Nordic Council of Ministers

The Circular Economy of Fishing Gear in Nordic Fisheries

The situation and challenges

Contents

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Summary

The Nordic countries, with their extensive fishing industry, have taken significant steps towards incorporating the principles of a circular economy into the management of fishing gear. This report examines how end-of-life fishing gear (EOLFG) is currently managed in Greenland, Iceland, the Faroe Islands, and Norway, with an emphasis on regional challenges, innovative practices, and opportunities for improvement.

Although fishing gear, which is primarily made from synthetic materials, is durable and practical, it poses environmental risks when lost or improperly discarded. Abandoned, lost, or discarded fishing gear (ALDFG) can contribute to ghost fishing and marine pollution. While all the Nordic countries have improved their handling of EOLFG, challenges remain in tracking gear, reducing loss, and ensuring proper recycling or disposal.

Regional differences have a significant impact on EOLFG management. Greenland faces logistical hurdles due to its vast, remote geography and topography. However, it has implemented effective systems, using empty containers on return trips from fishing settlements to transport used gear for sorting and recycling. Iceland has successfully developed a recycling pathway through the Recycling Fund with dismantling processes using local netlofts who are familiar with the material. However, materials still have to be exported due to a lack of local recycling facilities. The Faroe Islands share similarities with Iceland, benefiting from shorter distances, and rely on netlofts for dismantling gear before shipping it for recycling, primarily to Denmark. Norway, with its extensive coastline and a mix of commercial and recreational fisheries, has set an example through its gear loss reporting system and annual retrieval missions to reduce marine litter and ghost fishing.

Despite these advancements, gaps remain. None of the Nordic countries has a comprehensive system to track fishing gear from purchase to disposal. Marking systems, with a visible reference to the user and some even with Radio Frequency Identification (RFID) tagging or QR/bar-coding with more detailed references, can address this gap and improve traceability and reduce gear loss. Moreover, the inclusion of detailed information with marking systems about the materials used in fishing gear within these systems could improve recycling efficiency and encourage the development of standardised, sustainable materials.

A pressing issue is the loss of small gear fragments, such as from dolly rope strands or gillnet pieces, which are difficult to track but cause significant environmental harm. Research into alternative materials and cleaner fishing practices is essential to mitigate this issue. The Nordic countries could also benefit from increasing local recycling capacity, harmonising regional policies, and promoting collaboration in order to share best practices and innovations.

The project findings emphasise that while the Nordic region has made substantial progress in EOLFG management, more can be done to move towards a truly sustainable and circular fishing economy. Recommendations include improving gear traceability, expanding retrieval efforts, supporting fisher participation through incentives, and investing in research and recycling infrastructure. By leveraging their collective expertise and resources, the Nordic countries have the opportunity to lead by example globally in creating a sustainable fishing industry.

Introduction

The background of the project

A strong presence in the fishing industry is common to the Nordic countries, making them among the leading fishing nations globally. Fishing practices in the region are varied, encompassing both large, technologically advanced vessels and traditional, low-tech fishing methods. Of the 25 largest producers of wild marine fish worldwide, only four European countries are on the list: Russia, Norway, Iceland, and Spain. Two Nordic countries, Norway and Iceland, account for just under 5% of the global catch, contributing 3.1% and 1.8%, respectively (FAO, 2024). On the other hand, when considering the catch of marine fish per capita, the Faroe Islands are by far the world's largest nation when it comes to fisheries and aquaculture. In 2019, Faroese fish exports equated to approximately 11.6 tonnes per inhabitant (www.faroeseseafood.com). While specific per capita figures for Greenland are not readily available, it is noted that Greenland, along with the Faroe Islands and Iceland, also has a high fish landing rate per capita. While some fishing traditions have persisted in northern regions for thousands of years, with some techniques remaining largely unchanged, one significant aspect has undergone a universal transformation. Like elsewhere in the world, fishing gear has predominantly transitioned to being composed of synthetic materials. The advent of plastics just over a century ago revolutionised the production of ropes and nets, which are now primarily manufactured from these synthetic materials. While modern fishing gear is designed to be durable and resilient, it still requires regular maintenance and, when in use, frequently encounters unforeseen events that lead to loss, either in part or in its entirety. As a result, fragments of fishing gear are commonly found along Arctic coastlines, even in remote areas far from human settlements.

While plastic pollution is primarily attributed to land-use sources, the Nordic countries likely exhibit more plastic pollution from fishing gear in their marine environments than many other regions; they are even stated to have more plastic from fisheries and aquaculture than anywhere else in the world (Eurofish, 2022). Fishers in the Nordic countries generally possess a heightened level of awareness regarding this issue. Generally speaking, completely preventing the loss or disposal of fishing gear into the sea using various means can pose a challenge in any fishery and fishing community. Consequently, the act of cleaning beaches and collecting lost fishing gear at fishing grounds has been looked at as a necessary action

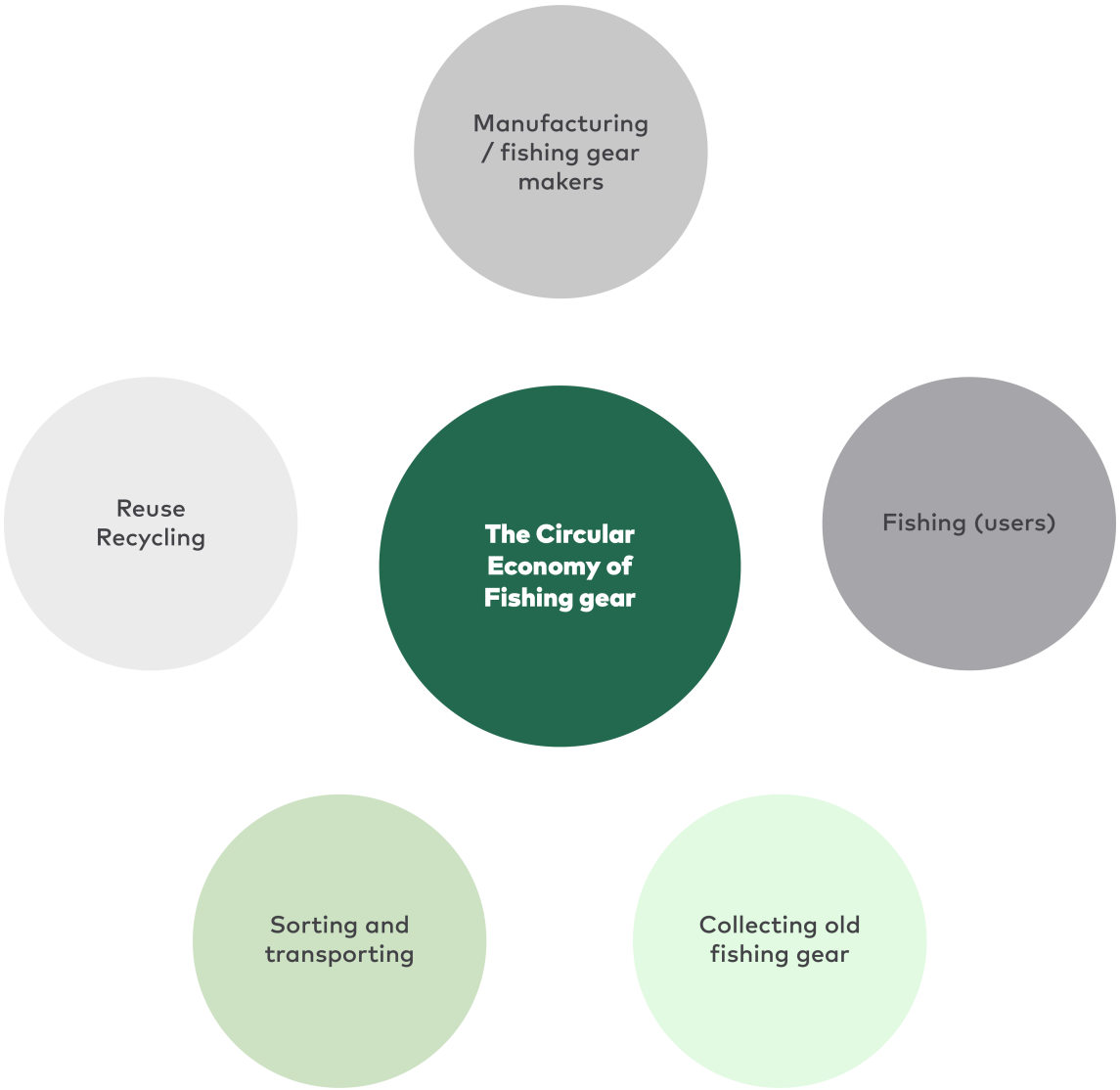
(Langedal, G. et al., 2020). Additionally, the seafood industry is progressively becoming more involved in combating plastic pollution associated with fishing gear. Some companies and even fishery associations have embarked on implementing measures such as collecting used and EOLFG and facilitating its recycling or appropriate disposal.

Objective of the project

This project aims to provide a comprehensive overview of the circular economy of fishing gear, specifically identifying areas of concern and determining key optimisation factors. Furthermore, the study aims to identify regions where challenges are most prominent and assess whether any of the Nordic countries have viable solutions in progress or are prepared to adopt solution-oriented approaches for minimising fishing gear loss and maximising plastic reuse.

A comprehensive understanding of the challenges associated with ALDFG requires a thorough examination of its entire lifecycle, from production and usage to disposal and potential recovery. By involving each stage of the economic cycle, a comprehensive overview can be obtained, highlighting areas requiring improvement and uncovering the root causes of the issues. This research project has dissected the cycle into five principal components, each addressing a distinct aspect. An analysis is conducted within each component, identifying noteworthy examples that exemplify the current state of affairs within that particular value chain segment. After examining each component, recommendations are made to address the identified issues.

The circular economy of fishing gear comprises five key components:



Fishing activities

This stage covers how fishers operate their gear. While traditional practices dominate, there are opportunities to optimise techniques, such as adopting new methods or technologies, to reduce gear loss.

Collection of used gear

Once fishing gear reaches the end of its useful life, having accessible and well-organised disposal options is essential. Fishers need proper facilities and a straightforward system to return or discard nonfunctional gear without unnecessary obstacles. This requires establishing clear responsibilities for collection, ensuring the availability of drop-off points, and providing adequate facilities for disassembling, cleaning, and sorting various gear components. By making disposal both convenient and efficient, participation in recycling and recovery initiatives can

be significantly improved, reducing the likelihood of gear being abandoned, lost, or even discarded at sea.

Sorting and transporting

The collected gear must be efficiently sorted and transported to recycling or disposal facilities. This step requires that logistical challenges be addressed, particularly in isolated or small fishery communities that lack proper waste disposal facilities. In such areas, EOLFG may accumulate over long periods due to limited collection options, making transportation less cost-effective.

Reuse, repurpose, and recycle

Lastly, it is essential to evaluate whether used fishing gear is effectively recycled and how much of the recycled material finds its way into new products. The efficiency and sustainability of the recycling process need to be examined, along with opportunities for repurposing or reusing components of old fishing gear.

By focusing on these five key components, this project will provide a holistic view of the circular economy surrounding fishing gear, identify current challenges, and recommend solutions to reduce gear loss and enhance recycling efforts.

The project committee held two separate meetings, one in Iceland and the other in Greenland, and gathered information not only from available various publications but also through visits to key stakeholders, including net lofts, sorting stations, and waste incineration facilities, as well as interviews with fishers and management representatives. These engagements provided valuable information on existing workflows, logistical challenges, and emerging trends in fishing gear management. By synthesising these findings, this study offers practical recommendations for enhancing the circular economy of fishing gear, reducing environmental impact, and supporting more sustainable fisheries across the Nordic region.

Production and assembly

The production and assembly of fishing gear in the Nordic countries involves a combination of local craftsmanship and imported materials. Much of the fishing gear is made from virgin plastics derived from petrochemical industries, including materials such as polypropylene, polyethylene, and polyamide (nylon), with other plastics and metals also being used. Raw materials such as twines and ropes are often imported, and assembly is performed locally or by specialised netlofts. In some cases, complete fishing gear is imported and sold directly to fisheries, while the Nordic countries also export assembled gear.

Considerations pertaining to recycling and the circular economy are gaining importance in the fishing gear industry (Hampiðjan Group, 2023). Although a small but growing effort is being made to incorporate recycled materials into new fishing gear, it is still more common to use virgin plastics. The challenge lies in the complexity of materials used in fishing gear, which often includes mixed polymers that are difficult and costly to recycle. High costs are associated with sorting, dismantling, and cleaning the gear before it can be reused or repurposed, which makes large-scale recycling efforts challenging. This is especially problematic in remote fishing communities, where transport costs for recycling can be high.

To improve circularity, stakeholders are exploring opportunities to redesign fishing gear for easier recycling, prompted by ongoing discussions and growing calls for innovation. For example, reducing the variety of materials used in fishing gear and improving traceability by way of tagging systems to track gear loss are key steps being discussed. Marine biodegradable materials are also being explored, and although their practical use is still limited (SFI Dsolve, 2023), concerns about unintended environmental consequences remain. Moreover, workshops and projects advocate adopting guidance standards for the circular design of fishing gear to encourage the use of more recyclable materials and reduce reliance on virgin plastics (CINEA, 2023; OSPAR Commission, 2020).

Equally important is the reuse aspect inherent in the maintenance of fishing gear. Fishing gear is continuously repaired both by the users themselves and by the producing netlofts, a process that generates its own stream of waste. Like the assembly process, these repair activities yield materials and components that can be recovered and reintegrated into the production cycle, thus forming a vital part of the gear's circular economy.

The Nordic countries have initiated the development of collection points for old fishing gear and improved port-side co-ordination to prevent gear loss and contamination. However, infrastructure for collection and recycling still needs to be further developed, and recycling facilities are scarce, making large-scale recycling of EOLFG difficult. In addition, the perception that recycled materials are of lower quality than virgin plastics still hampers wider adoption (OSPAR Commission, 2020).

It is important to ensure industry collaboration, the development of new standards, and technological advancements to reduce the environmental impact of fishing gear while promoting a circular economy approach in moving forwards.

Importing material and fully assembled fishing gear

Importing fishing gear components, such as twine, rope, and synthetic fibres, is driven by the high demand for durable and efficient materials in modern fisheries. These materials, which are primarily derived from petrochemical processes, include polypropylene, polyethylene, and polyamide, which are imported from major industrial suppliers, often outside of the Nordic region. The value of imported fishing gear and related components has been substantial in recent years. In 2023, Norway imported fishing-related goods worth approximately USD 4.85 million, with China being the largest supplier, accounting for USD 1.79 million (World Bank, 2023).

Importing fully assembled fishing gear, in particular pots or parts of specialised gear, is common in the Nordic countries. Fishing gear or parts can be designed and manufactured in other European or Asian countries and imported into the region by fishers or any domestic supplier. Despite local production capabilities, the Nordic countries, including Iceland, Norway, Greenland, and the Faroe Islands, rely on these imports due to the globalised nature of the fishing industry and the constant need for high-quality, durable gear that meets environmental and operational standards.

Offcuts and remnants when manufacturing fishing gear

In the Nordic region, manufacturers of large-scale fishing gear such as purse seines and trawls have developed sustainable practices to manage offcuts and remnants. During the production of such gear, primarily made from synthetic materials such as high-density polyethylene (HDPE) or nylon, offcuts of nets, ropes, and other components are collected. These offcuts are often sorted into categorised containers and effectively treated as high-quality raw material because they are unused and possess similar properties to virgin plastics. This practice helps reduce waste and provides an immediate source of recyclable material for manufacturing new nets.

Many netloft manufacturers integrate offcuts directly into their production processes. These facilities frequently produce custom fishing gear, sometimes combining virgin plastic pellets with reclaimed offcuts. Other independent netlofts in the region are increasingly embracing this practice, recognising the environmental and cost benefits of reusing materials. This closed-loop recycling approach ensures that offcuts are efficiently reintegrated into production, thereby reducing waste and minimising the environmental impact of fishing gear manufacturing.

This approach reflects a broader trend in the fishing gear industry, in which sustainability is becoming a key consideration, particularly in regions like the Nordics, which are heavily dependent on marine resources. Efforts to reuse offcuts help to reduce the reliance on virgin plastics and align with circular economy principles that are increasingly being integrated into Nordic industrial practices.

For instance, companies such as Nofir, established in Norway in 2008, collect discarded equipment from fishing and fish farming industries worldwide. They process materials such as trawl nets, purse seine nets, gill nets, and ropes into raw materials for the recycling industry, which are used in various products (Nofir, n.d). Furthermore, Danish company Plastix has developed a method to recycle discarded fishing gear by converting it into pellets that can be used to produce plastic items. This process not only reduces waste but also provides a sustainable source of raw materials for manufacturing (Eurofish, 2017). These initiatives exemplify the commitment within the Nordic fishing gear industry to sustainable practices and the circular economy, effectively managing waste and reducing environmental impact.

Users of fishing gear

Fisheries in the Nordic Atlantic operate in harsh and often challenging environments. Some fishing grounds become inaccessible during winter due to extreme weather conditions, ice coverage, and prolonged darkness. Large and powerful vessels are often necessary to access certain fishing areas safely and effectively. Using robust fishing gear is essential as weaker materials can lead to life-threatening situations in some fisheries in these demanding conditions.

Environmental factors such as low temperatures and drifting ice significantly impact the properties of the materials used in fishing gear. Additionally, rough seas and winter darkness can result in gear loss as surface markers become challenging to locate. The use of AIS (automatic identification system) on marking buoys for fishing gear was prohibited from 1 January 2025. These challenges necessitate the use of specialist and durable gear to withstand the region's unique conditions.

The Nordic fleet can be categorised into three main types of fisheries based on vessel size and the fishing gear employed:

Industrial fleet

- Primarily consists of large vessels exceeding 24 metres in length, owned by family-run, small to medium-sized businesses and, in some cases, larger companies.
- Vessels are equipped with advanced and robust fishing gear, including purse seines, pelagic and demersal trawls, auto liners for longline fishing, demersal seine and, in a few cases, gillnets.
- Operate in offshore and distant fishing grounds, built to withstand extreme weather and maximise efficiency.

Small-scale commercial fishery

- Comprises smaller vessels, mostly shorter than 24 metres, owned by private individuals or small companies.
- Utilises a variety of gear types, including:
  - small trawls
  - longlines (both automatic longliners and hand-baiting operations)
  - gillnets, traps or pots, and jigging equipment
  - demersal seine
- Operate closer to shore, often in inshore waters during winter, or may remain inactive during the harshest months.

Recreational fishing fleet

- Consists of small vessels, mostly shorter than 12 metres, primarily owned by private individuals.
- Predominantly uses jigging gear, though traps or pots and gillnets are also employed in some areas.
- Operates mainly during the summer, but in closed fjords where weather has less impact, the season may extend for longer. Fishery is restricted to coastal or inshore waters due to the size and capacity of the vessels.

Methods of sourcing fishing gear for Nordic fisheries

Manufacturing fishing gear for the domestic market is a vital industry across all the Nordic countries. This sector not only supports local fisheries but also serves a substantial export market, particularly for large, mobile fishing gear such as trawls and purse seines. These gears are in high demand globally due to the region's expertise in producing durable and efficient equipment capable of withstanding harsh conditions. Countries such as Iceland, the Faroe Islands, and Norway play critical roles in this industry, assembling fishing gear locally by combining imported raw materials, made primarily of synthetic fibres. Smaller static fishing gear such as gillnets and pots are typically imported into the Nordic countries. However, they might be rigged up at netlofts or by fishers themselves.

The Nordic countries rely heavily on imports from Asia for smaller, static fishing gear such as gillnets and pots. It is worthy of note that the majority of pots arrive from Asia fully assembled and rigged. However, these imported components are often rigged or customised locally by netlofts or fishers to meet specific requirements.

While fishing gear manufactured domestically is sold directly to local fishers, there is currently no unified system in place to register the quantity, weight, or types of materials used in the gear. Suppliers sometimes tag or mark the fishing gear for large fishing gear such as purse seines and large trawls, allowing them to track which vessel is using it for later maintenance and servicing. Although this practice provides some level of traceability, it remains inconsistent. In contrast, smaller gear types, including gillnets, longlines, traps, and pots, are typically imported through mixed supply chains. In some cases, fishers procure their fishing gear independently, either in whole or as parts, bypassing centralised suppliers.

Due to the diverse supply routes and lack of systematic registration, the Nordic countries lack a complete understanding of the total quantity and type of fishing gear in use at any given time. Estimates are typically based on indirect, often inaccurate data, such as import and sales records or fishery-specific studies.

Abandoned, lost, or discarded fishing gear (ALDFG)

The primary reasons for fishing gear becoming marine debris are categorised internationally into three main fractions: Abandoned, lost, or discarded fishing gear (ALDFG). In the Nordic context, it is unlikely that a significant number of fishers deliberately abandon their gear, although isolated cases of such behaviour can happen. Historically, it was common practice among the Nordic countries to discard used fishing gear at sea rather than bringing damaged or unusable gear back to land. However, this practice is now believed to be rare, as waste management systems onshore have improved significantly. Additionally, fishers are increasingly aware of the problems that discarded fishing gear can cause in the long term. However, fishing gear continues to be lost in Nordic fisheries, as in fisheries worldwide (Richardson et al., 2022). This typically involves parts of gear, such as sections of trawl nets or fragments of gillnets, rather than complete gear. However, there are instances where entire fishing gear such as longlines or sets of traps are lost due to strong currents, drifting ice, or other environmental factors.

Norway stands out for its systematic approach to documenting lost fishing gear. Fishers in Norway can report lost gear, including its location, cause, and quantity, without facing repercussions. It is relatively simple for commercial fishers to register the loss of fishing gear using an interactive website[1], while recreational fishers can use a mobile app for the same[2]. Although the exact proportion of Norwegian fishers reporting such losses remains unknown, the low number of unreported findings (without the towing wire) suggests high compliance with the reporting requirement. Regular annual retrieval efforts are believed to be key in maintaining this compliance. This documentation enables regular retrieval missions

1. https://www.barentswatch.no/fiskinfo
2. https://www.fiskeridir.no/Fritidsfiske/Meld-tapt-og-funnen-reiskap

using large vessels to clear areas where lost fishing gear is known to be located or even accumulating, a practice that Norway has sustained for more than 40 years (Vodopia et al., 2024). In contrast, other Nordic countries lack comprehensive systems for recording lost fishing gear. As a result, retrieval missions are infrequent or non-existent, allowing fishing gear to accumulate on the seabed. The loss of smaller components of fishing gear, such as snood lines from longlines, dolly rope threads from trawl codends, and fragments of gillnets, are frequently lost during fishing activities. Additionally, trimming and maintaining gear can also contribute to these losses. Although measuring the quantity of such losses is challenging, some isolated studies have attempted to quantify them. These more minor losses, though less noticeable, can have significant environmental impacts (Kammann et.al., 2023; Richardson et.al., 2022).

A particularly striking example involves nesting sites of the Northern gannet (Morus bassanus). These birds often use fragments of fishing gear, particularly dolly ropes, in their nests. These materials, originating from bottom trawling operations domestically or internationally, entangle adult birds and chicks, often causing them to hang or starve to death (O'Hanlon et al., 2019; Massetti et.al., 2021).

The fishing industry should prioritise developing more sustainable materials for gear components known to harm the environment, even when lost in small quantities. Efforts to address this issue could include research into alternative materials, improved maintenance practices, and increased accountability for gear use and disposal.

Nesting site of the Northern gannet (Morus Bassanus) at Eldey, Icelandic largest gannet colony.
Photo: J. Kermarec, Environment Agency of Iceland)

Collecting and transporting end-of-life fishing gear

The collection of end-of-life fishing gear (EOLFG) was the part of the circular process that the report authors received the most information about through visits and interviews with stakeholders and fishers. Evidently, this aspect of the circular economy is very significant and was one of the main areas lacking in the past. However, all the Nordic countries have made substantial improvements in this regard, bringing the process to a better state. While Greenland, Iceland, the Faroe Islands, and Norway engage in similar types of fishing in terms of target species and methods, the challenges related to the collection of used fishing gear differ significantly between the countries.

Greenland is an extremely large and sparsely populated country, with vast distances between coastal settlements. Supplies are delivered to some locations only a few times per year. Despite these logistical challenges, Greenland has established an effective system for collecting used fishing gear. Empty containers are utilised for return trips from small fishing villages, where they are brought for sorting, either at a waste incineration facility in Nuuk or at a netloft. In addition, Greenland has invested in modern incineration facilities, including one in Nuuk and another under construction in Sisimiut, to improve waste management. After sorting, suitable material categories are shipped to Denmark for recycling, while other fractions, such as iron scrap, trawls, and nets, are directed toward appropriate waste processing or recycling initiatives. However, this is not considered a permanent solution.

Although transporting fishing gear between remote locations in Iceland and the Faroe Islands does not pose the same challenges as in Greenland or Norway, nearly all materials destined for recycling are shipped abroad, as no local companies specialise in such services.

The development of fisheries' gear recycling in Iceland has followed a unique path. In 2005, the Federation of Icelandic Fishing Vessel Owners agreed with the Waste Management Authority, known as the "Recycling Fund" to independently manage the recycling of synthetic materials from used fishing gear. This agreement exempted fishing gear from a special fee imposed in 2006 on the entire industry to cover proper waste disposal costs. Instead, the federation negotiated with third-party facilities to accept and recycle used gear. Initially, fishers were required to

dismantle, clean, and pack the gear for transportation, receiving compensation for their efforts. Those returning unclean or undismantled gear had to pay a fee. Over time, the process has evolved, and fishing gear manufacturers now take care of the disassembly and packaging of gear for onward shipment to recycling facilities. While most fishing gear collected is recycled, some material is still sent to landfill. Despite ongoing challenges with recycling certain materials, Icelandic fishing gear manufacturers are actively addressing these issues. With continued efforts, all materials used in fishing gear are expected to become fully recyclable in the near future. Notably, Iceland's largest fishing gear manufacturers, which also operate branches in nearby countries, have begun implementing these practices abroad.

In the Faroe Islands, the collection and transportation of EOLFG is similar to the system in Iceland, although the shorter distances simplify logistics. Netlofts are crucial in dismantling old trawls and preparing them for shipment to recycling facilities, primarily in Denmark and the Netherlands.

Norway faces distinct challenges in collecting EOLFG due to its extensive coastline and complex network of inshore systems, including fishing ports of varying sizes across the country. Additionally, the popularity of recreational fishing in Norway complicates the collection of smaller fishing gear, as it is often dispersed and more difficult to retrieve. However, EOLFG is now collected and transported to and from all regions in Norway for dismantling and recycling. Moreover, Norwegian environmental authorities are working on implementing a nationwide system that will enable all Norwegian fishers to deliver fishing gear to any fishing port. However, the details of this system are still under development.

Many of those interviewed by the project group mentioned that much of the fishing gear currently being collected is old or even very old. Efforts are underway to clear harbour areas and storage sites of unusable gear. The volume of collected gear is anticipated to decrease over time or stabilise once these cleanup activities are completed.

Estimating the amount of fishing gear disposed sent to landfill or incinerated

As mentioned above, none of the Nordic countries maintain accurate records of the total volume of fishing gear in use at any given time. No registration system tracks fishing gear from its initial use to its end-of-life stage, whether lost, dismantled, or recycled. However, when fishing gear enters the system through manufacturers, waste facilities, or incineration plants, it is recorded in terms of quantity and disposal method. This allows for partial data collection on material flows into various recycling pathways.

Despite this, a significant portion of EOLFG bypasses formal waste management systems. Some gear is disposed of in landfill without being registered as fishing gear, while other gear is incinerated under inadequate conditions and, in some cases, illegally. The extent of this unregulated disposal is difficult to quantify and varies by region and over time. Overall, there is no comprehensive system for tracking the total amount of discarded fishing gear. While some records exist for materials deemed unsuitable for recycling and sent to landfill, the unregistered portion remains unknown, potentially representing a substantial share of all discarded fishing gear.

In all the Nordic countries, many volunteers are actively involved in beach-cleaning activities. These activities often collect a large quantity of EOLFG of varying ages and states. Recycling these materials is often impossible as there is too much dirt and biomaterial in the plastic fibres, making it difficult or impossible to clean out. In some cases, this material does not go through any registration process but ends up directly in landfill.

Styrofoam floats, disassembled from a purse seine and still attached to ropes. As a material, Styrofoam is usually not recycled. Photo: Haraldur Arnar Einarsson.

Challenges of recycling, reuse, and repurpose

Although challenges persist, efforts to recycle and reuse materials from fishing gear in the Nordic countries are progressing as part of circular economy initiatives. A key issue is the degradation of material strength from recycled fishing gear made from synthetic materials such as nylon and polyethylene, which often limits its reuse. Additionally, many types of fishing gear contain mixed materials, such as various plastics and metals, which complicates recycling (CINEA, 2023).

There are several challenges with recycling materials that originate from used fishing gear. For example, recycling synthetic materials such as nylon and polyethylene is hindered by contamination and the degradation of material strength after multiple recycling cycles. The recycled materials often need to meet the high standards required for certain fishing operations, limiting their reuse. Additionally, fishing gear is often made of mixed materials. Material flow analysis (MFA) has been applied in Norway to assess the plastic waste generated from commercial fishing gear, providing vital data on how these materials flow through the economy and highlighting the inefficiencies in collection and recycling systems (Deshpande et al., 2023). Despite these challenges, experience from Norway's retrieval programme for lost fishing gear demonstrates that reuse can make a significant contribution to the circular economy. By 2024, 50% of recovered fishing gear was successfully returned to its owners for reuse, highlighting the practical potential of gear recovery programmes in extending the lifespan of fishing gear and reducing overall waste.

The main challenge when it comes to reusing fishing gear is ensuring the strength of the materials after mechanical recycling. Plastic recycled from fishing gear often has weaker tensile strength than virgin plastics, especially when subjected to harsh marine conditions. This affects their viability in the manufacture of durable, high-stress gear such as trawl nets or gillnets. Nonetheless, technological advancements and blending processes are being researched to maintain the mechanical properties of recycled materials. MFA studies in Norway have underscored the importance of understanding how material strength degrades through the value chain, providing insights into where recycled materials can be effectively reused (Deshpande et al., 2023).

Although recycling rates for collected fishing gear are improving, the total amount of circulated fishing gear remains relatively low. An unknown quantity of fishing gear is lost at sea or discarded without being collected for recycling. According to an MFA conducted in Norway, there are significant inefficiencies in the recycling process, primarily due to the high costs of collecting, transporting, and processing old fishing gear, especially from remote communities (Deshpande et al., 2023). These costs often outweigh the potential savings from using recycled materials, making virgin plastics a more attractive option for many manufacturers.

The fishing industry is exploring ways to standardise gear design for easier recycling and incorporate marine biodegradable materials where feasible to improve recycling rates. In addition, efforts are being made to reuse components such as gillnets, floats, and lead lines, which can be repurposed even when the primary gear reaches the end of its life. While full recycling of most fishing gear remains challenging, reusing specific components is more practical. Nylon, for example, which is commonly used in gillnets, can be recycled if it is relatively free from biomaterial contamination. Similarly, lead from lead lines is often melted down and repurposed into new products, significantly reducing the waste stream from discarded gear. The MFA study in Norway (Deshpande et al., 2023) highlights the potential for expanding these reuse practices by enhancing collection and sorting infrastructure.

The use of recycled materials and the reuse of fishing gear components are critical for reducing the environmental impact of the fishing industry. However, they require ongoing advancements in recycling technologies and more cost-effective solutions. MFA studies such as those conducted in Norway provide valuable data on the plastic waste generated by commercial fishing gear, offering a roadmap for improving the circular economy in this sector (Deshpande et al., 2023). As collaboration between industry stakeholders grows, the Nordic countries are poised to lead in developing sustainable fishing practices that minimise the need for virgin plastics and improve recycling rates.

Discussion

Based on interviews with stakeholders involved in various stages of the circular economy for fishing gear, from manufacturing to the recycling of end-of-life materials, this project highlights a clear consensus. All stakeholders recognise the importance of collecting and repurposing EOLFG. Across the Nordic countries, significant progress has been observed in areas once cluttered with discarded gear. Some of these locations have since been transformed into attractive natural spaces, showcasing the positive impact of improved waste management.

Despite similarities in fisheries and fishing methods across the Nordic region, the challenges associated with collecting and transporting EOLFG vary considerably between countries. Greenland faces logistical difficulties due to its vast and remote geography, where some coastal settlements receive supplies only a few times a year. Iceland and the Faroe Islands primarily have to contend with the challenge of exporting materials for recycling. Meanwhile, Norway must address gear loss from its extensive coastline and complex inshore systems, which host both commercial and highly active recreational fisheries. These variations underscore the need for tailored, context-specific solutions while emphasising the potential for sharing knowledge and practices across the region.

Although the Nordic countries have made significant strides in managing EOLFG, further improvements are needed, particularly when it comes to quantifying the total amount of fishing gear in use at any given time and ensuring its traceability throughout its lifecycle. Increasing collection and recycling, establishing a mandatory registration system for lost gear, and conducting regular retrieval expeditions to recover accumulated gear from fishing grounds should be prioritised. Achieving these goals requires greater awareness from all stages and implementing a well-managed system that facilitates responsible gear disposal and recovery.

A key step in improving fishing gear management is marking and making gear traceable to its owner (Einarsson et al., 2023). Tracking systems such as Radio Frequency Identification (RFID) tagging, barcoding, or other digital solutions can link gear ownership to fishers and assist in monitoring fishing gear movements throughout its lifecycle. However, more straightforward tagging methods, such as a basic written tag, could be effective if widely implemented and supported by a well-organised registration system. Most of the Nordic countries have already implemented or are in the process of introducing mandatory fishing gear marking. That said, establishing a comprehensive registration system for in-use fishing gear

has not been as strongly emphasised in the debate. Strengthening such systems would improve gear traceability and accountability while supporting efforts to reduce gear loss, prevent ghost fishing, and improve recycling initiatives.

While gear tagging alone may not be a game changer, it would increase awareness among fishers and industry stakeholders significantly. Combined with a structured registration system, it can help reduce gear loss at sea, prevent ghost fishing and marine pollution, and improve material traceability for recycling efforts. Additionally, traceability is crucial for ensuring legal compliance and combatting illegal, unreported, and unregulated (IUU) fishing, though IUU fishing is a relatively minor issue in the Nordic region. Strengthening these measures will contribute to a more sustainable and circular economy for fishing gear, ultimately minimising its environmental impact and supporting responsible fisheries management.

As already implemented in Norway, registering accidental gear losses is crucial for enabling systematic follow-ups, such as when cleaning fishing grounds and retrieving lost gear. Incorporating detailed information about the materials used in fishing gear into gear tags and registration systems could further enhance efficiency and value throughout the lifecycle. Such data would facilitate better material sorting, recycling, and the development of standardised, sustainable materials for future gear production.

A particularly challenging issue to address is the loss of small fragments of fishing gear, which are often overlooked, complex to register, and sometimes impossible to recover. Identifying the components that cause environmental harm is essential, followed by the development of improved materials. A notable example is the dolly rope used on trawl codends, which inevitably sheds fragments during use. These fragments have been found in significant quantities in marine ecosystems, where they pose a threat to wildlife.

Despite these challenges, the Nordic countries have developed unique strengths within the circular economy. Greenland has implemented effective logistics for collecting EOLFG from remote locations. The Faroe Islands have established facilities for collecting, storing, and processing EOLFG for future recycling. Iceland has successfully developed a recycling pathway through the Recycling Fund, and Norway has established an exemplary system for registering gear loss and conducting organised annual retrieval missions. Together, a collaborative effort across the Nordic countries could serve as a global example of how to adopt and promote circular economy practices in fisheries, reducing environmental impact while maximising resource efficiency.

While significant progress has been made in EOLFG management in the Nordic region, there is still room for improvement. The following section presents key recommendations and ideas for advancing towards a more sustainable fishing gear lifecycle across the region.

Recommendations and ideas

Gear marking and owner identification

- **Implement mandatory gear marking**

  Require all fishing gear to be marked with an owner identification system, ensuring traceability and accountability.

- **Encourage hybrid marking solutions**

  Combine simple physical markings (e.g., engraved ID tags, printed labels) with cost-effective electronic tracking (e.g., RFID, QR codes, NFC tags) to enhance identification while keeping costs manageable.

Registration system for fishing gear

- **Develop a centralised digital registration system**

  Establish a mandatory national registry where fishing gear is recorded at the point of purchase and tracked throughout its lifecycle (usage, loss, retrieval, and disposal).

- **Ensure digital accessibility**

  The system should allow fishers and authorities to update it in real-time, improving data collection for better management, enforcement, and sustainability initiatives.

Lost gear reporting and retrieval

- **Mandate the reporting of lost gear**

  Implement clear and standardised reporting requirements for fishers to improve retrieval efforts and prevent ghost fishing.

- **Expand retrieval programmes**

  Strengthen or introduce annual gear recovery expeditions, ensuring lost gear is removed efficiently.

Enhance regional collaboration

- **Share best practices**

  Establish a Nordic collaboration platform to exchange knowledge on gear loss reporting, recycling pathways, and remote collection logistics.

- **Harmonise policies**

  Work towards standardising policies and regulations for EOLFG management across the Nordic countries to ensure consistency and efficiency.

Address fragment loss

- **Develop improved materials**

  Invest in research to develop fishing gear materials less likely to fragment during use, such as alternatives to dolly rope or changes to biodegradable materials for frequently lost gear parts.

- **Strengthen regulations**

  Implement or enhance legislation requiring less polluting materials in fishing gear to reduce microplastic and synthetic debris pollution in marine ecosystems.

- **Encourage cleaner practices**

  Promote methods to minimise the loss of small fragments during operations, repairs, and fishing gear maintenance.

Increase recycling capacity

- **Invest in local recycling facilities**

  Explore opportunities to establish regional recycling plants, especially in countries such as Iceland, the Faroe Islands, and Greenland in order to reduce export dependency.

- **Streamline material sorting**

  Improve infrastructure and technology for sorting materials at collection points to enhance recycling efficiency.

Support and incentivise fisher participation

- **Provide incentives**

  Introduce financial incentives or subsidies for fishers who return EOLFG to recycle or register gear loss responsibly.

- **Education and awareness**

  Conduct training and outreach programmes to educate fishers on the importance of EOLFG collection, recycling, and traceability.

Expand retrieval efforts

- **Organise retrieval missions**

  Implement regular missions to retrieve lost fishing gear at sea, especially in areas identified as hotspots for ghost gear accumulation.

- **Implement a cleanup fee**

  Introduce a fee on fishing gear sales or fishing licenses to fund retrieval efforts and cleanup initiatives. This approach ensures that those benefiting from marine resources contribute to maintaining clean and sustainable fishing grounds.

- **Monitor and map gear loss**

  Use existing technology, such as underwater drones with cameras and sonar (side-scan sonar), to map areas with high concentrations of lost gear for targeted retrieval efforts.

Promote a circular economy

- **Incentivise design innovation**

  Support the development of fishing gear that is easier to dismantle, recycle, or repurpose, such as single-material designs or biodegradable options.

- **Encourage reuse and repurposing**

  Foster markets for second-hand fishing gear or components such as nylon threads and other fibres, to reduce waste.

Enhance data collection and research

- **Quantify EOLFG impact**

  Conduct studies to estimate the amount of EOLFG generated, its environmental impact, and the effectiveness of current measures.

- **Standardise metrics**

  Develop consistent tracking and reporting frameworks across the Nordic region to monitor progress and guide policy improvements.

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Haraldur Arnar Einarsson, Augusta Jeremiassen, Meinhard Gaardlykke, Georg Haney, Gjermund Langedal

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Denmark
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The Nordic Council of Ministers
Nordens Hus
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DK-1061 Copenhagen
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