# APPROACHES TO SUSTAINABILITY IN THE FISHING SECTOR

THE CASE OF CORNELIS VROLIJK'S PELAGIC FISHERIES FROM THE NORTHEAST ATLANTIC

*Industrial ecology master thesis*

**Approaches to sustainability in the fishing sector: the case of Cornelis Vrolijk's pelagic fisheries from the northeast Atlantic**

Thesis to obtain the degree of Master of Science in Industrial Ecology

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# Abstract

The meaning of what a sustainable fish food product demands can differ among the stakeholders who are knowledgeable in the product system. This thesis applies methods and tools from the field of industrial ecology to understand what sustainability means when it comes to a pelagic fish product from the Northeast Atlantic. The study covers a need of the company Cornelis Vrolijk to evaluate their environmental performance. An LCA study is performed on four of their products: blue whiting, herring, mackerel and horse mackerel. Besides hotspot identification, the practicality of the suggested improvements proposed is analysed by looking at the case of fuel sustainable procurement. Lastly, sustainability indicators for the company´s CSR are proposed. The LCA study is conducted in team, with other industrial ecology master student. The study took place from February to August 2017.

# Preface, acknowledgements and thank you notes

This is quite long and all is important. But this first paragraph will be strategic. I need to express my gratitude towards top managers, especially Caroline Vrolijk, Jacques Toennaer, and Peter Koets, for their support during the project. I hope this work is useful for your sector. For over six months I watched every documentary and read all kind of literature about marine ecosystems. There are so many problems and angles to them. At the same time, I was learning about fishing through the eyes of sector experts. This way I got a more complete story (I now eat fish, pelagic fish). Mrs. Vrolijk, I also want to say that I believe your company is beautiful. In the beginning I though your CSR policy was nice, in the end I think it is truthful. My choice of message for managers is that more than comparing the fish footprint to other food products, the results stress the need to divest from fossil fuels now, as much challenging as it is.

Now to acknowledgements, thanks and some detail about the project.

I was asked in several occasions how had I come to be working with this fishing company. So, the choice of topic for my thesis was unexpected. The one sure thing was that I really wanted Ester van der Voet to be my supervisor. And in September 2016 my ideas on topic were swirling around the landscape approach and climate smart agriculture. But at some point during the start of the semester, René Klein advised us that life could be easier if the choice of thesis topic matched the supervisor's interest. All this while I was reading an announcement posted by Ester about a study for *analysing the process of pelagic fish caught by Dutch freezer-trawlers to determine the environmental footprint per standardized unit of fish for the company Cornelis Vrolijk* (CV). I wasn´t thrilled about doing a life cycle assessment (LCA), and really knew nothing about fish. But I do like everything related to food production and I made up my mind quite easily. After expressing my desire to go on a fishing trip if possible, and getting a "we can certainly ask" from Ester, I was pretty happy about my choice. Thank you Ester, and René.

Rebecca Joubert was also interested in this study. It was decided that we would work on the LCA part together, and that each one would do something else in addition. I had learned about corporate social responsibility (CSR) at Graz university during my first MIND year. And since CV had initiated the project as part of its CSR programme, together with Aukje Coers from the company, we decided my something else part would be concerned with indicators for CSR. At the time I explored some other ideas, and I'm thankful to Aukje, Ester and Jaco Quist (who agreed to be my second supervisor later on) for listening to them and guiding me into clarity. Analissa Colombino from Graz university also advised me to focus on an LCA-CSR thesis, and dive into animal geography later on once I really had time. This really helped me move on. Likewise, my friend Juanita Barrera gracefully listened and listened and listened to me during all the thesis time.

The fishing trip was possible in December 2016. Aukje sent me off with all her own gear and lots of well-intended advice including primatour *tegen wagen-, zee- en luchtziekte*. Colin Ansink kindly took me to the vessel near Fécamp, and explained the rules to follow. Captain Huig van der Plas was very welcoming and for starters left me be at the bridge with Jaco Kuyt and Arjan van Duijn. They allowed me to observe them fish from front row all the time. Jaco also explained about nets, ropes, the fish pump and what fish meant to him. Arian explained sensors, fish biomass, the graphs on all the screens. Huub Kraijenoord explained fuel consumption and took me around the whole machine room to see the different equipment used and understand material flows; this was really the starting point to get the idea going in my head on what the LCI would have to include. Quality manager Peter de Haar showed me the fish factory; he knew

every indicator on material and waste flow that I asked about. And he also told me about his fish pets. Many more crew members shared stories with me during the three days I was there. Fun and interesting stories. Mr. Celino, who seemed to speak every language, told me about life at Sea during meal times. Many more guys also did. And chief cook Henk van Hoogdalem let me help him a bit when I had nowhere else to be (I really liked watching him cook; it's hard to explain what it is that one sees when he is working but it's really cool). I will forever be thankful to Cornelis Vrolijk for the fishing trip, and to the Afrika crew for their time, help and shared memories.

In gathering all the needed data for the LCA model we had the input of many people at the company. Maurice Tujin and John de Wit provided fuel data. Martin Fluit put us in contact with paint and refrigerants suppliers. Willem de Wit also provided paint and refrigerant data, and helped us with technical doubts. Martin Kok explained refrigerant log books and helped me figure out some mistakes in my calculations. Erik Roleverd explained fleet management and also waste management together with Wouter Beeloo. Pieter Daniels provided the landings and storage data, and helped me revise storage stay time calculations. Cees Bruinink explained us pallet flows. Bert van Duijn answered every technical doubt: refrigerants, fuel, vessel construction, waste, and put us in contact with their naval architect. Arie Aalbers provided us with all required data on vessel construction. Johan Muller helped Rebecca estimate fuel consumption over all the process stages. Mart van der Meij explained us fishing electronic equipment, put us in contact with their netting provider, and shared many iteresting stories. Erik de Graaf explained us netting production and provided all required data on the subject. Several engine rooms provided refrigerant records and filled out our data tables. Thank you to all who collaborated one way or another in facilitating our work. Likewise, I am grateful for all the time that skippers and engineers gave me when visiting the vessels. Little by little I was able filled in the gaps that allowed for understanding the system better. And finally, thank you Cok van Look for being always so welcoming; and Anton Dekker for explaining demersal fisheries and taking us to a fish auction. Thank you Rebecca, for all the time shared and the fun. This was easier and nicer because I got to do it with you and your easy going self.

Moving on to acknowledgements concerning interviews for CSR indicators. July 2017 was awesome for all the persons that I got to meet, who transmit a sense of passion and care for the fishing sector. Martin Pastoors told me about social licences and provided useful literature. Katell Hamon explained the links between bycatch, habitat protection and fish selectivity. Ian Vázquez told me about the challenge of holistic management against single fishery management. Bas Weenink put in context regulations, SDG implementation and deep Sea mining. Jurgen Batsleer explained issues concerning communicating sustainability, educating consumers and innovating the sector. Anne Reijbroek told me about public policy programs for the fishing industry and cleared out my doubts on fuel subsidies. Anne Marie Svoboda shared her view on challenges for small fisherman communities in the Netherlands and her experience working with them. Victor Simoncelli summarized how MSC certification works and described the commons problem concerning wild fisheries. Miriam Offermans gave me a very clear view of material issues for the sector at the moment and for the future, and provided very interesting material on communication strategies. Captains Huig and Hans van der Plas filled out my questionnaire providing the skipper's view on sustainability. And both shared experiences about their job on several occasions. Mart van der Meij once again made time for my new questions and shared his view as skipper and fleet manager; captain or not he was the perfect interviewee. Wesley de Kok also kindly provided his view on sustainability from fleet management perspective. Likewise, Dirk Vink explained health and safety management, and also help me understand barriers for natural refrigerants adoption. Last but not least, Jaco de Ridder described fuel sourcing, provided me with the list of suppliers, and explained practical barriers in marine fuel procurement. I am very grateful to all for your time and effort in helping me. This quick summary makes no justice to all the detail from your rich conversation.

Throughout the project Aukje helped us improve the LCA model, attended meetings with our supervisors, help us speed up data gathering, suggested improvements for the report and presentations, and provided advise all the time. I came with her to a workshop on climate change scenarios for the sector, and to a herring party the same day. This was the starting point for starting the CSR/sustainability interviews. Oh, and together with her we tried our first raw herring on Flag day. All that came with this thesis goes back to Aukje, who is fierce and passionate about her work. Thank you so much.

This research meant exercising what I had learned from the MIND program on LCA in Leiden university, and CSR and eco-controlling at Graz. I am thankful to my teachers from these courses: Valentina Prado, Jeroen Guinée, Ulli Gelbmann, Martina Zimek, and Arijit Paul. I literally took out my notes, went back to their provided slides and literature, and the work simplified. Equally, in real time, Ester always provided clear cut solutions to my doubts and in the last run really pushed me to improve the results. Jaco Quist, and also Andrea Ramirez, who was Rebecca's supervisor, provided detailed input for refining the drafts. And from a time before MIND, what Gemma Cervantes thought me also found a place here in this theses. Thank you to all.

Thinking on the whole master program, I would like to name all the teachers from whom I learned in the past two years and mention what I specially remember them for because I don´t want to forget it. But I will just say how enormously grateful I feel towards the MIND program lecturers for widening my view on life. And it really comes back to the passionate teachers who left a mark on me, who gave quality food for my mind which will last there for much longer. Specially concerning this thesis, several times I felt like telling professor Justin Winkler that I saw and felt aesthetics in fishing, and that I think the case is similar to that of forest appreciation.

My parents and brother, and grandma and aunts, and my dearest friends from all over, are always there and emphatic towards what I'm doing and how I feel. I am grateful for your love.

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# Executive summary

## Research questions

Cornelis Vrolijk, a Dutch fishing enterprise, started this study to calculate the environmental footprint of their pelagic fish through a life cycle assessment (LCA). Four fish species are regarded: herring, mackerel, horse mackerel and blue whiting. The company was interested in identifying hotspots in their production processes, and be provided with recommendations for their corporate social responsibility (CSR) policy. Thus, the research questions are the following:

- What are the environmental pressures and impacts of the cradle-to-gate of four of CV's pelagic fish products, namely blue whiting, herring, mackerel and horse mackerel?
- What improvement options could be identified from the above analysis?
- What indicators derived from the analysis are suitable to be included in CV's CSR policy?

In regard to contributing to the industrial ecology field, a fourth research question is

- Can results from LCA be better embedded in CSR literature and could this benefit from supply chain management thinking?

## Cornelis Vrolijk

The fishing company uses freezer trawlers for its operation and relies on large storage space to maintain their fish fresh until selling. The first part of the process happens off shore in their multiple vessels. A fishing trip lasts around five weeks. It involves steaming to fishing grounds, and then simultaneously fishing, freezing, packaging, storing, and then steaming in to port. One a shore the fish is unloaded and stored in on-shore storehouses until sold.

Concerning their CSR, the company greatly focuses on complying with institutions and ensuring employees wellbeing. Targets on reducing their carbon footprint from vessels and storehouses in 2021 are stated in their 2016 report. Furthermore, the company claims to contribute to the food security in west Afrika.

## Methodology and Results

Two main topics are treated: an LCA on four fish products, and a set of indicators for CSR reporting. More briefly, barriers for sustainable sourcing of marine fuels and the interlinkages between LCA, CSR and supply chain are discussed.

### LCA of Cornelis Vrolijk's pelagic fish

System boundaries are set as cradle to on-shore storage gate. Functional unit is 1 kg of fish. The reference flows are providing one kilo of either herring, mackerel, horse mackerel, or blue whiting for consumption. Geographically, the study represents fishing operation in the north east Atlantic. No biological categories are studied. The baseline impact categories CML 2001 method are used to calculate the environmental profile. Physical allocation is chosen, and economic allocation is applied for the sensitivity analysis. Contribution analysis is performed for the whole system, for process stages and for some vessels to illustrate differences. Scenarios are assessed based on the hotspot identification. In one case it is proposed that all the vessels would use 100% marine diesel. In a second one first generation biodiesel is used.

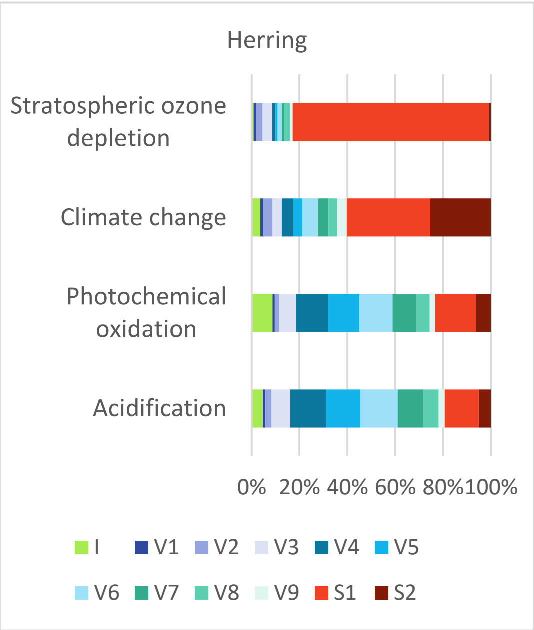
## *Environmental profile*

The carbon footprint ranges from 1 kg $CO_2$-Eq for herring, to 1.19 kg $CO_2$-Eq for horse mackerel. Human toxicity shows the highest normalized impact results, followed by depletion of abiotic resources, acidification, and climate change.

| Impact category | Herring | Mackarel | Horse mackarel | Blue whiting | Unit |
|---|---|---|---|---|---|
| Land use, competition | 0.385 | 0.391 | 0.423 | 0.591 | $m^2a$ |
| Eutrophication | 1 | 1.13 | 1.26 | 1.42 | g PO4-Eq |
| Depletion of abiotic resources | 4.79 | 5.23 | 5.75 | 6.17 | g antimony-Eq |
| Acidification | 7.72 | 9.17 | 10.3 | 10.5 | g $SO_2$-Eq |
| Photochemical oxidation | 0.252 | 0.294 | 0.333 | 0.354 | g ethylene-Eq |
| Climate change | 1 | 1.11 | 1.19 | 1.16 | kg $CO_2$-Eq |
| Terrestrial ecotoxicity | 1.91 | 1.97 | 2.21 | 3.04 | g 1,4-DCB-Eq |
| Freshwater aquatic ecotoxicity | 81.1 | 75.7 | 87.2 | 154 | g 1,4-DCB-Eq |
| Stratospheric ozone depletion | 67.7 | 75.2 | 78.9 | 65.6 | mg CFC-11-Eq |
| Human toxicity | 0.41 | 0.421 | 0.49 | 0.734 | kg 1,4-DCB-Eq |

## *Contribution analysis*

All fish species follow the same trends. In terms of on shore (vessels) and off-shore (storehouses) activities, in almost every impact category, vessel operation contributes with more than 60% of the total impact but stratospheric ozone depletion. Infrastructure's contribution (I) is negligible in comparison to the other two (vessels V#, and on-shore storage S#). See figure.




Fuel is the main input driving the environmental performance of the fish production in almost every impact category. Around 50% of photochemical oxidation comes from sulphur content in the fuels. Sulphur also contributes to about 40% of acidification. Concerning climate change, carbon dioxide from the combustion of marine diesel and heavy fuel oil in the vessels contributed 17-23% and 20-28% respectably; but emissions of refrigeration fluids (HFC-134a, HFC-143a, HFC-125) from storage also contribute. And regarding human toxicity, combustion of heavy fuel oil contributed 28-38% due to emissions of benzene, arsenic, nickel, and polycyclic aromatic hydrocarbons.

When fuels consumption is taken out of the system impact contribution shows that within the vessel operation, packaging is an important stage to keep in mind. Interventions in packaging include: pallets, cardboard and plastic packaging materials, and related solid waste. Zooming into the contribution within the packaging stage shows that production of unbleached board (for the production of cardboard boxes), and high density polyethylene are important processes to look at.

For the storehouses off-shore, the possibility of reducing impact would lie in the refrigerants concerning the climate change category. This would imply completely changing to natural refrigerants (ammonia and carbon dioxide) and avoiding leakages as much as possible.

### *Sensitivity*

Economic allocation diminished environmental impact blue whiting, and increased for mackerel and horse mackerel compared to results for physical allocation. Changes are around 20% for mackerel, horse mackerel and blue whiting. Results for herring change only marginally. In any case, both options appear to represent the reality as explained at the company. That herring. mackerel and blue whiting are fisheries in a much better shape, in comparison to horse mackerel which landings take more effort. And in the case of blue whiting, the higher results concerning physical allocation make sense when considering that the fishery is found much farther away that the other and thus requires more steaming in and out resources.

### *Scenarios*

The straightforward improvement would be avoiding the usage of heavy fuel oil by substituting it with marine diesel. This change would not bring an improvement to climate chance, but it would certainly translate into relevant improvements for acidification, photochemical oxidation categories and human toxicity.

A second analysed scenario was the usage of first generation biodiesel instead of heavy fuel oil and marine diesel. Results show potential trade-offs in many categories. contribution to climate change, acidification and resource depletion is reduced, but impact to other categories such as eutrophication, land use and ecotoxicity can be increased. Thus, in order to decrease the potential trade-offs, the company would need to pay attention to the supply chain. Biofuels are in fact one of the most prominent alternatives to fossil fuels in the marine sector (IRENA, 2015).

Besides these two scenarios concerning fossil fuel consumption, many others could be imagined. The ones presented were chosen for their simplicity in evaluation.

## Indicators for CSR reporting

Environmental indicators are proposed for CV to include in their CSR policy. The boundaries for designing the indicators were set the same as for the LCA: pelagic business unit. Objectives and themes from a materiality assessment are the base for proposing the indicators, many of them taken from literature. To account for materiality, stakeholders from inside and outside the company knowledgeable in the fishing sector were contacted and asked to respond to five open questions regarding what their view on sustainability was. In total 15 interviews were conducted.

Overall, the indicator set (1) stakeholder opinions from interviews, (2) literature revision on supply chain, sustainability and fisheries available indicators, (3) criteria on sustainable aquatic supply chains, (4) 2016 CV’s CSR report, and (5) insights into sustainable procurement concerning fuels.

## Sustainable procurement

Having as background the LCA results and potential improvement options, an interview on fuels procurement with the company´s purchasing department gives insights into the matter.

The results from the LCA study showed fuel is the greatest contributor to environmental impact. The problem is the industry greatly relies on this input to operate. Other alternatives for operation are wind and solar energy, still quite uncommon for large vessels, and biofuels which appear to be promising but are still in a development stage. Thus, the recommendation for Conelis Vrolijk is to switch from using heavy fuel oil and marine diesel to 100% marine diesel, and to green its supply chain as much as possible. The option is technically possible, although challenging at some extent; economically, it still has to be assessed. But there is a third issue to consider: the supply chain

CV mostly relies on brokers to find their fuel suppliers. Such brokers translate into mainly six physical suppliers, whose information regarding sustainability seems to be is not made readily available (only available information online was searched for). In fact, there is very little experience in sustainable supply chain management (SSCM) in the oil and gas industry. The first studies were only published in 2007. And to this date, there seems to be no systemic SSCM studies, which is a gap in the field given the importance of this sector in the global economy. (Ahmad, et al. 2016)

The recommendation for CV is to include in their purchasing policies an approach to environmental and human rights protection as requirement in their procurement policy. Pushing their fuel suppliers to comply with having a CSR policy in place would be a good practice. Likewise, CV should monitor itself concerning its "level of procured green products" and the "number of its innovation projects in regard to divesting from fossil fuels usage".

## CSR indicators

Overall, 32 indicators are proposed to include as part of in Cornelis Vrolijk's CSR reporting. It was possible to estimate the baseline value for many of them using the data available from the LCA study. The next table summarizes the results. Furthermore, the coloured cells show (green) if the indicator is easy to estimate by the company even calculation for this research was not done, or (orange if it is a new indicator for the company and possibly harder to estimate.

| I# | Indicator | Baseline value |
|---|---|---|
| 1 | Level of bycatch **[%/year]** | 13 |
| 2 | Average size of fish caught **[cm]** | |
| 3 | Harm to habitat structure **[number of incidents]** | |
| 4 | Level of clean electricity consumption **[%]** | |
| 5 | Level of clean fuel consumption **[%]** | 56 |
| 6 | Level of energy consumption at vessels **[MJ/kg fish at vessel]**<br>Level of energy consumption at on-shore storage stage **[MJ/kg fish at storage]** | 7.9<br>0.3-5.5 |
| 7 | Average carbon footprint per unit of product **[kg$CO_2$/kg fish]** | 1-1.2 |
| 8 | Refrigeration fluids lost through leaks **[%]** | |
| 9 | Level of procured materials with sustainable sourcing approach **[%]** | |
| 10 | Mass of netting lost at Sea **[t/year]** | |
| 32 | Waste fish landed **[%/year]** | 1.5% |
| 11 | System flows managed under a circular economy approach **[number]** | |
| 12 | Innovation projects related to divesting from fossil fuel usage **[number/year]** | |
| 13 | SDG targets to which the company contributes **[number]** | |
| 14 | Fish sold for human consumption **[%]** | |
| 15 | Sponsored activities **[number/year]** | |
| 16 | Skippers contributing to collective knowledge about the state of marine zones **[%]** | |

| I# | Indicator | Baseline value |
|---|---|---|
| 17 | Trips made in cooperation with the scientific community **[number]** | |
| 18 | Available institution briefs and company's remarks **[number]** | |
| 19 | North Sea GES report **[metrics relative to GES threshold]** | |
| 20 | Catch per unit effort **[kg/day-person]** | 17-113 |
| 21 | Food miles **[km]** | |
| 22 | Sold species with "good to know information" data sheet available **[%]** | |
| 23 | Visits to/from fishing schools **[number of students], [number of visits]** | |
| 24 | Vessels with safety management system in place **[%]** | |
| 25 | Vessels with stablished rules for healthy living styles **[%]** | |
| 26 | Employees aware of CSR policy **[%]** | |
| 27 | Trained employees rate **[number/year]** | |
| 28 | Improvement suggestions submitted by employees **[number/year]** | |
| 29 | Sold fisheries MSC certified **[number]** | |
| 30 | Campaigns started in regard to the business unit **[number/year]** | |
| 31 | Management positions with specific sustainability responsibilities **[number]** | |

Out of the 32, 19 indicators can already be easily reported (green cells). But from the whole set, it will be up to the company to decide to use them all or only some.

Based on the CSR indicators proposed in the previous section, a SBSC is arranged in order to signal connections among indicator concerning the customer, internal process, learning and growth, and financial perspectives of the business unit.

The design of indicators was improved by taking into account findings from the supply chain of fuels as it is for the company. In sum, several interlinkages between the three approaches (LCA, CSR and supply chain) were identified:

- Gaps in LCA inputs can become relevant indicators to monitor as part of the CSR policy
- Data gathering for LCA fosters channels of communication inside the company
- Understanding the supply chain of relevant inputs for the LCA results allows for sounder improvement recommendations and for better indicator design
- LCA gives a starting points for "greening" the supply chain
- CSR compliments LCA and supply chain analysis, they alone cannot speak of sustainability integrally

## Conclusions

Goals for this thesis were accomplished and all four research questions answered. The need of Cornelis Vrolijk to identify hotspots. Indicators for their CSR policy were also proposed. And finally, interlinkages between LCA CSR and supply chain are the following:

the identified linkages are the following:

- Gaps in LCA inputs can become relevant indicators to monitor as part of the CSR policy
- The process of data gathering for LCA fosters channels of communication that can be the base for embedding the CSR policy of the company in a shared mental model among all staff

- Understanding the supply chain of relevant inputs for the LCA results allows for sounder improvement recommendations
- Understanding the supply chain of relevant inputs for the LCA results allows for better indicator design
- LCA points to which inputs can be the most relevant when starting to “green” the supply chain
- CSR compliments LCA and supply chain analysis, they alone cannot speak of sustainability integrally

# 1. Introduction

The topic for this thesis proposal developed from the need of a fishing company, Cornelis Vrolijk (CV), to analyse environmental aspects of its production process. CV is a Dutch enterprise that started operations back in 1880. Currently it fishes the Atlantic Ocean and the North Sea. Its core activity is fishing for pelagic fish with freezer-trawlers in European waters. About 600 people are involved in the pelagic fishing activities by the company.

At the moment, CV is interested in calculating their environmental footprint. As a company concerned with sustainability, they will monitor and report environmental indicators as part of their Corporate Social Responsibility (CSR) strategy.

CV has certified several of its products by the Marine Stewardship Council, which means their catches are aligned to biotic resources conservation. However, different information sources portray many other themes related to sustainable fish. Some claim the Sea is being emptied, and propose we should innovate the sector by relying on genetically modified fish (Greenberg 2015). Forced human labour is another topic related to some fisheries in some countries (The Guardian 2016). Nutrition and food system issues also arise (Seaver 2010). Animal rights activists argue if eating fish is moral (Joy 2009). While concerning technical issues, marine traffic is said to be the reason behind sea mammals beaching (Dougherty y Hinerfeld 2015). And along with aviation, marine traffic contributes to transboundary greenhouse gas and air pollutants emissions; ships in port are a significant contributor to poor local air quality due to the burning of fossil fuels in combination with old combustion technology (Parth Trilochan 2015).

The title of this thesis, approaches to sustainability in the fishing sector, does not address all the above listed topics. Mentioning them is mainly to set the context for the industry, commonly regarded in a not so positive manner. That is what I knew about the sector before this research. But in fact, most of the above mentioned issues about fish production and consumption are systemic; if problematic, they are not solvable by one single company changing its way of operation.

At the moment of starting this research CV was interested in identifying hotspots in the production processes of four of their fished species, and be provided with recommendations for their corporate social responsibility (CSR) policy. Thus, this research work involved the application of tools from industrial ecology to respond to CV´s needs.

The report is divided into four main sections. The first one and most robust one concerns a life cycle assessment (LCA) for identifying hotspots. The following ones derive from the LCA results. The second section is concerned with sustainability indicators suitable to be taken into account as part of the company´s CSR reporting. Its objective is to take indicators derived from the LCA results and related data that can be useful for the company, and compliment them with other indicators from literature and from acknowledging what is important for stakeholders. Likewise, in connection with the LCA results, the third section describes the barriers for implementing the recommendations derived from hotspot identification. The fourth and final section discusses the interlinkages between LCA data collection and results, sustainability reporting through CSR, and sustainable supply chains.

The LCA part of the research was developed in partnership with another industrial ecology student, Rebecca Joubert, whose second part of research went in the direction of analyzing trends in horse mackarel fish historical landings.

**Box 1. Brief history of Cornelis Vrolijk**

The company started by only trading fish. In its first decades it went from trading to fishing&trading and back several times. Fish used to be put in baskets, strewn with salt and placed in barrels. In 1902 it first fished with a *steam lugger* which had a steam engine. By 1914 it got its first *steel lugger* ship, and in 1915 it became motor-powered, gaining great advantage in productivity. By 1923 the company started with trawl fishing, beginning a golden period. WWII made fishing very dangerous, together with the fact that the North Sea, where they fished, had started to show signs of overfishing. After the war the fish population had recovered. (Cornelis Vrolijk Holding BV 2002)

By the 1960's the company had improved its technology moving to the *stern trawler,* having better freezing facilities. The 1970's brought the commons fishing policy. During all this time the main product for the company had been herring, but its fishing came to a halt between 1978 and 1982, and the market for other products was developed. At the time the owners focused on the European market. But in the 1980's, with the introduction of fishing quotas, the company joined the Dutch seafrozen fish foundation. At that time, such organization had the mission of finding new markets, west Africa being the first targeted one. After a few years they were successful in turning the Egyptian and West Africa population into major consumers of herring. Also in this decade, the company grew by acquiring subsidiaries in UK and France. (Cornelis Vrolijk Holding BV 2002)

Fishing in Africa started in the 1990's, specifically in Mauritania and Marocco. In fact, one of Cornelis Vrolijk´s biggest vessel, the Caroline, is especially suited for tropical waters. During the 2000's their available storage infrastructure greatly increased. To date, Cornelis Vrolijk is one of the most importanf fishing companies in the Netherlands and Europe. (Cornelis Vrolijk Holding BV 2002)

Concerning pelagic fish, herring keeps on being the most important species in terms of catches. And although the company still has European buyers, their main market now is in Africa. And most of their fish are sold for human consumption. 70% of their production go to the African market. On average they provide 1.5 million fish meals a day in West Africa (Cornelis Vrolijk 2012).

The research questions for this study were the following:

- What are the environmental pressures and impacts of the cradle-to-gate of four of CV's pelagic fish products, namely blue whiting, herring, mackerel and horse mackerel?
- What improvement options could be identified from the above analysis?
- What indicators derived from the analysis are suitable to be included in CV's CSR policy?
- Can results from LCA be better embedded in CSR literature and could this benefit from supply chain management thinking?

The main goal was to respond to the need of an industry to identify hotspots and propose potential improvement options for their environmental performance. But more personally, it was to develop a case for what a sustainable fish product would entail by studying the real case of the company Cornelis Vrolijk. To accomplish this, the following objectives were considered:

- Producing an LCA study on four of CV pelagic species.
- Proposing possibilities for improving the environmental performance of CV.
- Suggesting indicators to be part of CV´s CSR strategy.
- Analysing the interlinkages between LCA, CSR and supply chain management to derive improvement options for CV

**Box 2. The fishing sector at glance**

Fish is one of the most traded food commodities worldwide. More than half of exports by value originate in developing countries. 87% of fish production was used for direct human consumption in 2014. And it is expected that more and more fish will contribute to food security and nutrition in the coming years. World per capita fish consumption has reached about 20 kg per year in 2015, but it is larger in more developed nations. In developing countries fish consumption is driven more by supply than demand because consumption tends to base on the available products. (FAO 2016) Concerning pelagic fisheries, they are often overlooked as a food option in developed countries (Parker and Tyedmers 2015).

Freezing is the main method used for processing. In 2014 and 2015 the European Union was the largest market for fish imports, followed by USA and Japan. The Netherlands is among the top ten exporters of fish products, while Africa has been a net importer since 1985 (FAO 2016).

About 56.6 million people were engaged in capture fisheries and aquaculture in 2014. Women accounted for 19%. Globally, the total amount of vessels is about 4.6 million. Asia accounts for 75% of the global fleet. Small vessels (less than 12 m in length) dominate the sector. There are about 50 regional fishery bodies worldwide, which have a say in governance issues within the fishing sector. (FAO 2016). More than a national matter, marine fishing is related to the sea as a global common governed by fishing companies' institutions with the participation of governments and international NGOs (Barret 2008). It is relevant to mention that utilization of by-products is becoming an important industry for the food, chemical and energy industries (FAO 2016).

The share of fish stocks within biologically sustainable levels has decreased from 90% in 1974 to 69% in 2013. Global total capture of fish in 2014 was 93.4 million tonnes, 87% coming from marine waters (FAO 2016). During the 1990s world wild fish catch was below 80 million tons per year. Around the time, FAO believed the wold could not sustain extracting more than 100 million tons. (Meadows, Randers y Meadows 2004).

The catch of marine fish has stagnated already and will probably decline in the years to come to 2050 (Butcher 2017). FAO states production of capture fisheries is expected to remain constant for the next decades, but uncertainty is acknowledged when climate change and extreme weather events are considered. Physical and chemical changes in the ocean could mean changes in catch quantity and composition. Also, extreme weather events will have effects on infrastructure like ports and fleets, and on the raising costs of fishing. (FAO 2016) Likewise, fisheries will most probably face continued pressure by rising fuel costs and carbon related regulations in coming years (Parker and Tyedmers 2015).

Trade in fish is said to be mainly driven by demand from developing countries and in less degree to international trade rules. But other dynamics are also important. Requirements for quality and safety, technical standards and labels, voluntary certifications concerning biology, and human rights indicators are gaining momentum specifically for species targeted at better-informed consumes, or high value species such as tuna, shrimp, salmon, bass, etc. This is hardly the case for high volume, relatively low value, trade in large quantities species, such as small pelagic exported to low income consumers. (FAO 2016)

# 2. Background

## 2.1 LCA of fish products

LCA is considered a relevant tool for the fishing sector. Farmery et al. (2014) claim that using it in fisheries management can provide information that leads to enhance the sector's sustainability. In fact, interms of sustainable food, small pelagic fisheries rank among the most efficient forms of animal protein (Parker and Tyedmers 2015).

### 2.1.1 Methodological choices in literature

Pioneer studies of LCA applied to fishing started being published around 2003. A review on papers from the period 2003-2013, showed the following:

- Most studies have been attributional type and refer to European operations (Avadí & Fréon, 2013)
- Goals focused in identification of hotspots and the comparison of fishing methods. "All studies analysed fuel-related impacts, and several also analysed the use of metals" (Avadí & Fréon, 2013)
- Functional unit has been set in terms of mass of fish, and occasionally including packing material (Avadí & Fréon, 2013). The choice is not clearly justified, and there is usually no distinction between the FU and the reference flow. Authors arguing on appropriate FU for food products say mass and volume choices ignore important functions of food products. Nutrient and energy consideration in FU is encouraged, although complexity for reporting on it regarding fish products is recognized (Meissner Schau & Magerholm, 2008).
- LCIA methods used were: CML, EDIP and Ecoindicator99 (Avadí & Fréon, 2013). CML has been the predominant method (Vázquez-Rowe, Hospido, et al. 2012).
- Focus has been on typical categories. Global warming is the most popular one. Acidification and euthropication are also considered most of times. Abiotic depletion and ozone layer depletion follow. Photochemical oxidant formation, energy related and toxicity related categories have been regarded on a lower level (Vázquez-Rowe, Hospido, et al. 2012).
- Besides the typical LCA categories, some studies have included some fishery-specific impacts: discards, by-catch, sea floor disturbance, undersize catch, idle and ghost fishing gear, and marine pollution. Most common one has been discard reporting (Vázquez-Rowe, Hospido, et al. 2012). Findings suggest it is necessary to apply seafood-relevant impact categories in order to allow for whole supply chain analysis and comparisons (Avadí & Fréon, 2013). Biotic resource use (BRU), based on net primary productivity is said to be an attractive complement to other impact categories. A global discard index has also been proposed (Vázquez-Rowe, Hospido, et al. 2012).
- Most studies have focused on characterization results, while fewer consider normalization (Avadí & Fréon, 2013) (Vázquez-Rowe, Hospido, et al. 2012).
- During information gathering for the life cycle inventory, it is typical to find large differences concerning years and months. Most studies rely on short periods of analysis, usually one year, but expanded time lime analysis are encouraged. (Vázquez-Rowe, Hospido, et al. 2012)
- Sensitivity analysis has not been a regular practice in existing studies (Vázquez-Rowe, Hospido, et al. 2012).

- Discussion of socioeconomic issues has been minimal in the context of fisheries LCA literature, and there is a need for comprehensive assessment of environmental impacts of fisheries in the context of whole supply chains (Avadí & Fréon, 2013).

Special attention should be given to system boundaries. According to Avadí & Fréon (2013), most studies have excluded the construction phase and included transportation related to landing and delivery; while processing operations separated from extraction were also sometimes considered. But their discussion encourages a more detailed inventory concerning the construction phase because its impacts have been found relevant sometimes. They claim must studies use third party data without assuring the supply chain is actually accurate. A study from Portugal dealing with sardine claims not to have included the vessel and gears as part of their system boundary, since it was expected they would have minor contribution to the impact categories due to large life spans and large volume of landings (Almeida, et al., 2014). Most studies seem to have relied on factor calculation from national statistics or by a combination of data from several enterprises, leading to results of theoretical average products, not necessarily the ones found at a retailer´s. Transportation phase to wholesaler is not always considered. But some studies do include it. For instance, a study on pelagic species from Norway found transport abroad contributed less than 25% to the total carbon footprint (Ziegler, et al., 2012). Transport mode is very important. Boat transport of transcontinental fish is ten times more efficient in terms of energy than air flights (Andersen, 2002).

Regarding the fishing operation phase, use of lubricating oil and refrigerant agents have been found to have minor impact. Reporting on antifouling paint has had problems for characterization because it is composed of several metals not yet considered in data bases. Fuel use intensity and efficiency is dependent on fishing gear (Avadí & Fréon, 2013) and species class more than the region where they're fished (Parker and Tyedmers 2015). It is encouraged that fuels use is disaggregated as far as possible within the ship (Avadí & Fréon, 2013).

Solid waste and wastewater related to daily life in the ship are usually not accounted for because they have low importance and they are not directly connected to productivity. But bilge waters are considered.

Allocation is key topic of discussion within the literature. Besides mass, other approaches have included gross energy content, hybrid mass and economic, and quality (Avadí & Fréon, 2013). The gross energy content approach considers the ultimate function of fish is the provision of food energy. And although economic allocation is referred as very suitable by some (Avadí & Fréon, 2013), others argue it leads to misleading results due to prices of lower value and high value species (Almeida, et al., 2014). Another reason for avoiding it is said to be that fluctuations in prices introduces the problem of temporal variability (Ziegler, et al., 2012). There has been an increase in the use of mass allocation. The energy density approach has also been considered as a good one; but it is also thought that it would lead to further atomization in LCA results. For the sake of transparency and reproducibility, allocations should be deeply explained and justified (Vázquez-Rowe, Hospido, et al. 2012). Mass allocation is preferred for external communication to the market. As for internal purposes, both mass and economic are good choices; economic is preferred but final choice is study dependant (Svanes, et al., 2011).

The following Table summarizes main characteristics and findings from some pelagic fish LCA found in literature.

*Table 1. Summary of characteristics of pelagic species LCA literature.*

| Study | Functional unit and allocation | Impact categories | Key findings |
|---|---|---|---|
| Fozen herring and mackerell (among others) from Norway by Ziegler et al. (2012)<br>1 year data | 1 edible kg delivered to a wholesaler; mass allocation. | Climate change | Fuel use, refrigerants, product yield, and by-product use are key input.<br>There is considerable variability among fishing methods used to land the same species -> resource efficient ways of fishing |
| Atlantic horse mackerel in Galicia, Spain by Vázquez-Rowe et al. (2010) | 1ton of landed round Atlantic horse mackerel in a Galician port in the year 2008; mass allocation. | Abiotic depletion, acidification, eutrophication, global warming, ozone depletion and human and eco toxicity. | Main issues: diesel production, transport and consumption; cooling agent leakage and discard rates. Purse seiners performed better than bottom trawlers. |
| Atlantic mackerel from Basque country, by Ramos et al. (2011) | 1ton of landed round fish in a Basque port during the North East Atlantic mackerel fishing season for each of the selected years (8); no allocation needed. | Acidification, abiotic depletion, eutrophication, global warming, ozone depletion, marine aquatic ecotoxicity, discards, and fisheries in balance index (FiB). | Impact dominated by energy use. Strong differences found due to stock abundance between years. FiB dentified the evolution of the stock. |
| Purse seine sardine fishery in Portugal by Almeida et al. (2014). | 1kg of whole sardine landed in port; mass allocation. | Energy use, climate change, eutrophication, acidification, and ozone depletion, overfishing, overfisherdness, lost potential yield, mean trophic level and primary production required. | Fuel consumption as most important input. Inclusion of biological information showed there were problems in the sustainability of the stock. |

A set of common ground principles for the fishing activities have been suggested by Vázquez-Rowe et al. (Best practices in life cycle assessment implementation in fisheries. Improving and broadening environmental assessement for seafood production systems 2012) in order to set minimum requirements for data completeness and study reproducibility, facilitating comparison among studies. The following Table summarizes such requirements.

*Table 2. Suggested minimum requirements for fishing LCA studies.*

| Phase | Minimun requirements |
|---|---|
| Life cycle inventory | Diesel production and consumption, gear production and use, anti-fouling and boat paint, cooling agents, ice production, on-board processing of seafood, vessel construction, seafloor impacts, bait, captures and landings. |
| Goal and scope | Function of the product system, functional unit, system boundaries, allocation: economic or biophysical. |
| Life cycle impact assessment | Global warming, ozone layer depletion, abiotic depletion, acidification, eutrophication, marine ecotoxicity, biotic resource use, global discard index and other specific fishery impact categories. |
| Life cycle interpretation | Characterization results interpretation, sensitivity analysis for seafood products, LCA+DEA analysis for multiple vessel fleets. |

DEA stands for data envelopment analysis and is an attempt to reduce the effect of increased standard deviations. This is useful for LCA of fishing products because large studies usually deal with data using an average inventory of collected facilities under assessment, but high standard deviations are then created. The LCA+DEA method renders indicators dealing with inefficient operations, which is an added value to the approach (Vázquez-Rowe, Hospido, et al. 2012).

A general fish production system has been proposed for analysing the supply chain under sustainability purposes. Such system comprises: fishing vessel, fish catching, fish processing, transport, and purchase, as depicted (Figure 1). Impacts and outputs from the fish catching subsystem are shown in Figure 2. Fish processing can include freezing, mincing, heading, bleeding, gutting, defrosting, refinement activities, etc. These activities can either happen on or off-shore. Authors mention the importance of considering transportation to retailers, but leave out of scope transportation from suppliers to the fish production system. (Magerholm Fet, Schau and Haskins 2010)

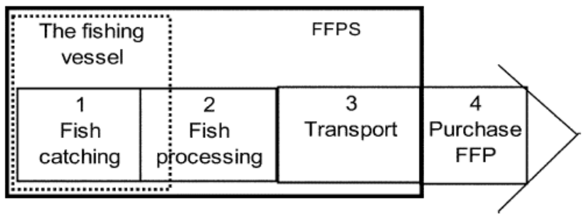



*Figure 1. Fish production system and fish catching subsystem. (Source: Magerholm Fet, et al., 2010)*

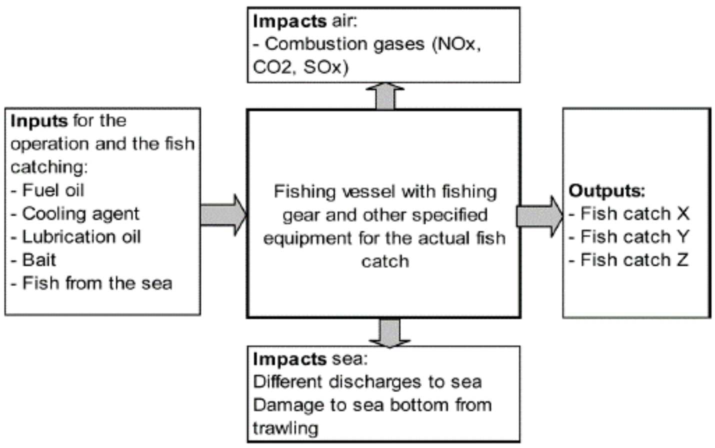



*Figure 2. Fish catching subsystem. (Source: Magerholm Fet, et al., 2010)*

It has been suggested that data for the fishing vessel should cover its entire life cycle. Fish catching should cover the operations of the vessel for the specific fishery under analysis. Data from the fish processing should include processing operations, packaging and transport to the retailer. (Magerholm Fet, Schau and Haskins 2010)

### 2.1.2 General findings on environmental impact

The industry is governed by national legislation applicable to the nation where vessels are at any moment. Among the most cited problematic aspects are obsolescence of fishing fleets and high fuel consumption. Similar vessels can have different energy usage depending on hull design and propulsion systems, propeller type and size and different techniques and tactics. Fuel usage reductions come from technical improvements and better fishing practices (Eurofish Magazine, 2011). According to LCA results, fuel use is referred as having the greatest environmental burden. (Avadí & Fréon, 2013). Between 30 - 50% of fishing expenditure is on fuel, accounting for 60 to 90% of GHG emissions up to landing. Median fuel use intensity of global fishery records since 1990 is 639 L per ton. (Parker and Tyedmers 2015).

On fuel consumption it can also be said that marine transportation is the fifth largest contributor to air pollution and carbon emissions. Besides carbon dioxide, other pollutants include sulfur dioxide, nitrogen oxides, volatile organic compounds, particulate matter and other greenhouse gases. But there is a high level of uncertainty concerning emissions estimations. Data is scarce and limited. This is delicate issue since the international regulatory institutions on the matter make it complex to abate air emissions. Existing policies mainly deal with quality of fuel used and technological available options, but enforcement is problematic. (Miola, et al. 2010)

Concerning other impact categories findings, data on the targeted fish is scarce. In any case, comparing LCA results is tricky due to system´s boundaries, functional unit definition, allocation choices, and in the case of fisheries, geographical location.

LCA can be used to determine the material flows occurring in the fish production process, identify hotspots and set the starting point to develop environmental improvements. In addition to that, supply chain analysis becomes relevant since improvements in the life cycle will most likely be coupled to changes regarding operations managed by suppliers and buyers. Lastly, reasons to advocate and implement sustainability improvement will be aligned to the firm's corporate social responsibility. Although this three approaches focus on different issues, they deal with the same systems of study. The next section revises available literature concerning corporate social responsibility for food systems and specifically fish products.

## 2.2 Corporate Social Responsibility

This section is divided in two main parts. The first one summarizes existent literature on CSR, some application examples, issues regarding implementation, and useful eco-controlling tools for implementation including indicators and the Sustainability Balance Scorecard (SBSC). The second part focuses on describing the current CSR policy of the fishing company: Cornelis Vrolijk.

### 2.2.1 Theory and applications

#### *Concept*

Corporate social responsibility is said to be a social construction, defined specifically to fit each individual business. The definition given by the European Commission is "the responsibility of enterprises for their impacts on society" (EC 2011). It is supposed to contribute to sustainable development by acknowledging stakeholders' concerns while complying with all regulations regarding environmental protection and human rights. Thus, the topics regarding a CSR strategy are of multidimensional nature. Figure 3 shows topics, motives and influencing factors for CSR in the food industry.

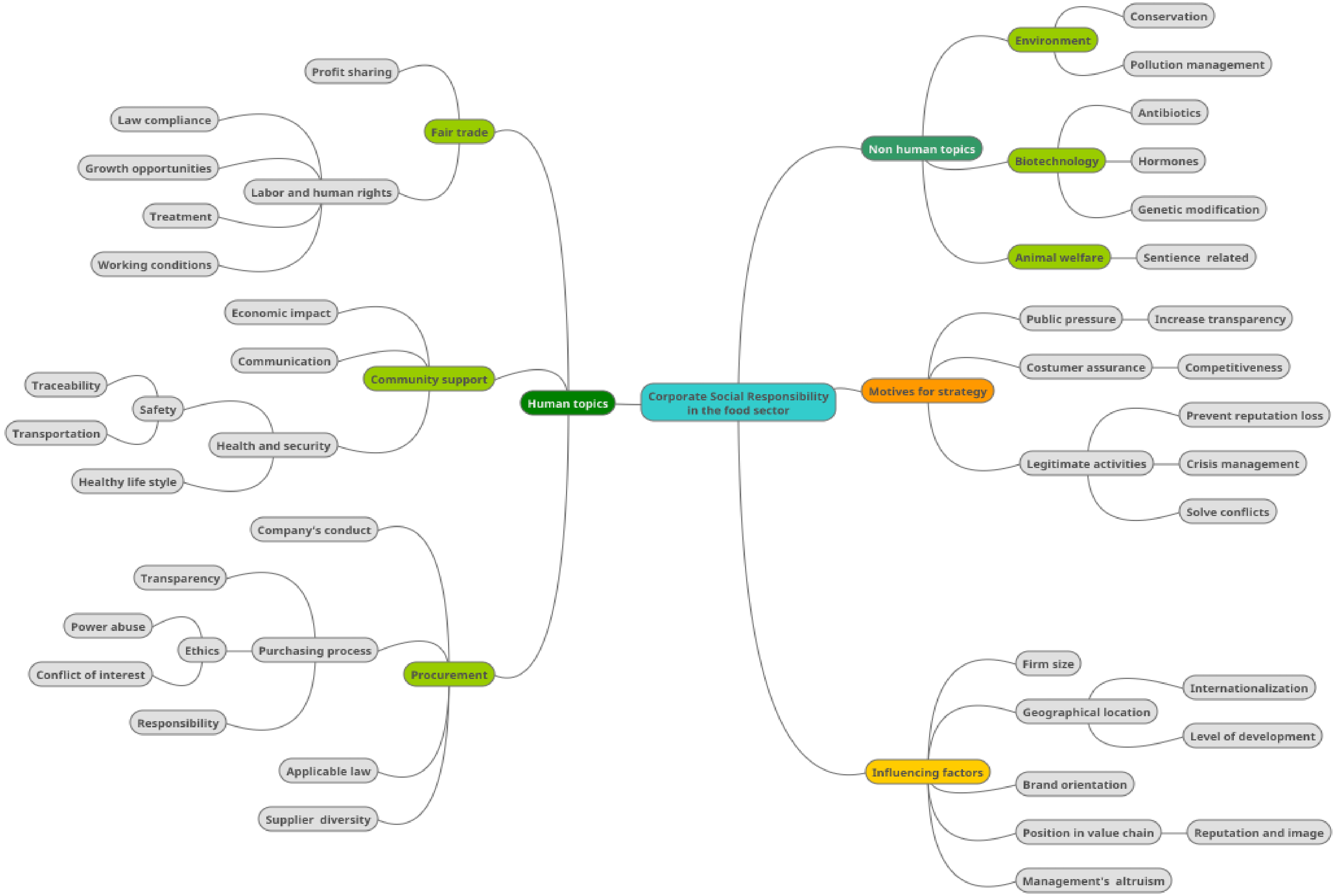



*Figure 3. Topics, motives and influencing factors for CSR in food industries. Source: with information from Luhmann & Theuvsen (2016).*

Since December 2016, it has become mandatory for large companies in the European Union with more than 500 employees, to report on their corporate governance, which is considered part of sustainable finance. The EU directive explicitly ask for "environmental, social and employee matters, respect for human rights, anti-corruption and bribery matters". The Directive asks for reference to the report on such matters following any related standard or a report taking into account the guidelines provided by the EU. (Oficial Journal of the European Union 2014)

The basic background of CSR is found in ISO 26000. But available standards proliferate. Among the instruments for designing a CSR strategy is the Global Reporting Initiative (GRI), which gives guidelines for reporting in relation to an analysis on materiality, stakeholder inclusiveness, the sustainability context and a completeness check (GRI, 2013). Other related standards are the UN global compact, OECD guidelines for multinational enterprises, International Labour Organization (ILO) conventions, International Organization of Standardization's (ISO) 14000 series, Social Accountability International's SA8000, Institute for Social and Ethical Accountability's AA100, among many others.

The Commission guidelines on non-financial reporting is said to take into account the 2030 sustainable development goals and the Paris agreement. The key principles of the guidelines are the following (Official Journal of the European Union 2017):

- Disclosure of material information, based on a materiality assessment
- Fair, balanced and understandable statements or indicators, presents in an unbiased way
- Comprehensive but concise reporting
- Strategic and forward-looking information
- Stakeholder oriented
- Consistent and coherent

CSR is always associated with stakeholders. They may include international organizations, non-governmental organizations and multinational corporations. (Kahraman Akdogu, 2017) Civil society pressures create a sense of urgency (Rotter, Airike and Mark-Herbert , Exploring political corporate social responsibility in global supplu chains 2014), so that every CSR policy is tailored to the company. Buckler (2017) implies that "CSR is about relationships created and maintained for the culture of the corporation, and dependent on the situation and needs."

Concerning the culture of corporation, a common topic of debate has been division of labor between the enterprises and the state. On one side economist Friedman argues the purpose of enterprises is to make business, and that of the government to ensure social wellbeing. On the other side, the stakeholder theory as proposed by Porter, suggest that it is in the best interest of business to create value by doing good to society. In fact, this is a topic analysed in applied ethics. For instance, consequentialism theory dictates that corporations should decide upon the moral institutions and principles to adopt in practice, following the best expected consequences for society. (Frederiksen 2017). From sociology, the discussion on CRS greatly deals with changing relations among civil society, state and businesses. But the amount of proposed ideas and practices is so diverse to the point of becoming meaningless, to the point choosing those which fit the needs of the company (Timms 2017).

It is said that over the three decades that CSR has been around, its motives have started to shift from demanding more socially responsible businesses to focusing in programmes with a purpose

(Vertigans and Idowu 2017). But in fact, a historical analysis on the term has shown that there is no novelty in the concept, as businesses have always had to deal with stakeholders and regulations. However, in terms of operational level, change is occurring rapidly since recent years. In a world of globalized supply chains, CSR tools are said to be needed for designing and implementing successful businesses strategies (Dahlsrud 2008). It is said CRS has brought about what is considered an "enlightened corporate governance" paying attention to long term orientation, strategic focus on stakeholders besides shareholders, accountability to stakeholders, and sustainable development besides financial performance. Overall, it is described as the reason behind rewiring the idea on the role of companies, their accountability, adoption of self-regulation and reporting (Aluchna 2017).

The factors influencing the depth a company attains in CSR are many and contingent. Differences among countries exist: while practices in the US are performed according to the social norm, in Europe they rely more on legal institutions (Matten and Moon 2008). In any case, when a broader approach is undertaken, CSR is understood as the management version of the sustainability concept; otherwise, it is only seen as a company's voluntary actions to maintain stakeholder approval (Luhmann and Theuvsen, Corporate Social Responsibility in agribusiness: literature review and future research directions 2016). In fact, academia suggests there are different types of CSR approaches. Thus, the following section presents available typologies on CSR.

### *Typology*

Timms (2017) proposes a three-dimension approach to study CSR activities: terminology or given definition to the CSR, content concerning who the companies are accountable to and responsible for, and the standards used for design, implementation and reporting. By looking at these three dimensions, the author proposes a categorization for CSR agendas:

- Political: business participate in the management and enhancement of environmental and social impacts, thus contributing to governmental roles. The motive is avoiding more legislation to comply with.
- Corporate: focuses on reports, websites, and marketing the commitment to improving the world by following set standards such as ISO26000, filling out CSR criteria and participating in saying that business with CSR are good to buy from.
- Professional: promotes the corporate agenda but from a position of professional boundaries. Involves competitions among CSR strategies, so that CSR becomes a tool to promote a positive corporate image to all stakeholders. It is an area under development, which has to look out for avoiding greenwashing.
- Activist: it is related to CSR being mobilized by activists, although some prefer corporate accountability over CSR because it can be argued that voluntary improvements will always compete with the effects on profits. By campaigning, activists can get a sit at the table and influence policy. For firms, activists can threaten their reputation, for instance through mock award ceremonies.

Another proposed typology as given by Camilleri (2017), describing three main models for CSR: strategic, corporate social performance, and global business citizenship. Each one increases in concern for doing good to society at large.

More generally, Rotter et al (2014) imply there are two types of CSR: instrumental and political.

- Instrumental CSR implies the notion that there is a clear division of responsibilities and power among state, business and society. Here, firms follow the applicable legislation to guide their conduct, apart from philanthropic donations, product innovation and codes of conduct.
- Political CSR aims to draw the agenda towards systemic problems such as climate change, human rights abuses and poverty, with a collective perspective. A collective perspective implies the participation of business, civil society and governments working together as equals. It is about "balancing questions of power and responsibility" through communicative action.

Matten and Moon (2008) resume it as implicit and explicit CSR, but overall seem to be similar to what Rotter and colleges (2014) present as instrumental and political.

- Implicit CSR takes part in roles within formal and informal institutions in society´s interests, while complying with mandatory requirements for corporations. It’s a reflection of the institutional environment.
- Explicit CSR policies address issues which are perceived as part of the social responsibility of the company. They are extroverted to stakeholders, communicating their doing to comply with expectations.

From the perspective of business management, Baumgartner and Ebner (2010) propose four corporate sustainability strategies, coupled with maturity levels regarding economic, ecological, and social aspects. The strategy types are the following:

- Introverted: seeks risk minimization by conforming to all legal requirements but not going deeper into side issues.
- Extroverted: seeks communication to increase its credibility and does more than what is legally obliged to. Its focus can be rather in communication than truly embedding sustainability in all the firm’s departments.
- Conservative: focuses on internal measures, and pays special attention to processes, appropriate technology, and adequate health and safety procedures for employees. Society related issues are less important.
- Visionary: is also referred as holistic. It’s committed to become a market leader regarding sustainability issues, and can be either targeted to have an impact on the market or on society.

Overall, the different typologies described focus on the level of responsibility firms want to take concerning issues for which they are not legally obliged to care. The highest level is found in what authors describe as political CSR (Timms, 2017; and Rotter et al, 2014), visionary sustainability strategy (Baumgartner and Ebner, 2010) and global citizenship CSR, which advocate for corporations to respond to non-market pressures considering the global context, reinforcing an ethical and social approach to making business (Camilleri, 2017).

Political CSR is criticised by some who consider it too altruistic and unlikely to succeed due to the complexity of the problems it targets. The dominant assumption is that firms have to make profit first, and only afterwards engage in voluntary CSR practices. Historically, CSR has generally focused on firm's responsibility towards primary stakeholders and the local context. However, the justification for CSR resonates specially in regard to global supply chains. It is said that in a globalized world, firms become actors with increasing power, who can address injustices when operating at countries where local government do not enforce legal frameworks (Sitnikov y Bocean 2017). In fact, sustainable development is said to depend on responsible enterprises today more than ever. (Rotter, Airike and Mark-Herbert , Exploring political corporate social responsibility in global supplu chains 2014)

### *Application examples*

The following are two examples of political CSR found in literature. The first one deals with a recognized CSR approach that is currently applied in some industrial parks and seems to have its roots in religion; it is called Economy of Communion (EoC). The second example is about the fishing sector, regarding supermarkets pushing the industry to provide sustainable certified fish.

#### Economy of Communion

Economy of communion(EoC) initiated as a project in Brazil back in 1991. Its aim was to implement a culture of fraternity and solidarity within economic activities in an area demeaned by great inequality. More recently, the approach has spread to include more than 800 companies involved all over the world (EoC 2015). The objectives attained under EoC are three: (1) creating new business and strengthening existing ones, (2) forming new persons able to run new companies under the same approach, and (3) helping the poor at a local and global level who donate their needs for the business to respond. Governance in this kind of organizations is based upon four tools: (1) a pact among stakeholders, (2) the sharing of experiences to enhance cohesion, (3) a so called “time of truth” for correcting mistakes, and (4) the use of dialogue. It is said that all this is to foster trust and create “relationship capital”. Additionally, accountability is kept by communication of a “rainbow score” which addresses the following sustainability aspects (Baldarelli and Del Baldo 2017):

- Red: involves all economic dimensions of the enterprise and relationships with the poor
- Orange: communion relations with inside and outside stakeholders
- Yellow: aspects related to ethical and just or legal operations
- Green: aspects of environment and health, and integrity of workers
- Blue: related to the built environment and organizational structures in which workers operate
- Indigo: activities of staff training oriented to both enterprise interests and human development
- Violet: internal and external communication system and network

Several industrial parks have taken after the EoC approach adapting it to their national context and circumstances. It is said that this kind of companies move from weak to strong social responsibility (Baldarelli and Del Baldo 2017).

#### CSR in the tiger shrimp fishery

Consumption of tiger shrimp has increased drastically due to demand from western countries, which in turn has promoted commercial aquaculture of this species. Environmental and social issues have followed: rising unemployment for moving towards intensive production methods; child labour; decline of biodiversity and water quality, and ecosystems degradation. However, globally, tiger shrimp supply chain generates livelihoods for about 900,000 fishermen, and plays a relevant role for national economy growth in developing countries where production happens. These countries are characterized by unclear regulations and corruption contexts. All this situation eventually turned into public pressure for three major shrimp Swedish retailers, who had to implement a fish policy to address the issue. (Rotter, Airike and Mark-Herbert , Exploring political corporate social responsibility in global supplu chains 2014)

Two companies implemented certification schemes. The third one opted for a broader view by taking an "extender stakeholder approach". Given that at the time World Wild Foundation had marked tiger shrimp as red species meaning the lack of sustainability in the fishery, the enterprise decided to stop selling this fish until an accepted solution was developed. The decision led to the drafting of internal guidelines for self-regulation concerning sustainability, which would also be used as basis for communication with customers. In summary, the Swedish company decided upon an approach to influence structural change by restricting itself from providing a consumer want based on an expert’s opinion. (Rotter, Airike and Mark-Herbert , Exploring political corporate social responsibility in global supplu chains 2014)

### *Implementation, indicators and SBSC*

Implementing CSR policies relies in having the support of highest level directors within the company, followed by effective governance. Having this in place, the International Institute for Sustainable development suggest four phases and related tasks for implementation (Table 3)

*Table 3. Phases and tasks in CSR implementation. Source: information taken from Hohnen (2007).*

| Phase | Tasks | Description |
|---|---|---|
| Plan | Conduct assessment | Defining type of desired CSR policy, identifying all legal requirements, and engaging stakeholders |
| | Develop strategy | Reviewing what other companies do, proposing actions and ideas, including business case, and deciding upon direction, boundaries, approach and focus areas |
| Do | Develop commitments | Consulting and engaging stakeholders, developing an integrated decision-making structure, implementing a CSR business plan, engaging employees, conducting CSR training, establishing mechanisms for solving problems, creating internal and external communication plans, and making commitments public. |
| | Implement commitments | |
| Check | Report on progress | Measuring and assuring performance, engaging stakeholders, and reporting internally and externally. |
| Improve | Evaluate and improve | Tracking of overall progress, learning from experience in implementation, revisiting goals, and determining what works or doesn´t work well, why and how |

The planning phase is concerned with building a strategy, which is described as a roadmap for action composed by the following points:

- Overall direction or course to be pursued for the firm´s CSR work
- Stakeholders and their interests
- Basic approach for moving ahead, stating the general “hows”
- Specific priority areas
- Timeline for action, responsible beings, and immediate next steps
- Process for revision and reassurance of outcomes

Phase “Do” greatly centers upon commitments. These are policies or instruments developed or signed on to indicate what the company intends to do to address its impacts. Commitments can be aspirational and long termed, or prescriptive and explicit. They must be consistent with CSR values; align business strategy, objectives, and goals; be a guide for employees on how to conduct themselves; and communicate the firm's approach to business partners, suppliers, communities, governments and civil society in general. (Hohnen 2007)

Implementing the commitments is the main part of the "do" phase, involving "day-to-day decisions, processes, practices and activities" for carrying out promises. This requires setting of measurable targets for the commitments. Targets are translated into indicators and metrics to be reposted and verified. In fact, corporate reporting should be the output of performance measurement and evaluation. Whereas verification can play a role in getting a social license to operate. (Hohnen 2007)

### Indicators

An indicator provides information on the state, condition or level of something. Its purpose is measuring progress, showing direction, and allowing comparisons. Indicators are useful for monitoring the fulfilment of goals and the achievement of the mission and vision of an organization (Klubeck 2017).

Both CRS reports and the guidelines for non-financial reporting by the EU discuss key performance indicators (KPI) for information disclosure. The guidelines ask for metrics used by the companies in their internal management. They speak of material KPIs both general and sectoral for providing information on progress and trends. (Official Journal of the European Union 2017) Suggested topics by the guidelines are shown in Table 4.

*Table 4. Potential metrics topics as suggested by the guidelines for non-financial reporting by the EU.*

| | |
|---|---|
| Environmental | Pollution prevention and control; impact from energy use; direct and indirect atmospheric emissions; use and protection of natural resources, and related protection of biodiversity; waste management; environmental impacts from transportation. |
| Social | Implementation on labor conventions; trade union relationships; human capital management; health and safety at work; consumer relations; impacts on vulnerable consumers; responsible market and research; and community relations. |
| Others | Disclosures on respect for human rights, and anti-corruption and bribery. Supply chain, and conflict mineral matters are also recommended to be reported if relevant for the company. |

Scientific literature suggest a variety of indicators as found in multiple revisions of corporate reports. They are mainly shown divided in social, environmental, and economic indicators. The following Table present indicators considered in corporate sustainability, supply management in general, and supply management in the food industry.

*Table 5. Indicators used in CSR reporting and, supply chainmanagement.*

| | Indicators in corporate sustainability (Pavláková and Kocmanová 2016) | Indictors in supply chain management (Gong, et al. 2016) | Indicators in supply chain in food industry (Turi, Goncalves and Mocan 2014) |
|---|---|---|---|
| Economic | Costs, investments, economic results, use of assets and funds, reliability of suppliers, sanctions, expenditure on R&D | Costs, revenues, profit sharing, creating sustainability value | Reverse logistics revenues, average transport costs, perfect order percentage, validity period in transport |
| Environ-mental | Energy efficiency, materials and raw materials consumption, transportation, water, | Emission reduction, natural sources usage, waste reduction, used | Level of energy consumption, average emissions per unit, |

| | Indicators in corporate sustainability (Pavláková and Kocmanová 2016) | Indictors in supply chain management (Gong, et al. 2016) | Indicators in supply chain in food industry (Turi, Goncalves and Mocan 2014) |
|---|---|---|---|
| | biodiversity, waste, emissions, compliance with legal requirements | material's disposal, use or recyclable materials, choice of suppliers by considering environmental criteria | number of green products. Food miles and food wastage (Govidan, 2017) |
| Social | Relations with the local community, equal opportunities, human rights, expenditure on education and training, fluctuation, labor relations, relationships in the workplace, code of ethics, accidents at work, health and safety of customers, customer satisfaction. | Degree of job localization, human rights, employee CSR training, health care and safety, degree of purchasing location, labor equity, community. | Trained employees rate, management levels with specific environmental responsibilities, improvement suggestions submitted by employees |

More specifically, concerning the marine ecosystem and fishing indicators, catch per unit effort and fish size were used for the assessment of small pelagic fish (Roeger, Foale and Sheaves 2016). Likewise, others are: fishing mortality rate (F=catch/biomass), fishing effort (f=trawling hours/year), technology coefficient (F/f), and mean trophic level of landings (Pauly 2010).

The Marine Stewardship Council (MSC) uses 31 performance indicators in their benchmarking tracking tool to evaluate if a fishery is sustainable. The standard is based in three principles which are divided into components. Components can include performance indicators related to outcomes, management, and available information. The outcome indicators, which are more directly related to the marine biology, are the following (MSC 2014):

- Stock status
- Limit and target reference points
- Stock rebuilding, if applicable
- Avoidance of risk or harm to retained species
- Avoidance of risk or harm to bycatch species
- Avoidance of risk or harm to endangered, threatened and protected species
- Avoidance of serious harm to habitat structure
- Avoidance of serious harm to key elements of ecosystem structure and function

The remaining indicators in the standard focus on readily available information supporting the outcome indicators, the management systems in place to collect such information, the governance situation, and the general fishery specific management system. (MSC 2014)

Indicators can also be derived from criteria. The International Institute for Sustainable Development has published a set of sustainability criteria for aquatic supply chains. It is outcome oriented and mostly focused on the context of developing countries (see Table 6).

*Table 6. Sustainability criteria of wild caught aquatic supply chains. Taken from Hanson et al. (2011).*

| |
|---|
| **Ecological factors** |
| · Biomass of the target species is maintained at a level that allowing optimal productivity and harvest over time, even under sub-optimal or fluctuating environmental conditions |
| · The operation of the fishery does not alter the structure of the ecosystem allowing ecological equilibrium and biodiversity maintenance |
| · A life cycle assessment shows no significant contribution to climate change |
| **Economic factors** |
| · Operations are not predicated upon subsidies, taxes or other economic instruments which are considered to be environmentally or economically perverse and/or not reflecting externalities |
| · There is full or maximum practicable utilization and value obtained from harvested resources (including bycatch) and waste minimization |
| · Operations are highly efficient concerning use of resources |
| **Social and regulatory factors** |
| · Traditional rights and local dependence of resources are not impinged |
| · Operations are in full compliance with national and international management measures, documented through monitoring and enforcement programs |
| · Applicable fisheries management systems are based on available and precautionary information |
| · The fishery is not illegal, unreported or unregulated, threatening sustainability |
| · Operations are conducted under sustainability management practices such as reporting, certifications, and continuous improvement. |

The potential indicators a company can estimate and report is large. This is why both CSR standards and the EU guidelines for non-financial information reporting ask for key performance indicators which are material or come from a materiality analysis. Materiality refers to importance, to information that holds such relevance that influences decision making by stakeholders. “[I]t is the threshold at which aspects become sufficiently important that they should be reported”. Determining if an aspect is material involves looking at internal and external factors that have an impact on the organization, its mission, and its competitive strategy. In this regard, significant impacts may be subjects of concerns by expert communities, or those identified by assessment methodologies and life cycle assessment. (GRI 2013)

Concerning the design of suitable indicators for industrial processes to monitor sustainability aspects, Cervantes (2017) proposes the following methodological steps:

1. Definition of system function and its boundaries
2. Definition of objectives and sustainable development topics: taking into consideration sustainability criteria, objectives are to be set, together with the desired direction for them (up, down or neutral). Topics are derived from the objective.
3. Design or establishment of indicators by topic, within each objective concerning environmental, social, and economic aspects. The final indicator battery must ensure all objectives’ progress measurability.

### Sustainability Balanced Scorecard

Selecting KPI for CSR seems challenging considering the amount of information which could be considered material. It has been claimed social and environmental management is unclear because it seldom is readily linked to the economic success indicators of organizations. The sustainability balanced scorecard (SBSC) is a response to such problem. It is a strategic management tool which identifies relevant issues and signals their causal contribution to the organization success metrics. It is based upon the “balance scorecard” as proposed by Kaplan and Norton in the 1990s. (Figge, et al. 2002)

The SBSC’s method of constructions leads to the identification of 15-25 most relevant aspects in a business unit, which are linked “causally and hierarchically towards the long-term success measured by the financial perspective” (Pavláková and Kocmanová 2016). The indicators in the scorecard are derived from the organization´s vision and strategy, and should be appropriate, consistent and balanced throughout four perspectives: financial, customer, internal, and organizational, as described in Figure X. It is worth mentioning that the basic balance scorecard as created by Kaplan and Norton do not address nonfinancial and non-quantitative issues, nor issues relevant to other stakeholders besides shareholders. (Möller y Schaltegger 2015)

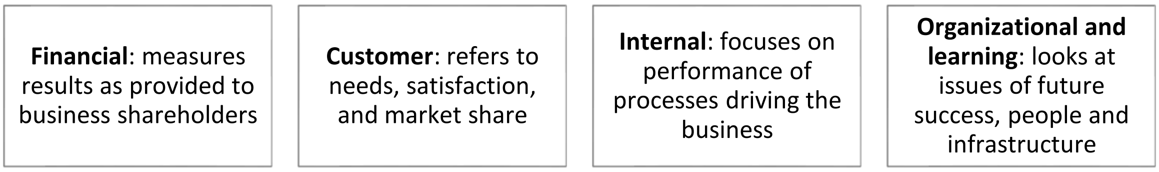



*Figure 4. Perspectives in the balance scorecard as proposed by Kaplan and Norton.*

Besides the four perspectives, the balanced scorecard framework is also strongly coupled with strategy maps, which are diagrams describing the causal relationships from one perspective to another for value creation by the organization. Strategy maps are presented in one single page for enabling better communication. (Kaplan and Norton 1993). What the sustainability approach adds to the original balanced scorecard is bringing into it soft factors. Figg et al. (2002) propose to integrate sustainability indicators throughout the four perspectives and, if necessary, introducing an additional non-market perspective affecting all the other conventional perspectives. A third option is to create an extension of the score card, dealing only with social and environmental issues in relation to the base scorecard of four market perspectives. The authors suggest that in order to justify the addition of a non-market perspective, two conditions should be met:

- Environmental and social aspects are strategically relevant
- It is not possible to appropriately include such aspects in the four conventional perspectives

The ultimate decision on how to formulate the sustainability balance scorecard depends on the nature of the organization and its particular material aspects. The basic requirements include: it should be business unit specific, aspects must not be generic, and indicator integration must follow the logic of strategic relevance. (Figge, et al. 2002) The suggested process for formulating a SBSC is presented in Figure 5. The core process is the identification and alignment of the relevant aspects, linking them along the different perspectives.

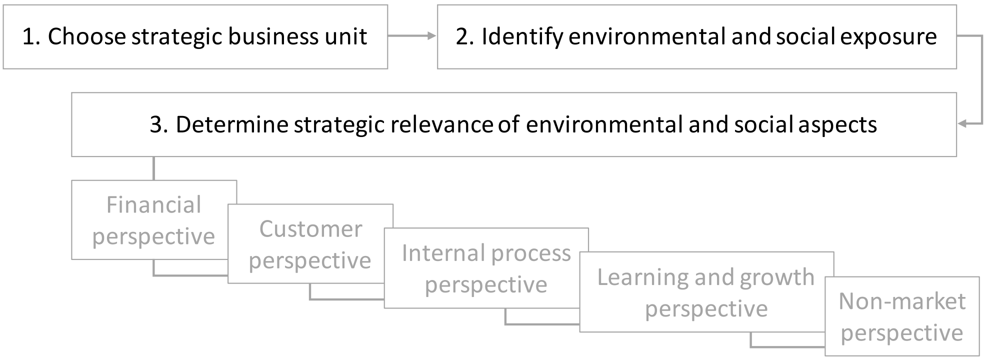



*Figure 5. Process for formulating a SBSC (taken from Figge, et al. 2002).*

Constructing a SBSC draws from an existing business strategy or one that is under formulation. It is said to be a tool for executing such strategy and if necessary enhancing it. Similar to CSR activities, the final outcome of the SBSC needs the agreement of top management. Otherwise, implementation would most likely fait to be successful. (Figge, et al. 2002)

*Research and implementation issues concerning CSR*

Variables influencing implementation of CSR include the following: need of an instrument to stay competitive, increasing public criticism, need to improve reputation and legitimacy, obtaining a social license to operate, response to public pressure, etc. Reasons and topics of concern are diverse. But few research work focuses on the contingency factors influencing CSR strategies. It is said that influencing factors need to be studied based on a complete context and comprehensive analysis. There is limited knowledge on how companies design and implement their CSR activities and the measures they prefer. (Luhmann and Theuvsen, Corporate Social Responsibility in agribusiness: literature review and future research directions 2016)

Concerning actual implementation of CSR, Vertigans and Idowu (2017) consider the current norm is having silos of chosen themes targeted to different groups of stakeholders. They claim application and academic rhetoric generally remain detached, and that there are literature gaps in application. Likewise, Baumgartner and Ebner (2010) suggest sustainability issues are treated without the framework of a strategy, and only coincidentally pursued. They claim there is only a partial approach to CSR both in practice and in academic literature. Thus, a holistic overview is said to be missing. And there is a gap between desired sustainability activities and implementation in business decision making "when metrics in theory and practice are unclear and lack applicable governance mechanisms" (Gong, et al. 2016)

Most common instruments used for CSR are guidelines and policy commitments in reference to specific products. But academics believe more effort should be put into studying alternative design instruments, interplay among instruments, influence of situational factors, managerial preferences, and efficiency concerning the choice of instruments. Likewise, other topics requiring further study are information requirements from consumers and communication instruments degree of success. (Luhmann and Theuvsen, Corporate Social Responsibility in agribusiness: literature review and future research directions 2016).

### 2.2.2 CSR in the fishing sector

*General view*

When revising existing CSR policies from fishing companies, certifications and ecolabels are highly publicized concerning sustainable fishing and quality assurance (Amacore, 2017) (Dansk

Supermarked Group, 2015) (Sydney fish market, 2017). Outside this generalization, specific topics addressed depend on the company. For instance, one international processor and supplier of high trophic level fish based in the Netherlands specifically mentions responsible sourcing and transparency in regard to supply chain aspects (Anova, 2016). The same company claims that about 60% of their sourcing is sustainable, and 84% of such sustainable products are sold in North West Europe (Anova 2016). Animal welfare is another topic of interest for north Europe consumers (Anova 2017), but it is said that outside this region, the sustainability focus is less important for consumers.

Literature suggests that concerned consumers are willing to pay higher prices for socially responsible and environmentally friendly products. European consumers are said to support regulation ensuring sustainable seafood even if that means reducing variety in the stores and minor price increases. Requirements for quality and safety, technical standards and labels, voluntary certifications concerning biology, and human rights indicators seem to be gaining momentum specifically for species targeted at better-informed consumes, or high value species such as tuna, shrimp, salmon, bass, etc. (Alfnes, 2017) However, this is hardly the case for high volume, relatively low value, trade in large quantities species, such as small pelagic exported to low income consumers. (FAO, 2016).

Market forces seem to be the ones driving better environmental performance through seafood guides and ecolabels when it comes to species for human consumption. The first seafood ecolabel appeared in 1999. The most recent development in ecolabels comes from the Global Sustainable Seafood Initiative. (FAO, 2016). But many other environmental product information instruments exist: EU-flower, German blue angel, Nordic swan, Naturland, Marine Stewardship council (MSC), Aquaculture Stewardship Council (ASC), and carbon footprints. However, according to Magerholm (2010), the most comprehensive way to report on product sustainability is to use environmental product declarations according to ISO 14025. Nonetheless, all can be part of CSR reporting.

### *The case of Cornelis Vrolijk*

Cornelis Vrolijk Holding BV is composed by five companies. Fishing with freezer-trawlers for pelagic fish is the company's main activity. The mission of the company is the following (Cornelis Vrolijk 2015):

"With our fishing activities we provide an important contribution to the food security of millions of people. We do this, as a family business, with a focus on future generations while maintaining healthy fish stocks, minimizing environmental impact and with committed and proud people. We stand for continuity whereby we treat the world around us with the utmost respect."

The CSR report states that although making profit is part of being successful, it is not the only objective CV strives for. At the moment its CSR policy focuses on the pelagic business unit, foreseeing that the demersal fisheries will be added later on.

The company's CSR policy based on four pillars (Cornelis Vrolijk 2015):

1. Healthy food, concerned with delivering the best quality fish and seafood products. It seems to be mostly focused on fish quality assurance.
2. Fishing forever, focused on keeping healthy fish stocks and looking after the marine ecosystem by reducing environmental impact as much as possible. MSC certifications are mentioned in this regard together with cooperation with the scientific community.
3. Daily sustainable is concerned with developing and using innovative fishing technology.

4. Care for people attains creating safe and pleasant working and living environment, and contributing to social development within local communities

Although the report does not present indicators, it introduces the CSR activities undertaken in 2016, and the ones that can be expected in the next five years (Table 7).

*Table 7.Overview of Cornelis Vrolijk's CSR activities. (Cornelis Vrolijk 2015)*

| CSR Pillar | Activities 2016 | Activities and objectives for 2021 |
|---|---|---|
| Healthy food | · Quality optimization<br>· Research from quality data recordings | · Possibly, renewed ISO certification |
| Fishing forever | · Provision of information to IMARES, including catch data<br>· Project on development of equipment for fish detection<br>· Involvement in policy making discussions about stock management<br>· Identification of relevant stakeholders<br>· Organization in regulations' compliance<br>· Testing of on-board camera systems for landing obligation implementation | · Engagement in management plan for horse mackerel in the North Sea<br>· Reduced by-catch levels<br>· Good and open relationship with stakeholders<br>· Well-organized compliance with all applicable regulations |
| Daily sustainable | · Analysis of possibilities for increasing recyclable material flows<br>· Sign up for Dutch 'Green deal'<br>· Ensure adequate management of hazardous waste<br>· Baseline estimation of CO2 footprint<br>· Research into energy efficiency in regard to propelling vessels and towing nets<br>· Investigation on improved deployment of solar panels<br>· Installation of charging for electric cars | · Documented choices regarding sustainable procurement and the green economy<br>· Investigated and possibly implemented environmentally friendlier alternatives for packaging<br>· All employees are aware and take into account CSR policy<br>· Reduced $CO_2$ footprint by 10% at Sea<br>· Reduced $CO_2$ footprint by 20% on shore<br>· Led light only on board vessels<br>· Application of new standards regarding refrigerants in all installations |
| Care for people | · Updating of health and safety policy<br>· Establishment of safety committee for each vessel<br>· Increased attention to personal protective equipment on board<br>· Improvement of food policy on board<br>· Inventory wishes for fitness training facilities on board<br>· Internal communication regarding employee personal development<br>· Offering of internship possibilities<br>· Developing a more structured approach to sponsorship activities<br>· Drawing up of activities to undertake in West Africa<br>· Working with subsidiary Primstar to develop CSR policy plan | · Up to date health and safety policy at all time<br>· Available broad range of tools for employees who wish to lose weight<br>· Contribution to improved quality of education at fisheries schools<br>· Introduction of proactive personnel policy<br>· Any employee can explain what CSR means for the company |

An important share of CV´s sales come from west Africa, mainly in Nigeria and Ivory Coast. Contributing to these countries besides food security has happened by facilitating infrastructure for fish quality maintenance within the supply chain. Training personnel in local companies is done, aimed at professionalizing local business operations.

## 2.3 Sustainable sourcing

As mentioned previously, besides the carbon footprint assessment, the company is looking at possibilities for more environmentally friendly supplies. Thus, this section briefly elaborates on sustainable sourcing.

Sustainable sourcing is only a small part sustainable supply chain management (Figure 6). Thus, at some level it is also associated to corporate social responsibility. Relation to LCA also matters. A product's footprint could easily be dependent on some part of the supply chain (Blass & Corbett, 2017), and sustainable sourcing could be the answer for achieving the environmental profile of products.

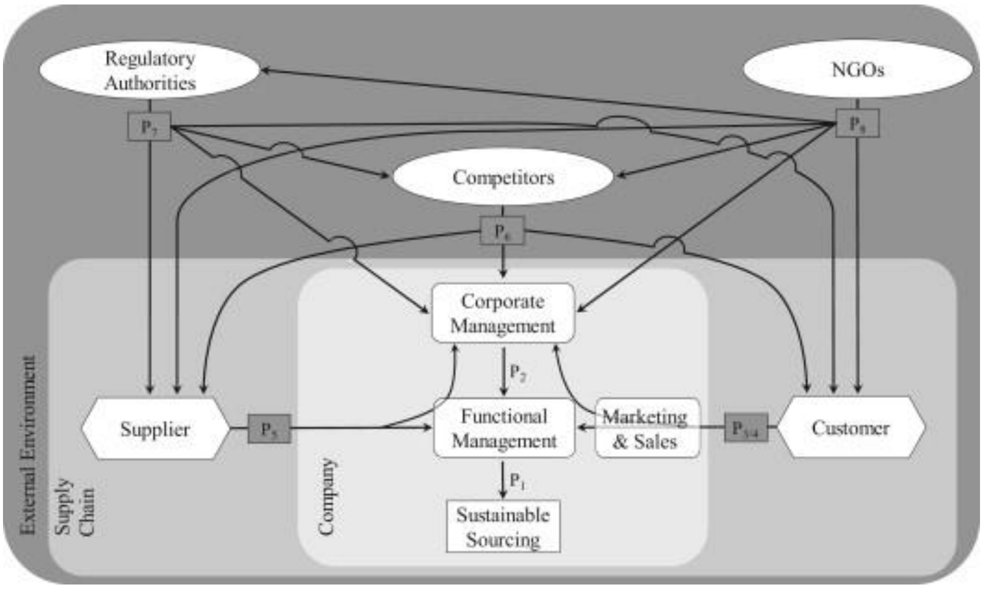



*Figure 6.Sustainable sourcing in relation to the supply chain and external environment. Taken from Hoejmose & Adrien-Kirby (2012).*

Procurement seems to takes after the same key aspects that are needed in a supply chain. Quality, speed, dependability, flexibility and cost are expected variables to consider primarily. Environmental performance is seen in the face of trade-offs, win-wins and minimum requirements, but it is increasingly gaining importance. Oppositely, the social dimension is hardly considered in supply chain management (Govidan, 2017). (Seuring & Müller, 2008)

Management of international food supply chains is said to focus on four key aspects: (1) trust, (2) governance to ensure traceability, (3) relationships to maintain competitive advantage, and (4) internal controls to manage risks. But besides maintaining profitable business, it is suggested that international supply chains play an important role in development. Such happens when companies take part in upskilling of workers, invest in infrastructure, create incentives for sustainable use of resources and ensure social rights, provide ways for monitoring, and promote research and development. (Dani 2015). Currently, the upgrading impact of firms concerning global value chains is under-researched (Hamilton-Hart y Stringer 2016).

However, sustainable procurement appears to be gaining attention. ISO recently published *standard 20400 sustainable procurement guidance*. It claims sustainable procurement represents opportunities in terms of: improving productivity, revising value and performance, engaging in communication among firms and stakeholders, and fostering innovation. Furthermore, it proposes a method for integrating sustainability into any company's procurement process. Among the topics covered by the standard are: decent work and labour practices; circular economy and life cycle approach; social responsibility and transparency; supply chains; sustainability aspects, issues and claims; environmental labels; and indicators, among others. (ISO 2017)

In relation to CSR, socially responsible procurement is defined as CSR practices related to procurement. It deals with achieving good environmental and social performance in the supply chain. (CIPS 2017).

A strategy for implementing socially responsible procurement is said to cover the following (European Commission 2010):

- Setting objectives and priorities
- Providing high level commitment
- "Measuring the risks and prioritising organizational spend categories to enhance social outcomes"
- Raising awareness and involving stakeholders

The last steps include implementation and monitoring of it in connexion to a reporting systems (European Commission 2010), which highly resembles CRS implementation as explained in the previous section. And much literature is concerned with public procurement.

Four approaches to public procurement procedure are proposed (European Commission 2010):

- Including social criteria as subject in the contract or specifications to be met by the supplier
- Prohibiting bidders to companies who have shown bad behaviour in the past
- Persuading tenderers to commit to specific standards for awarding the contract
- Getting the promise that once the contract is awarded, the supplier will comply with specific conditions

Hoejmose & Adrien-Kirby (2012) explain the complexity in implementing sound sustainable sourcing practices in regard to corporate- and supply chain-level challenges. They explain that operationalizing it depends on taking consideration of stakeholders´ expectations, purchasing functions, and mid and long term planning. Coordination of purchasing departments with marketing and sales ones is also advised.

# 3. Methodology

The methodology is comprised of three sections: LCA of pelagic fish, definition of suitable indicators for CSR in the fishing industry, and the fuel oriented sustainable sourcing.

## 3.1 LCA of pelagic fish

The following section gives an overview of the methods used to perform the pelagic LCA. This, in order to answer the following research question:

What are the cradle-to-gate Environmental impacts of delivering 1 kg of, respectively, herring, mackerel, horse mackerel, and blue whiting to the customer?

### 3.1.1 System overview

The four alternatives (fish) under study are fished using nine of CV’s vessels. Aliases were used throughout the study, by numbering the vessels rather than using their true names. All vessels operate under the same general process where fish are frozen almost immediately after they were caught. Operation within the vessel were chronologically sorted into the following activities:

1. Steaming
   - Out to fishing grounds
2. Fishing
   - Determining location of fish schools using sensors, radars, sonars, and skipper's experience
   - Setting of the net
   - Filling of the net and trapping of fish
   - Pumping of fish from the net inside the water to the fish tanks inside the vessel’s fish factory
3. Freezing
   - Fish sorting (includes size and quality segmentation, and by-catch removal) on conveyor belt
   - Freezing fish into flat rectangular blocks
4. Packaging
   - Package frozen fish blocks in plastic and cardboard boxes
   - Secure cardboard boxes with plastic strips
   - Printing labels on cardboard boxes for quality assurance purposes
   - Store on vessel
5. Steaming
   - In to port
6. Docking
   - Unloading fish filled cardboard boxes to onshore storage.

All these stages were taken into account in the model, along with vessel construction and maintenance. Also the infrastructure and operation of storage onshore were included.

### 3.1.2 Goal and scope definition

An overview is given of the scope of the project for which the stated goals are achieved. Here specifics (functional unit and reference flows) of the alternatives assessed, are identified. And technical, temporal, and geographical boundaries of the study set.

#### *Goal definition*

The aim of this LCA project was to identify hotspots regarding the environmental impact of pelagic fish products from the company Cornelis Vrolijk. Four species were regarded: herring, mackerel, horse mackerel, and blue whiting. The goal was not to obtain comparative assertions, but to determine hotspots and identify potential room for improvement.

The commissioner was the Company Cornelis Vrolijk. The study was conducted by two industrial ecology master students from Leiden University: Mariana Ortega and Rebecca Joubert. Review was carried out by the thesis supervisors at the university and a supervisor at the company. The target audience for this report are decision makers at Cornelis Vrolijk. The results will be used to inform decisions on product development, improvement, and strategic planning.

#### *Scope definition*

This LCA is attributional. The mode of analysis is descriptive, which means it is a starting point for hotspots identification. The processes covered are those of a cradle to gate system: vessel construction and maintenance, fishing, fish freezing, packing, and storage on board, transportation to on-shore storage, and storage until selling. Stages of transport to retailer and consumption were not included in the analysis.

Data for the 2016 operation of the company was considered for all alternatives. In some cases, an average of a number of years, usually 2009-2017, was used when the consumption of the material in question consumption was greatly variable over the years. Specifically: paint and refrigerants. Overall the study took into account the operation on nine of the company's vessels in 2016. Process specific data comes from company records from two office locations and also from interviews to department managers, fleet skippers and engineers, and some suppliers. Some information was also taken from oil record books kept by each vessel. Almost no information was taken from literature. Only some refrigerant consumption was estimated after data published by the CEPA (2016) on average leaks.

The baseline impact categories CML 2001 method were used. Interventions were assigned to ten problem oriented impact categories as suggested by Guinée, et al. (2002). Characterization, normalization, and contribution and sensitivity were performed. The uncertainty analysis was nor performed due to lack of time, but also because most data comes from first hand sources. Rather than relying on databases and many assumptions, as is the case for most LCAs, this LCA makes use of actual data representing a real situation. In fact, the number of assumptions made are relatively low. Therefore, testing the accuracy of the data can be considered unnecessary to a great extent.

This study took place from February to July 2016.

#### *Function, functional unit, alternatives, reference flows*

The function in the product system was defined as the production of fish cartons which weight varies depending on the fish species. The functional unit is 1 kg of landed and stored fish ready for consumption. The alternatives are herring, mackerel, horse mackerel, and blue whiting. Therefore, the reference flows are providing one kilo of either herring, mackerel, horse mackerel, or blue whiting for consumption.

### 3.1.3 Inventory analysis

The inventory analysis gives an overview of system boundaries and flowcharts of this study. And further elaborates on assumptions regarding data collection and allocation.

*System boundaries*

The system boundaries for this study were determined by the cradle to gate approach. The stages taken into account were vessel construction and maintenance; vessel operation, which included: steaming, fishing, packaging, freezing, and docking; and storage on shore. Every vessel fished for all alternatives, plus some other species during every fishing trip. This meant that the production of each alternative had two coproducts: other fished species also regarded as bycatch, and low quality fish or fish species for which the company has no quota.

Office space was not included; neither were lab tests for quality assurance. Transportation impacts from the supply chain were taken into consideration only when information was readily available: raw materials for netting products and steel for vessel construction. As mentioned before, almost all vessel in the fleet fishing for the four alternatives were modelled. For the storage, only two of the multiple locations were taken into consideration given data availability. Thereby, it was assumed that all other storage locations not included followed the same assumptions used for these two locations.

*Economy environment system boundaries*

All inputs included in the model were economic flows. Construction and maintenance materials, fuel, refrigerant fluids, lubrication oil, packaging material, and even the wild fish. They were considered to have crossed the environment-economy boundary once they were extracted from the Sea, frozen, packed, and stored. Sea water withholding the fish and taken for desalination remains in the environmental system. Exhaust gases and particulate matter from fuel combustion and painting operations, and also refrigeration leakages enter the environmental system. Heat from the fuels contained in cooling water returned to the Sea also enter the environmental system. This heat was not considered part of the modelled flows.

*Cut-off*

Several interventions from the vessel operation process were left out due to the difficulty obtaining this data. Absorbents, filters, chemical materials and random waste flows were not included in the model. These so called random waste flows were not included because they were not present in the records of every vessel during the year of study. In the storage stage, fossil fuel using forklifts and lorries were not accounted for due to lack of readily available data on their usage characteristics. However, the energy use of battery powered forklifts inside the storage facilities was accounted for in the energy consumption of the locations. Their production was not included to lack of readily available forklift production processes in ecoinvent.

The contribution of these cut-off interventions would have been very small in comparison to the entire process.

*Flowchart*

The flowchart in Figure 7 depicts all the different processes involved in herring production in 2016, and shows the way the model was set up in CMLCA. All four fish species essentially have the same product system, with minor details differing per species. For instance: fishing grounds, fuel consumption, and number of trips.

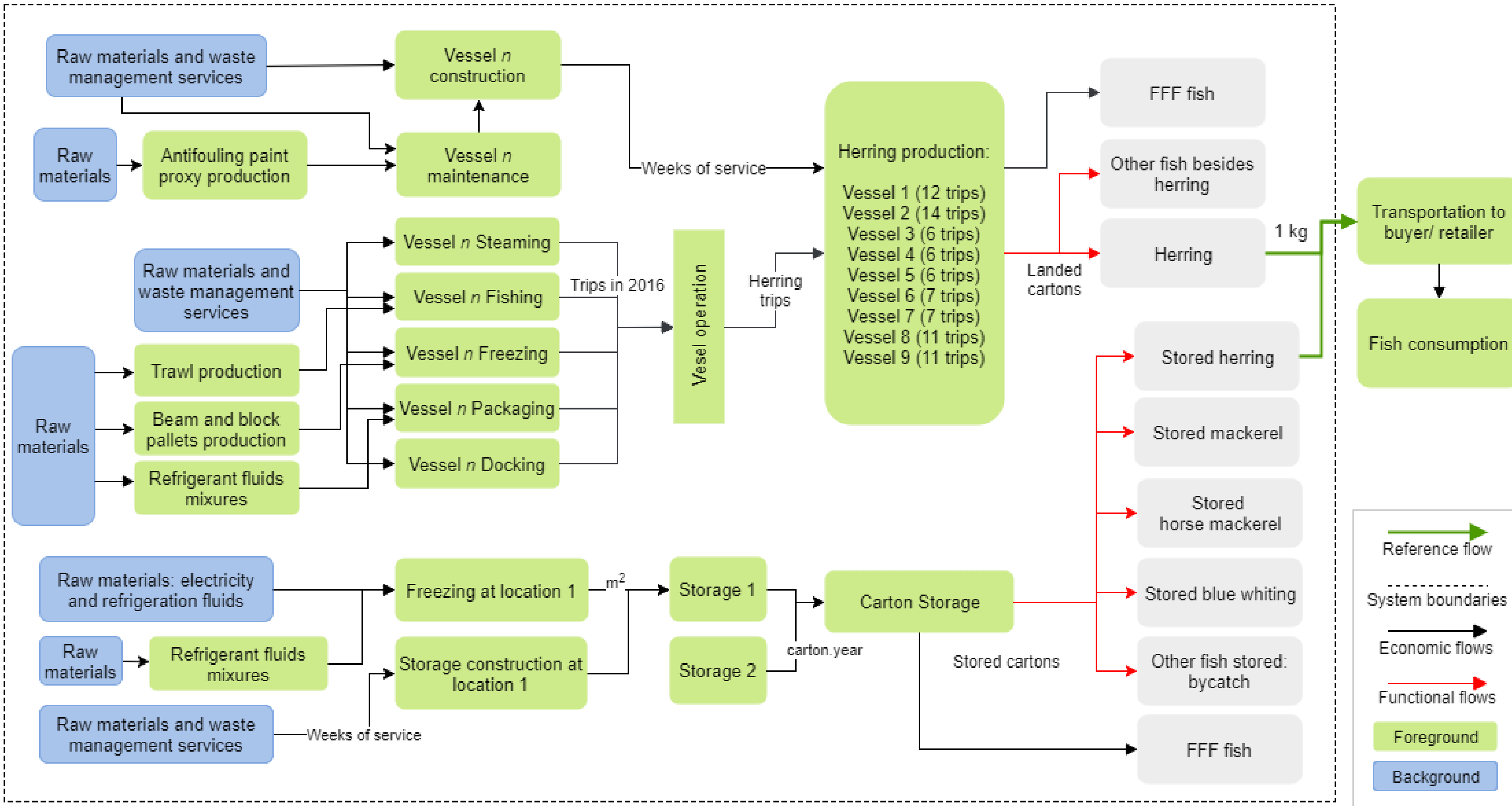



*Figure 7. Flowchart for the production system of the herring alternative.*

Fishing grounds differ per fish species, therefore the distance travelled to the specific fishing grounds from port also differs per species. Each species is fished for in a specific season, the weather circumstances also differ depending on the season, thereby fuel consumption could also differ per species. Figure 8 depicts trip number distributions, giving an indication of how these values can differ per fish species and could possibly affect the outcome of the four alternatives.

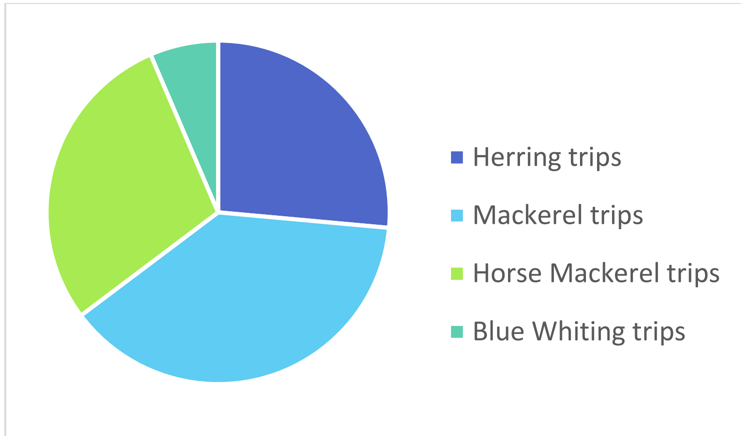



*Figure 8*. Overview of trip distribution over the four fish alternatives in 2016

Vessel construction data was obtained directly by interviewing the company's naval architect. The process included the main materials embedded in the ships, transportation of raw materials to the construction site, and their waste management in the end of life. The product of the vessels was given in weeks of life. Lifespan was set as 40 years for every vessel of the fleet.

Vessel maintenance included painting since this is a periodic operation over the lifespan of the ships. Other activities also take place as part of maintenance, but are contingent because they do not happen periodically. For instance: replacement of fishery equipment and engine overhauls. For this reason, as in the ecoinvent ship maintenance process, only painting was taken into account. Data was obtained from records in the company and from suppliers. Extensions were estimated using the volatile organic compound (VOC) concentrations given in product data sheets for antifouling paint, other used paint, and thinner.

Vessel operation was divided into five processes: steaming, fishing, freezing, packaging, and docking. Fuel consumption was divided over all of these stages using available data on trips timing records. Lubrication oil, sludge waste and bilge oil waste were considered part of the steaming stage. Fishing included netting production and its waste management. Packaging included pallets, packaging film, cardboard boxes, plastic stripe, and plastic and cardboard waste management. All refrigerant consumption was considered part of the freezing process. And finally, docking included electricity consumption for some vessels which can be plugged in once at port. The output of these stages were the number of trips each ship accomplished over 2016. During each trip, each ship produced a number of cartons of each alternative, a number of bycatch cartons, and a number of naked cartons of low quality fish (no cardboard is used). Cartons weight differed depending on the fish species.

It is worth explaining that fish is frozen, packaged, labeled and stored aboard the vessel within 24 hours. Temperature is kept very low in the storage area (-23°C). Fishing proceeds until the vessel is full, after which it returns to port. And trips usually last between three to five weeks. A combination of fuels is used to keep the vessel running. Usage depends on their prize and on meeting legal requirements from the area where the fishing happens. For example, marine diesel oil is used when at the North Sea or the Channel, but heavy fuel oil is used in other regions. Consumption greatly increases at the time of actual fishing. Exhaust gases are directly released to the atmosphere and emissions are not monitored, but the company complies with fuel characteristics as required by applicable legislation

Storage of landed cartons takes place at different locations in the Netherlands and abroad. Data was available for only two locations, which means storage is modeled only after these buildings. The on shore freezing process included: infrastructure as 52 weeks use of its total lifespan (50 years), refrigeration fluids production and extensions, and waste management for the site. The electricity used to operate the cold stores originates from the grid from a renewable source (hydropower) and from CV's solar panels. The output of this process were cartons of each alternative, cartons of other fish species (by-catch), and naked cartons of waste fish. Storage duration depends on the client's demand per fish species among other things (Figure 9).

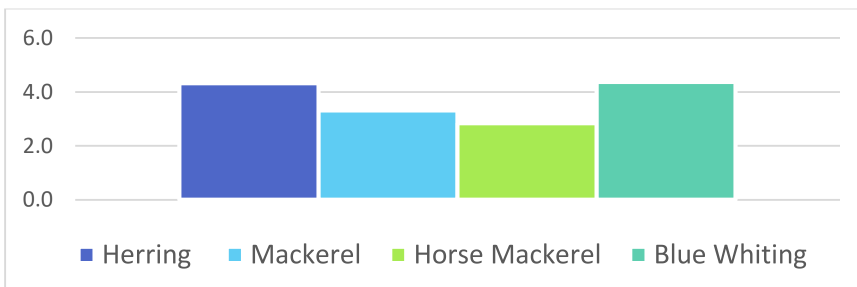



*Figure 9*. Overview of storage duration for each of the four fish alternatives in 2016 (y-axis = months).

Transportation to buyers and consumption were left out of the system's boundary.

Overall the flowchart followed the guidelines given at the LCA course taught at Leiden University (J. Guinée 2016).

### *Data collection and relating data to unit processes*

This section elaborates on data collection sources and assumptions. An annex spreadsheet shows the data collected and related to each of the model's unit processes. Data were collected from primary and secondary sources. By means of interviews, company data, literature or database Ecoinvent v2.2 (Frischknecht et al., 2015). The model was structurally the same for every alternative.

The basic structural setup and content of the model took after the ship products existing in the ecoinvent database, but as a whole it was tailor suited to Cornelis Vrolijk´s inputs. For processes such as: vessel construction and maintenance, paint production, marine diesel usage, heavy fuel usage, cardboard boxes, plastic straps, plastic film, etc., components in the original ecoinvent process were either added to or removed from a copied product when deemed appropriate. The netting production was created from scratch in the CMLCA file using the available data from suppliers. When data was unavailable, comparable means were used and reasonable assumptions made. The following lines in this section detail the considerations made for each of the processes used in the model.

### Vessel construction

The main source of data was the naval architect of the company, who provided an overview of all the materials, transportation and waste produced for five of the vessels of the company's fleet. The remaining vessels were assumed similar and modelled based on their gross tonnage. Assumptions were the following (Aalbers 2017):

- Steel for structure included: hull structure, hatch covers and welding. The net steel mass was multiplied by 1.1 to account for the production of steel that became leftovers and later went to recycling
- Steel for structure when missing was estimated with regression equation ($y = 0.4883x^{0.9789}$) using data from five vessels (y is steel; x is gross tonnage)
- Steel in the machinery was estimated (when missing) as 20% of the gross tonnage
- Paint was estimated as 1.1% of gross tonnage
- Carpentry materials were estimated as 2% of gross tonnage and the mass of each material considered the following shares: aluminum 73%, floors 14%, and plywood 14%.
- Insulation material was taken as polyurethane and as 4% of gross tonnage
- Cabling was estimated (when not given) using regression ($y = 0.0666x^{0.793}$) from data on three vessels (y is cabling; x is gross tonnage)
- For electronics, 4 tons were considered to be replaced every 15 years
- Transportation of carbon steel was estimated considering 20t trucks transporting the steel 100 km
- Transportation of machinery was estimated considering 20t trucks for 500 km
- Electricity consumption was taken from the ecoinvent *ship construction* process available as a starting base, and modified based on the ship´s gross tonnage. CV's fleet gross tonnage varies from 2-7 thousand tons. The ship from ecoinvent gross tonnage was estimated based on the amount of steel embedded, using equation $y = 0.4883x^{0.9789}$ (y is steel; x is gross tonnage)

All data inputs related to the lifespan of the vessels were established on a 40-year basis. And this number of years was allocated among the four main fished species and the bycatch (five outputs). Historical landings of the five outputs for the period 2009-2016 were obtained. The shared of landings per output were calculated. Then it was assumed that the shared of landings would equal the share of vessel lifespan used for such output. And this is how the impact the vessel construction stage was allocated.

### Vessel maintenance

Only the painting operations were considered in this unit process. Data was gathered from company's records from two suppliers. Three products were considered: antifouling paint, other paint, and thinner. For each product both density and VOC concentration were taken from product sheets to obtain the amount of product in mass units, and VOC emissions also in mass units.

An antifouling paint unit process was not available in ecoinvent. A proxy was created by copying the Alkyd paint unit process available in ecoinvent, and adding to it: 0.22 kg of copper oxide per kg of paint, and 0.22 kg of zinc oxide per kg of paint. These quantities were taken from a product data sheet of one of CV's paint suppliers.

The available data varied for each vessel. While some showed records for a long period (2001-2016), others only had two or three years of data available. A yearly average for the available data was made. The reason for using averages here was that even though painting was a periodic operation paint consumption shows great variation among years. Waste management for this unit process was not taken into account.

It was considered that construction and vessel maintenance together would account as vessel infrastructure for each one of the fish alternatives. The output of both is 52 weeks.

### Vessel operation

As mentioned before, the vessel operation included five unit processes: steaming, fishing, freezing, packaging, and docking. All data inputs from each stage were related to the number of trips accomplished by each of the nine targeted vessels over 2016.

#### Steaming

The following interventions were included in this process unit: engine room sludge, bilge oil waste, and lubrication oil. Sludge and bilge oil data was taken either from waste records invoices or oil record books. When invoices were not available, the total amount of oily waste reported in the oil record book of each vessel, was subsequently split into sludge (74%) and bilge oil (26%). This division was based on the average distribution calculated from the available invoices. Lubrication oil consumption was estimated based on the amount of energy produced by the fuel used. Calorific value of the fuels was used: 44 MJ/kg for the heavy fuel oil, and 45 MJ/kg for the marine diesel (NTNU, 2017); lubricant consumption was assumed 1g/kWh (Aalbers, 2017).

#### Fishing

All netting materials used by the vessels over one year were considered in the fishing process unit. Data was taken from interviews with one of the company´s net supplier, the main one. Data for vessels 1 and 2 were assumed to be the same as those of vessel 9, since they were the smallest vessels in the fleet. The supplier has calculated yearly netting consumption for each of the vessels using data over a 15-year period. It was assumed that 20% of the netting is lost at Sea; and that 90% of the netting waste brought to shore is recycled, while the remaining 10% is disposed in a landfill. 38% of the netting raw materials come from recycled inputs, but this was not taken into account in the unit process.

Net composition in terms of mass of materials embedded was given by the supplier for two types of nets: regular and dyneema, and two sizes: large and small trawl. An average of the four was used. All nets were produced using nylon, polyester, and polyethylene; their proportions vary among types and sizes. Waste produced was assumed at 5% of the total net weight. Transportation of raw materials was considered to be by road for an average of 1000 km. (de Graaf, 2017)

#### Packaging

This process unit took into account pallet production and usage, and materials for packaging the fish cartons. Cardboard boxes were modeled after the carton board boxes available in ecoinvent (0.534

g/carton); plastic strips were assumed as granulate polypropylene (9g/carton); and plastic film was assumed as HDPE packaging film (25g/carton). Waste flows were taken from waste management suppliers' invoices, but they were not available for every vessel and greatly varied in type and amount among vessels. The different types found in the invoices were: plastics, assumed to go to incineration; paper and cardboard, assumed to go to recycling; iron, also for recycling; building and demolition waste, assumed to be disposed as inert waste to landfill; and business waste which was regular waste, assumed to be packaging cardboard to municipal incineration. Waste management methods for each of these waste flows was based on the method the waste management companies mention in their webpage, but was not able to be confirmed by contacting them. This is why the stress on describing them as assumption is made.

Pallet production was modeled using primary data and the available pallet product in ecoinvent. The amount of materials embedded (particle board for outdoor use (74% volume), softwood (26% volume), and low-alloyed steel (195g/pallet) were calculated from volumetric measurements given in data-sheet specifications as provided by the company. There were two types of pallets: beam and block. Data for the number of each type used by each vessel was provided by the company. The total pallet inventory circulates between vessels and storage locations. No set value was available for the entire pallet inventory since it is highly dynamic; it depends on pallet-included fish exports, offshore storage stay time, pallet breakage and repairing, and pallet waste flows. In this sense, the number of pallets given for each vessel was adjusted by adding the number of pallets needed for renewing and maintaining the inventory, and by dividing this number by the lifespan. Assumptions were the following, as given by the pallet manager at the company:

- 20% was added in the number of new pallets needed to account for waiting time of repairing process and end of life
- 20% was added in the number of new pellets needed for substituting those that are lost when fish is sold pallet-included
- Lifespan for beam pallets was established as 3 to 7 years. For the block pallets it was 1 to 3 years. In both cases the average value was used
- Pallet waste flows were not accounted in this unit process, but in the on-shore storage one

### Freezing

The freezing process unit included all the refrigeration fluids used in each of the vessels. Data came from both vessel records of the stocks in 2016, and supplier's records on the flows (mass bought for refilling) over the period 2008-2017. A yearly average was considered to account for the flows. Information was not available for all of the vessels. When this happened, a 13% leakage annual rate was considered (CEPA, 2016).

Not all refrigerants were available as products in the ecoinvent database, since five out of nine used by the vessels were composed of a mixture of different refrigeration fluids. Compositions were taken from literature and included as new products in the CMLCA file. Refrigerant input was calculated as the yearly average flows, and extensions are also the average yearly flows.

### Docking

The docking process unit included fuel and/or electricity used when the vessel was docked. All vessels always used fuel in order to keep the necessary machinery running when docked. These processes could, to some extent, be taken over by shore-side electricity. Only one of the ports has the shore-side electricity provision fully setup. And only some of the vessels have had their electrical system rewired in order to be able to connect to shore-side electricity. Therefore, the electricity used for docking was only taken into account for these vessels.

### Distribution of fuel consumption among stages

Fuel consumption takes place in all five “operation” unit processes: steaming, fishing, freezing, packaging, and docking. Either marine diesel and/or heavy fuel is consumed, depending on the vessel and area of operation. In order to theoretically divide the total fuel consumption over these five processes the following assumptions and calculations were made.

When designing a vessel, a naval architect makes an electrical load balance. The electrical load balance (ELB) includes an overview of the power of all machinery used on board. However, the only ELB available, was that of vessel 4. Therefore, the assumption was made that the ratios of power between the five processes were similar to those of vessel 4 for all the CV fleet. Based on the ELB of this vessel and an interview at the fleet management department, an overview was setup for the amount of power each operation process used per day for each of the vessels. Subsequently the energy used per day and their ratios were calculated for each of the vessels.

Each vessel had an average number of days a trip took per year that differed from the other vessels. The duration of each of the five operation processes also differed amongst each other, the vessels and years. These data provided an overview of how much time/days each operation process took per trip per year, but was only available for some vessels.

The energy ratio for each operation processes per vessel multiplied by the cohering average duration of that operation process, lead to the amount of energy consumed per vessel per trip per year. Then ratios of energy consumption between operation processes were calculated. Dividing the total fuel consumption of each vessel over the five operation processes according to the ratios of cohering energy consumption per trip per year leads to the specific distribution of fuel amongst the five different operation processes per vessel per year.

For the vessels lacking trip time data, average fuel distribution among stages was calculated using results from the vessels that did have information: steaming 2%, fishing 13%, packaging 14%, freezing 66%, and docking 6%.

### Fuel usage process units

Here the development of the fuel usage process units for: marine diesel (gasoil), heavy fuel, and biofuel, are described. All three fuel usage process units operate under the same premise. The fuel use and emission conversion calculations can be found in the excel appendix.

#### *Heavy fuel*

A process unit was made for the use of heavy fuel oil, including heavy fuel production and heavy fuel use. The process unit included 1 kilogram of heavy fuel oil from storage as a product in, and the cohering extensions out (emissions) for the use of 1 kilogram of heavy fuel oil. The product out was the use of one kilogram of heavy fuel oil.

#### *Marine diesel (Gasoil)*

The process unit for marine diesel use was made using the same methods as was used for heavy fuel. Only now using low-Sulphur diesel instead of heavy fuel. Low-Sulphur diesel was used instead of marine diesel, because there was no appropriate marine diesel available in ecoinvent that matched the specification of that used by CV, while the low-Sulphur diesel did.

### *First generation biofuel*

The biofuel used for the scenario development was a first generation biofuel, produced from the rapeseed crop to make rapeseed oil, which reacted with methanol and glycerin to make rape methyl ester. This is an alternative to biodiesel, which in this study was used as a possible replacement for marine diesel and heavy fuel oil used in the LCA.

The process unit for biofuel use was made using the same methods as was used for heavy fuel and marine diesel. Only now using rape methyl ester from storage as the product in, and the cohering emission values for the use of one kilogram of biodiesel.

### Landings and number of trips per alternative

The number of cardboard boxes landed for each vessel and fish species were calculated from a database provided by the company´s financial department. Included data were: product code, species name, species group, carton count, trip number, ship name, ship number, and date ranging from January 2009 to December 2016. Using the database, the following indicators were calculated for each alternative for year 2016:

- Number of trips where the alternative was fished
- Number of the alternative's cartons
- Number of discard cartons
- Number of other fish beside the alternative's cartons

The database was also used to produce monthly landing fish flows by species, later used to estimate on-shore storage stay times.

### On-shore fish cartons storage

There are multiple storage locations where CV stored and froze their fish cartons after landing. However, CV is not (100 percent) owner of all of these cold stores. Therefore, it was not possible to obtain data for all locations. More accurately, there was only specific data available for two and thus these were the only ones taken into account for the model. The model included: construction, on-shore freezing, and waste management. The lifetime of a cold store was assumed to be 50 years (2600 weeks). Maintenance of the cold stores was left out of consideration because there was not a recurring point set in time when the cold stores were maintained, and if they were maintained it was only after long time period (+/- 30 years). This in fact varied greatly among the different locations.

### On-shore storage facility construction

The construction unit process of the storage included the following building materials: Wood and steel for the structural components of the building, metal sheeting for the outside of the building, and the insulation which was represented by polyurethane (PUR), polyisocyanurate (PIR) and polystyrene. The disposal of all construction materials was modelled as a service (excluding the wood and steel). There were no documents available that could indicate what the original construction materials were. Therefore, the original construction materials were assumed to be the same as those used for the maintenance of the storage buildings.

### Wood and steel construction

Dimensions were calculated based on the floor plans, which were provided by the technical department. The total building area was used to calculate the amount of material that makes up the structural components of the building. This was represented by a general process offered by the Ecoinvent database; which included and represented the steel and wood used for the construction of the storage building (frieschknecht et al. 2005).

### Sheeting and insulation construction

The circumference in combination with a 'length indication' were used to calculate the amount of sheeting and insulation that was used for the storage building construction (appendix. storage). The length indication was a calculation for which the average height of the storage buildings were subtracted by the average dam wall length (1.80 m). The average height of the storage building differed per location.

Either polyurethane or polystyrene could be used for insulation. It was chosen to use polyurethane, rigid foam, at plant in the model. According to the floorplans, the floors and roofs of the storage buildings were isolated with polystyrene.

### Sheeting material

The sheeting material used was SAB 35/1035, with a specific material thickness of 0.75 mm (Stolk bouwmaatschappij, 2014; Stolk bouwmaatschappij, 2013). This thickness correlated to 7.11 kg of material per $m^2$ (Tatasteel, 2015). The material was in its simplest form galvanized steel: S-320 GD+Z-275 or Galalloy® or MagiZinc® (Tatasteel, 2015). There was no galvanized steel available in ecoinvent, therefore Chromium steel was used as a proxy for the sheeting. The disposal of the sheeting was also modelled as a service in the construction.

### *Insulation* materials

#### *PIR - polyisocyanurate*

This is a thermoset plastic, of which the chemistry was similar to polyurethane (PUR) (Building science corporation, 2007). Except that the proportion of methylene diphenyl diisocyanate (MDI) was higher and a polyester-derived polyol was used in the reaction instead of a polyether polyol (Building science corporation, 2007). Catalysts and additives used in PIR formulations also differed from those used in PUR (Building science corporation, 2007). There was no PIR available in the ecoinvent database, therefore PIR was represented by PUR in the model with the density of PIR.

#### *PUR - Polyurethane*

The density of PUR ranges anywhere from 65 to 400 kg/m3 (Philips et al., 1974). Therefore, when PUR was used as a proxy for PIR, the density of PUR was assumed to be the same as that of PIR, 40 $kg/m^3$ (Isoclad PIR, 2015).

#### *Polystyrene*

The floors and roof were insulated with polystyrene according to the floorplans. Polystyrene foam slabs had a density of 30 $kg/m^3$ and a thermal conductivity of 0.035-0.04 W/mK (Frischknecht et al., 2005).

*Average thickness and amount of the insulation*

The average values were: walls = 50 mm, floors = 30 cm, and roof = 30 cm. These values were based on information gathered from the floor plans. The assumption for the amount of insulation used could be challenged. Because the average height of the storage areas was estimated to be 9 meters, and since there were some minor height variations here for each of the buildings, the estimated 9 meters could vary from reality. The thickness of the insulation for the floors and roofs was assumed to be 30 centimeters, because these numbers were only available in the floor plans of some of the buildings. These values were multiplied by the circumference of the entire storage area, rather than the separate cooling cells.

### On-shore Freezing

The freezing unit process of the storage included: the electricity and refrigerants used to store the cartons of fish.

### Electricity

The electricity data was provided by the financial department concerning storage 1, and by the Operational department concerning storage 2. The electricity was used for the freezers and charging of the batteries of electrical forklifts used in the cold stores. A small amount of electricity is used for the office buildings.

### Refrigerants

The freezing process unit included all the refrigeration fluids used in each of the locations. Data came from the technical department at CV where the stocks and the annual flows were recorded. The stock was the capacity of the system, and the flows accounted for the annual loss of refrigerants to the atmosphere. The same considerations as for refrigerants used in the vessels apply for data input to the model.

### Storage waste

The waste created in the cold stores consisted of wood, cardboard, and construction waste. Wood waste originated from pallets and cardboard waste from the cartons in which fish was packaged. The wood and cardboard waste here also represented the wood and cardboard waste for the entire production chain, not just storage. Since they were not discarded anywhere else in the system.

The construction waste was a mix of wastes that could not be separated or further identified based on the invoices. It consisted of some cardboard and wood, but mostly included other materials that were not the direct result of practices in the storage area. Therefore, demolition waste and wood were summed up and disposed of together. Waste was treated in accordance with the waste retrieval companies their regulations.

### Carton storage stay-time

Storage stay time for each fish species was used to correct for the impact of the different species' cartons stored, as depending on sales situation they remain in storage for variable periods. The number of cartons was multiplied by the fraction of year the species in question was stored for in 2016.

Average stay time was estimated using Little's law (Little & Graves, 2008): $L = \lambda \cdot W$

L is average number of items in queuing system, W is average waiting time in the system for an item, and λ is average number of items arriving per unit of time. Cartons in queu (L) were calculated from the company´s overall 2016 inventory per quarter, which included the amount of cartons stored at five moments in the year for each of the species. Cartons arriving per unit of time were calculated using the landings data base.

The average number of cartons of each species at each storage location in 2016 was multiplied by W. Thus, the obtained units for the on shore storage process unit were [carton·year].

### 3.1.4 Multifunctionality and allocation

Allocation is partitioning of input and/or output flows of a multifunctional process in the product system (Guinée et al., 2007). There were three multifunctional processes in each product system: the vessel infrastructure, with five functional flows; the fish production, with two functional flows; and the on-shore storage with five functional flows (Table 8). Physical allocation was applied since system expansion was not an option due increased complexity and lack of time for taking into account transportation to buyers and consumption stages.

*Table 8. Multifunctional processes summary.*

| Multifunctional unit process | Functional flows | Allocation | Partitioning |
|---|---|---|---|
| Vessel construction (vessels 1-9) | Construction for herring<br>Construction for mackerel<br>Construction for horse mackerel<br>Construction for blue whiting<br>Construction for other fish species | Physical | In Excel appendix |
| Herring production | Herring fish<br>Other fish besides herring | Physical | 0.768<br>0.232 |
| Mackerel production | Mackerel fish<br>Other fish besides mackerel | Physical | 0.261<br>0.739 |
| Horse mackerel production | Horse mackerel fish<br>Other fish besides horse mackerel | Physical | 0.120<br>0.880 |
| Blue whiting production | Blue whiting fish<br>Other fish besides blue whiting | Physical | 0.489<br>0.511 |
| Ijmuiden storage | Ijmuiden herring storage<br>Ijmuiden mackerel storage<br>Ijmuiden horse mackerel storage<br>Ijmuiden blue whiting storage<br>Ijmuiden by-catch storage | Physical | 0.744<br>0.159<br>0.0255<br>0.0432<br>0.0274 |

A comparison of physical versus economic allocation was performed as part of the sensitivity analysis. Considered price averages provided by the company are given in Table 9.

*Table 9. Data used for economic allocation.*

| Functional flow | Average price (€/carton) |
|---|---|
| Herring fish | 15.80 |
| Other fish besides herring | 19.10 |
| Mackerel fish | 20.60 |
| Other fish besides mackerel | 13.60 |
| Horse mackerel fish | 18.70 |
| Other fish besides horse mackerel | 14.30 |

| Functional flow | Average price (€/carton) |
|---|---|
| Blue whiting fish | 12.60 |
| Other fish besides blue whiting | 18.10 |

### 3.1.5 Selection of Impact Categories

Selected impact categories can be seen in Table 10. Odor, noise, human activities, and biodiversity aspects are excluded from the analysis.

*Table 10. Overview of the selected impact categories and category indicators.*

| Label | Impact Category | Unit |
|---|---|---|
| [C51] | land use, competition[GLO] | $m^2a$ |
| [C53] | eutrophication, generic[GLO] | kg $PO_4$-Eq |
| [C55] | resources, depletion of abiotic resources[GLO] | kg antimony-Eq |
| [C65] | acidification, generic[GLO] | kg $SO_2$-Eq |
| [C67] | photochemical oxidation (summer smog), high NOx POCP[RER] | kg ethylene-Eq |
| [C72] | climate change, GWP 100a[GLO] | kg $CO_2$-Eq |
| [C79] | terrestrial ecotoxicity, TAETP infinite[GLO] | kg 1,4-DCB-Eq |
| [C82] | marine aquatic ecotoxicity, MAETP 100a[GLO] | kg 1,4-DCB-Eq |
| [C86] | freshwater aquatic ecotoxicity, FAETP 100a[GLO] | kg 1,4-DCB-Eq |
| [C96] | stratospheric ozone depletion, ODP steady state[GLO] | kg CFC-11-Eq |
| [C100] | human toxicity, HTP infinite[GLO] | kg 1,4-DCB-Eq |

### 3.1.6 Selection of characterization methods, category indicators, and characterization models

Eleven of sixteen impact categories were selected from the generally suggested 'family': "CML2001". With two category totals were added to the 'family' for the normalisation: "World 2000" and "Netherlands 1997-1998". This resulted in two characterization methods: "CML2001_Baseline, reference, World, 2000" and "CML2001_Baseline, reference, Netherlands 1997-1998". The category indicators are given in table 11.

*Table 11. Overview of the climate change category indicator derivation.*

| Characterization of Impact Category | Climate change, GWP 100a[GLO] |
|---|---|
| LCI results | Emissions of greenhouse gases to air (kg) |
| Characterization model | CML 2001 model |
| Category indicator | Carbon dioxide ($CO_2$) |
| Characterization factor | Global warming potential for a time horizon of 100 years for each greenhouse gas emission to air (kg $CO_2$-eq/kg emission) |
| Unit of indicator result | kg $CO_2$-eq |

### 3.1.7 Normalization choices

Normalization values were calculated for the impact categories of the characterization methods: "CML2001_Baseline, reference, World, 2000" and "CML2001_Baseline, reference, Netherlands 1997-1998". The "World 2000" totals included the total quantity of interventions for the reference year 2000 and the geographical area, World. “Netherlands 1997-1998” totals included the total quantity of interventions for the reference years 1997-1998 and the geographical area, Netherlands.

### 3.1.8 Contribution, sensitivity and scenario analysis

Contribution analysis was done by life cycle processes per impact, per general stages within the process (vessel operation and on-shore storage), and per each vessel and storage location. To better understand each part of the process, inside the vessel operation, the contribution was also analyzed considering: steaming, fishing, processing, freezing, docking and vessel infrastructure with and without fuel. Likewise, the storage contribution was analyzed per location concerning construction and operation. Furthermore, the contribution of electricity and non-natural refrigerants was analyzed.

The sensitivity analysis was done considering two choices of allocation for the output of fish production in the vessel operation stage: physical and economic partitioning.

Scenarios were assessed based on the hotspot identification. In one case it was proposed that all the vessels would use 100% marine diesel, eliminating the usage of heavy fuel oil. In a second scenario it was proposed that instead of fossil fuels, biofuel would be used. In this case the amount of it to consume was estimated base on the calorific value of both types of fuels.

## 3.2 Indicators for CSR

Environmental indicators are proposed for CV to include in their CSR policy. The methodology suggested by Cervantes (2017) is applied, implying the definition of boundaries, objectives and topics for sustainability, and indicator establishment ensuring its measurability.

The boundaries for designing the indicators were set generally the same as the ones for the LCA study: fishing and storage operations.

Objectives for sustainability are established using the aquatic supply chain criteria proposed by Hanson et al. (2011), the company´s 2016 CSR report sustainability pillars and topics, and the results from interviews to stakeholders from the sector. The results on hotspot identification from the LCA study are also considered. Overall from all this sources of information an approach to materiality assessment is made. And by clarifying materiality themes for the industry, the objectives are established.

Insights from the interviews were key for determining sustainability concerns. Stakeholders from inside and outside the company knowledgeable in the fishing sector were contacted and asked to respond to five open questions regarding what their view on sustainability was. In total 15 interviews were conducted to stakeholders from the following organizations:

- Cornelis Vrolijk, CSR department
- Cornelis Vrolijk, Health and Safety department
- Cornelis Vrolijk, Fleet management department
- Cornelis Vrolijk, Skippers from two vessels
- Cornelis Vrolijk, Communications department
- Pontificia Universidad Católica in Peru, LCA-fiseries researcher
- VisNed Coöperatie Kottervisserij Nederland U.A, Science and Policy Advisor

- CERES, Economics of Aquatic Resources researcher
- Pelagic Freezer-trawler Association, Fisheries researcher
- Ministry of infrastructure and environment, Director of water and soils
- Ministry of economic affairs, Policy officer concerning marine protected areas and European Maritime Fund; and Senior adviser on Marine Waters
- Marine Stewardship Council, Fisheries and Commercial Manager

As mentioned before, the interviews were seen an approach to defining materiality for the industry in the form of questionnaire-based research (Luhmann y Theuvsen 2016). The questionnaire format is presented in Annex A. The five topics considered in it are the following:

1. Specific topics that come to mind when thinking about sustainability in the fishing sector
2. Ranking of these topics in importance and explanation
3. Regulation consider important in relation to the industry's sustainability
4. Sustainability related challenges for the fishing sector at the moment
5. Recommend to a non-expert fish consumer

Sustainability topics as suggested by the interviewees are presented graphically, showing frequency and weighted average ranking of responses. Weighting is based upon the frequency of the responses.

In summary indicator definition included taking into account the following information sources: (1) stakeholder opinions from interviews, (2) literature revision on supply chain, sustainability and fisheries available indicators, (3) criteria on sustainable aquatic supply chains, (4) 2016 CSR report, and (5) insights into sustainable procurement concerning fuels. This last point is explained in the next methodology approach section.

Lastly, once the set of indicators was established, they were fit to a sustainability balance scorecard having the business perspective as base. This was done with the intention to ponder whether the proposed metrics seemed strategic enough and in line to a more business-like approach.

## 3.3 Insights into sustainable procurement and interlinkages between CSR, LCA and supply chain

Fuel supply is selected as the input to analyse concerning sustainable procurement. Fuel is the main input driving the environmental performance of the fish production. Thus, the reasons for looking into fuel procurement are threefold. First, to improve the recommendations to be made to Cornelis Vrolijk by confronting the supply chain barriers that changes in fuels could imply. Secondly, to improve the design of CSR indicators. And thirdly, to discuss if results from LCA can be more embedded into CSR policies when considering supply chain management at the same time, as suggested by Blass & Corbett (2017).

Having as background the LCA results and potential improvement options, an interview on fuels procurement with the company´s purchasing department gives insights into the matter. The questions posed in the interview were the following:

1. Who are the suppliers?
2. What is each supplier's competitive advantage? Why are they the chosen ones?

Next, the list of suppliers was investigated through a web search to know if they acknowledged sustainability in some way throughout their webpage. Results are documented and discussed upon literature review on the matter. Finally, a discussion about the interlinkages between CSR, supply chain management and LCA is made having the case of Cornelis Vrolijk as example.

Sections 2.2 and 2.3 of this methodology chapter really ran in parallel in practice. Even during the LCA part, when gathering information and having interviews about the different foreground processes considered, the fuel topic would be discussed if relevant. The following figure summarizes the whole methodology approach.

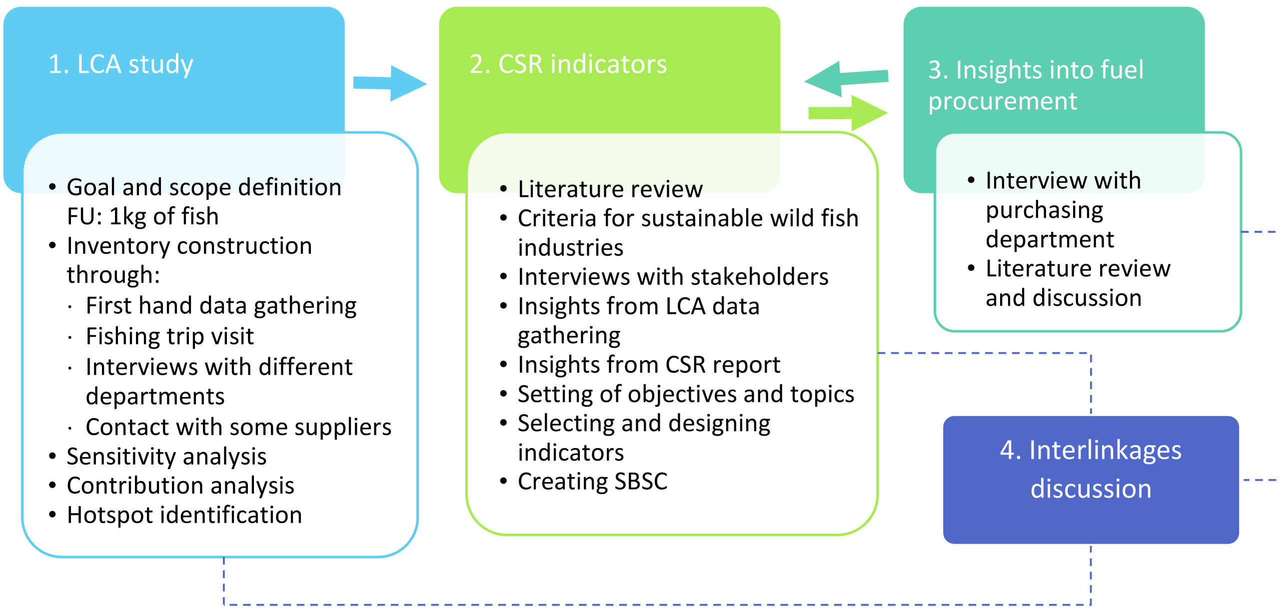



*Figure 10. Overview of methodology.*

# 4. Results: LCA of pelagic fish

Life cycle impact assessment (LCIA) entails selection of impact categories. Results of which are classified, characterized, and normalized for the four alternative fish species (herring, mackerel, horse mackerel, and blue whiting).

## 4.1 Inventory analysis

Results of the inventory analysis of the four systems can be seen in the Excel file appendix.

## 4.2 Impact assessment

Life cycle impact assessment (LCIA) entails the assessment of selected impact categories. As mentioned before the selected impact categories were: land use, eutrophication, depletion of abiotic resourced, acidification, photochemical oxidation, climate change, terrestrial ecotoxicity, marine aquatic ecotoxicity, freshwater aquatic ecotoxicity, stratospheric ozone depletion, and human toxicity. The results for marine aquatic ecotoxicity and freshwater aquatic ecotoxicity were excluded. It is widely accepted that they are highly uncertain categories, and thus are commonly left out of the analysis. Including them further than just for the sake of and initial completeness check would only distort the final results of the LCA.

### 4.2.1 Interventions for which characterization factors are lacking

Interventions for which characterization factors were lacking are located in the Excel file appendix. Among extensions directly stemming from the vessel processes were the non-methane volatile organic compounds, which did not have characterization factors. Other extensions without characterization factors were: biochemical oxygen demand (BOD), chemical oxygen demand (COD), heat waste to water, and oils to water and soil. All of these extensions occur as part of the vessels' operation, though they were not accounted for in the model due to lack of time and readily available information for quantification.

### 4.2.2 Classification

Results of the classification of the selected the impact categories are located in the Excel appendix file.

### 4.2.3 Characterization

Results of characterization are visualized in table 12. Herring has an overall lower environmental impact than the other three alternatives. However, the differences between alternatives are not drastic, overall impacts are similar (Figure 11).

*Table 12. Overview of the environmental profile.*

| Impact category | Herring | Mackarel | Horse mackarel | Blue whiting | Unit |
|---|---|---|---|---|---|
| Land use, competition | 0.385 | 0.391 | 0.423 | 0.591 | $m^2a$ |
| Eutrophication | 1 | 1.13 | 1.26 | 1.42 | g PO4-Eq |
| Depletion of abiotic resources | 4.79 | 5.23 | 5.75 | 6.17 | g antimony-Eq |
| Acidification | 7.72 | 9.17 | 10.3 | 10.5 | g $SO_2$-Eq |
| Photochemical oxidation | 0.252 | 0.294 | 0.333 | 0.354 | g ethylene-Eq |
| Climate change | 1 | 1.11 | 1.19 | 1.16 | kg $CO_2$-Eq |

| Impact category | Herring | Mackarel | Horse mackarel | Blue whiting | Unit |
|---|---|---|---|---|---|
| Terrestrial ecotoxicity | 1.91 | 1.97 | 2.21 | 3.04 | g 1,4-DCB-Eq |
| Freshwater aquatic ecotoxicity | 81.1 | 75.7 | 87.2 | 154 | g 1,4-DCB-Eq |
| Stratospheric ozone depletion | 67.7 | 75.2 | 78.9 | 65.6 | mg CFC-11-Eq |
| Human toxicity | 0.41 | 0.421 | 0.49 | 0.734 | kg 1,4-DCB-Eq |

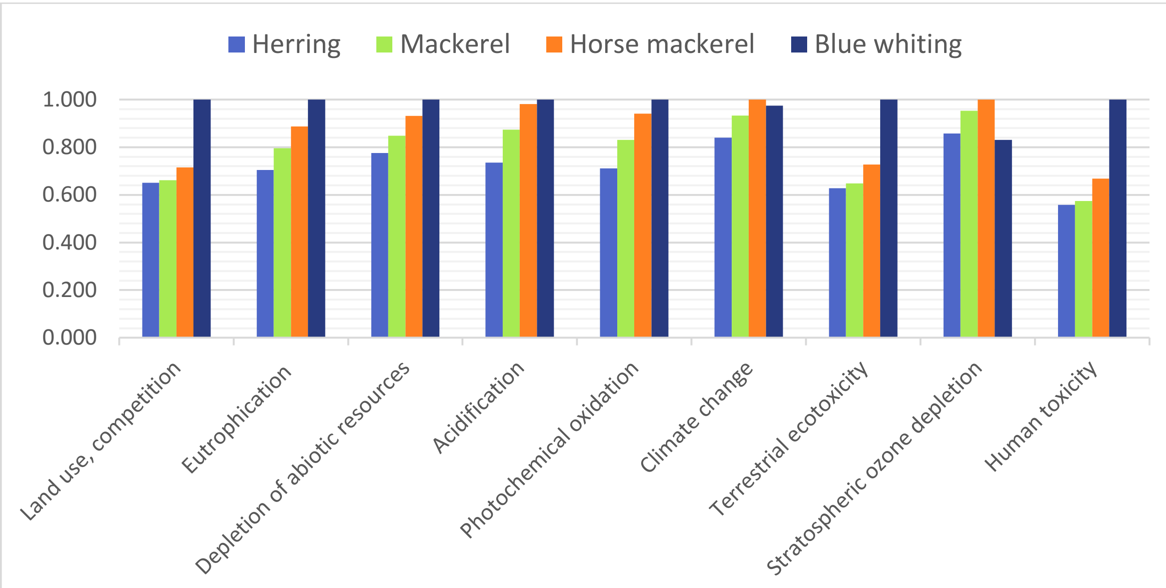



*Figure 11. Environmental profile using baseline family with all impact categories scaled to 1.*

Looking at the climate change impact category, the carbon footprint ranges from 1 kg $CO_2$-Eq for herring, to 1.19 kg $CO_2$-Eq for horse mackerel (Table 13). These results were larger than those reported on by other studies for the same fish species, but in the same order of magnitude (Ziegler et al. 2013; Vázquez-Rowe et al. 2010; Ramos et al. 2011; Buchspies at al. 2011; Winther et al. 2009) (table 10). The difference in results are related to system boundaries and differences in the production processes. And although they refer to the same species, the geographic zone of fishing is different, which can certainly imply different steaming distances and fishing gears used. All of this has an implication on the amount of fuel used. As it will be presented in the contribution analysis, fuel consumption highly determines the impact level.

*Table 13. Comparison of different studies [kg CO-eq /kg].*

| Species | This study | Ziegler et al. 2013 | Vázquez-Rowe et al. 2010 | Buchspies et al. 2011 | Winther et al. 2009 |
|---|---|---|---|---|---|
| Herring, frozen | 1.0 | 0.7 | - | - | - |
| Herring, at harbor | - | - | - | 0.47 | 0.4 |
| Mackarel, frozen | 1.11 | 1 | - | - | - |
| Mackarel, at harbor | - | - | - | 0.32 | 0.4 |
| Horse mackarel, frozen | 1.19 | - | 0.796 - 1.136 | - | - |
| Horse mackarel, at harbor | - | - | - | - | - |

| Species | This study | Ziegler et al. 2013 | Vázquez-Rowe et al. 2010 | Buchspies et al. 2011 | Winther et al. 2009 |
|---|---|---|---|---|---|
| Blue whiting, frozen | 1.16 | - | - | - | - |
| Blue whiting, at harbor | - | - | - | - | - |

### 4.2.4 Normalization

Normalization results increase the understanding of the relative importance of the impact categories among the alternatives. The results of the normalization indicate the contribution of the alternatives to the total reference impact in a year. The land use category is missing since there is no world total available. Magnitudes of normalized results can help identify inconsistencies. Comparing the normalized profiles is not recommended, but the results do allow for the identification of impact categories that might be necessary to analyse with more detail with contribution analysis.

*World 2000*

The Normalization results for "World 2000" are visualized in figures 12, 13, and 14. What the graphs show are category relevance and lack of error in the calculations, since magnitude among indicator results are alike and very small.

Three groups of impact categories can be proposed according to the normalization results. The first one shows the lowest relative importance: eutrophication, photochemical oxidation, terrestrial ecotoxicity, and stratospheric ozone depletion. The second group, which normalized impact result more than doubles those of the first group, includes: depletion of abiotic resources, acidification, and climate change. Human toxicity shows the highest normalized impact results.

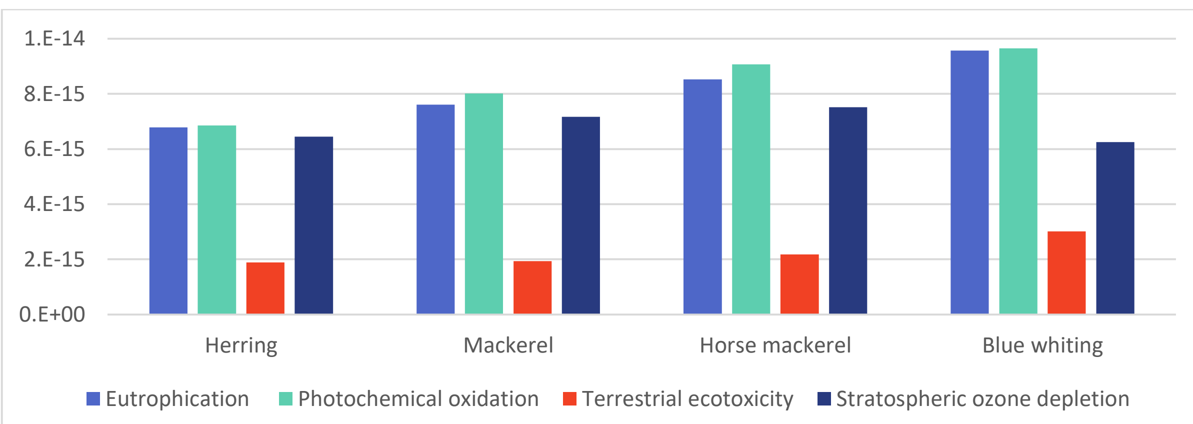



*Figure 12. Normalized impact results for lower impact group (in years).*

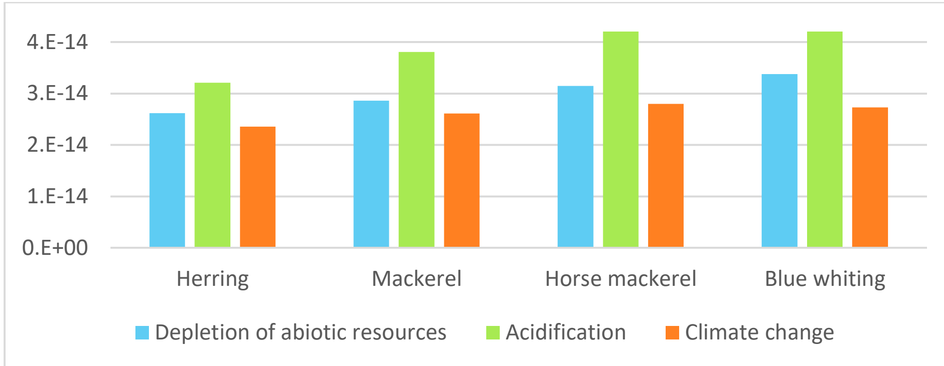



*Figure 13. Normalized impact results for categories with higher impact (in years).*

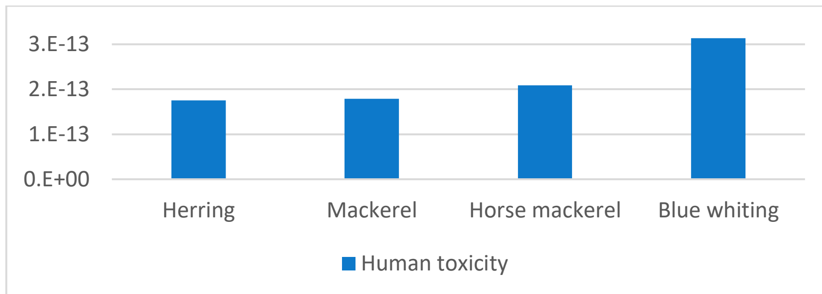



*Figure 14. Normalized impact results for categories with highest impact (in years).*

### *Netherlands 1997-1998*

The Normalization results of "Netherlands 1997-1998" are visualized in figures 15 and 16.

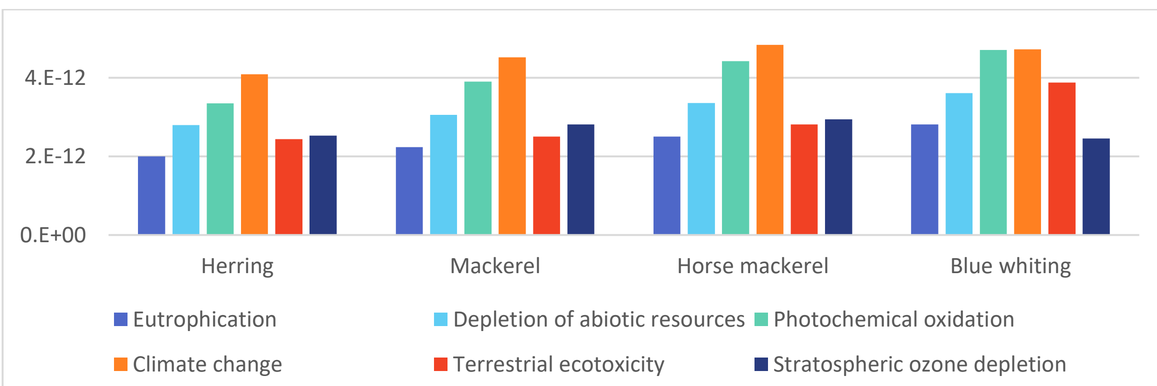



*Figure 15. Normalized impact results for lower impact group (in years).*

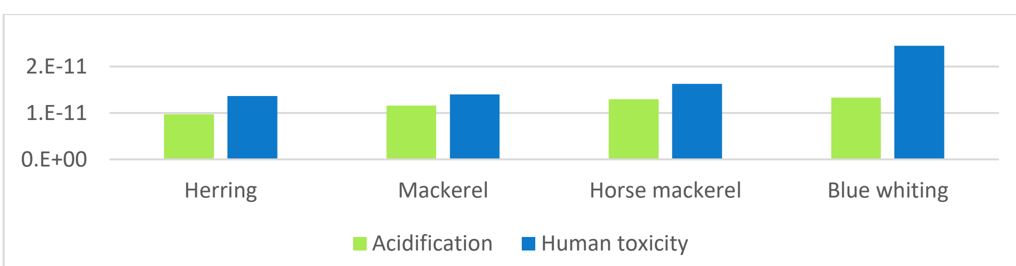



*Figure 16. Normalized impact results for categories with higher impact (in years).*

The overall trend was the same for the results of both normalized totals between fish species and between impact categories. The impact categories: human toxicity, acidification, depletion of abiotic resources, and climate change resources show the largest normalized results and thereby are most influential in both cases.

There were also some dissimilarities between the normalized total results. Where depletion of abiotic resources followed the three most influential impact categories for "World 2000", while instead photochemical oxidation followed for the "Netherlands 1997-1998" totals.

## 4.3 Interpretation

Interpretation evaluates the consistency and completeness of the goal and scope definition, and the. Furthermore, a contribution analysis for relevant impact categories is presented. Lastly, sensitivity analysis performed for evaluating the robustness of the model.

### 4.3.1 Consistency check

The consistency check ensures that all assumptions and data used in the study comply with the goal and scope, and for the selected methods. The model is tailor suited to Cornelis Vrolijk. All foreground data comes from primary sources, and were in this sense completely in line with the goal of the study. The same goes for the scope. Quite possibly, the only important assumption made was to include only two of the cold store sites, being that the company has many more. But information was not available, especially because some locations are outside the Netherlands.

### 4.3.2 Completeness check

The completeness check ensured that all relevant data had been included in the model. The missing information included the cut-offs, already explained as interventions from the operations of the vessels which were difficult to quantify. In the end, the fishing gear was also left out of the analysis since the information was not readily available in the timeframe of the study. Only netting was included, but tools such as: sonar cables, fish sensors, hooks, connectors, shackles, cranes, sounder cables, and wire had to be excluded. For the refrigeration fluids, the production of R143a 1,1,1-trifluoroethane was not accounted for, since it was not available in the ecoinvent database. None of these interventions were expected to greatly modify the analysis results.

The storage stage was considered to be oversimplified and thereby possibly underrepresented in the model. Because an ecoinvent process was used for the structural building materials, the forklifts and lorries were not included. No other locations besides two cold store locations were modelled. The model could be improved by adding the missing cold store locations. Nonetheless, by modelling the system to have all cold store locations be resembled by the ones included, it can be said that the model is complete.

### 4.3.3 Contribution analysis

Here the contribution of processes and their elementary flows indicate which processes and/or elementary flows are essentially impacting the corresponding system. Contribution analysis results gives headway to where improvements could possibly be made to lower the environmental impact.

In general, the interventions contributing the most to the impact in every category are the same for every alternative:

- Land use: more than half of the impact came from the production of softwood, hard wood also contributed with around 15%. They were used in the production of cardboard boxes for packaging and pallet production for storage.
- Terrestrial ecotoxicity: steel production was responsible for around 10% due to mercury emissions to air; ferrochromium production used in background processes was responsible for chromium VI emissions to air contributing around 5%; zinc production was about 3% of the impact; the use of marine diesel in the vessels (4%) contributed 1% from chromium emissions to soil, and 3% zinc emissions to soil; the use of heavy fuel oil in the vessels (15%) was 2% due to arsenic emissions, 3% due to mercury emissions, and 10% due to nickel emissions; finally, other emissions of mercury to air, vanadium to air, barium to soil and chromium to soil, coming from fossil fuel and electricity background production processes, contributed to around 30% of the impact.
- Stratospheric ozone depletion came mainly (75-81%) from the emission of CFC-113 (79%) and HCFC-124 (2%) in refrigerant R134a used as refrigeration fluid both in some vessels and the storage sites.
- Photochemical oxidation came mainly from the use of heavy fuel oil emitting sulfur dioxide (53-59%) and carbon monoxide (4-5%); another 8% of the impact came from background processes related to fossil fuel production (burning and venting of natural gas, burning of heavy fuel oil).
- Eutrophication: a third of the impact came from the use of heavy fuel oil which emitted nitrogen oxides to air (35-43%); the use of marine gasoil or diesel oil also emitted nitrogen oxides to air contributing about 10%; coils of zinc coating, probably related to the production of paint, contributed about 2% in the form of ammonia to air; and production and usage of fossil fuels, along with its residues disposal (sulfidic tailings and spoil from lignite and coal mining) contributed around 35% and includes nitrogen oxides to air, chemical oxygen demand in river water, and phosphates to ground water.
- Climate change: carbon dioxide from the combustion of marine diesel and heavy fuel oil in the vessels contributed 17-23% and 20-28% respectably; emissions of refrigeration fluids (HFC-134a, HFC-143a, HFC-125) from one of the storage locations contributed 8-11%; background processes related to natural gas production and usage also contributed around 12% in the form of methane and carbon dioxide emissions.
- Acidification: most impact came in the form of sulfur dioxide (36-40%) and nitrogen oxides (29-31%) emissions from the combustion of heavy fuel oil; nitrogen oxides from the combustion of marine diesel also contributed 6-8%; ammonia from coils of zinc coating contributed 2%.
- Depletion of abiotic resources: crude oil production contributed 55-66%; natural gas production contributed 16-19%; extraction of lignite and hard coal contributed 10-16%.
- Human toxicity: combustion of heavy fuel oil contributed 28-38% due to emissions of benzene (±1%), arsenic (±2%), nickel (±10%), and polycyclic aromatic hydrocarbons (±15%); ferrochromium production emitting chromium VI, contributed 20-24%; processes in relation to aluminum production contributed 3-4% in the form of polycyclic aromatic hydrocarbons; background processes related to fossil fuels production and disposal of its residues as emissions of selenium to groundwater (±4%), barium to river water (±1%), barite

to ocean water (±6%), and polycyclic aromatic hydrocarbons (±5%) contributed around 11-16%.

- Freshwater aquatic ecotoxicity: most impact (38-40%) came from disposal of residues from coal and lignite mining; disposal of nickel smelter slag contributed 15-17%; sulfidic tailings disposal contributed 5%; disposal of slags and sludge from steel production processes contributed 3-4%; solid waste to landfill contributed 2%; production of carton board boxes contributed 2%. Emitted compounds were beryllium (±13%) to ground water, cobalt to ground water (±10%), copper ions to ground water (±3%), nickel ions to ground water (±38%), and vanadium ions also to ground water (±8%).

Foreground processes and inputs which significantly contributed to impact categories in each of the alternatives are given in tables 14, 15, 16 and 17.

*Table 14. Impact contribution from foreground processes for the herring alternative [%].*

| | Refrigerant R134a | Carton board boxes | Storage 1 | Storage 2 | V5 | Use diesel, low-sulphur | Use heavy fuel oil |
|---|---|---|---|---|---|---|---|
| Acidification | | | | | | 8 | 65 |
| Climate change | | | 8 | 11 | | 21 | 14 |
| Eutrophication | | | | | | 10 | 35 |
| Freshwater aquatic ecotox. | | 2 | | | | | |
| Human toxicity | | | | | | | 28 |
| Photochemical oxidation | | | | | | | 57 |
| Stratospheric ozone depletion | 81 | | | | 2 | | |
| Terrestrial ecotoxicity | | | | | | 3 | 11 |

*Table 15. Impact contribution from foreground processes for the mackerel alternative [%].*

| | Refrigerant R134a | Carton board boxes | Storage 2 | Storage 1 | V5 | Diesel, low-sulphur | Heavy fuel oil |
|---|---|---|---|---|---|---|---|
| Acidification | | | | | | 8 | 70 |
| Climate change | | | 8 | 6 | | 23 | 18 |
| Eutrophication | | | | | | 11 | 42 |
| Freshwater aquatic ecotox. | | 2 | | | | | |
| Human toxicity | | | | | | | 38 |
| Photochemical oxidation | | | | | | | 64 |
| Stratospheric ozone depletion | 76 | | | | 2 | | |
| Terrestrial ecotoxicity | | | | | | 4 | 15 |

*Table 16. Impact contribution from foreground processes for the horse mackarel alternative.*

| | Refrigerant R134a | Carton board boxes | Storage 2 freezing | Storage 1 freezing | V1 | Diesel, low-sulphur | Heavy fuel oil |
|---|---|---|---|---|---|---|---|
| Acidification | | | | | | 7 | 71 |
| Climate change | | | 8 | 6 | | 27 | 23 |
| Eutrophication | | | | | | 10 | 43 |
| Freshwater aquatic ecotox. | | 2 | | | | | |
| Human toxicity | | | | | | | 37 |
| Photochemical oxidation | | | | | | | 64 |
| Stratospheric ozone depletion | 77 | | | | 1 | | |
| Terrestrial ecotoxicity | | | | | | 4 | 15 |

*Table 17. Impact contribution from foreground processes for the blue whiting alternative.*

| | Refrigerant R134a | Carton board boxes | Storage 1 Freezing | Storage 2 freezing | Diesel, low-sulphur | Heavy fuel oil |
|---|---|---|---|---|---|---|
| Acidification | | | | | 6 | 16 |
| Climate change | | | 8 | 10 | 17 | 20 |
| Eutrophication | | | | | 7 | 36 |
| Freshwater aquatic ecotoxicity | | 1 | | | | |
| Human toxicity | | | | | | 21 |
| Photochemical oxidation | | | | | | 57 |
| Stratospheric ozone depletion | 80 | | | | | |
| Terrestrial ecotoxicity | | | | | 1 | 11 |

*Contribution by stages, vessels and storage locations*

A contribution analysis by stage (fishing and on-shore storage) was performed for the four fish alternatives for those categories where foreground processes contribute to more than 50% of the total impact. In almost every impact category, fishing contributes with more than 60% of the total impact.

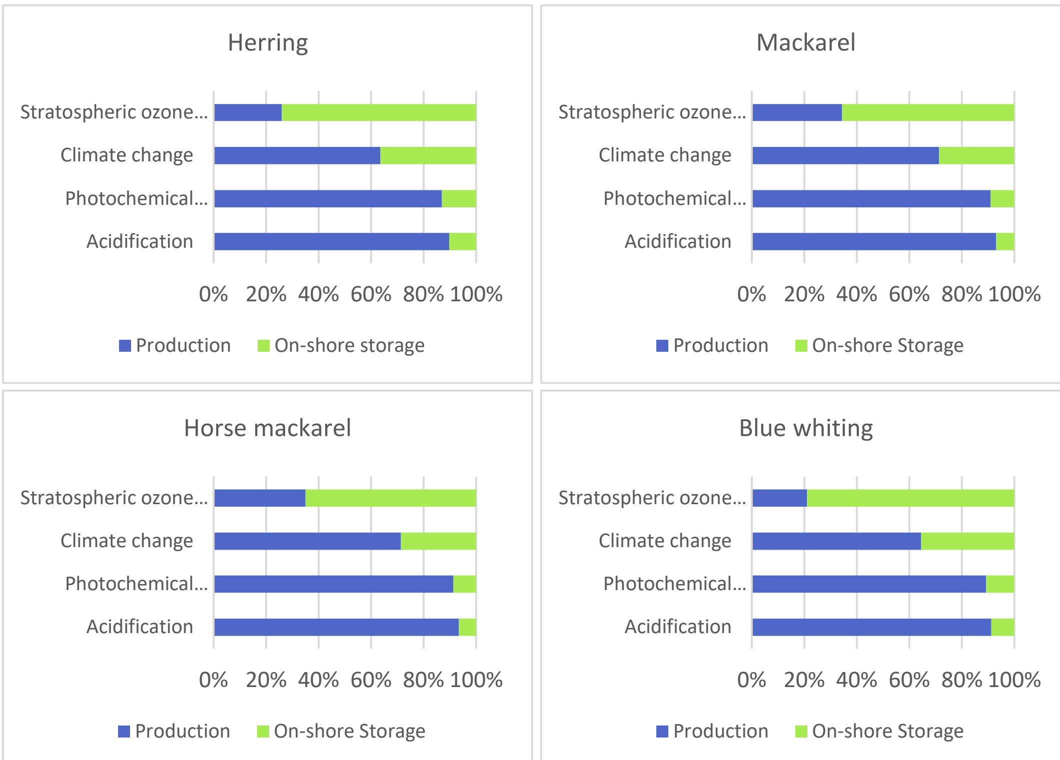



*Figure 17. Impact contribution by stage for the four alternatives.*

The graphs in Figure 18 show the contribution to impact by each of the vessels and storage locations. Vessel contribution was divided among operation (V#) and infrastructure (I), while storage (S#) included both its construction and operation.

Results, as expected, correlated to the amount of cartons produced and stored. Looking at herring and mackerel only, all vessels seemed to contribute similarly. But looking at horse mackerel some distinction can already be seen: vessel 5 dominated in certain categories since it was the biggest vessel in the fleet and caught 15% of this species' landings, only after vessel 6 which caught 28% but is a smaller one.

Taking into account the landing shares made the results obtained for the blue whiting alternative understandable. Most impact came from only two vessels (4 and 6), but together they caught 80% of this species' landings.

Concerning storage, all alternatives show the same trend: location 1 contributed much more than location 2. The reason is that the former one stored about 70% of the landings kept between the two, and besides, the amount of non-natural refrigeration fluids used in Storage 1 was much higher in comparison.


*Figure 18. Impact contribution by vessel infrastructure (I), vessel operation (V#), and storage (S#).*

### *Contribution within vessel operations*

The following graphs depict impact contribution within the different stages of the ship's operation: steaming in to and out of port; locating fish and fishing; processing and packaging of the fish; freezing and cold storage; and docking of the vessel once at port. The vessels infrastructure, which includes construction and maintenance processes is also shown.

Figure 19 focuses on blue whiting production by vessel 6. Graph *a* shows that in most categories the greatest impact comes from the freezing stage, followed by the packaging stage. Freezing inputs include fuel usage and refrigeration fluids. Packaging includes pallets, cardboard and plastic packaging materials, and related solid waste. Due to the usage of wood and paper, the land use category is entirely affected by the packaging stage. Steaming, fishing and docking contribute to less than 20% of the vessel operation impact. Infrastructure also has little contribution in most categories, but is relevant for human and freshwater ecotoxicity due to background processes for the production of compounds such as aluminium and copper, and disposal of waste such as sludge from steel rolling and spoils from coal mining.

When fuels consumption is taken out of the system (graph *b*) impact distribution greatly changes. Instead of freezing, packaging becomes the main contributor; fishing contribution is reduced to non-visible showing the impact of netting is negligible; the share from steaming increases showing the importance of lubricating oil, and disposal of sludge and bilge oil waste. By comparing the freezing stage contribution to climate change in both graphs, it is seen that refrigeration fluids are important make the stage still relevant when taking out the fuel. This however is dependent upon the type of refrigerants used by each vessel; vessel 6 uses non-natural refrigerants. In comparison, Figure 20 shows the same characterization analysis but applied to vessel 4 which uses natural refrigerants. It can be seen that the impact from the freezing stage in graph b is less apparent.

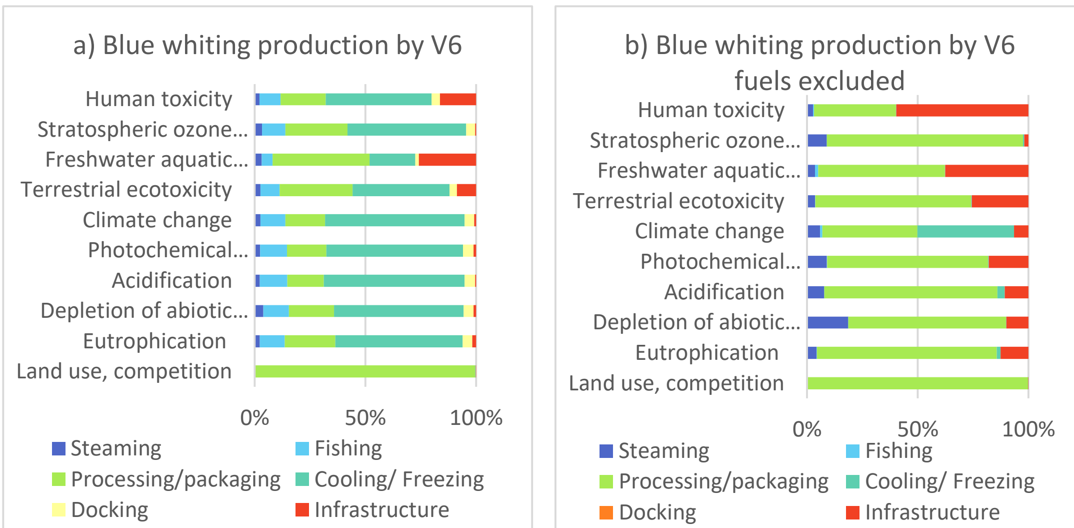



*Figure 19 Impact contribution from blue whiting production by V6.*

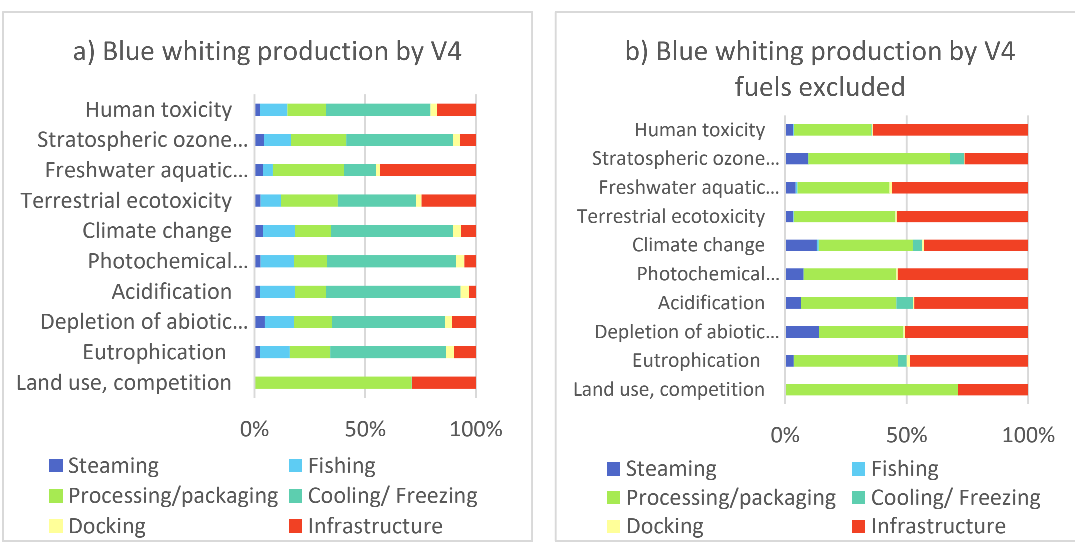



*Figure 20. Impact contribution from blue whiting production by vessel 4.*

Although the relative results from the contribution analysis from fish production stage vary by vessel and species, the trend persists. Freezing is the main contributor in most categories due to fuel usage, packaging follows, then steaming, and then fishing. The relative contribution of infrastructure depends upon the quantity of landings per fish species. Since allocation is based on physical partitioning concerning infrastructure, construction and maintenance impact is bigger for vessel 4 concerning blue whiting since this ship is somehow specializes in this fishery, having landed about 50% of the total catches for this species in the studied year.

Figure 21 shows the impact contribution of the production of herring by vessel 3. Presenting the relative contribution to impact of the production processes by vessel and not by the system as a whole is useful since looking at the specific vessels allows for better hotspot identification given that each vessel has singular qualities. Some seem to focus more on certain species, for instance. Fish which are harder to find or that are further away would spend more fuel in this stage. More importantly inputs differ per vessel in three main ways: some use heavy fuel oil and marine diesel, while others only use marine diesel; only some can use electricity while docking; and all use a different mix of refrigeration fluids for cooling and freezing and their leakages vary.

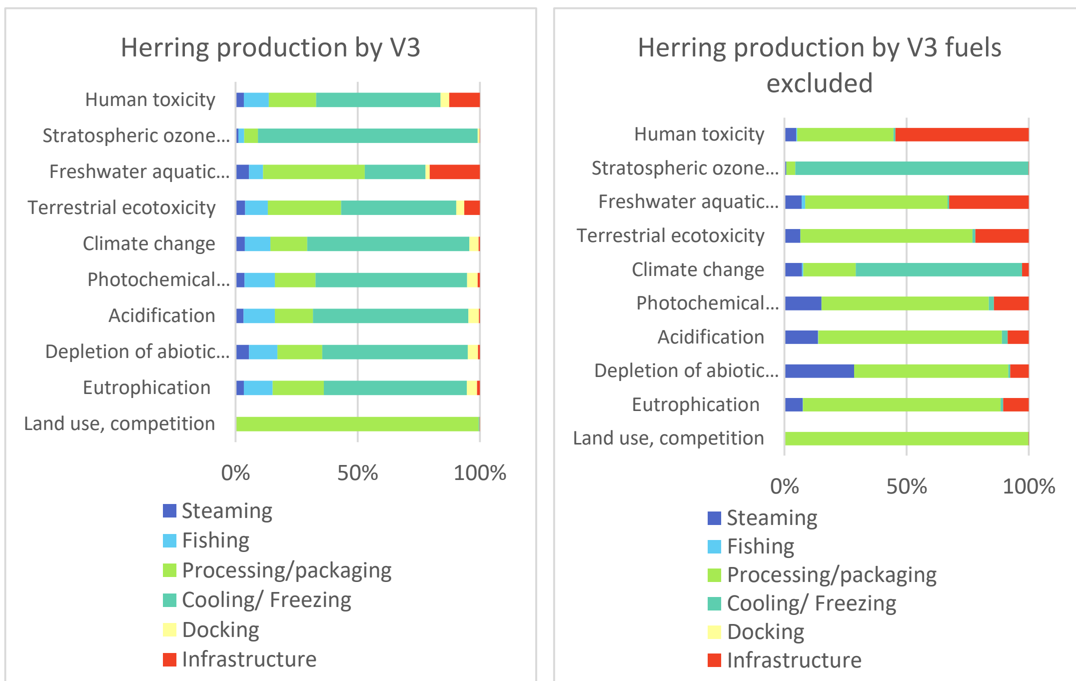



*Figure 21. Impact contribution of herring production by vessel 3.*

It has already been pointed out that the biggest hotspot is fuel consumption. Taken aside, the possibility of reducing impact would lie in the refrigerants concerning the climate change category. This would imply completely changing to natural refrigerants (ammonia and carbon dioxide) and avoiding leakages as much as possible. Furthermore, making improvements to the packaging stage would affect almost every impact category. Inputs to this stage are pallets, cardboard, plastic film and stripe, and plastic and other waste. Zooming into the contribution within the packaging stage shows that production of unbleached board (for the production of cardboard boxes), and high density polyethylene about in 20% to photochemical oxidation, 27% to acidification, and 20% to climate change.

*Contribution within the storage*

Figure 22 shows the contribution of the storage concerning herring and horse mackerel. All species follow the same trend, where the warehouse construction contribution to impact is negligible in comparison to the operation. As mentioned before, storage site1 has a larger impact than storage site 2. More relevant, the inputs included in the storage operation are electricity, refrigeration fluids and solid waste. Electricity contributes to about 20% of the impact in most categories, while refrigerants are mainly important for the climate change (41%) and stratospheric ozone depletion (95%) categories (Figure 23).

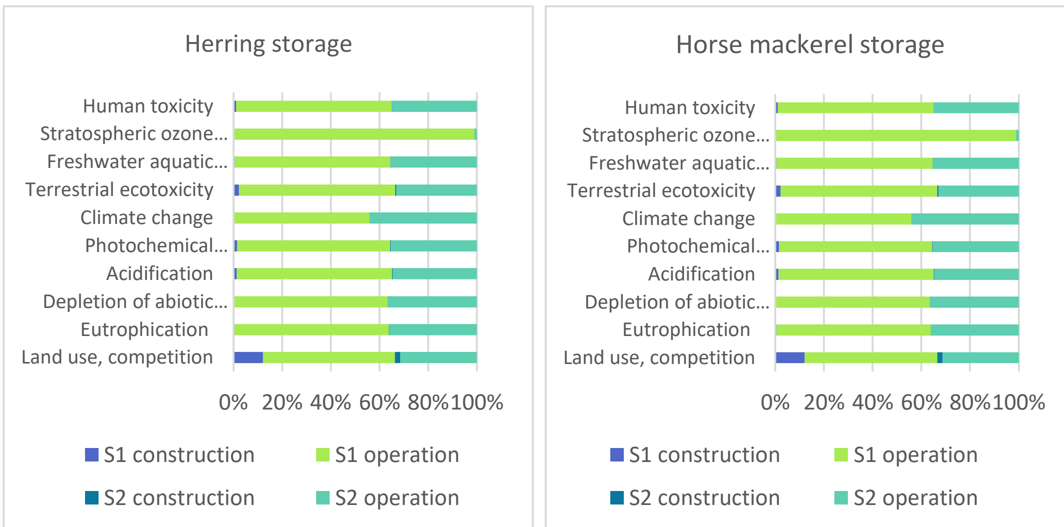



*Figure 22. Impact contribution of herring storage sites.*

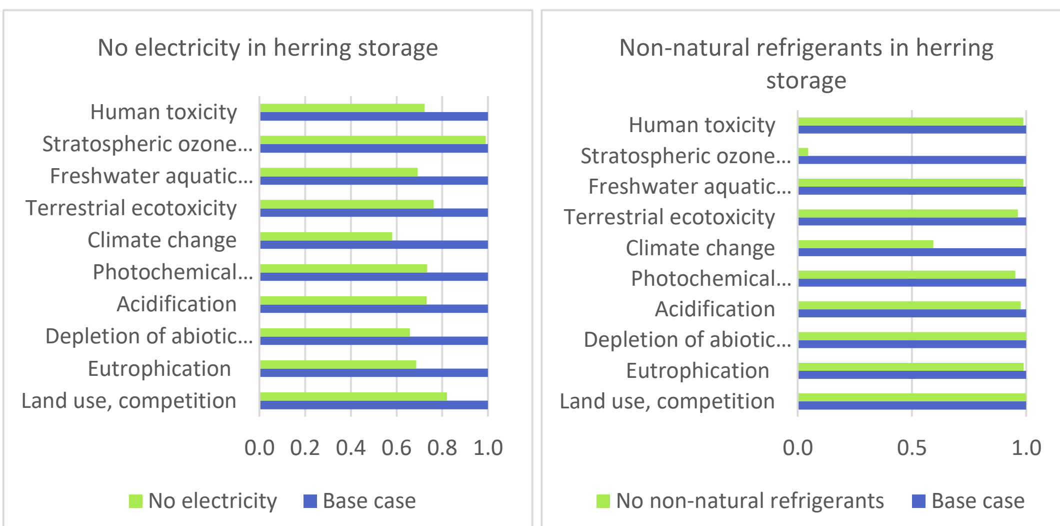



*Figure 23. contribution of electricity and non-natural refrigerants to herring storage.*

## 4.3.4 Sensitivity analysis

Here the influence that a couple of essential assumptions made in the modelled systems, were analysed for their sensitivity. This was done by altering possibly sensitive process assumptions, to resemble a similar process under slightly different circumstances. Followed by an interpretation of the newfound results. These results lead to insights; adding to the robustness of the model. And suggestions as to which processes could be improved and how.

### *Economic allocation*

As mentioned before, sensitivity was proved by comparing economic to physical allocation. Results are shown in Figure 24.

#### Within Species

Results with economic allocation diminished for herring and blue whiting, and increased for mackerel and horse mackerel compared to results for physical allocation. Changes are around 20% for mackerel, horse mackerel and blue whiting. Results for herring change only marginally.

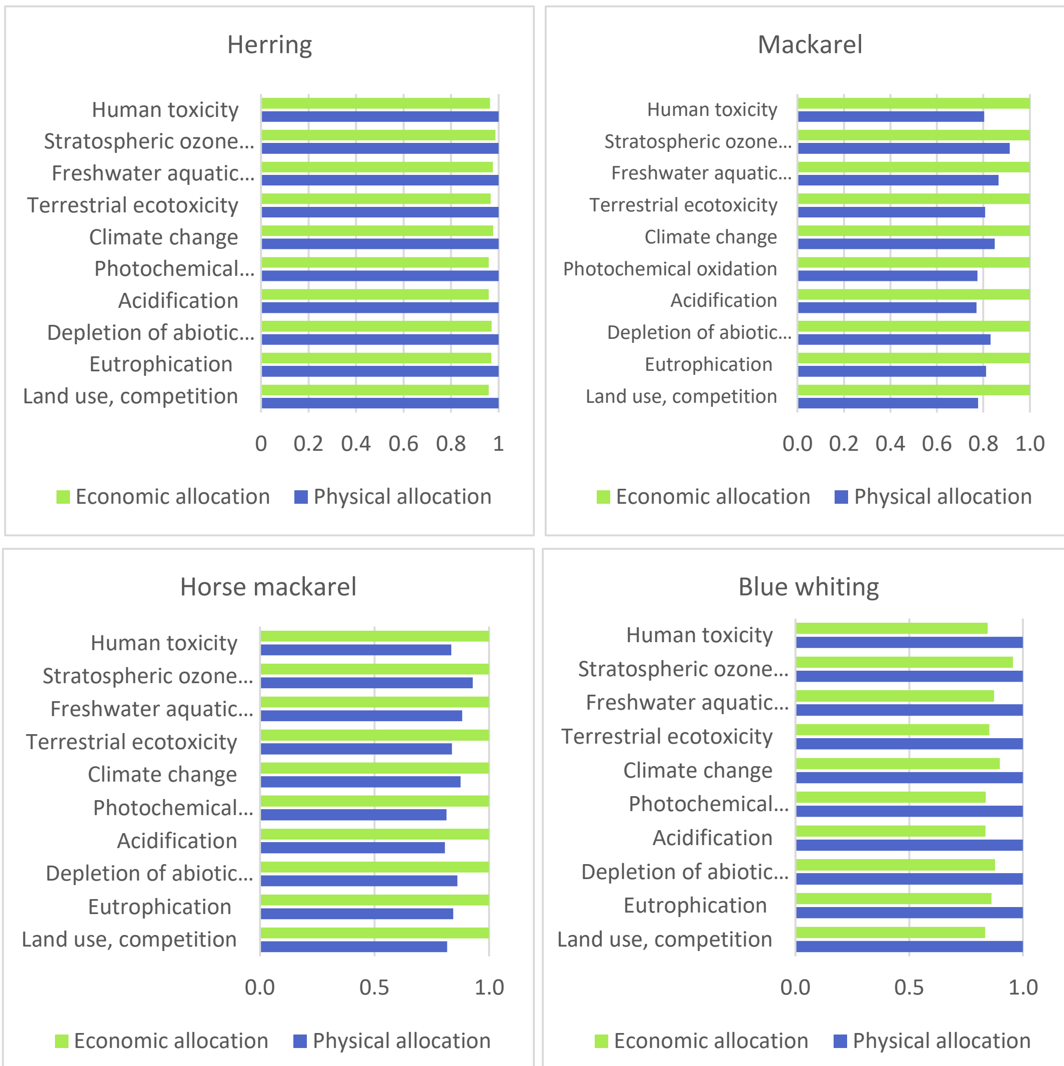



*Figure 24. contribution of electricity and non-natural refrigerants to herring storage.*

#### Between Species

When physical allocation was performed, herring had the lowest environmental impact for all impact categories, except: stratospheric ozone depletion (2nd lowest). Mackerel had the second lowest environmental impact for all impact categories, except: stratospheric ozone depletion (2nd highest). Horse mackerel had the second highest environmental impact for all impact categories, except: climate change (highest) and stratospheric ozone depletion (highest). And Blue whiting had the highest environmental impact for all impact categories, except: climate change (2nd highest) and stratospheric ozone depletion (lowest).

When economic allocation was performed, herring had the lowest environmental impact for all impact categories, except: climate change (2nd lowest). Mackerel had the second highest environmental impact for all impact categories, except: terrestrial ecotoxicity (2nd lowest). Horse mackerel had the highest environmental impact for all impact categories, except: human toxicity (2nd highest. And blue whiting had the second lowest environmental impact for all impact categories, except: terrestrial ecotoxicity (2nd highest) and human toxicity (highest).

To summarize, when performing economic allocation rather than physical allocation, there was a shift of environmental impacts between the four alternative species. Overall herring is always the alternative with lowest impact, not really sensible to changes in the model. The other three change. Blue whiting moves from having the highest impact in some cases, to being the 2nd lowest when economic allocation is applied. This is due to its much cheaper price in comparison to its bycatch. The opposite happens with mackerel and horse mackerel. Their impact applying economic allocation increases because they have higher price than their bycatch, and higher number of landings in the case of mackerel, and higher fuel consumption per unit of carton in the case of horse mackerel.

*Vessel sensitivity*

Sensitivity was also analyzed for the assumption surrounding vessel lifespan by changing the lifespan of the vessels from 40 to 30 years. But changes proved to be minimal.

### 4.3.5 Scenarios

Scenarios were developed assuming changes to the main hotspot in the system which is fuel consumption.

*Marine diesel*

The straightforward improvement would be avoiding the usage of heavy fuel oil by substituting it with marine diesel. In fact, some of the vessels already run entirely on marine diesel. The results show (Figure 25) that this change would not bring an improvement to climate chance, but it would certainly translate into relevant improvements for acidification and photochemical oxidation categories. Human toxicity is another category showing potential relevant improvements. Improvements in these categories is quite important, even when they ate not as popular as the climate change one nowadays. Transportation, including ships, greatly contributes to transboundary pollution, meaning that contaminants emitted in a certain point move throughout the atmosphere in this case and end up having effects in another geographical location. Air pollutants from combustion are also greatly related to some non-communicable diseases such as lung cancer or asthma for example, which stresses the relevance for companies concerned with corporate social responsibility to acknowledge their indirect impacts to society, and in this case make the choice for operating with the cleanest available fuel.

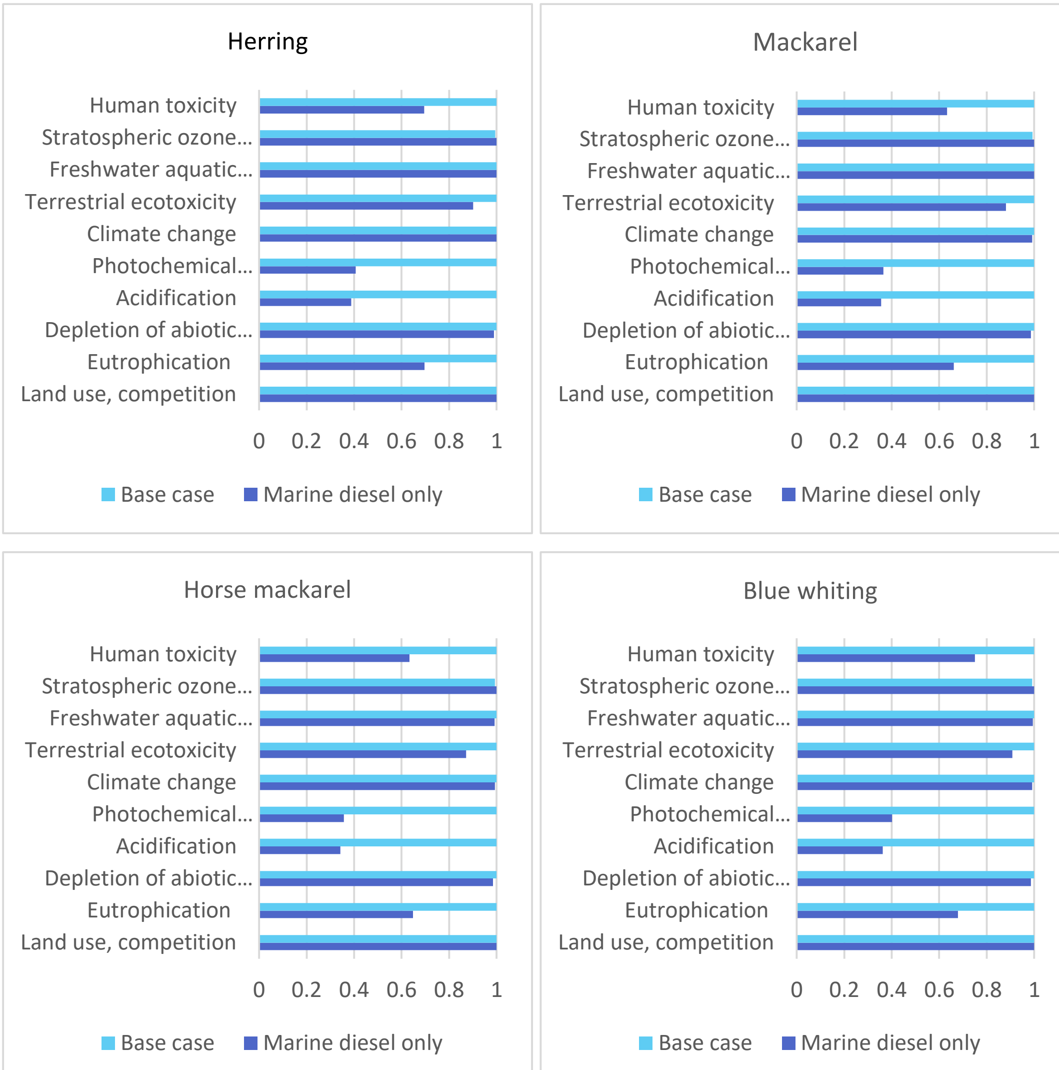



*Figure 25. Environmental profile of using marine diesel instead of heavy fuel oil.*

### *Biofuel: biodiesel from first generation crop*

A second analysed scenario was the usage of biofuel instead of heavy fuel oil and marine diesel. Results show potential trade-offs in many categories. Concerning the ones that came out as relevant from the normalization analysis, the following can be said: contribution to climate change is reduced around 40%; acidification is reduced by about 35%; depletion of abiotic resources is reduced to around 50%; freshwater aquatic ecotoxicity is increased in around 50%; and human toxicity is reduced by around 35%. In terms of trade-offs: terrestrial ecotoxicity is increased by more than 90%, eutrophication is also increased by nearly 40%, and land use competition is increased by close to 45%. Much of the impact coming from biofuel is related to the production process of the involved raw material concerning for instance fertilizers, pesticides used and land use change. In order to decrease the potential trade-offs, the company would need to pay attention to the supply chain.

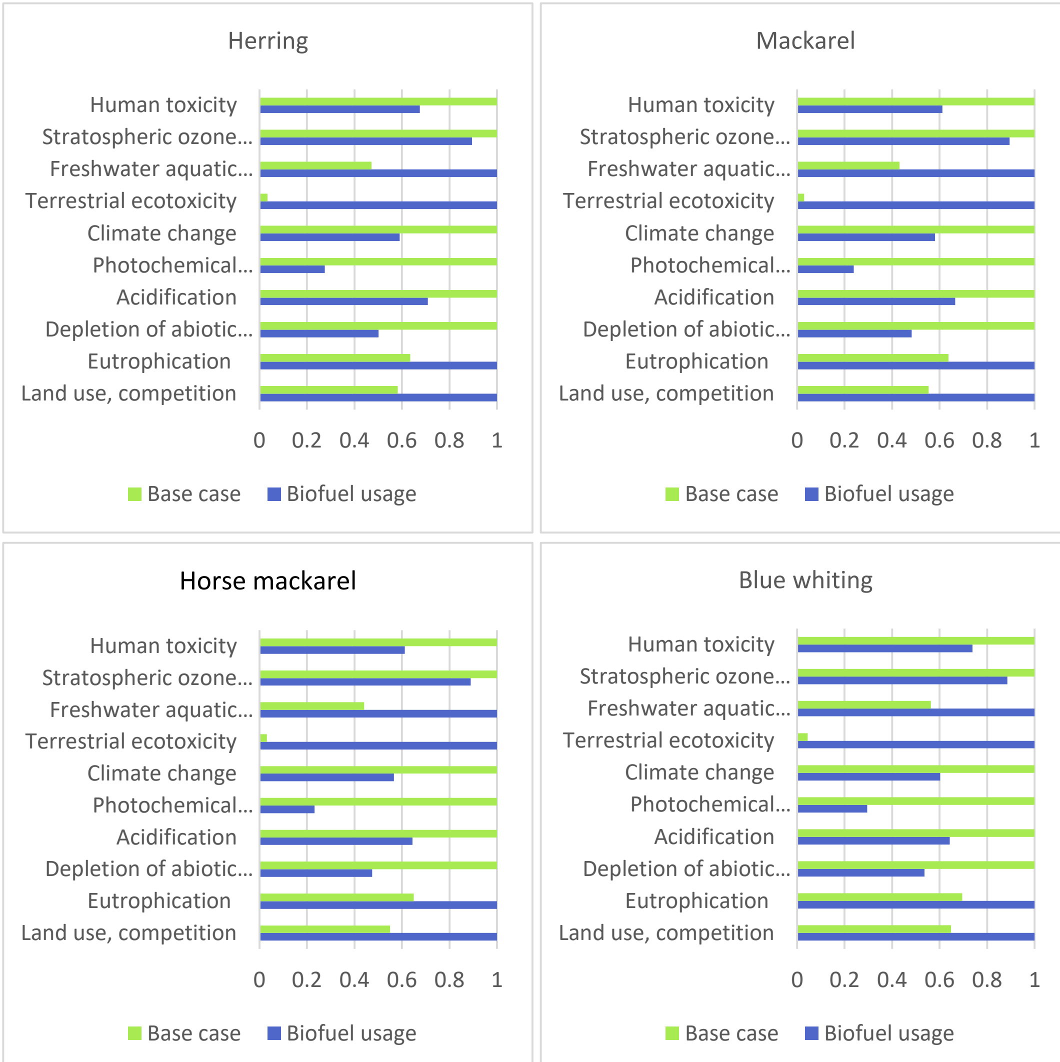



*Figure 26. Environmental profile of using biofuel instead of fossil fuels.*

It is important to mention that the scenario was run using a first generation biofuel alternative. Thus, the tradeoffs reflect such choice. If the biofuel were second or third generation, results would certainly be very different. Biofuels are in fact one of the most prominent alternatives to fossil fuels in the marine sector. Other renewable technologies relying on solar and wind power also exist, but for smaller vessels than the ones used by Cornelis Vrolijk, (IRENA, 2015)

Besides these two scenarios concerning fossil fuel consumption, many others could be imagined. The ones presented were chosen for their simplicity in evaluation. Other scenarios such as changing to gaseous fuels would require a deeper study to account for needed modifications in infrastructure and trade-offs involved in terms of space availability in the vessels. Although interesting and possibly relevant for the industry, going beyond simple scenarios is out of the scope of this study.

# 5. Results: insights into the fuel procurement in relation to sustainable supply chains

Supply chain analysis is a recognized topic for sustainability analysis. Green supply chain management deals with the insertion of environmentally sound decision making in a company's supply chain. Aspects included are product design, procurement, sourcing and supplier selection, manufacturing and production process, logistics and delivery, and end-of-life management. (Stuart and Vivek 2010)

Triggers for sustainable supply chain management involve a focal company being pressured to comply with new institutions regarding environmental, social and economic concerns. The focal company it passes the burden on to suppliers. On the other side, barriers for supplier management may include higher costs, coordination effort and complexity, and insufficient or missing communication. Product based green supply faces the need of developing product´s environmental indicators using LCA and identifying those operations that are out of the control of the focal company. (Seuring y Müller 2008)

Concerning fish products supply chain, knowledge is fragmented. Topics generally studied include protection of fisheries, fish products economics and stakes, conditions of international trade and price setting. But information about the situation of logistics is less abundant. Seafood carbon footprints address the issue, but they hardly consider how sustainability improvements balance in relation to other factors defining the supply chain such as institutions governing the industry. Changes in fish products supply chain over time have included: fishing quota agreements, the greening of vessels and processing facilities, and improvements regarding refrigeration systems, transportation, storage, cross-docking, and packing and conditioning. Change dissemination is said to happen because novel institutions come in interaction with the technical and organizational part of companies. Likewise, globalization and consumers becoming familiar with electronic trade is expected to contribute to existent and novel dynamism within fish products supply chain. (Douet 2016)

It is recognized that not all practices leading to sustainable consumption and production systems bring a competitive advantage to firms. But this fact can be diminished in the face of some stakeholders' own interest, their roles, influence on other stakeholders, their importance in the supply chain, and their possibility of using different instruments to induce changes. (Govidan 2017)

The results from the LCA study showed fuel is the greatest contributor to environmental impact. The problem is the industry greatly relies on this input to operate. Other alternatives for operation are wind and solar energy, still quite uncommon for large vessels, and biofuels which appear to be promising but are still in a development stage. Thus, the recommendation for Conelis Vrolijk is to switch from using heavy fuel oil and marine diesel to 100% marine diesel, and to green its supply chain as much as possible.

This small part of the thesis describes the barriers that Cornelis Vrolijk has to confront if they were to take this recommendation into practice. Results mostly draw from an interview with the purchasing department at the company.

## 5.1 Fuel supply system description

The choice of the fuel supplier is made upon the best price-quality offer. The purchasing department provides a set of specifications and mainly asks brokers to send them available options of fuel. Usually they ask for proposals from 3 international companies and two Dutch companies. The best price and respectable quality is chosen. The technical department is responsible for deciding upon the quality specifications.

The first issue that arises when proposing the change to 100% marine diesel is economics. The price for diesel is about twice as high as heavy fuel oil, so it would most probably be a difficult decision in economic terms. Technically, engineers prefer heavy fuel oil because it has better combusting qualities and gives them less trouble concerning maintenance when they have to switch fuels. The switching comes because heavy fuel oil cannot be used in every zone of the ocean. For example, in the North Sea it is only allowed for vessels to run on marine diesel. But when fishing around Mauritania, vessels can use heavy fuel. Nevertheless, there are some vessels that only run on diesel. The option is technically possible, although challenging at some extent; economically, it still has to be assessed. But there is a third issue to consider: the supply chain.

Fuel companies are referred by the purchasing and fleet management departments in the company as difficult to work with, implying that they can be dishonest concerning the quantity and quality of fuel. In fact, CV hires a surveyor when they are having big bunkering operations to monitor the quality and quantity of fuel they are getting. The surveyor supposes an additional cost, but losses by leaving the fuel company operate alone compensate. Having this sort of problems implies that among the available fuel companies, there may not be much room to choose from. And the suppliers of marine diesel are less than those offering heavy fuel oil. The purchasing department explains that in some countries there are simply no options of suppliers because the industry is a monopoly, and in others there is simply no offer of this fuel.

As mentioned before, Cornelis Vrolijk mostly relies on brokers to find their fuel suppliers. In sum they have four brokers who supply them in Holland, Las Palmas and Mauritania. Such brokers translate into mainly six physical suppliers, four for Holland, one for Las Palmas and one for Mauritania.

The revision on available information concerning sustainability reporting for brokers and traders contracted by Cornelis Vrolijs is summarized in Table 18.

*Table18. Available online information on the sustainability policy of fuel brokers and physical traders.*

| Fuel providers | Available information online | CSR report available |
|---|---|---|
| Broker 1 | Mention about keeping up to date with legislation | No |
| Broker 2 | “Product is supplied by reputable suppliers” | No |
| Broker 3 | Part of a larger group that claims to “fulfill our social responsibility on environment protection” with an environment & quality system in place. ISO14001, ISO9001 certifications available. | No |
| Broker 4 | Policy includes commitment to combating modern slavery throughout their supply chain | No |
| Physical supplier 1 | Anticorruption, health & security, honesty and integrity and a has a suppliers’ code of conduct, suggesting they adhere to the UN global compact | Supposed to have it, but couldn´t be found |

| Fuel providers | Available information online | CSR report available |
|---|---|---|
| Physical supplier 2 | Claims to operate strict safety, health and environmental procedures, to monitor their suppliers and to conduct their business beyond compliance with regulations | No |
| Physical supplier 3 | Readily available terms and conditions applicable | No |
| Physical supplier 4 | Ethical behavior, integrity, transparency and full compliance with all applicable laws and regulations | Brochure about the company available |
| Physical supplier 5 | Local company, offering sharp prices and excelent service | No |
| Physical supplier 6 | Claims to "fulfill our social responsibility on environment protection" with an environment & quality system in place. ISO14001, ISO9001 certifications available | Brochure about the company available |

It comes as no surprise that information regarding sustainability is not made readily available from oil companies. It is said that sustainable supply chain management (SSCM) is in its infancy, but in the oil and gas industry there is even less experience. The first studies were only published in 2007. To this date, there seems to be no systemic SSCM studies, which is a gap in the field given the importance of this sector in the global economy. (Ahmad, et al. 2016)

## 5.2 Recommendations for Cornelis Vrolijk

Literature suggests that supply chain performance can be improved more effectively when suppliers are clear about the sustainability requirements that must be fulfilled, and they monitor them through performance management systems (which ensure that goals are being met) (Seuring y Müller 2008). Thus, the recommendation for Cornelis Vrolijk is to include in their purchasing policies an approach to environmental and human rights protection as requirement for their suppliers. Pushing their fuel suppliers to comply with having a CSR policy in place is highly recommended. Likewise, CV should monitor itself concerning its "level of procured green products" and the "number of its innovation projects in regard to divesting from fossil fuels usage", as proposed in the following chapter.

A similar exercise as with the fuels suppliers was meant to be done for refrigeration fluids. However, the main supplier for this products is one, and the reasons for choosing it are the same (although there is no problem of honest behaviour concerning the refrigeration industry). The same recommendations apply about asking the suppliers to make their CSR policy available. What is more interesting maybe, is to describe the barriers for the adoption of natural refrigerants $CO_2$ and $NH_3$ instead of flour-carbon compounds, which, as shown from the LCA results, represent a greater impact for the company´s operations.

Installing natural refrigerants poses the need of additional training, sensors, and some other changes in the vessels and store houses. In some cases, the retrofit might be too expensive and the choice to continue with non-natural refrigerants is made. But using ammoniac is considered especially risky onshore, in storehouses surrounded by the city. Thus, although past recommendations by the city government were to adopt greener refrigeration fluids, there seems to be hesitation about it now.

As a conclusion from this brief exercise, it can be said that acknowledging this sort of practical barriers for the adoption of the improvement options identified through the LCA study gave a more realistic approach to the whole study. Coupled with the identification of suitable sustainability indicators, it was possible to give a more complete piece of advice for the company while identifying the interlinkages between LCA, CSR and sustainable supply chain. The next chapter deals with the set of CSR indicators proposed.

**Box 3. IMO United Nation's International Maritime Organization**

Insights from their 71$^{st}$ session, July 2017:

- From September 2017, all ships will be required to have a ballast water management plan and keep a ballast water record book
- From 1 January 2020, implementation of the 0.50% m/m global limit of the sulphur content of ships' fuel oil come into effect
- Draft initial IMO Strategy on reduction of GHG emissions from ships is due 22 September 2017
- "2,500 new ocean-going ships have been certified as complying with the energy efficiency standards"

(IMO 2017)

# 6. Results: indicators for Corporate Social Responsibility reporting

This part of the research documents the process for designing suitable indicators for the CSR reporting of Cornelis Vrolijk. It draws from the insights obtained during the life cycle inventory construction. The starting point for this part of the research was a list of indicators already suggested by literature. Such base indicators are discussed and later supplemented by the LCA results, but specially by information obtained from a number of interviews with stakeholders from inside the company, the Dutch government, and the international scientific community.

Results are presented as follows. First, the materiality assessment focused on "sustainability topics" is presented based on findings from interviews, insights from the LCA results, and literature findings. Secondly, the set of proposed indicators is presented based on sustainability objectives and topics. Thirdly, a sustainability balance scorecard for the pelagic business unit of Cornelis Vrolijk is proposed.

## 6.1 Materiality assessment

Materiality is supposed to refer to all relevant issues for a company´s CSR, generally considering social, economic and environmental aspects. However, economic aspects are less mentioned when asking stakeholders about sustainability. This is reflected throughout this section. It is a clarification worth making, because a complete materiality assessment would have included interviews with top management and other stakeholders from the company, more concerned with the business model. This however, was out of scope for this project. And in this sense the materiality analysis covers the same boundaries as the LCA and mainly focuses on the fish production and storage stages.

The information presented in this section draws from a questionnaire addressed to 15 stakeholders knowledgeable in the fishing sector. Their answers reflect what is important in terms of sustainability for people who know the sector from inside and outside the company.

This section is structured following the four topics from the questionnaire, with the intention of summarizing the significant issues that, given the results from the interviews, should be addressed by a fishing company as part of its CSR reporting.

### 6.1.1 Sustainability main topics and their ranking

Around 1990 *Sustainability* as term was said to be in danger of becoming an empty shibboleth (Daly 1990). About two decades later, the Worldwatch Institute published that "we live today in an age of *sustainababble*, a cacophonous profusion of uses of the word *sustainable* to mean anything from environmentally better to cool" (Engelman 2013). In fact, after conducting a life cycle analysis (LCA) on wild fish, Meissner (Environmental lafe cycle assessments of fish food products with enphasis on the fish catch products 2012) discusses that the main focus when studying the sustainability of fishing has been on the stock populations, while in fact the sustainability problem consists of three factors: dependency on the resource, consumption of it, and economic output for each fished unit. The author states that "sustainability is a difficult notion where different stakeholders have their own view of what is sustainable ", and that in order to expand the study of sustainability, the usage of other analytical tools to address the social and economic dimensions is required.

This concerns with the word *sustainability* stood up during the interviews. For instance, considering the responses of interviewees working in the nexus science-industry and science-policy, the following was said. While *interviewee 1* referred to the problem of an inexistent collective understanding of what sustainable fishing operations are, *interviewee 2* suggested the sector is finally moving into the direction of acknowledging what sustainable fishing is. *Interviewee 2* was refereeing to fishing under the maximum sustainable yield (MSY) indicator, which is about maintaining fish mortality rate below accepted levels to ensure stock abundance (FAO 2016). But in this regard, *interviewee 3* pointed out the challenge of moving from measuring sustainability in terms of individual species stocks, and monitoring the health of the marine ecosystems in a more integral way.

Insights from interviews proved very rich, and although responses were quite varied, there is some consensus concerning the ranking of issues. The question asked was: to mention 3-5 sustainability topics and rank them in importance.

It's worth mentioning that generally, interviewees framed the responses in terms of avoiding negative situations. Two topics were mentioned by more than half of the interviewees: fish stocks and fuel consumption and related greenhouse gas emissions. The third one in terms of number of mentions is selective fishing. Coincidentally, these topics are also ranked among the most important ones.

Selective fishing holds relation to other mentioned topics highly ranked: bycatch minimization, fish size, and marine habitat protection. Concerning this last topic, the experts firstly point out the problem of bycatch (the fished non-targeted species) and next, the impacts to the seabed. Both are related to the fishing gears used. Other environmental aspects ranked as less important are waste prevention, future impacts from climate change (concerning changes in temperature and pH in the Oceans), and animal welfare as an emerging issue expected to grow in importance in the future.

The social aspect was also addressed concerning decent labour, cooperation between research organizations and industries, and the need for improving understanding of non-experts and consumers in general concerning the fishing sector.

The economic or market related aspects are ranked in lower levels. These are: labels and certifications, and business approach to remain active in the future.

The following graph shows the frequency of responses (Figure 27).

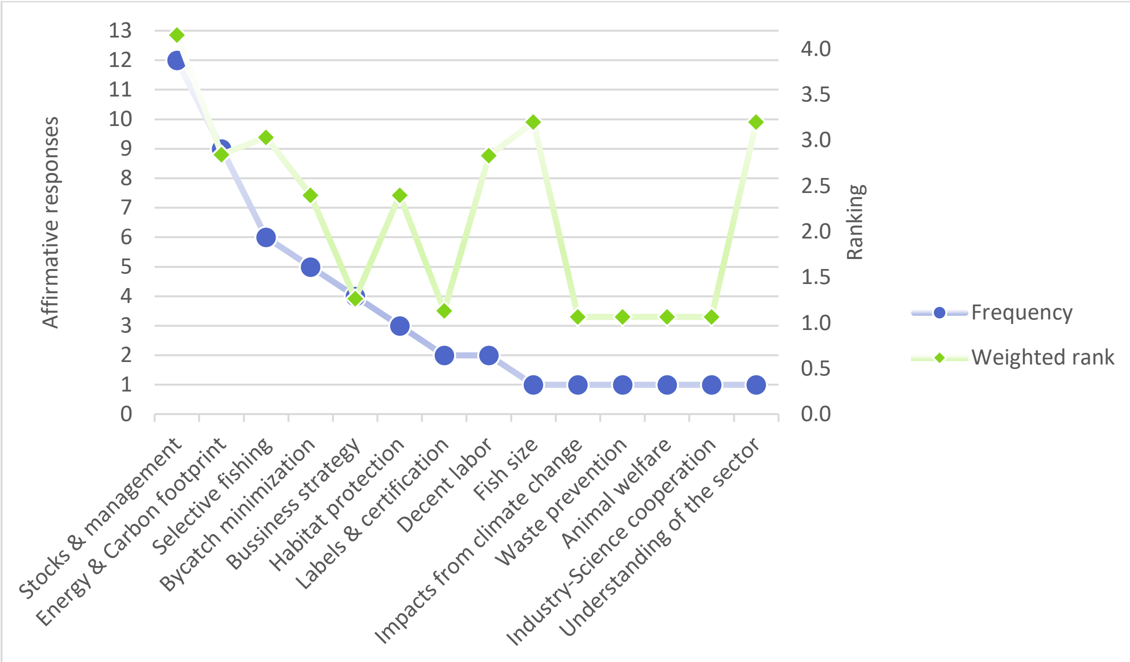



*Figure 27. Important sustainability topics from interviews.*

### 6.1.2 Relevant regulation for the sector

The second addressed theme in the interviews was institutions of importance for the sector.

Most interviewees referred to the commons fishery policy as the key regulation for the sector. The landing obligation was mentioned as a challenge concerning implementation. Although some actors seem confident about its potential contribution to better stock management, others hold reservations about its future impacts.

Some skippers consider that the marine ecosystem seems to have finally reached an equilibrium: stocks and fishing doing well, and bird population used to how the system worked before the landing obligation. Thus, concern comes when thinking how modifying the system is going to affect all the implied variables. From the scientist point of view, one of the interviewees also expressed the existence of concerns about birds' populations which have gotten accustomed to feeding from what used to be discarded bycatch. However, the same scientist considers the obligation is based on scientific and should be trusted to be in benefit of the marine ecosystem.

**Box 4. Commons Fishery Policy**

- Restructured in 2014
- The concept of maximum sustainable yield (MSY) is the main reference
- It now incentives more selective fishing
- Objective: all fish stocks are exploited at MSY rates by 2015 where possible, and by 2020 at the latest.
- Recognition of advisory councils composed of industry and other interest groups stakeholders, who can submit recommendations to the EC and provide information for the development of conservation measures.

(European Commission 2016)

The rules concerning quota were also mentioned as relevant, explaining that the distribution of quota (amount of fish that a company can caught) is determined based on historical records of landings since the 1970s. These two topics (quota and landings) can be regarded as the most directly linked ones to fishing operations.

Another group regarding broader institutions includes international, regional, and national pieces of legislation. At international level, the sustainable development agenda for 2030 includes one goal specifically targeting conservation and sustainable usage of oceans, and it was addressed both as a legal framework and a challenge for countries concerning its implementation. At European level, most mentioned institutions were the Marine framework directive, and the Habitat directive. National legislation in general was also mentioned (Dutch Natura2000), as well as the IMO regulation. It was clarified that some important laws do not specifically address the Sea or "fishing" in its title, but govern pollutants emissions from vessels, and emissions to water bodies that eventually reach the Ocean. Programs regulating specific regions, such as the North Sea, are also important.

Lastly, there are the policies specific to each fishing company, and the rules for acquiring certifications, such as the MSC.

### 6.1.3 Sustainability related challenges

Concerning stakeholders inside the company, the most commonly cited challenge is related to the anticipation of what the political context will bring for the fishing sector in the region now that the United Kingdom left the European Union. The question is whether the rules will change, and will European ships still be able to fish inside UK's economic zone. Out of this concern, the remaining ones cannot be grouped. They are:

- Adequate management of horse mackerel stocks
- Bycatch minimization
- Discards ban in relation to implementing the landing obligation
- Improvement in the way of assessing stocks: get to an integrated approach
- Developing of certification standard for mixed species
- Reliance on fossil fuels
- Climate change impacts in the longer term
- Implementation of SDG 14 (See Box 8)
- Deep Sea mining (See Box 7)
- Coming to consistency regarding what sustainable fish is
- Education of consumers and social licence for operation
- Economic burden of ecolabels
- Innovating the sector

**Box 5. Landing obligation**

Discarding is the practice of returning unwanted catches to the sea.

The CFP aims at eliminating discarding through the introduction of the landing obligation.

It requires all catches of regulated commercial species on-board to be landed and counted against TAC or quota.

TAC is total allowable catch and only some species have it.

In 2015, the obligation began to cover small and large pelagic species

The deadline for complete implementation in 2019

Successful implementation of the obligation is coupled to "making gears more selective, developing new IT tools for fishermen, finding ways to store fish on vessels or on land, and increasing the value of by-products from landed catches"

The institution is not only supposed to improve sustainability, "but also boost data collection"

Members states should send additional data to the scientific committee for updating discard plans.

(European Commission 2017)

Outside the boundaries of this analysis concerned with industrial fishing of pelagic species in the North Sea, but relevant for the fishing sector as a whole, other mentioned challenges were overfishing and lack of institutions enforcement outside the North Sea, and small scale fishing continuity regarding lack of younger persons who want to become fisherman and lack of long term thinking.

**Box 6. EU Marine Framework Directive**

Adopted in 2008. Its objective is that objective that "biodiversity is maintained by 2020".

Requires "Good Environmental Status" (GES) by 2020. Three criteria for GES have been identified for commercial fish and shellfish:

- Level of exploitation
- Reproductive capacity
- Healthy age- and size-distribution

Establishes marine regions and sub regions, and considers a monitoring program for assessment and regular update of targets. (European Commission 2017)

### 6.1.4 Recommendations for consumers

When asking the interviewees to give advice for consumers who are not knowledgeable in the sector, it came as a surprise that many of them though of this as a very difficult question. The easy way, most claimed, is to look for ecolabels. Although many agreed that it is hard to make a choice based on labelling since there are plenty withholding different issues. The MSC one is the most recognized one, and considered truth to its mission.

A second suggestion is avoiding threatened species and stocks being depleted by following available fish food guidelines and being aware of the zone where fish comes from, if it's a well-managed zone or not.

The third recommendation was to choose local species and developing ownership about the local fish, to care for it. In connection to this, for non-coastal regions the suggestion was choosing to eat fish as fresh as possible, avoiding complex supply chains and highly processed products. Less frequent points made were to avoid believing the media, and instead be critical about the sector; to pay more attention to the social aspect of fisheries; and to be willing to pay a higher cost for certified fish.

**Box 7. Deep Sea mining**

The International Seabed Authority is concerned with this matter.

From 8 contractors interested in claiming seafloor in 1970-2010, the number triple to 25 in 2011-2015. Knowledge on the matter is scattered. (Sharma 2017)

"Most mining-induced loss of biodiversity in the deep sea is likely to last forever on human timescales, given the very slow natural rates of recovery in affected ecosystems." (Van Dover, et al. 2017)

## 6.2 Results: CSR indicator set

As shown by the interviews' results, the topics on sustainability concerning the fishing sector are vast. The first step to develop a suitable indicador set for Cornelis Vrolijk was to write objectives based on the interview responses.

Topics were first sorted into aspects (environmental, social or economic/market). Then, similar topics were grouped and be the framework to define an objective. Objectives would then include multiple topics.

In a second phase, topics that became a personal concern from the LCA study were also added as topics within the proposed objectives. These are related to (1) reducing impacts, and (2) improving data collection for the next life cycle inventory:

- Need to divest from fossil fuel usage
- Choosing natural refrigerant over non-natural ones for all freezing installations
- Monitoring the amount of netting lost at Sea even when its consider to be relatively small
- Looking at improvements for packaging through a circular economy approach

The third phase consisted of comparing the list of topics created to the list of activities mentioned in CV's 2016 CSR report, including their expected activities in 2021 (described in the background section, table 7). If an activity mentioned in the CSR report was not already in the topic list, then a new topic would be added.

Lastly, indicators were assigned to the final output topics. The relation between the topics and CV's CSR activities can be consulted in Annex B. In most cases, the choice of indicator comes from an already reported example of it in literature. But some were specifically proposed in regard to the defined topics.

The following sections present the sustainability objectives, topics, and indicators proposed for CV concerning environmental, social and market aspects.

### 6.2.1 Environmental indicators

The objectives proposed for the environmental aspect are four, out of which 11 topics and 12 indicators are derived (Table 19). Objectives are the following:

- EO1. Fishing from healthy fish stocks
- EO2. Reducing the environmental footprint
- EO3. Adopting a circular economy approach as much as possible
- EO4. Contributing to sustainable innovation in the sector

*Table 19. Proposed indicators regarding environmental aspects.*

| EO# | Topic | Indicator |
|---|---|---|
| EO1 | Selective fishing | (1) Level of bycatch [%/year] |
| | Fish quality | (2) Average size of fish caught [cm] |
| | Habitat protection | (3) Harm to habitat structure [number of incidents] |
| EO2 | Electricity sourcing | (4) Level of clean electricity consumption [%] |
| | Fuel sourcing | (5) Level of clean fuel consumption [%] |
| | Energy intensity | (6) Level of energy consumption in product stage [MJ/kg fish] |
| | Contribution to climate change | (7) Carbon footprint per unit of product [kg$CO_2$/kg fish] |
| | | (8) Refrigeration fluids lost through leaks [%] |
| | Sustainable procurement | (9) Level of procured materials with a sustainable sourcing approach [%] |

| EO# | Topic | Indicator |
|---|---|---|
| | Waste management | (10) Mass of netting lost at Sea [t/year] |
| EO3 | Closing material cycles | (11) System flows managed under a circular economy approach [number] |
| EO4 | Technology development | (12) Innovation projects related to divesting from fossil fuel usage [number/year] |

The discussion on the relevance of these indicators follows.

Two out of the three indicators in relation to “fishing from healthy stocks” (EO1) are easy for the company to estimate and monitor for the pelagic business unit.

- The level of bycatch is easily estimated from the landings database which was used during the LCA study. The desired tendency for this indicator would be decreasing, although for pelagic fisheries the calculated baseline value is considered to be small (13%).
- The average size of fish caught is considered relevant to monitor that fishing of very young individuals is avoided and is suggested in literature (Roeger, Foale and Sheaves 2016). It appears to be another easy indicator calculate from records of quality management tests in the company. However, this data was not used for the LCA and its baseline value not estimated.
- The third indicator proposed is “harm to habitat structure”, which was tricky to define concerning the topic habitat protection. It comes from the MSC guidelines for certification, but its definition is ambiguous. Habitat is defined as the location or environment where the organism lives, occurs or is likely to be found (Biology-online 2008). For pelagic fish this would be the water column, and thus in theory no harm from fishing is to be expected (Coers 2017). In practice, from conversations with skippers, it seems that it is possible that the netting touches the ocean bottom sometimes. In summary, it is quite hard to say how harm to habitat could be measured by the company. When the topic was mentioned by stakeholders they were most probably thinking of demersal fisheries. Thus this indicator might be more relevant for the demersal business unit. Nevertheless, it is recommended that the CSR manager together with skippers discuss which are the potential events in pelagic fishing that could cause habitat harm, and the best way to report on them.

Concerning the objective EO2 “reducing environmental footprint” several topics are considered: energy consumption, climate change through carbon footprint of the fish and refrigerants’ leaks, material procurement, and waste management.

- Level of clean electricity consumption is relatively easy to estimate. At the moment the company sources it from hydropower and solar panels installed at one location. Thus, when reporting the indicator, it is advisable to report the share of each kind of energy source and the boundaries covered. The LCA gathered information for only two storage locations, but the remaining ones should also be considered even if they are rented spaces. The desirable tendency for this indicator is that it increases.
- Level of clean fuel consumption needs to report on what “clean fuel” is defined as. At the moment, marine diesel can be regarded as the cleaner fuel between the two used (heavy fuel oil is the main one). The shares should be calculated from the total consumption of fuel estimated in terms of energy units and never mass. Concerning the data was gathered for the LCA study, the baseline for this indicator would be 56% for the whole pelagic fleet, but if

regarded by vessel the range goes from 27 to 100%. The desirable tendency is that it increases. Furthermore, the definition of clean fuel could change and come to include biofuels.

- Energy intensity is a relevant indicator to complement the level of clean energy consumption. It can serve as indicator for efficiency in fishing and fish storage. It should be reported in energy units per unit of product, and by stages. Concerning fish production, the baseline value is 7 MJ/kg of fish. Concerning the storage, the value depends on the location and the stay time. The stay time was used for allocation purposes in the LCA study, and is used as well for calculating this indicator per species (Table X). Desired tendency would be for the indicator to decrease.

*Table 20. Energy intensity from fish storage, by species (MJ/kg).*

| Species | Storage 1 | Storage 2 |
|---|---|---|
| Herring | 0.28 | 0.33 |
| Mackerel | 0.72 | 1.47 |
| Horse mackerel | 7.45 | 2.19 |
| Blue whiting | 5.01 | 5.54 |

- The carbon footprint indicator is taken from the LCA study. The baseline value per species ranges from 1 to 1.2 kg/kg of fish (Table X from the LCA chapter). When reporting this indicator, it should be mentioned that the boundaries are cradle to storage gate, and that physical allocation is applied. When recalculating the values for future years, the LCA should be done following appropriate standard and guidelines, such as the one done in this research. Also, comparable values must have the same system boundaries and allocation choices. Finally, if for future studies new foreground data is made available and included or the system´s boundaries expanded, the baseline value should also be recalculated. Desired tendency would be for the indicator to decrease.
- Refrigerants leaks can be easily calculated from the company records. Some vessels and storage locations' data are missing or relied on assumptions for the LCA study. However, in time, the company could collect the data and monitor this indicator by vessel and storage location. An example of the sort of calculation done with available data is shown in the following Table. It shows the percentage of refrigerant emission in 2016, in relation to the stock in the freezing/cooling installation. The complete set of estimated values per vessel and storage location are presented in the annexed excel file. Desired tendency would be for the indicator to decrease.

*Table 21. Refrigerant leaks in 2016 (partial results).*

| | Vessel 3 | Vessel 6 | Vessel 7 | Storage 1 |
|---|---|---|---|---|
| Refrigerant X (%) | 53 | 13 | 89 | - |
| Refrigerant Y (%) | - | 41 | 24 | 73 |

- The level of procured materials sourced with a sustainable sourcing approach could not be estimated for this study. First, the company should stablish a sourcing policy and the list of materials from which the indicator calculation should follow. It is suggested that a starting point for the materials to consider be the same ones included as part of the inventory phase of the LCA study (only foreground materials). Desired tendency would be for the indicator to increase.
- Concerning waste management, the only identified waste flow which needs improved monitoring is netting. The issue with it, is that there is uncertainty about how much netting

material is lost at Sea. A comprehensive mass balance could not be made out of the information provided by the supplier. It is believed the yearly amount of lost netting is small, but there were no available records at CV for estimation. Thus, it is recommendable that fishing companies pay attention to this gap. SDG14.1 advocates for reducing marine pollution, and already vessels follow strict norms concerning the management of bilge, sludge, and solid waste produced in the ship. Monitoring of netting waste would be an addition to that.

- The indicator proposed for objective EO3 "closing material cycles" is: number of system flows managed under a circular economy approach. Netting management is an input that already falls into the circular economy approach. The supplier sells the service of providing new nets and net fixing, and also manages the waste. Most netting used by the company is produced from recycled raw materials, while the waste is used to produce different goods for aquaculture usage, as car tyre re-enforcement materials, and for the production of pillows and second grade nylon filament (de Graaf 2017). A second flow to consider for closing material cycles could be cardboard. The reason follows.

During the life compilation of inputs for the LCA inventory phase, one of the hardest data to systematize with was waste. Cornelis Vrolijk relies on several waste management companies to deal with the vessels and office residues according to regulation. However, it is in many cases not clear which is the specific way of treating each waste flow. It is considered that a good practice would be for the company to become more knowledgeable about the life cycle of their waste flows, promoting that they are managed with a circular economy approach. For instance, when the fuel is taken out of the equation in the LCA contribution analysis, it is seen that the packaging stage becomes very important. And cardboard consumption is relevant in this stage. Part of it becomes waste managed by the company, while the greatest part reaches the buyers and at some point also becomes waste. Knowing what happens to the cardboard at the consumption stage was out of scope for the conducted LCA study, but it is a waste flow that the company might be interested in further studying for managing it with a circular approach. In fact, incorporating a circular economy into their business would be aligned to the Dutch national objective of "a 50% reduction in the use of raw materials" (Ministry of Infrastructure and Environment 2016). In the case of implementing a strategy for recovering cardboard, an interesting additional indicator to consider would be "reverse logistics gains, costs and revenues" as proposed by Turi, et al. (2014).

- The last topic in the environmental objectives is about technology development for sustainable innovation in the sector (EO4). The proposed indicator is the number of innovation projects in relation to divesting from fossil fuel. This cannot be estimated from the gathered data for the LCA study, but interviews to the technical and fleet management department put it clear that the company is involved in projects for reducing fuel consumption through: (1) designing a more energy efficient ship, and (2) developing improved netting which plays an important role in reducing energy consumption during fishing.

### 6.2.2 Social indicators

Five objectives are proposed for the social aspect. Derived topics are 13, and indicators 16. The objectives are the follow, while Table X summarizes the topics and indicators.

- SO1. Contributing to society
- SO2. Collaborating in research and policy making activities

- SO3. Enhancing communication to educate society about fish products
- SO4. Ensuring the safety of employees and promoting healthy lifestyles
- SO5. Enhancing employee engagement

*Table 22. Proposed indicators regarding social aspects.*

| SO# | Topic | Indicator |
|---|---|---|
| SO1 | SDG | (13) SDG targets to which the company contributes [number] |
| | Food security | (14) Fish sold for human consumption [%] |
| | Sponsoring | (15) Sponsored activities [number/year] or [€/year] |
| SO2 | Industry-government nexus | (16) Skippers contributing to collective knowledge about the state of marine zones [%] |
| | Industry-science nexus | (17) Trips made in cooperation with the scientific community [number/year] |
| SO3 | Existent institutions | (18) Available institution briefs and company's remarks [number] |
| | Sea zones status | (19) North Sea GES report [metrics relative to GES threshold] |
| | Sustainable fish | (20) Catch per unit effort [kg/unit-person] |
| | | (21) Food miles [km] |
| | | (22) Sold species with “good to know information” data sheet available [%] |
| | Collaboration with schools | (23) Visits to/from fishing schools [number of visits and students who participated] |
| SO4 | Safe infrastructure | (24) Vessels with safety management system in place [%] |
| | Healthy environment | (25) Vessels with stablished rules for healthy living styles [%] |
| SO5 | CSR policy ownership | (26) Employees aware of CSR policy [%] |
| | Career development | (27) Trained employees rate [number/year] |
| | | (28) Improvement suggestions submitted by employees [number/year] |

The discussion for each indicator follows. The first objective “contributing to society” includes three indicators which scope goes from global to local aspects: contributing to sustainable development goals (SDG), and to food security in west Afrika, and maintaining sponsoring active.

- One concern from the interviews, specifically coming from the government side, is the challenge of implementing SDG number 14, which is about the Oceans' state. SDG14 includes ten specific targets to achieve in 2030. None of them directly mention the fishing industry, but there are certainly goals to which fishing companies not only could contribute but would possibly be most interested in taking part. Thus, reporting on the company´s activities that help advance the different SDG is recommended.

**Box 8. SDG 14 Life below water. Summary of targets**

- 14.1 By 2025, prevent and significantly reduce marine pollution of all kinds.
- 14.2 By 2020, sustainably manage and protect ecosystems to avoid significant adverse impacts, and take action for their restoration
- 14. 3 Minimize and address the impacts of ocean acidification
- 14.4 By 2020, effectively regulate harvesting and restore fish stocks at least to levels that can produce maximum sustainable yield
- 14.5 By 2020, conserve at least 10 per cent of coastal and marine areas
- 14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, illegal, unreported and unregulated fishing
- 14.7 By 2030, increase the economic benefits to less developed countries from the sustainable use of marine resources
- 14.a Increase scientific knowledge, develop research capacity and transfer marine technology, in order to improve ocean health
- 14.b Provide access for small-scale artisanal fishers to marine resources and markets
- 14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law

(United Nations 2015)

In fact, other SDGs in regard to the company are SDG2 zero hunger; SDG9 industry, innovation, and infrastructure; and SDG12 responsible consumption and production.

- The second indicator in regard to contribution to society is percentage of fish sold for human consumption. The company sells a large part of its landings to countries in Africa. Thus, reporting on the purpose each of the sold fish species meets is advisable. The desired tendency for this indicator is that it increases. It was not calculated since no data on the matter was collected as part of the LCA study.
- The third indicator is concerned with sponsoring and comes from the list of activities reported in the 2016 CSR report.

The second social objective is collaborating in research and policy making activities. Thus, two indicators are proposed:

- Some fishing companies such as Cornelis Vrolijk make fishing trips which objective besides fishing is cooperating with the scientific community in conducting fish surveys. Reporting on these contributions is relevant since these are optional activities, not conducted by every fishing industry. The suggested indicator is number of trips made in cooperation with scientists. The desired trend would be for the indicator to remain stable or to increase.

- Likewise, it would be reasonable to encourage skippers to collaborate with scientist and policy makers more closely. The indicator is percentage of the company´s skippers who contribute to collective knowledge about the state of marine zones. But more insight into the sector is needed to make a more specific recommendation.

Everyone in the industry recognizes skippers as the individuals with knowledge and practical skills that so far cannot be substituted by machine learning. And when interviewed, one can sort of understand it by how they describe their job and how they express their concerns about the landing obligation, or the depletion of some stocks: skippers seem to feel the Sea. Internal communication among skippers working in the company allow for exchanging information about the state of the Seabed and the historical location of fish. This provides a competitive advantage for their company, since they are constantly registering clues for finding fish or avoiding bad ground.

From the above, one wonders if skippers, independently from a company, could contribute to an open platform where the objective be not to create competitive advantage, but collective knowledge in collaboration with scientists to care for the Sea. In fact, the integration of a transdisciplinary approach to the governance of fisheries is proposed in literature in order to produce better political outcomes. It is said that participation of broader range of stakeholders would result in a more solid platform for planning and making decisions about the management of marine resources. (Stephenson, et al. 2017). The potential of this idea is something the government could explore, but it could also be something the skippers and other stakeholders as part of civil society could take up on their own.

Going back to objectives, topics and indicators. The third social objective (SO3) proposed is enhancing communication to educate society about fish products. And four topics are covered: existent institutions, status of the different Sea zones, characteristics of sustainable fish, and collaborations with schools. Indicators follow.

- The first indicator is number of available institution briefs and company's remarks about it. The proposition is that CV publishes short briefs about relevant regulation the company complies with. This could be part of the website available information. And it would be a resource for consumers and civil society in general to learn about how the sector operates. Furthermore, it would provide a space for the company to express its view towards each institution regarding room for improvement, and also what the company does to comply with it.
- Next, it is proposed to publish information about the state of the stocks in the marine zones where the company operates. The suggested indicator is: state of stocks in the North Sea based on the Good Environmental Status (GES) report by the EEA. In the North Sea, it appears that about two thirds of the assessed fish stocks are in good GES (EEA 2015). But information should be provided when available for the specific species. It was out of the scope of this research to go into the detail of biological indicators, but they are needed. Choosing and reporting on them on an understandable way for civil society seems to be needed to get to the point where consumers are aware of the fish they decide to buy. During the interviews, experts suggest as consumer one should be aware of where the fish is coming from and what is the state of its stock.
- In connection to the above mentioned, a second proposition for Cornelis Vrolijk is to communicate through their webpage "good to know" information about the fish they sell. This

may be in the format of a product data sheet, that could very concisely list key indicators about the production of each of their fish products such as where they are fished, what are their nutritional characteristics, where they are sold, and how they are consumed. Here, the indicator for CSR reporting would be the percentage of sold species with "good to know information" data sheet available.

- Another important indicator to consider in this regard would be the food miles (the distance a commodity travels from point of production to point of consumption) of each species. This indicator can to some extent cover the necessity expressed by most interviewees to communicate an idea of how far away the fish comes from. Its reporting could be separated into production-storage and transportation to consumer stages. The LCA study does not allow for knowing this information about the first stage, and in the case of transportation to the consumer boundaries would have to be enlarged to account for the data. The desirable trend would be for it to decrease.
- Continuing with communication efforts, another indicator derived from the 2016 CSR activities is the number of visits and visiting students from schools to the company or fishing vessels.
- The last indicator proposed for SO3 is catch per unit effort. This is an indicator found in literature which seems useful for comparing vessel operation or the company against other similar ones in terms of its level of production. The indicator is a mix of fishery-fisherman productivity, and it clearly allows to see differences among species. The indicators estimated for the company in 2016 show the least efficient fishery is horse mackerel, followed by mackerel.

*Table 23. Species catch per unit effort in 2016.*

| 2016 | kg/day-person |
|---|---|
| Herring | 113 |
| Mackarel | 37 |
| Horse mackarel | 17 |
| Blue whiting | 94 |

Next objective in lines is SO4 about ensuring employees health and safety. Two topics and two indicators are considered. The first ones about providing safe infrastructure, and the second one about healthy environments. Both topics are already addressed as part on the 2016 activities in the company's CSR report, and their expected activities in 2021. The proposed indicators are the following.

- Percentage of vessels in the fleet with a safety management system in place, and
- Percentage of vessels with stablished rules for healthy living styles.

Concerning healthy living styles, the 2016 CSR report let see that these, although promoted by the company, is a choice left for the employees to some extent and also addressed by making changes and additions to available facilities in the company's buildings and vessels. Additionally, Yuil (2017) proposes that for successful internal CSR that maximizes health and wellbeing, it is advisable to set up a policy which looks at health from a social model point of view, focused on root problems and long term interventions. Also, the author suggests that instead of asking people to make changes in their lives, companies should modify the context in which the employees take part and put focus on "control, reward and shallower hierarchies".

The last social objective deals with enhancing employee engagement concerning two topics: ownership of the company's CSR policy, and career development. Both topics are addressed in the 2016 CSR report. In total, three indicators are proposed:

- Percentage of employees aware of CSR policy, should be able to reflect the degree to which this policy is embedded as a shared mental model among the everyone in the company. Since this at the core is a more qualitative indicator, an approach to its measurement could be a survey design to test awareness. Defining the metrics definitely requires more work.
- Concerning career development, the first proposed indicator is trained employee rate as suggested by literature.
- The second one is number of improvement suggestions submitted by employees, also found in literature. In fact, starting the conversation with employees about their opinion on potential improvements in their area of operation would one the way to start fostering a shared mental model of the company´s mission and CSR policy. Shared mental models are often mentioned when studying the management of common resources. In this regard, social scientists suggest that resource management can be more influenced by communication than by the rules crafted around it (Janssen, Bousquet and Ostrom 2011). And in fact, in lab experiments, the organization of communication is more important than the content of it (Poteete, Janssen and Ostrom 2010).

To enhance employee engagement and the recognition of the CSR policy, it is recommended that special attention is put in its communication strategies. Also, a second recommendation for the company is that training of employees and suggestions for improvement should not only reflect technical related activities, but all sustainability related ones.

### 6.2.3 Market indicators

The economic aspect of sustainability is named "market aspect" in the proposed indicator set. The reason is that no economic indicators are proposed since going into that direction was out of the scope of this research. Thus a market perspective was chosen, focusing on topics that can potentially have an impact over sales. Two objectives are proposed:

- MO1. Adding value to the sold fish products
- MO2 Staying transparent and fair

*Table 24. Proposed indicator regarding market aspects.*

| MO# | Topic | Indicators |
|---|---|---|
| MO1 | Certifications | (29) Sold fisheries MSC-certified [number] |
| MO2 | Compliance with institutions | (30) Campaigns started in regard to the business unit [number/year] |
| | CSR reporting | (31) Management positions with specific sustainability responsibilities [number] |

Objective MO1 deals with adding value. In marketing this means to increase the extent to which the product is perceived by the customer as better in terms of meeting needs and wants, and thus the willingness to pay may increase. More recently, the concept of shared value was proposed as "a meaningful benefit for society that is also valuable to business" (Porter and Kramer 2006). And there is also the claim that creating shared value poses a change to legitimize business (Porter and Kramer

2011). A topic concerned with adding value in fishing industries is certification. And concerning this issue, a thought arises in the sense that by certifying all its fisheries, Cornelis Vrolijk not only would be adding value to its products, but would also be contributing to creating shared value.

The fact remains that many fisheries even in the North Sea, which is in a better state in comparison to other zones, are not assessed yet in terms of their GES. Many species are not MSC certifiable yet (Simoncelli 2017). But by adopting certification as the straightforward policy for industries that care, the whole sector might start considering it as the social norm to follow, and consumers regarded as something to expect. Thus, not certified fish would be seen as not complying with the social norm. At the moment the, MSC certification is a market instrument but if more and more industries adhere to its framework, maybe the time can come when fish certification becomes institutionalized.

- From the interviews, it was clearly recommended by stakeholders to rely specially in MSC certification. Thus, the indicator proposed is the number of fisheries in the company that hold such certification. By doing so, it would also be ensured that biological specific to the company´s operations are available for reporting.

The second market objective deals with staying transparent and fair through complying with institutions and reporting on CSR. Two indicator are proposed in this regard. The first one is about social campaigns and articles reported in the news about the company, either in positive or negative terms. The second one is about management positions in the company with specific sustainability responsibilities.

- By reporting the number of campaigns started in regard to their business units, the company can stay transparent about the issues that concern stakeholders and open up a space to communicate their own message in return.
- Concerning management positions with sustainability responsibilities, the information could be presented with an organigram showing who is responsible for the sustainability activities. Many more sustainability activities could be defined, but for starters the people who will be responsible for either gathering the LCA data or reporting each of the proposed indicators can be regarded as having a sustainability related activity.

The next section summarizes the whole set of indicators and their baseline value when available.

### 6.2.4 Validation against sustainability criteria

Hanson et al. (2011) propose twelve criteria for aquatic supply chains concerning wild caught fish. As a way of validating the indicator set designed for Cornelis Vrolijk, the criteria are revised against the indicators to check that all are being covered. A simplified list of the criteria described in chapter 2 follows:

*Table 251. Proposed indicators based on sustainability criteria for wild caught fish.*

| Criteria | Indicator suitable for a fishing industry |
|---|---|
| Fish biomass is sustained | (2) Size of fish caught; (29) Sold fisheries MSC certified [number] |
| Ecosystem is in appropriate health | (19) North Sea GES report; (3) Harm to habitat structure |
| Minimized contribution to climate change | (7) Average carbon footprint per unit of product |
| Externalities are avoided | |
| Fish waste is minimized | |

| Criteria | Indicator suitable for a fishing industry |
|---|---|
| Operations are efficient | (6) Level of energy consumption; (20) Catch per unit effort |
| There is respect for traditional rights | |
| There is full supply chain traceability | (29) Sold fisheries certified |
| Compliance with conservation institutions is met | (18) Available institution briefs and company's remarks |
| There is adequate fishery management | (1) Level of bycatch; (29) Sold fisheries MSC certified [number] |
| Operation is legal | (18) Available institution briefs and company's remarks [number] |
| Sustainability reporting is done under best practices | |

The criteria column in Table 11 is coloured according to the general topic addressed. Light green is for environmental related topics, blue for social and institutional aspects, and grey for communication related topics.

Almost all environmental criteria are covered but fish waste minimization. For this, an indicator regarding the percentage of FFF fish (which is low grade or broken fish) produced by the business unit can be added to the set. This is easily estimated from databases used in the LCA study (1.5%), and can be added to the waste management topic in EO2 about reducing environmental impact.

The social and institutional criteria indicators are trickier to propose, probably because there are related to less tangible and addressed topics (Stephenson, et al. 2017). The criteria about externalities avoidance is quite difficult to bring to a general theme for monitoring, same as respect for traditional rights. In fact, both criteria might not be entirely applicable to CV at least regarding the pelagic business unit. No indigenous rights being threatened seems to occur. And concerning externalities, the company also plays by the rules set for the industry. Nonetheless, one potential externality to mention is related to air pollution from the combustion of fuels. These are to some extent subsidized in the form of tax relief for the whole maritime sector in the Netherlands (Reijbroek 2017). Thus, more than providing CV with an indicator about externalities, the thought arises for recommending the sector and the government to reconsider if fossil fuels should still be subsidized. As shown with the LCA results, most of the impact of the company derives from fossil fuel use. And in this regard, incentives are needed for fishing companies to divest from heavy fuel oil and all fossils in general. Furthermore, these subsidies play against the global policy to mitigate GHG emissions.

Lastly, in regard to communication, the two criteria to meet are: full supply chain traceability which can be covered by the MSC certification, and best practice reporting. About reporting, more than being measured by an indicator, this is covered by communicating all the other criteria openly and in a transparent way. In conclusion, all criteria are met and the final set of indicators is summarized and presented in the next section.

### 6.2.5 Baseline

Overall, 32 indicators are proposed to include as part of in Cornelis Vrolijk's CSR reporting. It was possible to estimate the baseline value for many of them using the data available from the LCA study. The next table summarizes the results. Furthermore, the coloured cells show (green) if the indicator is easy to estimate by the company even calculation for this research was not done, or (orange if it is a new indicator for the company and possibly harder to estimate.

*Table 26. CSR indicators proposed to Cornelis Vrolijk.*

| I# | Indicator | Baseline value |
|---|---|---|
| 1 | Level of bycatch **[%/year]** | 13 |
| 2 | Average size of fish caught **[cm]** | |
| 3 | Harm to habitat structure **[number of incidents]** | |
| 4 | Level of clean electricity consumption **[%]** | |
| 5 | Level of clean fuel consumption **[%]** | 56 |
| 6 | Level of energy consumption at vessels **[MJ/kg fish at vessel]**<br>Level of energy consumption at on-shore storage stage **[MJ/kg fish at storage]** | 7.9<br>0.3-5.5 |
| 7 | Average carbon footprint per unit of product **[kg$CO_2$/kg fish]** | 1-1.2 |
| 8 | Refrigeration fluids lost through leaks **[%]** | |
| 9 | Level of procured materials with sustainable sourcing approach **[%]** | |
| 10 | Mass of netting lost at Sea **[t/year]** | |
| 32 | Waste fish landed **[%/year]** | 1.5% |
| 11 | System flows managed under a circular economy approach **[number]** | |
| 12 | Innovation projects related to divesting from fossil fuel usage **[number/year]** | |
| 13 | SDG targets to which the company contributes **[number]** | |
| 14 | Fish sold for human consumption **[%]** | |
| 15 | Sponsored activities **[number/year]** | |
| 16 | Skippers contributing to collective knowledge about the state of marine zones **[%]** | |
| 17 | Trips made in cooperation with the scientific community **[number]** | |
| 18 | Available institution briefs and company's remarks **[number]** | |
| 19 | North Sea GES report **[metrics relative to GES threshold]** | |
| 20 | Catch per unit effort **[kg/day-person]** | 17-113 |
| 21 | Food miles **[km]** | |
| 22 | Sold species with “good to know information” data sheet available **[%]** | |
| 23 | Visits to/from fishing schools **[number of students], [number of visits]** | |
| 24 | Vessels with safety management system in place **[%]** | |
| 25 | Vessels with stablished rules for healthy living styles **[%]** | |
| 26 | Employees aware of CSR policy **[%]** | |
| 27 | Trained employees rate **[number/year]** | |
| 28 | Improvement suggestions submitted by employees **[number/year]** | |
| 29 | Sold fisheries MSC certified **[number]** | |
| 30 | Campaigns started in regard to the business unit **[number/year]** | |
| 31 | Management positions with specific sustainability responsibilities **[number]** | |

The formulas used for calculating the baseline indicators are made available in the excel spreadsheet attached to this document. It is worth mentioning that the LCA study, besides producing the carbon footprint indicator and the whole environmental profile for the four fish, it allowed to easily estimate the level of bycatch, catch per day effort, level of energy consumption by stages, and level of clean fuel consumed.

Out of the 32, 19 indicators can already be easily reported (green cells). But from the whole set, it will be up to the company to decide to use them all or only some. The set was only partially validated at the company, meaning that there wasn´t a one by one indicator revision and discussion. However, given the methodological steps followed for designing the set, it is believed that all 31 are relevant and useful for Cornelis Vrolijk.

## 6.3 Results: Sustainability Balance Scorecard for Cornelis Vrolijk

Based on the CSR indicators proposed in the previous section, a SBSC is arranged in order to signal connections among indicator concerning the customer, internal process, learning and growth, and financial perspectives of the business unit.

Figure 28 is the resulting SBSC. Out of the 32 indicators, 22 were chosen to be part of this subset of strategic indicators. At the top of the card is the financial perspective showing revenues, cost structure and value creation. One step down is the customer perspective, grouping four of the indicators and signalling their links to the indicators from the perspective on the top. What are thought to be stronger relations are shown in continuous arrows, while weaker ones are shown in dashed arrows. And the same applies for the perspectives in the bottom. As some of the proposed indicators did not fit any of the four conventional perspectives, the non-market one was added as suggested in literature.

It is recommended that either a general indicator set table as the one in the previous section, or a SBSC such as the one presented here, are used by CV as a tool to follow up on their CSR activities. Also that more indicators are included as part of the CSR report, since currently it mainly describes activities. Using the indicator set can allow over periods can then allow to report on yearly comparisons, while the graphic representation can show useful linkages to explain changes.

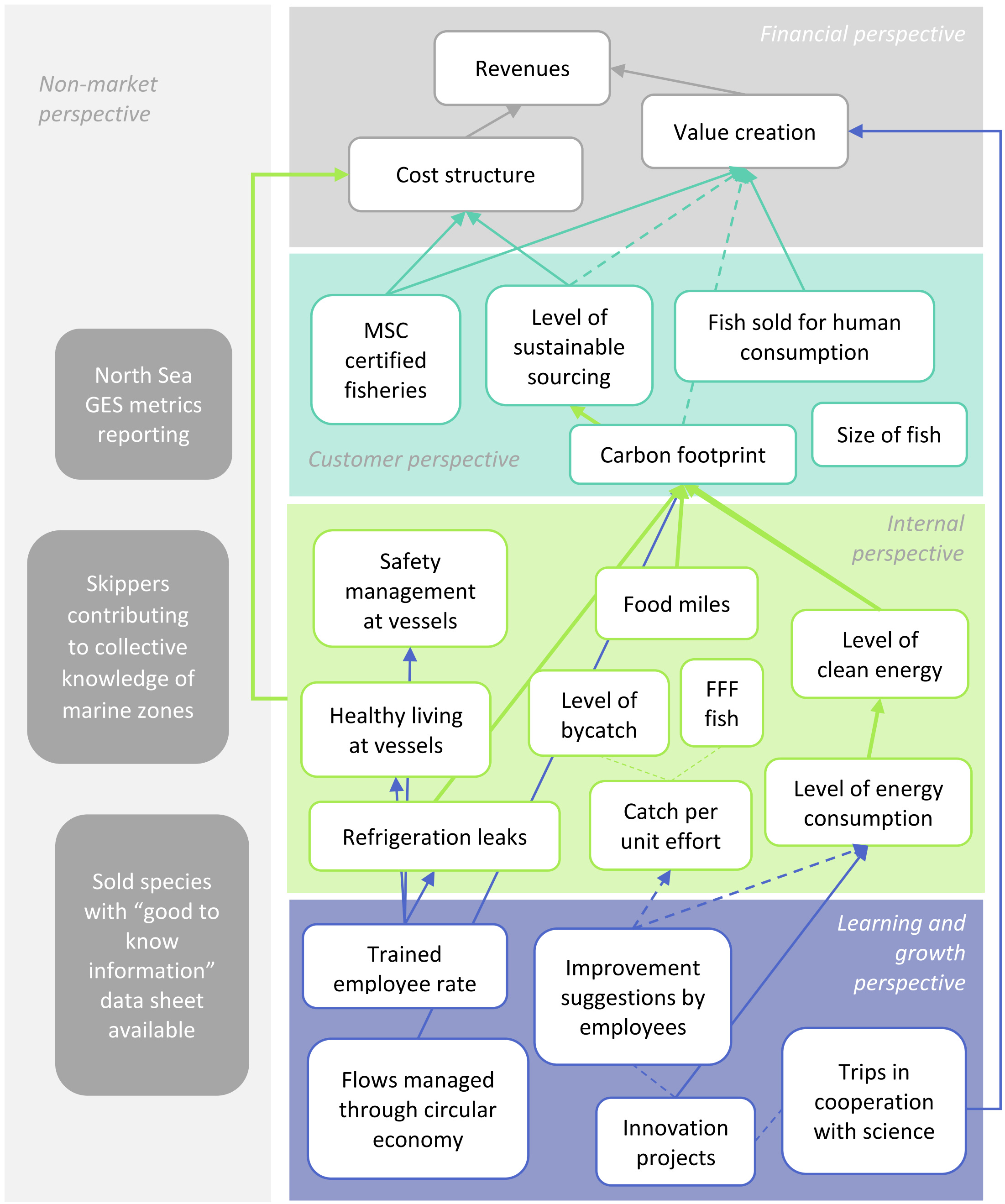



*Figure 28. SBSC based on CSR indicator set.*

# 7. Discussion

## 7.1 LCA study

Results from the LCA are comparable to literature. They do not differ much from general findings in the consulted LCA articles regarding pelagic fish. But these results are more complete by reporting on the whole environmental profile rather than only the climate change category. This way, it was possible to show the company that although the carbon footprint matters, many other aspects also do.

Furthermore, the model is greatly representative of CV´s operation as it built with mostly first hand data. And as it is built, it can be useful to derive many more indicators for the company than the ones provided by the environmental profile or the CSR indicator set. Footprints by average fishing trip per vessel can be estimated for instance. And this can allow to explore differences within vessels, crossing over fleet management information and crew hands-on knowledge. In this sense, if the company decide so, the LCA model we built for them can become a living tool for sustainability management.

Possibly, one drawback of the LCA is that fish biology and marine ecosystem cannot be really characterized. Thus, the company should pay attention to the fact that LCA results alone do not cover the whole aspect of sustainability for fishing industries. Reporting on the fisheries and marine environment using other tools.

It is recommended that the LCA is enlarged to cover the next steps in the lifecycle, namely fish transportation to the different retailers and applicable modes of transportation. This is also in line with estimating the food miles indicator. Likewise, this is a topic unaddressed in the reviewed literature, and seems quite interesting to explore. The same goes for a study on the system with the view of geography of consumption.

## 7.2 CSR and indicators

The 2016 CSR report of CV covers the main concerns that came out of the materiality assessment conducted. However, the report lacks more solid indicators besides the proposed reductions in carbon dioxide emissions expected by 2021. This could be cover by the set of proposed indicators.

Defining clear objectives is also recommended. Although not all the activities enlisted in the 2016 CSR report are represented by an indicator in the proposed set, all of them are part of at least one of the proposed objective's topics.

From the 2016 CSR analysis, it appears CV's CSR policy follows a conservative sustainability strategy, focused on efficiency and oriented towards internal measures. This implies appropriate and sophisticated technology, up to date health and safety management, and ecological sustainability, as described by Baumgartner and Ebner (2010). All of which suits CV. The recommendation is that this gest measured, monitored and reported.

Lastly, since already the business unit is very successful, the company might want to start thinking to push itself towards a more visionary CSR or sustainability strategy. Visionary strategies involve commitments focused on making the company a market leader in terms of sustainability. Selling-only MSC certified fisheries come to mind, the same as fossil-free fuelled vessels. This would also reflect somehow moving towards a more political CSR.

## 7.3 Interlinkages between LCA, CSR and supply chain

Literature point out that management of sustainable supply chains is correlated to corporate social responsibility, since both deal with decision making for the protection and promotion of human rights, and labour and environmental standards to care for society and ecosystem services (Stuart and Vivek 2010). While supply chain management deals with day to day operations, CSR deals with ensuring and communicating the supply chain characteristics.

Likewise, there is also a linkage with LCA. On its own, LCA measures environmental impacts and sets the base for improvement by quantifying material flows. Supply chains are more about information flows. But the fact is that CSR, supply chain management, and LCA all deal with almost the same system of study. Looking at their interlinkages is relevant to develop sound improvements to the system, as was proved with the case of Cornelis Vrolijk.

Literature revisions on LCA of fish already suggested fuels as the key contributors to impact. The obtained results from the actual calculation were no surprise to anyone. But besides giving more detailed insight into the contribution to impact by stages and signalling relevant impact categories besides climate change, what the LCA brought was understanding of the whole process. While compiling the input data, it is possible to notice differences in management of data among departments and locations within the company. One also realizes where are the gaps concerning flows monitoring, and this in turn automatically becomes a recommendation for the next LCA round. However, in this case those gaps were translated into indicators for monitoring which can be included as part of the company´s CSR. This is the first found link.

A second link identified is in relation with communication. Throughout the interviews with the different departments in the company while gathering data, it was possible to open up the conversation about why such information was needed. And in the process of pushing people to dig for data by asking suppliers, one starts realizing who the suppliers are and how willing they are to facilitate their information. So the data gathering allows to identify who manages the process in turn, what the involved operations are, and why things are done in a certain way with certain supplies and/or suppliers. By the end of the LCA, this allows for making sounder recommendations that can be contextualized in the reality of the company. And speaking the language of the company fosters trust. Showing that one can be a bridge by putting together the insights from different departments and even different voices in the sector seems to make the topic interesting to people. This sort of communication, I believe is the basis for creating a shared mental model inside a company. This share mental model should be understanding of the CSR policy and acknowledging that almost everyone has a role to play in it.

Another link comes when analysing the recommendations derived from the LCA. For them to be practical for the company, it is necessary to look into the related supply chain and be confronted with the barriers for adoption. This in turn allows to propose more suitable CSR indicators sets. For example, a solo indicator concerning fuels would be “share of clean fuel usage”. But this is difficult number to change for the company given the supply chain status. Thus, it is necessary to add reporting on the number of innovation projects concerning giving up fossil fuels.

One more link that may come as obvious, but still should be mentioned is that LCA allows for identifying where it is more relevant to start when looking to green the supply chain. In the case of CV, it is with the fuels.

Lastly, since LCA and supply chain analysis focus more on material flows, without CSR they alone cannot speak of sustainability. Thus it is advisable that when building a sustainability strategy for an industry they are all considered complimentary.

In summary, the identified linkages are the following:

- Gaps in LCA inputs can become relevant indicators to monitor as part of the CSR policy
- The process of data gathering for LCA fosters channels of communication that can be the base for embedding the CSR policy of the company in a shared mental model among all staff
- Understanding the supply chain of relevant inputs for the LCA results allows for sounder improvement recommendations
- Understanding the supply chain of relevant inputs for the LCA results allows for better indicator design
- LCA points to which inputs can be the most relevant when starting to “green” the supply chain
- CSR compliments LCA and supply chain analysis, they alone cannot speak of sustainability integrally

Methodologically, all the tools used for this research are widely publicised in literature and commonly used in the industrial ecology field. The novelty may come from putting them together for a case study. Although the research did not go much deep into any topic (the LCA, the CSR policy and the sustainable procurement), I believe the result is more useful for the companies this way in many cases and this was one of them.

# 8. Conclusions and recommendations

## Conclusions

Goals for this thesis were accomplished and all four research questions answered. The need of Cornelis Vrolijk to identify hotspots through an LCA and obtain improvement recommendations was covered. The main pressure comes from fuel consumption for most impact categories. But when taken out of the model, the packaging stage becomes the most relevant due to inputs of cardboard and plastic, and related waste streams. Furthermore, it was expected that refrigeration fluids would considerably contribute to impact, and they do so for the ozone depletion category and climate change. But concerning their impact to ozone depletion, in terms of normalized figures the impact is much less relevant in comparison to other categories such as the ones concerned with human toxicity and acidification.

The above answers the first research question, which was: What are the environmental pressures and impacts of the cradle-to-gate of four of CV's pelagic fish products, namely blue whiting, herring, mackerel and horse mackerel? In relation to the four species, it can be said that it seems that there seems to be no significant difference concerning the results obtained for each one. However, the goal of the study was not to make comparisons among them.

The second research question was: What improvement options could be identified from the LCA analysis? In this regard, the recommendations made to the company were to switch to the usage of 100% marine diesel instead of using heavy fuel oil, and also to switch to natural refrigerants. But when confronted with the barriers of the state of the supply chain, proposals for improvement take a more managerial approach by suggesting that the company monitors itself concerning their participation in innovation projects that can help them start divesting from fossil fuels, and also that they ask their suppliers to have a CSR or sustainability policy in place.

The third research question was: What indicators derived from the analysis are suitable to be included in CV's CSR policy? For this, a series of interviews about the meaning of sustainability in the fishing sector were conducted with stakeholders inside and outside the company. This was in addition to the information gotten from the LCA data gathering stage. The interviews allowed to make a materiality discussion and confront the results with indicator proposed in literature. Altogether, it was possible to propose 32 indicators that are suitable to be taken into account for the company's CSR policy and arrange them in the way of a sustainability balanced scorecard.

Finally, the fourth research question was if results from LCA be better embedded in CSR literature and could this benefit from supply chain management thinking. The answer is yes. It was found that literature indicators concerning CSR in fisheries did not include indicators that only came into being due to findings from the LCA data collection stage. Likewise, the design of indicators was improved by taking into account findings from the supply chain of fuels as it is for the company. In sum, several interlinkages between the three approaches (LCA, CSR and supply chain) were identified:

- Gaps in LCA inputs can become relevant indicators to monitor as part of the CSR policy
- Data gathering for LCA fosters channels of communication inside the company
- Understanding the supply chain of relevant inputs for the LCA results allows for sounder improvement recommendations and for better indicator design

- LCA gives a starting points for “greening” the supply chain
- CSR compliments LCA and supply chain analysis, they alone cannot speak of sustainability integrally

### Recommendations

The following are summarized from the different chapters.

**To Cornelis Vrolijk**

- Switch from using heavy fuel oil and marine diesel to 100% marine diesel
- Define a procurement policy which considers sustainability
- Push suppliers, but particularly fuel suppliers to comply with a sustainable procurement policy
- Ask suppliers to make their CSR policy available.
- Report on the company´s activities that help advance SDG14
- Measure netting waste
- Together with skippers discuss which are the potential events in pelagic fishing that could cause habitat harm, and the best way to report on them.
- Encourage skippers to collaborate with scientist and policy makers more closely.
- Use either both the proposed indicator set table and SBSC as tools for periodic follow up on CSR activities.
- Pay attention to the fact that LCA results alone do not cover the whole aspect of sustainability for fishing industries
- Reporting on the fisheries and marine environment using other tools, MSC-certification of all the fisheries would be a way
- Broaden the scope for the next LCA study to cover the next steps in the lifecycle, namely fish transportation to the different retailers
- Start moving from the conservative sustainability management to a visionary one

**To insdustrial ecologists**

- When making recommendations regarding product improvement from a LCA perspective, look into the related supply chain and be confronted with the barriers for adoption.
- Since LCA and supply chain analysis focus more on material flows, without CSR they alone cannot speak of sustainability. Thus it is advisable that when building a sustainability strategy for an industry they are all considered complimentary.

**To governments**

- Reconsider if fossil fuels should still be subsidized. As shown with the LCA results, most of the impact of the fishing companies derive from fossil fuel use. And in this regard, incentives are needed for fishing companies to divest from heavy fuel oil and all fossils in general. Furthermore, these subsidies play against the global policy to mitigate GHG emissions.

**To civil society**

- Buy MSC certified fish, it’s the easiest political vote for sustainable fish

- Become aware of the zone where the fish you buy comes from, acknowledge the state of such zone
- Choose local species or the fresher fish, meaning the less processed ones
- Be willing to pay a higher cost for certified fish

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# Annex A. Interview format

July-2017

**Questionnaire for fishing sector experts**

Objective: obtain first-hand information about what stakeholders perceive as important regarding sustainability in the fishing sector, specifically concerning the pelagic fishery. The results will be used as input for a master thesis being conducted in relation to Cornelis Vrolijk.

Interviewer: Mariana Ortega-Ramírez, MSc Industrial Ecology candidate

Interviewee*: ________________________________

1. Can you mention three to five specific topics that come to your mind when thinking about sustainability in the fishing sector?

_______(Rank:_)

_______(Rank:_)

_______(Rank:__)

2. Can you rank these topics in importance and explain a little bit?
3. Thinking about legislation in your field of expertise, can you mention a couple of regulations that you consider important in relation to the industry's sustainability?

4. In your opinion, are there sustainability related challenges for the fishing sector at the moment, if yes, what are they?

5. As an expert in the fishing sector, is there something you would recommend to a non-expert to be aware of when buying or consuming fish?

*By the end, to be asked for permission to possibly cite responses in the thesis report.

# Annex B. Relation between the proposed sustainability topics and CV's CSR activities

| **Aspect** | **Objective** | **T#** | **Topic** |
|---|---|---|---|
| Environmental | Fishing from heathy stocks/ fishing forever | 1 | Selective fishing |
| | | 2 | Fish quality |
| | | 3 | Habitat protection |
| | Reducing environmental footprint/ daily sustainable | 4 | Electricity sourcing |
| | | 5 | Fuel sourcing |
| | | 6 | Fuel consumption efficiency |
| | | 7 | Contribution to climate change |
| | | 22 | Sustainable procurement |
| | | 16 | Waste management |
| | Adopting a circular economy appoach as much as possible/ daily sustainable | 8 | Closing material cycles |
| | Contributing to sustainable innovation | 9 | Technology development |
| Social | Contributing to society | 26 | SDG |
| | | 25 | Food security |
| | | 20 | Sponsoring |
| | Collaborating in research and policy making activities | 16 | Industry-Government nexus |
| | | 10 | Industry-Science nexus |
| | Enhancing communication to educate sociey about fish products | 11 | Existent institutions |
| | | 12 | Sea zones status |
| | | 13 | Sustainable fish |
| | | 23 | Collaboration with schools |
| | Ensuring the safety of employees and promoting healthy lifestyles | 17 | Safe infrastructure |
| | | 18 | Healthy environment |
| | Enhacing employee engagement | 24 | CSR policy ownership |
| | | 19 | Career development |
| Economic | Adding value to fish products | 14 | Certifications |
| | Staying transparent and fair | 15 | Compliance with institutions |
| | | 21 | CSR reporting |

| Activities in 2016 | Related to T# |
|---|---|
| × Quality optimization | T2 |
| × Research from quality data recordings | T10 |
| × Provision of information to IMARES, including catch data | T10 |
| × Project on development of equipment for fish detection | T9 |
| × Involvement in policy making discussions about stock management | T16 |
| × Identification of relevant stakeholders | T21 |
| × Organization in regulations' compliance | T15/T11 |
| × Testing of on-board camera systems for landing obligation implementation | T9 |
| × Analysis of possibilities for increasing recyclable material flows | T8 |
| × Sign up for Dutch 'Green deal' | T15/T11 |
| × Ensure adequate management of hazardous waste | T16 |
| × Baseline estimation of CO2 footprint | T7 |
| × Research into energy efficiency in regard to propelling vessels and towing nets | T9 |
| × Investigation on improved deployment of solar panels | T9 |
| × Installation of charging for electric cars | T4 |
| × Updating of health and safety policy | T17 |
| × Establishment of safety committee for each vessel | T17 |
| × Increased attention to personal protective equipment on board | T17 |
| × Improvement of food policy on board | T18 |
| × Inventory wishes for fitness training facilities on board | T18 |
| × Internal communication regarding employee personal development | T18 |
| × Offering of internship possibilities | T19/T16 |
| × Developing a more structured approach to sponsorship activities | T20 |
| × Drawing up of activities to undertake in West Africa | T21 |
| × Working with subsidiary Primstar to develop CSR policy plan | T21 |

| Expected activities In 2021 | Related to T# |
|---|---|
| × Possibly, renewed ISO certification | T14 |
| × Engagement in management plan for horse mackerel in the North Sea | T16 |
| × Reduced by-catch levels | T1 |
| × Good and open relationship with stakeholders | T21 |
| × Well-organized compliance with all applicable regulations | T15 |
| × Documented choices regarding sustainable procurement and the green economy | T4/T5 |
| × Investigated and possibly implemented environmentally friendlier alternatives for packaging | T22 |
| × All employees are aware and take into account CSR policy | T19 |
| × Reduced $CO_2$ footprint by 10% at Sea | T7 |

| Expected activities In 2021 | Related to T# |
|---|---|
| × Reduced $CO_2$ footprint by 20% on shore | T7 |
| × Led light only on board vessels | T6 |
| × Application of new standards regarding refrigerants in all installations | T22/T7 |
| × Up to date health and safety policy at all time | T17 |
| × Available broad range of tools for employees who wish to lose weight | T18 |
| × Contribution to improved quality of education at fisheries schools | T23 |
| × Introduction of proactive personnel policy | T19 |
| × Any employee can explain what CSR means for the company | T24 |