il n'est pas rédigé comme un guide de recommandation"	Ok, pris en compte dans la dernière version du rapport
Présentation	Utiliser le temps présent pour le rapport	Ok, pris en compte dans la dernière version du rapport
Représentativité ICV	Quelle est la représentativité des triplets par rapport à l'ensemble de l'activité de pêche Française	Très compliqué de connaître la part débarquée par le triplet vs. le tonnage global de l'espèce
Représentativité géographique	Mieux définir la distinction entre la pêche pour la zone géographique France et la "pêche Française"	Ok, j'en parle dans le paragraphe "Représentativité géographique" 1.5.2 du rapport
Description triplet	Pour chacun des triplets, spécifier s'il correspond à la pêche en France ou à la pêche Française	Ok, j'en parle dans le paragraphe "Représentativité géographique" 1.5.2 du rapport
Description triplet	Est-ce que chaque triplet est caractérisé par un bateau moyen ?	Oui
Allocation	Le bateau moyen est-il pondéré au prorata de sa contribution à l'effort de pêche?	Oui
Description triplet	Les engins de pêches similaires sont-ils modélisés de la même manière d'un triplet à l'autre.	Oui
Description triplet	Les triplets ayant des périmètres différents (transformation, conditionnement) il serait opportun de mentionner les étapes communes et les étapes spécifiques par triplet.	Pas fait mais il existe des différences à l'intérieur même de chaque triplet, certains navires conditionnent directement en vrac, d'autres en caisses etc...
Représentativité géographique	Coquille, le triplet est-il représentatif du/des gisement(s), d'un pays (France) ou d'un type de produit "pêche française".	Il est représentatif du gisement en baie de Saint-Brieuc
Frontières système	Il serait utile de préciser que le port est exclu du périmètre.	Ok, pris en compte dans la dernière version du rapport
Unité Fonctionnelle	Gadidés : UF en kg de gadidé ou en kg de chacune des trois principales espèces, en cas d'UF gadidé est-il possible de descendre au niveau de l'espèce pour une granulométrie plus fine	En kg de gadidés tous confondus
Frontières système	Pour les gadidés, est-ce que le poisson reste frais pendant 15 jours, y a-t-il des débarquements pendant la marée ou y a-t-il une congélation?	Il reste dans la glace pendant 10-12 jours

Représentativité géographique	Hareng et Maquereau, les ports sont localisés aux Pays-Bas quelle est la représentativité géographique de ces ICV?	J'ai changé la représentativité géographique de ces triplets dans Simapro
Frontières système	Hareng et Maquereau, il y a une partie de transformation à bord.	Non, congelé entier (voir tableau de présentation au débarquement p15)
Frontières système	Lieu noir frais et éviscéré avec marées de 10 jours, le poisson est-il conservé pendant tout ce temps simplement au frais?	Oui
Représentativité géographique	Sardine et Anchois, port d'attache marocain, s'agit-il de pêche Française?	J'ai changé la représentativité géographique de ces triplets dans Simapro
Frontières système	Sardine et Anchois Maroc, sont-ils débarqués frais et éviscérés?	Frais et entier (voir tableau de présentation au débarquement p15)
Frontières système	Les taux de captures non utiles et possiblement rejetés sont-ils les mêmes quels que soient les triplets?	Non, cela varie suivant l'engin utilisé
Représentativité géographique	Sardine du Golfe de Gascogne, la représentativité est-elle locale ou nationale?	Elle correspond à la zone étudiée
Description engin de pêche	Le filet trémail est-il modélisé différemment du filet droit?	Oui
Allocation	Pour sole, y a-t-il des espèces déchets ou bien toutes les espèces sont des coproduits (ex de l'araignée)?	Tout est coproduit
Allocation	Sole débarquée quelle est le ratio entre frais et éviscétré? Comment cette distinction est-elle prise en compte dans l'allocation?	En fait toutes les soles sont éviscérées (voir tableau de présentation au débarquement p15)
Allocation	Pour la sole, Il faudrait faire une extension du système en retirant l'éviscération au sol pour assurer l'équivalence des produits pour le kg de sole débarqué.	En fait toutes les soles sont éviscérées (voir tableau de présentation au débarquement p15)
Description capture	Comment est modélisé de chalutage en bœuf, comment sont allouées les captures à chacun des bateaux?	Ils se répartissent à peu près les captures sur l'année si j'ai bien compris ce que me disait les professionnels
Allocation	Quelle allocation est appliquée pour le chalutage du thon germon, entre chalutage en bœuf, multi-espèces?	
Frontières système	Quelle est la limite du périmètre pour le thon rouge, la cage est-elle incluse ou pas?	Non elle n'est pas incluse, comme spécifié dans le paragraphe sur l'unité fonctionnelle 1.3
Unité Fonctionnelle	L'UF du thon rouge péché à la senne doit-elle être le kg de thon péché ou le nombre d'individus? Qu'est-ce qui reflète le mieux la réalité économique de ce secteur?	Le thon est vendu au kilo donc la masse est une bonne UF
Allocation	Les bateaux de pêche de thon rouge à la palangre ont-ils une autre	Oui certains font du filet ou ciblent d'autres espèces à la

	activité?	palangre.
Présentation	un tableau décrivant les triplets pourrait spécifier la présentation du produit sortant.	Ok, pris en compte dans la dernière version du rapport
Présentation	un tableau décrivant les triplets pourrait spécifier la représentativité du triplet	Ok, pris en compte dans la dernière version du rapport
Présentation	un tableau décrivant les triplets pourrait spécifier le ou les types de bateaux de référence et leur nombre	Compliqué...
Présentation	un tableau décrivant les triplets pourrait spécifier les ports d'attache des bateaux.	Ok, pris en compte dans la dernière version du rapport
Présentation	un tableau décrivant les triplets pourrait spécifier le périmètre de l'ICV pour chaque triplet.	Ok, pris en compte dans la dernière version du rapport
Unité Fonctionnelle	UF est 1 kg de produit sur le bateau et prêt à être débarqué, le port n'est pas pris en compte, il ne s'agit donc pas de poisson débarqué.	Ok, j'ai essayé de ne plus parler de "poisson débarqué" mais de "poisson prêt à être débarqué"
Unité Fonctionnelle	l'UF ne s'applique pas au thon rouge à la senne	Ok déjà spécifié dans le paragraphe sur l'unité fonctionnelle 1.3
Présentation	Il serait souhaitable de définir une UF par triplet et de les rappeler dans un tableau de présentation des triplets	Ok, pris en compte dans la dernière version du rapport
Objectif ICV	L'objectif est de "fournir les données de base destinées à être utilisées par les acteurs de la filière aval" dans ce cas il faut définir les limites de la représentativité des triplets (pêche Française, locale, France)?	Ok, pris en compte dans la dernière version du rapport
Flux élémentaires	Les émissions directes sont-elles prises en compte peinture, huile, eaux usées?	Oui
Frontières système	Le remplacement des pièces des bateau est-il pris en compte y compris dans la fin de vie des pièces démontées?	Certaines pièces importantes oui
Frontières système	Préciser les triplets pour lesquels un transport additionnel doit être modélisé du fait du débarquement dans un autre port (ex : Lochinver en Ecosse).	Ok, pris en compte dans la dernière version du rapport
Frontières système	Démontrer que chaque processus exclu du système à une contribution mineure à chacune des catégories d'impact étudiée	J'ai fait un paragraphe à ce propos en 1.4.2.1
Frontières système	Quelle limite de cut off est retenue?	J'ai fait un paragraphe à ce propos en 1.4.2.1
Frontières système	Est-ce que la station de traitement des eaux usées à bord est incluse?	Pas vraiment de station à proprement parler mais prise en compte dans le bilan de matière oui

Frontières système	Infrastructure portuaire, vie des marins à bord sont exclues du système, quels sont les autres éléments (ou processus) qui pourraient être exclus? (ex : traitement eaux usées, rejet des prises non désirées, assemblage des bateaux, pertes matière et gestion des déchets de production des bateaux, déchets d'entretien et de maintenance, fin de vie des bateaux, activité de démontage, découpe, émissions directes lors de l'entretien et maintenance, idem pour les engins de pêche, rejets huile et peinture, équipement accastillage comme élingues et bouées, emballage de stockage des poissons, utilisation eau douce, électricité à quai, etc.)	J'ai ajouté des phrases à ce propos en 1.4.2.2 sur les processus exclus, notamment à propos du fait qu'un bilan de matière est insuffisant pour véritablement modéliser la construction d'un navire (cf. hélicoptère)
Description	Les produits de nettoyage sont exclus, s'agit-il des produits de nettoyage du bateau, des équipements de transformation des poissons, des cuisines?	Produits de nettoyage du navire et des divers équipements
Frontières système	Il serait utile de distinguer les bateaux avec une vie à bord et les bateaux petits à usage dans la journée, les exclusions du système pouvant être différentes d'un bateau à l'autre.	Ok
Représentativité temporelle	Années de collecte des données est 2011-2015, la date de référence des ICV est 2018?	Oui
Représentativité géographique	Il faut définir pour chaque ICV sa géographie de référence afin de valider la représentativité spatiale.	Ok, pris en compte dans la dernière version du rapport (tableau en 1.5.2)
Représentativité technologique	Concernant la représentativité des technique il faut valider que la technique étudiée est bien la principale technique de pêche pour chacun des triplets.	C'est le cas pour tous les triplets
Source des données	Il faudrait faire la liste exhaustive des données primaires collectées en données d'activité et préciser les bases de données utilisées comme données secondaires pour la modélisation et les calculs des impacts	Fait en annexe
Description	En quoi le RMD est-il utilisés dans les ICV?	Il est utilisé pour le calcul de l'indicateur, annexe, concernant la pression exercée sur les stocks
Description	Tableau 3 : la pedigree matrix est-elle issue d'ecoinvent ou d'Agrybalise, et le cas échéant quelles sont les différences avec ecoinvent?	Issue d'Agribalyse, a priori cohérente avec ecoinvent, voir avec l'ADEME
Flux élémentaires	Quelle nomenclature a été utilisée pour définir les émissions directes. Serait-il possible de faire référence à une version de la nomenclature ILCD?	
Flux élémentaires	Il faudrait une annexe avec l'ensemble des flux élémentaires input et output utilisés dans la base de données, et les compartiments correspondants	Fait en annexe

Flux élémentaires	Comment a été modélisée l'eau en consommation de ressource et en émission.	J'ai fait une phrase sur l'eau en 1.3
Représentativité géographique	Revoir la représentativité géographique sur la base de la localisation de référence de l'ICV dans les métadonnées.	Oui, j'ai pris ça en compte suite à tes remarques
Représentativité technologique	Quelle méthodologie a été mise en œuvre pour s'assurer que les flottilles de navire sélectionnées pour les coquilles saint jacques et les gadidés sont représentatives du triplet?	Expérience des professionnels (ANOP, FEDOPA etc.)
Représentativité technologique	Quelle méthodologie a été mise en œuvre pour s'assurer que le triplet est représentatif de la pêche française?	Expérience des professionnels (ANOP, FEDOPA etc.)
Représentativité technologique	Quelle validation de la représentativité des 30 navires a été réalisée au plan technique et en terme de tonnage?	Nous avons effectué une typologie préalable aux enquêtes
Description	Comment les classes sont-elles déterminées (page 21)?	Via une classification ascendante hiérarchique (classes déterminées en maximisant l'inertie interclasses)
Description	La partie saisie de données concerne principalement les données des bateaux, comment sont collectées les données de capture, les données d'engins de pêche?	C'est renseigné dans le paragraphe 2.2.3.2
Description	L'absence de l'annexe 4 ne permet pas de juger l'exhaustivité et de la fiabilité des données collectées	Ok, pris en compte dans la dernière version du rapport
Description	Pourquoi entrer l'indicateur biotique en métadonnées?	Pour informer l'utilisateur de la pression exercée par la flottille sur les stocks exploités
Description	Est-ce que les années de l'indicateurs biotiques sont les mêmes que celles des captures.	L'indicateur biotique est calculé à partir des données de capture notamment
Frontières système	Spécifier que pour engins de pêche et bateau seuls les bilans matière sont pris en compte. Les processus de transformation de la matière, d'assemblage, déchets de production, transport amont, etc. ne sont pas pris en compte.	Ok, pris en compte dans la dernière version du rapport
Description	Est-ce que tous les bateaux utilisent le même type de carburant ?	Quasiment tous au gasoil (renseigné si non : hareng maquereau)
Description	Est-ce que la combustion de diesel correspond à l'émission des bateaux ?	Oui
Source des données	Qu'est-ce qui a motivé le choix de alloc rec par rapport aux autres types de données ecoinvent disponibles?	C'est renseigné au paragraphe 2.3.2.3
Description	Quelle version d'ecoinvent a été utilisée?	Ecoinvent 3.3

Source des données	Comment ont été modélisés les transports amont (market for ou activity), quels choix de données ecoinvent a été retenu?	
Description	Les processus modélisés sur la base d'ecoinvent et les modalités de modélisation manquent (absence annexe 4).	Ok, pris en compte dans la dernière version du rapport
Allocation	Comment est pris en compte l'écart de masse pour les poissons éviscérés et étêtés lorsqu'ils sont impliqués dans une allocation?	Pas pris en compte, on a alloué sur la base de la présentation au débarquement
Frontières système	Il manque une analyse des qui permette d'identifier les processus dominants.	Oui, à mettre en limite
Impact	La construction des ICV nécessite de sélectionner les catégories d'impact permettant de définir les processus dominants et valider l'exclusion des processus.	Oui, à mettre en limite
Flux élémentaires	Il n'est pas spécifié à quelle nomenclature de flux élémentaires l'ICV doit se référer. Serait-il possible de préciser la version considérée?	
Frontières système	Il manque une évaluation quantitative validant que les processus exclus sont bien dans le respect du cut off.	J'ai fait un paragraphe à ce propos en 1.4.2.1
Frontières système	Il manque une analyse systématique permettant de valider l'exhaustivité des processus couverts.	Oui, à mettre en limite
Flux élémentaires	A l'instar de la nomenclature il est nécessaire de définir l'unité de quantification des flux élémentaires (ex eau en L). Il semble que les unités utilisées soient les unités SI mais cela n'est pas systématiquement vérifiable.	
Flux élémentaires	Il n'est pas spécifié dans l'inventaire si les émissions sont spatialisées en particulier pour les consommations d'eau.	Emissions non spatialisées
Impact	Il faudrait préciser dans la méthodologie ICV les méthodes d'évaluation des impacts qui permettent de faire l'analyse des hotspots.	Oui, à mettre en limite
Unité Fonctionnelle	La nomenclature des flux intermédiaires (noms des ICV) ne peut pas être "at landing" car il manque les infrastructures portuaires.	Ok, pris en compte dans la dernière version des inventaires
Représentativité géographique	Il y a une confusion dans le nom des ICV entre pêche française" et ICV représentatif de la zone "FR".	Ok, pris en compte dans la dernière version des inventaires
Description	En page 2 du PPT il est manque l'étape "average boat".	Ok, pris en compte
Description	Il manque un PPT illustrant une pêche multi spécifique (ex : gadidé) qui permette de voir comment sont reflétées les clés allocation.	Ok, pris en compte
Description	En terme de présentation, le PPT pourrait également reporter quels sont	Ok

	les processus pour lesquels des flux élémentaires directs sont pris en compte et quels sont-ils?	
Description	Le PPT pourrait aussi afficher des code couleurs différent pour les processus directement pris dans ecoinvent et ceux remodélisés lors du développement de l'ICV.	Ok
Description	Il est mentionné que la fin de vie des bateaux et des engins de pêche est prise en compte dans indiquer les modalités de prise en compte ni ce qui est couvert par la fin de vie.	Ok

Pris en compte
A éclaircir
Non pris en compte