

SDG 14 Life Below Water

Introducing Fish Skin as a Sustainable Raw Material for Fashion

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ABSTRACT

In recent years there has been a growing interest in fish skin – a by-product of the food industry – as an alternative sustainable raw material for fashion. Global production of fish has steadily increased over the last decade and more than 50% of the total remaining material from fish capture results in 32 million tonnes of waste. A substantial amount of this waste is the skin of the fish; only a small percentage of this skin is processed into leather. While, to date, the European Environment Agency allows seafood processors to dispose of fish skins in marine waters, this is expected to change as the decomposing organic waste can suck up available oxygen from marine species and introduce disease into the local ecosystem. Fish skin leather processing could prevent and significantly reduce marine pollution and sustainably protect marine ecosystems in order to achieve healthy and productive oceans. This paper describes the conditions necessary for the development of fish skin craftsmanship within a Fashion Higher Education sustainable curriculum. In order to enhance the innovation and sustainable design of fish leather products, the author has developed an impactful capacity-building approach connecting fashion students with the Icelandic fish leather industry, which is renowned for sustainable sourcing from Nordic fish farms, promoting the sustainable use of ocean-based resources.

KEYWORDS: Fish skin; Food Industry By-Product; Sustainable Management of the Oceans; Arctic Economic Growth of Fisheries; Fashion Education for Sustainability

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CHAPTER ONE: INTRODUCTION

This chapter outlines the importance of fish skin, a by-product of the food industry, as an innovative sustainable material for fashion. Fish skins are sourced from the food industry, using waste and applying the principle of circular economy. None of the fish used to make this alternative leather are farmed for their hides. They require no extra land, water, fertilisers or pesticides to produce them and they have low environmental impact, unlike conventional leather (Jacobs, 2018). The processing of fish skin leather avoids throwing the fish skins into the ocean and can significantly reduce marine pollution and sustainably protect marine ecosystems in order to achieve healthy and productive oceans.

The Atlantic Leather tannery, located on the north coast of Iceland, has processed fish leather since 1994, based on the ancient Icelandic tradition of making shoes from the skins of catfish. It supports local economies by sourcing from sustainably-managed Nordic fish farming. The manufacturing of fish skin leather works with three aspects of sustainability: the economic benefit of creating value from waste; the social benefit of reconciling sustainability with fashionably exotic fish skin; and the environmental benefit of producing skins without damaging biodiversity or endangering animals.

The results presented in this study are based on the United Nations Sustainable Development Goal 14, Life Below Water, and they highlight the opportunity to develop fish skin leather as a key part of achieving sustainable development of the ocean. SDG 14 deals with the conservation and sustainable management of the oceans, seas and marine resources and it is strongly connected with other SDGs, in particular SDG 2 (ending hunger and achieving food security, improved nutrition and sustainable agriculture) and SDG 12 (sustainable production and consumption).

Fisheries and aquaculture make a crucial contribution to global food security, nutrition and livelihoods, but overfishing, unsustainable seafood farming practices, ocean pollution and acidification will threaten the future of seafood availability worldwide.

The oceans are recognised as indispensable for addressing many of the global challenges facing the planet, from food security and climate change to the provision of energy and natural resources. The use of the sea and its resources for sustainable economic development (Blue economy), contributing to prosperity today and into the future (WWF 2015), is expanding rapidly, but the oceans are under stress. They are already over-exploited, polluted and

confronted with climate change. As carbon emissions have risen over time, the ocean has absorbed much of the carbon dioxide, leading to acidification. Sea temperatures and sea levels are rising, resulting in loss of biodiversity and habitat and changes in fish stock composition. Future ocean development is threatened by overfishing and depleted fish stocks in many parts of the world (OECD 2016).

Atlantic Leather, an Icelandic fish skin tannery, uses the full potential of the ocean by taking a responsible, sustainable approach during fish skin processing, and taking into consideration the wealth of the ocean and its great potential for boosting economic growth, employment and innovation.

This chapter explores the qualities of fish skin leather, a by-product of the food industry and part of the ocean economy: its capacity for creating future employment and innovation and its role in addressing the global challenges facing oceans. Special attention is given to the new technologies used in fish skin production, their potential for innovation and their contribution to addressing challenges such as energy, environment and climate change.

The World Ocean Council (WOC) has been working to advance global ocean business collaboration to develop industry-driven solutions to sustainable development. The Atlantic Leather fish skin tannery is playing an influential role in promoting sustainable practices, producing fish skin leather that implements sustainable concepts, reducing environmental impacts and creating social value. Creating sustainable value chains within ocean and maritime industries is a key priority for the Icelandic fishing sector. Since maritime technology has been developed in Iceland and private companies have set more value on businesses supporting ocean sustainability than before, the concept of the Blue economy has received increasing attention and interest (Hansen, 2018).

Atlantic Leather works with fisheries with blue technology, which considers the intersection of the economic benefits of the ocean, environmental health and societal value in policies and best practices (Hansen, 2018) and exploits the harvested raw material of fish skin to the maximum level within its value chain. By maximising the usage of fish skin, Atlantic Leather has added value within the fishing industry; the company's efforts to utilise 100% of the raw material contribute to maintaining fish stocks at biologically sustainable levels. Using the entire fish adds to the value chain, benefitting fashion buyers as well as the fisheries themselves. Since the benefits of 100% utilisation can be applied when the supplier or fishermen are

registered and connected within the value chain, this idea of 100% utilisation helps reduce undocumented fisheries and over-fishing.

The activities of Atlantic Leather which are most closely related to the relevant SDG 14 targets are:

- 1- Reducing ocean acidification: Atlantic Leather reduces CO₂ emissions by ceasing to throw fish skins into the ocean.
- 2- Regulating harvesting, and ending overfishing and illegal unreported fishing practices: 100% utilisation of fish raw materials is applied when the supplier or fishermen are registered and this helps to decrease undocumented fisheries and overfishing.
- 3- Increasing economic benefits from the sustainable use of marine resources: Atlantic Leather develops fish skin leather while preserving environmental biodiversity by sourcing from Nordic sustainably managed fish farming.
- 4- Providing access for small-scale artisanal fisheries to marine resources/markets: Atlantic Leather promotes value-added profits within the value chain by creating new job opportunities for coastal dwellers using a by-product of the fishing industry to produce fish skin leather for the luxury fashion industry.
- 5- Increasing scientific knowledge, developing research capacity and transferring marine technology: Atlantic Leather uses new technologies for the development of sustainably produced fish skin leather.

This chapter has presented a brief introduction of the development of fish skin use and reflected on the sustainable concepts of fish skin production in Iceland. The study proposes that the sustainable development of fish skin as a by-product could become an innovative sustainable raw material for the fashion industry. After this introduction, Chapter 2 reviews the historical context of fish skin leather. Chapter 3 introduces the fish skin Concepts of Sustainability, the main contribution of knowledge to this field, and then reviews how fish skin leather and the Atlantic Leather tannery align with the SDG14 Life Below Water. Through the findings presented, this chapter aims to provide insights relevant to policymakers, fish industry stakeholders and academia, and to encourage continuous improvement towards more sustainable fashion practices. Chapter 4 introduces methods and methodology for the case study and action research.

Chapter 5 presents a case study of **Best Practices in Fashion Higher Education** with Arctic students. The study examines a fish skin workshop developed at the Icelandic tannery Atlantic Leather involving fashion students from five Nordic universities, providing new data on cross-collaboration between industry and academia. Such insights will inform industry and academia how fish skin leather, a by-product of the food industry, can better contribute to responsible marine resource use. Chapter 6 focuses on implementing measures and recommendations for both academia and industry, followed by the conclusions of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Historical Context: Fish skin through history

Making leather from fish skin is an age-old craft practised by many societies along rivers and coasts around the world and there is evidence of historical fish skin leather production in Scandinavia, Alaska, Hokkaido, Japan, north east China and Siberia. Before synthetic fibres were invented, people clothed themselves with natural materials available in the surroundings where they lived, including fish skin (Jiao, 2012).

Arctic people display a remarkable intelligence in utilising natural resources, reforming natural conditions, adapting to the environment and creating a better life; in the past, this included making clothes from fish skin leather. However, the shortage of raw materials and the omnipresence of modernity have challenged the preservation of the fish skin craft. Better access to the modern world meant that Arctic people were able to access textiles like cotton and silk to create their clothing, leaving fewer people to develop the traditional fish skin craft. There are currently only a few people left who know how to create these fish skin garments (Campbell, 2010). Overfishing and water pollution have caused fish stocks to drop and many Arctic aboriginals have turned to farming and tourism to make a living, abandoning their fish skin skills (Lin, 2007).

2.2 Iceland's traditional knowledge of fish skin

For much of their history, Icelanders wore shoes made of fish skins processed using traditional tanning methods. Each shoe was cut from a single piece of fish skin, with a vertical seam at the heel and a seam at the toe. They were soft, supple, flat-soled traditional footwear (Mould, 2018). Contemporary accounts of travels around Iceland in the mid to later 18th century describe and illustrate men wearing traditional fish skin shoes (Hald, 1972), suggesting that the working man wore them on a daily basis. Icelanders made their shoes from wolf fish leather and they measured distances by how many pairs of fish skin shoes would be worn out by walking over the path.

2.3 Fish waste: Use of fish by-products by aboriginal peoples

The use of fish by-products was well-known to aboriginal peoples in Arctic communities (Hardy, 1992). The specific material properties of fish skin have been known since ancient times. Some human cultures developed unique techniques to process fish leather from fish skin

and used this leather for clothing and shoes (Ehrlich, 2015). Icelandic history, right from the settlement of Iceland in the 9th century, has been interwoven with marine resources and fish have been their main source of food and income (Sigfusson and Arnason, 2017). Icelanders are known for reusing everything and they still have their ancestors' spirit of finding the useful in everything. Improved usage of so-called waste and other by-products could help meet increasing demand for seafood without further stress to the ecosystem. Some "waste" products can have a very high value if they are used. A more efficient use of resources will benefit society, the environment and the industry's bottom line (Bechtel, 2003).

The use of fish skin by the Arctic's aboriginal peoples has recently been assimilated as an innovative sustainable material for fashion due to its low environmental impact. Fish skins are sourced from the food industry, using waste, applying the principle of the circular economy (Jacobs, 2018).

2.4 Protecting natural and cultural resources

For indigenous Arctic people, the relationship with fish, and specifically with salmon, plays an important role in maintaining their identities as distinct cultures. Salmon provides them with more than nutrients. It also plays a role in ceremonial traditions, creating important ties between people and their environment.

The Arctic is undergoing dramatic climate change which threatens indigenous people, impacting their food security and traditional knowledge systems which rely on fishing activities for their physical, cultural and spiritual wellbeing. Coastal indigenous peoples in the Arctic share links to marine environments, mainly through fishing. The relationship with the sea plays an important role in maintaining their identities as distinct cultures, but climate change is threatening indigenous people's ties to oceans and marine resources around the world (Yoshitaka, 2017). Fisheries management is a human security issue as well as an environmental issue, and we need to bring social equity into global governance of the oceans, to respect coastal indigenous peoples and their relationship with fish.

Preserving traditional knowledge with regard to fish skin is essential to the Arctic world. This chapter seeks to draw attention to the vital importance of traditional fish leather craft to the Arctic people as the basis of their culture and a component of their identities and to encourage their artisans to re-introduce the skills used by their ancestors as a tool for community development.

CHAPTER THREE: SUSTAINABILITY CONTEXT

Icelandic fish skin leather: Concepts of sustainability. Aligning fish skin leather with the United Nations Sustainable Development Goal 14. Life Below Water.

3.1 SDG 14.3 Reduce ocean acidification

Sustainable Development Goal 14:3 is “Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels”.

Atlantic Leather’s production of fish skin leather using fish waste aligns with this goal.

Global production of fish has steadily increased over the last decade and more than 50% of the total fish catch becomes waste material resulting in 32 million tonnes of waste (Arvanito, Kassaveti, 2008). To date, the European Environment Protection agency allows seafood processors to dispose of fish skins in marine waters, but this is expected to change as the decomposing organic waste can suck up available oxygen from marine species and introduces disease into the local ecosystem (EPA, 2012). Unlike the EU’s fisheries policy, the Icelandic system decrees that non-saleable fish cannot be tossed back into the ocean, but must be brought ashore and counted towards the quota, therefore maintaining fish populations (Deliso, 2015).

Fishermen create waste by using fishing methods that are not discriminating enough or by targeting only part of the fish (e.g., roe, fins) and discarding the rest. Fishermen and sea processors are incentivised to discard low-value species or trimmings to help maximise the value of their catch. Moreover, fish waste is typically unsorted and geographically dispersed, which makes it costly to collect and process. The high-value uses of seafood by-products like fish leather make fish skin collection and upcycling more feasible and attractive for the fishing industry (Henning, and Jain, 2017). Iceland has also made voluntary commitments to reduce marine litter in its waters and to address acidification by producing an updated climate mitigation strategy by the end of 2017, in line with the Paris Agreement, with obligations of a 40% reduction of greenhouse gas emissions by 2030 (Gunnarsdóttir, 2017).

The technology for sustainable processing of fish leather can be of great environmental benefit as well as profit for the global economy. Fish skin leather processing could prevent fish waste ending up in marine waters and significantly reduce marine pollution and sustainably protect marine ecosystems in order to achieve healthy and productive oceans. Before Atlantic Leather

started using fish skin to produce leather, fish skins used to be thrown away. Now, they are a source of income for the local people, besides avoiding being turned into biological waste.

3.2 SDG14.4 Regulate harvesting and end overfishing.

Sustainable Development Goal 14:3 is “Conserve and sustainably use the oceans, seas and marine resources for sustainable development”.

By 2020, the aim is to effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest feasible time, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

3.2.1 Marine biodiversity

Concentrating on improving the sustainable value chain, Atlantic Leather works closely with the fisheries who supply them with fish skin to improve the sustainability of fish resources and to unite the efforts of the world’s leading seafood industries to reduce the global extent of illegal, unregulated fisheries. These activities and efforts have linked Icelandic private enterprises in a common movement to save Icelandic marine biodiversity by restricting illegal fishing and undocumented fisheries. The fish catch in Iceland is made in a conscious and non-predatory way that respects environment laws and procreation periods.

Atlantic Leather uses fish from Nordic government regulated farms with sustainable management, which provides employment for local communities and a sustainable source of food while maintaining fish stocks. Fish is a key part of both food and the local economy in Iceland.

The fishing is carried out in a sustainable way, under the control of government agencies dedicated to the preservation of species and biodiversity. It helps the local communities and respects the Nordic environmental balance. With stock sustainability and the ecological effects of fishing and management systems as core concerns, Iceland has become even more competitive in the global marketplace (Sigfusson, and Arnason, 2017).

3.2.2 Sustainable management of Arctic fisheries

As much as 40% of the ocean is heavily affected by depleted fisheries and other human activities (UN 2018). The growth in aquaculture could put stress on the fish industry to meet increased demand, by ignoring fishing quotas imposed by responsible governments. The

sustainability role of the fisheries industry is an important issue which has to be taken into consideration as a concern about the future availability of raw material for fish (Bechtel, 2003).

Fisheries are the single most important industry in Iceland and the living marine resources are their most important natural resources, but they are limited, and it is important to utilise these resources in a sustainable way. In 1984, fixed quotas for each vessel were introduced in order to control exploitation of the fish stocks (Valdimarsson, 1990). The main objective of the quota legislation was to prevent overfishing and to encourage responsible handling of all catches and exploitation of under-utilised marine life. There is no doubt that the quota system has had a major effect on changing attitudes towards full utilisation of catches. The fishermen and the processing industries are becoming more aware of the possibilities of making marketable products from raw materials that are currently discarded, such as fish leather. Through research and development, publicly funded institutions assist the industry to increase the utilisation of seafoods (Bechtel, 2003). Iceland, as an Arctic coastal state, takes part in the ongoing negotiations on a new agreement to prevent unregulated high seas fisheries in the Central Arctic Ocean and has been engaged, within the Arctic Council, in consultations on increased Arctic Marine cooperation (Gunnarsdóttir, 2017).

3.2.3 Fish skin as a by-product of the food industry. Resource efficiency by generating value from waste.

Fashion is an extremely wasteful and polluting industry, creating a negative impact on the environment and on people. The fashion industry is currently going through a significant change in its approach towards sustainability (BCG, 2017). Therefore, the fashion industry as a whole must strive to change and rethink its raw materials and processes. There is a trend for the adoption of new materials, which have a lower environmental impact than their conventional alternatives (Textile Exchange 2016). Fish skin is an innovative and sustainable alternative material with a lower environmental and social impact than conventional leather. Fish skin as a new raw material for the fashion industry could provide a (partial) solution for aquaculture waste, which the European Union has committed to reduce through actions in the Circular Economy Package.

Almost half of the fish caught for human consumption is discarded before it even reaches our shelves. This represents a significant amount of potential profit that is effectively being thrown away. The average production of one tonne of fish fillets results in roughly 40 kilograms of discarded skins. Improved usage of fish by-product waste could help meet increasing demand

for seafood without further stress on the ecosystem. More efficient use of resources will benefit society, the environment and the industry's bottom line. Reducing discards and up-cycling by-products will likely increase profitability (IOC, 2013).

When Atlantic Leather converts the fish skins into leather, it creates new value and far-reaching economic opportunities. Atlantic Leather has been perfecting the fish skin tanning techniques to turn it into high value products for non-food sectors (fashion) by up-cycling fish skin into exquisite fish leather. Recycling fish skin into leather is eco-friendly, cost effective and sustainable. With an estimated 43% of fish and shellfish resources ending up as wastage, Atlantic Leather is converting once discarded parts of the fish into desirable products and income: fashion and accessories; the tannery is proud that it can reduce waste while sourcing salmon skins from certified sustainable Nordic fisheries. Atlantic Leather is part of a group of pioneering industry experts from Iceland involved in the commercial fishing, aquaculture and processing sector and the creation of value from fish processing by-products. Companies in Iceland, the pioneers of this industry, have developed a wide range of uses for fish waste: enzymes, pharmaceuticals, dietary supplements, cosmetics and leather goods (Sigfusson, and Arnason, 2017).

3.2.4 Chrome-free tanned fish skin

The processing of leather is most commonly linked with environmental pollution. Many of the chemicals used during tanning are toxic, with substances like mineral salts and chromium routinely used. Environmental protection standards tend to be insufficient in primary leather producing regions, with waste water and solid waste from the tanning process dumped directly into rivers, devastating nearby flora and fauna. Tanning does not just have an environmental cost; a number of the chemicals used to tan leather are carcinogenic, endangering the health of those who labour in tanneries (Shean, 2018).

Atlantic Leather Commits to SDG 14: Actions for Businesses: Record and disclose information on the chemical usage within products to facilitate closing the loop. Atlantic Leather produces chrome-free fish leather using mimosa bark in a traditional process of vegetable tanning, avoiding chromium salts, which are extremely toxic and polluting. Vegetable tanned fish leather is sustainable, durable and surprisingly strong, even stronger than other kinds of leather. This is due to the alignment of the fibres in the skin: in mammals, these run parallel to each other, but in fish they are in a cross-hatched pattern, making fish leather much stronger for the same thickness.

3.2.5 Harnessing renewable energy

Iceland has a unique situation in an era when climate change is making it necessary for countries around the world to implement sustainable energy solutions. Today, almost 100% of the electricity consumed in Iceland comes from renewable energy. The glaciers and rivers of the interior of the country are harnessed to generate 80% of the country's electricity needs through hydropower, while the geothermal fields provide the remaining 20%. Iceland has also focused on sharing its knowledge and technical expertise in geothermal development (Logadóttir, 2015). The entire process of producing fish skin at Atlantic Leather relies on the power of nature and is non-impactful on the environment – even in terms of electricity consumption, as geothermal water is used to produce fish skin leather and their electricity comes from a nearby hydroelectric power station.

The use of geothermal energy for fish by-products is likely to increase in the future. The interest in Iceland is focused on the use of geothermal energy in low-heat regions. It can be expected that the price of oil will increase more than the local energy in the future, and therefore it is worth paying attention to the use of locally available energy sources for the fishing industry (Bechtel, 2003).

3.3 SDG14.9 Support Artisanal Fishermen

Sustainable Development Goal 14:9 is: Provide access for small-scale artisanal fishermen to marine resources and markets

In recent history, fisheries and fish processing jobs have been in decline in Iceland. Like many other countries, Iceland has been mindful not to overfish. With stock sustainability and the ecological effects of fishing and management systems as core concerns, Iceland has become even more competitive in the global marketplace by using fish by-products. Iceland has discovered one way of creating value and jobs, especially in remote and rural areas where such opportunities are not taken for granted (Sigfusson, 2017).

This approach has been beneficial to all levels of the supply chain, including fishermen in remote areas who have seen the prices of fish triple in recent years due to increased interest in value-added issues. The sustainability of the Icelandic system means that fishermen now rank among Iceland's highest-paid workers. The Icelandic model has proved reliable and this model could be duplicated in seafood industries around the world, creating new opportunities in coastal areas (Sigfusson, 2017).

3.3.1 Creation of new job opportunities for coastal dwellers.

Since the 9th century, Icelanders have derived vitality and stamina from fish. Atlantic Leather has propelled a Nordic tradition to increase the utilisation and value from fish waste to create fish leather and in so doing create new job opportunities, especially for coastal dwellers.

The Atlantic Leather tannery sits in a thriving community on the North East coast of the island – inhabited by fewer than 3,000 people, with fishing grounds located just off-shore. Such proximity to the source means that transportation to the point of manufacture is significantly reduced; it also presents the innovation that the tannery only uses waste fish skins from food consumption.

Atlantic Leather creates blue tech and blue jobs in a remote coastal area promoting a sustainable ocean industry. A key challenge for these coastal areas is to maintain the viability of the fisheries sector and to attract young people to work in it. Atlantic Leather aims to preserve the rich cultural traditions that have been developed within the Icelandic fishing industry when processing their fish leather.

Fish leather is also benefiting other sectors, such as tourism. In 2014, Atlantic Leather – Iceland's last remaining tannery – opened a museum for tourists. The museum recreates the traditional and contemporary tanning process of fish leather and displays historical photos and implements (Deliso, 2015).

CHAPTER FOUR: METHODOLOGY

4.1 Study Methodology

The aim of this case study is to explore the link between sustainable materials (fish skin, a by-product of the fish industry, as a new raw material for fashion) and transferring the intangible heritage skills of fish skin craft from Arctic ethnic minorities to higher education fashion students from Nordic universities.

The literature review highlighted that in Iceland, as in many other countries around the world, better utilisation of marine resources is being widely called for. There is well-documented support for the Icelandic commitment to a sustainable seafood sector and a reduction of sea food waste.

To reflect upon the interaction of fish skin using traditional craft techniques, bibliographic and documentary research was initially done:

- Enquiry [Theory]. Following the workshop (see Chapter 5), data was collected through primary and secondary sources to reveal areas of potential development.
- Contextual and visual analysis.
- Making [Practice]. Higher education students produced fish skin samples in collaboration with an Arctic ethnic minority craftsman. Photographic documentation was used for the illustration and classification of results.
- Sharing [Dissemination]. Feedback has been sought through activities such as conferences, published articles, teaching and communication via the author's website <http://www.fishskinlab.com>

4.2 Methods

Action research was used during this study. The data was collected through:

- Archival research in museums to study traditional knowledge in fish skin processing.
- Mapping traditional fish skin crafts to validate their technical feasibility.
- Field Trip. The field trip covered the area around Sauðárkrókur on the North East coast of Iceland.

- Workshop on fish skin leather craft to test ideas through teaching and learning, observing students' design approaches using fish skin as an alternative material.
- Photographs and video recording.
- A documentary filmed during the workshop, featuring interviews with students, curators and craftsman to observe students' development of fish skin finishes as a form of design research.
- Sketchbook development.
- Literature review.

CHAPTER FIVE: DISCUSSION AND RESULTS: BEST PRACTICES IN FASHION HIGHER EDUCATION

Increasing the co-production of knowledge sharing indigenous/traditional knowledge with Arctic higher education fashion students.

The Fish Leather Craftsmanship workshop was organised by the author, Elisa Palomino, BA, Fashion Print pathway leader at Central Saint Martins, London and Katrin Karadottir, Programme Director in Fashion Design at Iceland Academy of the Arts, in collaboration with Atlantic Leather tannery, with the participation of students from Iceland University of the Arts, the Royal Danish Academy of Arts, Boras University, Aalto University and Central Saint Martins.

In order to provide an inspiring environment in Arctic higher education, to enhance student engagement and test a new learning experience, the author designed a workshop encouraging Arctic design students to produce fish leather designs using traditional skills built over generations by Arctic indigenous peoples. The aim was to promote the vast set of knowledge and skills on fish skin that the North possesses, developing sustainable design within the Arctic's traditional ways of life in areas with a history of fish skin leather production, such as Iceland, Sweden, Finland and Denmark, preserving and using fish skin cultural heritage and strengthening networking activity.

The workshop took place in Sauðárkrókur, Iceland, and combined learning about traditional knowledge on fish skin tanning with studying the technological progress of the Icelandic tannery Atlantic Leather, which has been turning local fish skin into highly sustainable leather since 1994. A total of ten students from universities in the circumpolar area (Iceland, Denmark, Sweden, Finland) and the UK benefited from the workshop. A Swedish craftsperson from the Sami ethnic minority delivered the workshop. Lotta Rhame shared traditional Sami fish skin tanning methods and passed down the endangered fish skin craft to the next generation of Nordic students as part of a sustainable fashion higher education programme to learn best practices for social change and sustainability. The programme included preparation, implementation, evaluation and a follow-up phase.

The workshop was designed to build community knowledge around material culture and to bring participant voices together to promote understanding of fish skin craft culture, with the

aim of improve knowledge of fish skin craft to address the pressing sustainability issues in the current fashion industry and to understand the duty to change fashion systems through education, inculcating fashion students with the values of sustainability. The workshop aimed to develop new fashion practices, taking students out of the classroom and into nature and contributing to the learning experience about fashion sustainability. Another important aim was to improve the awareness and protection of traditional Arctic fish skin culture. Students learnt traditional fish skin handcraft heritage in order to integrate it into their fashion practice. According to Fletcher, participatory design and co-design structures are key to changing fashion systems and to fostering lasting relationships between the makers and the final product (Fletcher, 2008). The workshop's main objectives were to:

- Map existing traditional knowledge of fish skin craft from the Sami ethnic minority in the Arctic.
- Build an interdisciplinary collaborative network which intersects craftspeople from Arctic ethnic minorities and higher education students to study fish skin ancient traditions.
- Preserve and disseminate Arctic cultural heritage connected with fish skin, promoting sustainable development of their unique craft culture.
- Help higher education students develop fish skin leather samples as an environmentally responsible alternative material for fashion.
- Enhance the visibility and attractiveness of fish skin leather as a new sustainable material for Nordic fashion students.
- Bring together sustainable methods from fashion design and traditional crafts to foster international knowledge exchange that will develop the capacity for practice in these fields.
- Identify tools about best practice on fish skin leather craft and test the ideas at higher education fashion institutions in the Arctic and internationally, supporting students to engage in sustainability facilitated through the use of fish skin as an alternative material.
- Promote collaboration between industry and education in order to ensure that fashion programmes are meeting industry needs; industry involvement to train fashion graduates on sustainability issues; attracting Arctic fashion students to the maritime industry.

The workshop was five days long and included:

- An introduction to the sustainability background
- Lectures on historical fish skin artefacts at international museums
- A visit to the Atlantic Leather fish skin tannery
- A visit to the local textile museum
- Traditional fish skin tanning
- Sketchbook development

The workshop brought together traditional knowledge holders and community representatives from across the Arctic in order to explore the roots of Nordic fashion and design traditions linked with fish skin, to create space for communities to share wisdom, skills and techniques around fish skin processing and to co-produce new work using both traditional knowledge and British sustainable design methodologies. The workshop promoted sustainable material engagement through a full immersive experience in a teaching-in-the field approach, creating a collaborative network for further projects, and setting up an international design environment for sharing knowledge.

The workshop methodologies reflected the geographical contrasts of the area. The harshness of the weather, the isolation and the limited availability of materials formed a unique source of creativity and inspiration for the students during the workshop. Fish skin was the only available material, spurring students to think creatively and seek new design possibilities. Eco-consciousness played a fundamental role in the students' designs using remnant materials. Fish leather offers outstanding longevity, one of the most important elements in sustainability, and has the benefit of being a highly biodegradable natural by-product.

The object of the workshop was the preservation and dissemination of the cultural heritage connected with fish skin. In order to achieve this, the collaboration and cooperation among different Arctic areas, universities and professionals provided a key element in the project. This was a fine example of an innovative way of linking the preservation of traditional knowledge and culture and the development of culturally relevant programmes for students, community involvement and the conservation of resources. The project provided a case study for working across Arctic universities to develop their cultural identities and foster narratives of social sustainability. The cross-disciplinary project has created a new structure to demonstrate how much Arctic communities have in common.

The workshop seeks to inspire fashion lecturers involved in the development of sustainability and craftsmanship within their curriculums to implement this transformative teaching and

learning experience in their own practice. Hopefully, the workshop will inspire new ideas across the student and staff communities that were involved, which in turn may contribute to public debate on sustainability issues in the fashion industry (Fletcher and Williams, 2010). The Nordic fish skin network has blended the highly qualified skills of a Swedish craftsperson, Lotta Rhame, with British cutting-edge sustainable design education. Development of sustainability within the curriculum has been identified as a high priority for students (Reid, 2011) and this project's outputs will inform existing courses naming sustainability, as well as a broad spectrum of design courses.

Through this workshop, the author, as a member of the London College of Fashion, Centre for Sustainable Fashion, has brought its commitment to using fashion to drive change, build a sustainable future and improve the way we live, using human and ecological resilience as a lens for design in fashion's artistic and business practice (CSF 2015). The author has made a contribution to the field of Design for Sustainability (DfS) in fashion, furthering the sense of our interconnections as people and to our natural world. This workshop has specifically supported the following four of the seventeen United Nations Sustainable Development Goals:

- SDG 4 – Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- SDG 12 – Ensure sustainable consumption and production patterns.
- SDG 13 – Take urgent action to combat climate change and its impacts.
- SDG 14 – Conservation and sustainable management of the oceans, seas and marine resources.

The workshop has developed a collaboration framework between industry and education and has managed to:

- Raise awareness on ocean-related issues and the maritime economy with higher education students.
- Create new cooperation between education and maritime industry.
- Improve the employability of students thanks to the acquisition of new sustainability and craft skills.
- Share resources between different educational institutes and industry at the trans-national level.

The case study recommends transferable skills for educational models and demonstrates how relevant the indigenous fish skin knowledge in partnership with sustainable design strategies -

can be to connect people to their culture, communities and the environment. The case study reflects on the dialogue between indigenous craftsmen and Nordic fashion students on common Arctic issues, in particular issues of sustainable development, sustainable material innovation and Arctic environmental protection, in order to restore some of the damage that has already happened to the Arctic's indigenous culture related to fishing rights and fish skin clothing traditions, helping to build resilience amongst the Arctic communities. This project recommends engagement with local communities and traditional fish skin knowledge holders, laying the groundwork for an assessment that is co-produced by both traditional knowledge and British fashion education.

CHAPTER SIX: IMPACT SUSTAINABILITY - FINAL REMARKS

The supply of fish in the oceans is not endless and therefore we need to manage fisheries in a more sustainable way. By developing fish skin leather, we could achieve sustainable ocean development, optimising fisheries management and increasing the value of the catches. (Bechtel, 2003). The future availability of seafood, however, is threatened by overfishing, unsustainable seafood, farming practices, ocean pollution and acidification. Strategies aimed at increasing the utilisation of fish skin that would otherwise be discarded must be carefully considered. Creating markets for fish skin runs the risk of incentivising bigger catches and creating fishing pressure for species currently viewed as fish skin potential.

The Icelandic fish skin model has proved reliable and this model can be duplicated in seafood industries around the world, creating new opportunities in coastal areas (Sigfusson, 2017).

The project could be scaled up by developing a model of fish leather-waste production that can be used by factories in other countries with a big consumption of fish in their diet and countries with a history of using fish skin leather. By doing so, indigenous fishing communities which used to subsist upon, and dress themselves with, fish skin leather items – like the Ainu in Hokkaido, the Nanai in Siberia and Alaska’s Inuit – will be able to reach agreements with nearby fishing plants for the supply of fish skins to recover their ancient craft skills of tanning fish skins and develop productions that will boost their economy.

Fish skin leather can be used in wallets, bags, and shoes. The process is low-tech and requires little capital, which makes it ideal for small businesses or for setup in developing countries (Henning and Jain, 2017). The overall findings align with the Icelandic industry’s commitment towards greater sustainability. The study suggests that there is a great financial opportunity to use fish skin as a new raw material for fashion. Countries with both high demand and cultural reliance on fish are potential candidates for the marketing and sale of fish skin leather. It is highly recommended that similar case studies are developed in other fish-producing consumer areas.

The case study has also given new insights into the potential for even greater sustainability actions through the implementation of workshops within higher education fashion. Students have studied how fish by-products are used in the value chain and how it demonstrates positive waste reduction.

Through examining the strategic management of fish skin, this study has outlined the ability for the aquaculture industry to produce more value from the same amount of resources. In conclusion, there are economic and environmental benefits that should be considered in order to develop fish skin further as a new raw material for fashion.

With collaboration between industry and academia, the rise of fish skin as a new by-product raw material for fashion will contribute to the sustainable development and future growth of the aquaculture and fashion industries.

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