Chapter 5
Opportunities for Circular Business Models and Circular Design Related to Fishing Gear

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Abstract There is growing interest in circularity and fishing gear-driven emerging legislative, standards, NGO interest and other stakeholder pressures. At present, there has been little focus on new circular business models (CBM) or circular design of fishing gear. The chapter will overview fishing gear, highlight key legislation and introduce CBMs and circular design in this context providing: (i) description of fishing gear used for fishing, (ii) European Commission (EC) Single Use Plastics (SUP) Directive and the related Extended Producer Responsibility (EPR) legislation as it relates to waste fishing gear, (iii) opportunities for more circular business models (CBMs) from fishing gear and (iv) design strategies to the improve the product circularity of fishing gear (circular design).

Keywords Fishing gear · Circularity · Circular business models · Circular design · Extended producer responsibility

5.1 Introduction

This chapter focuses on Circular Business Model (CBMs) and circular design of fishing gear—two new concepts and issues for the sector. Essentially, producers and assemblers have produced a variety of fishing gear to catch fin-fish and shell-fish and issues related to circular economy are new to leadership teams and designers/developers. The growing awareness of circular economy worldwide amongst policymakers, civil society, business and academia is leading to a discussion over the need for a transition away from linear *take-make-waste* economy to a more circular economy. This is particularly being driven by the European Commission through its Circular Economy Action plans and the Sustainable Product Initiative. Circularity is impacting on the fishing gear sector through the development of EPR legislation and new European standards that are now being developed under the

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technical committee: CEN TC 466. Waste fishing gear in the world's oceans is a widespread and enduring problem globally. There is agreement on this fact, however, the size of the problem is fully not agreed on. One study suggests that 10% of all marine plastics are waste fishing gear (Macfayden et al. 2009), and the European Commission (EC) use a figure of 27% (by weight) of marine plastics being waste fishing gear (EC 2018). Another study suggests that 70% of floating macro plastics in the ocean gyres is fishing related (UNEP 2016; Eriksen et al. 2014). Fishing gear containing plastic poses a significant risk to marine ecosystems, biodiversity and human health: there are additional risks to marine-related economic activities including tourism and shipping.

There are essentially two categories of waste fishing gear[1]: end-of-life of fishing gear; and abandoned, lost or discarded gear (ALDFG) which is commonly known as *ghost gear* (EC 2008). End-of-life gear is often left in piles in harbour facilities due to the absence of a waste management plan for fishing gear, which means it often goes to landfill or incinerators as a final destination. Ghost gear is abandoned, discarded or accidentally lost fishing gear that fish or marine animal predators and scavengers can get caught and, typically, die as a result.

To tackle the marine plastics problem, the EC have passed measures to reduce the impact of certain plastic products in the marine environment through the Single Use Plastics (SUP) Directive (EU) 2019/904. This includes the reporting and monitoring requirements of fishing (and aquaculture gear) being placed on the market. The annual (calendar year) reporting period began on 1 January 2022. Reporting will need to be in place 18 months after the calendar year by each Member States of the European Union (e.g. by June 2024). The SUP Directive will place increased responsibilities on fishing gear producers and assemblers (that place plastic fishing gear on the market), and governments to improve the recovery, accountability and outcomes related to fishing gear within the context of a circular economy. EPR legislation will come into force on 31 December 2024. As indicated above, in addition, there are European standards that are being developed through a new technical committee: CEN TC466.

Research (Circular Ocean, n.d and CfSD, n.d) has indicated that there are a series of key points to be considered, when thinking about circular business models (CBMs) and circular design for fishing gear.

Economics

- Fishing operators work to very tight margins and do not want their fishing gear to fail
- Fishing gear can be expensive, with some individual fishing gear costing up to €200,000; however, some monofilament fishing nets are even more expensive

[1] "Waste fishing gear" is defined as: as any fishing gear covered by the definition of waste, including all separate components, substances or materials that were part of or attached to such fishing gear when it was discarded, including when it was abandoned or lost.

Manufacturing and assembly

- There is a range of scientific working groups that work on technical requirements for the development of fishing gear[2]
- Fishing gear is often assembled in Europe, for example, with polymers and components procured from suppliers in India, China and South Korea
- Fishing gear is generally made to order; therefore, there is often considerable dialogue between the fishers and fishing gear manufacturers and assemblers
- Customisation of fishing gear is common, with adaption based on individual experience of fishers, leading to a variety of co-design of fishing gear.

Design and development

- A complex and wide variety of fishing gear is used to catch finfish and shellfish in fresh water, saltwater and in aquaculture farms.
- New gear design and development requires technical trials and the construction of model fishing nets built to scale to take account of vessel size, engine types, fish behaviour and gear interaction.
- Design and development processes for fishing gear often appear to be based on senior people's knowledge and experience in fishing gear production or assembly rather than following a structured product design and development process, e.g. a stage-gate process that might be found in other market sectors.
- Fishing gear is typically repaired and modified by the fishers and/or sometimes by the fishing gear suppliers as part of "take back" contracts with fishers.

5.2 Fishing Gear

Fishing gear comprises a complex series of products used for active and passive fishing in addition to rearing or growing different types of finfish and shellfish. Fishing gear includes nets, ropes, components and peripherals. A significant proportion of fishing gear is produced from polymers, but metals, rubber and other materials are also used. The table below illustrates the variety of gear used for different types of fishing. This chapter uses the term waste *fishing gear* when referring to fishing nets, ropes, components and peripherals (FNRCPs).

Table 5.1 is an indicative classification of fishing gear used to catch finfish and shellfish. The table was compiled from multiple sources (Sea Choice n.d, MSC n.d and FAO 1990) and should be viewed as a indicative document for further discussion and research. There were three main challenges in compiling the table: lack of easily accessible information on the topic; many different terms used in the fishing sector that vary geographically as well as between policy, academia and industry; and

[2] There are scientific working groups that focus on technical issues related to fishing gear development including those within International Council for the Sea (ICES), Scientific, Technical and Economic Committee for Fisheries (STECF) and Food and Agricultural Organisation of the United Nations (FAO) [Working Group on Fishing Technology and Fish Behaviour (WGFTFB).

Table 5.1 Fishing gear category and corresponding gears

Type	Name	Active or passive	How the fishing gear are used	What the fishing gear are made of	Position in the ocean	Catch		Notes
						Finfish	Shellfish	
Nets	Trawls (Pelagic)	Active	Nets are towed by one or two boats (pair trawling)	A cone-shaped net with a closed "cod-end" to holds the catch	Midwater	Herring Hoki Mackerel		Specific mesh sizes, exclusion devices and acoustic deterrents prevents bycatch
	Trawls (Demersal)	Active	Nets are towed by one or two boats (pair trawling)	A framed cone-like net with a cod-end bag	Ocean bottom	Atlantic cod Rockfish Hake	Shrimp	
	Dredges	Active	Rigid structures rake the seabed to dislodge the catch into the net which is dragged over the sediment	A triangle iron frame with a front bar (with or without teeth). Has either fine nets or a metal collecting basket	Ocean bottom		Scallops Oysters Clams	Specific mesh sizes and escape panels prevents bycatch Highly regulated to prevent the loss of habitat
	Purse Seine	Passive	A vertical net "curtain" is placed in the water which traps the catch by drawing in the bottom of the net	Bottom-weighted nets	Midwater	Salmon Herring Tuna Mackerel		
	Danish Seine	Active	Nets are towed by one or two boats (pair trawling)	Tunnel shaped net	Ocean bottom	Tiger flathead Eastern school whiting		

(continued)

Table 5.1 (continued)

Type	Name	Active or passive	How the fishing gear are used	What the fishing gear are made of	Position in the ocean	Catch		Notes
						Finfish	Shellfish	
	Gillnets (stationary)	Passive	Nets are placed in the water (in a line, a circle, left drifting, or stationary) and entangle the catch	Wall or curtain of netting that hangs in the water—size of fish caught can be determined by the mesh size	Shallow water	Manitoba Whitefish Salmon		Attaches acoustic deterrents to nets to deter marine mammals
Hook and line	Longlines	Active	Lines are dragged behind boat	Long lines of baited hooks	All levels of depth	Swordfish Tuna Halibut Sablefish		Weights are placed on lines and use tori lines to prevent unintended interactions with non-target fish, seabirds and other marine life
	Bottom (demersal)	Active	Uses hooks to catch fish	Long lines of baited hooks	Ocean bottom	Halibut Rockfish Cod		

(continued)

Table 5.1 (continued)

Type	Name	Active or passive	How the fishing gear are used	What the fishing gear are made of	Position in the ocean	Catch		Notes
						Finfish	Shellfish	
	Pole and line (chumming)	Active	Creates the illusion of a school of prey fish by spraying water from the back of the boat and scattering small bait fish onto the sea surface	A hand-held wooden or fibreglass pole with a short line and barbless hook attached	Midwater	Tuna		
	Handlines, jigs and trolls	Active	Uses hooks to catch fish yet the lines are shorter than longlines and in the water for a shorter time	One hook to one fishing line	All levels of depth	Tuna, Swordfish Mahi-mahi Cod Haddock		
Traps	Pots Stow Bag nets Fixed traps	Passive	Stationary enclosed spaces with cone-shaped entrance tunnel that are laid on the seabed for 24–48 h then are hauled onto a boat for harvesting and re-baiting. Laid in strings (with traps attached to a long rope)	Consists of wood, metal, wire netting or plastic and rope	Ocean bottom		Lobster Crabs Shrimp and Sablefish	Mesh walls should be sized so that small fish can escape. Exclusion devices prevent larger marine animals becoming entangled

NB Fish Aggregating Devices (Fish aggregating devices are floating objects that are designed and strategically placed to attract pelagic fish (NOAA Fisheries n.d), https://www.fisheries.noaa.gov/national/bycatch/fishing-gear-fish-aggregating-devices) are not included in this categorisation

distinguishing between different types of fishing gear and fishing techniques is not always clear cut. It is recommended that further research is completed with input from gear technologists, industry experts and other stakeholders from the fishing community.

There is a significant variety of fishing gear used to capture finfish and shellfish with different requirements for the fishing gear dependant on the finfish and shellfish targeted. Comprehensive lists of gear have been difficult to find; however, the need for such categorisation is now being driven by legislative and standards development in Europe. In addition, there are different polymers used for different types of gear. The focus historically purely on the function of the gear rather than what materials they were made from.

5.3 Legislative and Standards Development in Europe

The development EPR legislation in Europe by the EC is now leading to emerging discussion over circular economy in the fishing gear sector. Whilst most producers of fishing gear will focus on compliance, a number are likely to be interested in new circular business models. In addition, to the legislative development new European standards are now being taken forward by CEN through TC 466 that includes guidance for stakeholders on circular design and circular business models (see later section).

The EPR legislation embedded within the Single Use Plastics Directive (SUPD) aims to tackle the many challenges posed by waste and end-of life fishing gear made from plastics. The SUPD is based on the "Polluter Pays" principle: the aim is to make fishing gear producers and/or assemblers responsible for the end-of-life phase of fishing gear by taking on the costs of managing the products' waste streams. Prior to implementation of the EPR there are requirements to collect and report data on fishing gear placed on the market and on waste fishing gear (containing plastic) collected in Member States. In addition, implementation of the Port Reception Facilities (PRF) Directive will mean collection infrastructure will need to be set up for waste and end-of-life fishing gear. EPR will seek to increase the collection rate of waste and end-of-life fishing gear, thus reducing disposal at sea as well as disposal by landfilling and incineration, and the associated environmental and economic impacts of marine plastics.

Under the SUPD, member states will need to bring into force laws, regulations and administrative provisions to enable the introduction of EPR for fishing gear by the 31st December 2024. Member states will be able to design and implement tailored legal, administrative and economic instruments to create local solutions at ports and/or within fishing communities.

In 2027, the EC will evaluate the SUPD and may include new legislative proposals or binding collection targets related to the EPR of fishing gear.

Under EPR, member states will have the flexibility to develop EPR schemes in consultation with stakeholders including producers and assemblers of fishing gear, fishers, recyclers, SMEs, entrepreneurs, co-operatives or social enterprises.

5.4 European Standards Development: European Committee for Standardisation (CEN) TC466

5.4.1 Background

A Standardisation request M/574 (COMMISSION IMPLEMENTING DECISION) related to circular design of fishing gear in support of Directive (EU) 2019/904 was submitted by the Directorate-General for Maritime Affairs and Fisheries (DG MARE) to CEN in November 2019. In November 2020, CEN established a technical committee—CEN TC 466—to progress standards development related to circular design, circular business models (CBMs) and recyclability of fishing gear as highlighted in M/574 (CEN 2020). The secretariat for the CEN TC 466 is provided by the NEN (Dutch standards body). The deadline for publication of the standards is May 2024, but NEN has applied for an extension to December 2024 to align with legislative development. As at March 2022, seven standards are being developed under three working groups (WGs), convenors of the WGs have been appointed and writing of the text has now started. Of note, is the secretariat of WG2—that is developing guidance on CBMs—moved to CENTEXBEL[3] in January 2022.

5.4.1.1 Scope

The scope of CEN TC 466 is standardisation in the field of circularity and recyclability of plastic-based materials in fishing gear and aquaculture equipment. Excluded is standardisation work concerning fish processing, fish packaging, fish food products and general work on materials and equipment covered by other CEN technical committee.

[3] Centexbel is an institution recognised by the application of the Royal Decree of January 30th, 1947 (a.k.a. "Law De Groote"). Its mission is to promote research and technological development with the intention of enhancing the cost-effectiveness, quality and production capacity of the Belgian textile industry.

Table 5.2 CEN TC 466 working groups (WGs)

WG 1: Technical requirements of circular design of fishing gear (CDFG)
1. Technical requirements of CDFG
WG 2: Environmental and circular requirements for fishing gear and aquaculture equipment
1. Environmental requirements of CDFG (part 4)
2. Circularity requirements of CDFG (part 5)
3. Circular business models for fishing gear and aquaculture equipment (part 6)
WG 3: Guidance on implementing CDFG
1. The standard on the CDFG (part 1)
2. Principles and user manual of CDFG (part 2)
3. Digitalization of gear and components (part 7)

5.5 Circular Business Models (CBMs) and Circular Design

Growing awareness of Circular Economy opportunities, EPR legislation and standardisation activities may encourage fishing gear producers to explore new CBMs, e.g. reuse, modular design, leasing, etc. and start to integrate circularity in gear design and development. Further discussion of CBMs related to fishing gear can be found in the next section.

Extending the life of fishing gear—through repair—is already commonplace amongst fishers but not reported or monitored. For example, fishers in British Columbia, Canada, often take salvageable and reusable parts of old fishing nets (that would otherwise have been discarded) and use them to patch up their current, serviceable fishing nets.

The implementation of the PRF Directive will mean that infrastructure for the regular collection of waste and end-of-life fishing gear in all European Union (EU) member state harbours and ports will need to be set-up, which will potentially create a market for 2nd life polymers and other materials. PRF Directive and EPR in EC member states and outside the EU, e.g. in Norway and UK, could also become a trigger for innovative solutions for start-ups, SMEs, entrepreneurs, co-operatives and social enterprises:

- Ports, coastal cities and towns, and fishing communities could establish initiatives to support local SMEs in the reuse, upcycling, repurposing and recycling of waste fishing gear to tap in the national targets for a circular economy
- Centralised collections might be established to facilitate public–private partnerships to undertake larger scale repair, servicing, remanufacturing and recycling activities
- Solutions need not be small scale and/or artisan. They could be industrial scale within a local circular economy model.

The implementation of EPR could result in the development of new products, new businesses and jobs, for example, by:

- Using recycled plastics from fishing gear to produce pellets (using mechanical recycling) for use in injection moulding of products, e.g. sunglasses, skateboards, toys, surfing and fishing accessories
- Using recycled fibres using the de- and re-polymerisation (chemical recycling) of nylon fishing nets to produce socks, clothes, swimwear, carpet tiles, etc
- Repurposing of fishing gear into bracelets, keyrings, necklaces, dog leashes, bike, garden accessories and mats.

In 2018, The Centre for Sustainable Design ®[4] (CfSD) at UCA Business School completed research into commercial products produced from recycled plastics, e.g. pellets from fishing nets, or through the re-use of fishing gear or materials. It indicated that the number of commercially available products was limited at the time of publication (Charter et al. 2018). There are indications that the number of commercialised products has increased, but total numbers are still small.

Informal discussions with fishing gear manufacturers have indicated that the product design and development processes operated by fishing gear producers and/or assemblers are often not formalised; and formal product design and development training, tools and methodologies are less likely to be used in the sector compared to many other market sectors. Therefore, at present, ecodesign and more specifically circular design strategies, processes and tools are unlikely to be implemented by fishing gear manufacturers and assemblers, unless there are external drivers, e.g. from customers (fishers) and/or there are policy drivers. One gear technologist indicated that he had used specialist computer-aided design (CAD) software to design fishing gear, but the current CAD software did not include any environmental modules. Environmental modules provide guidance on design strategies to reduce product-related environmental impacts, e.g. design for modularity, design for repairability, design for dismantlability, etc. This is reinforced by unpublished cross-sectoral research completed by CfSD, that indicated that few CAD tools have incorporated environmental modules to date and none have integrated product circularity modules.[5] Further research needs to be completed in this area.

[4] The CfSD has built world-class knowledge and expertise of sustainable innovation and product sustainability. The Centre research, develops and disseminates understanding of present and future sustainability impacts and solutions related to innovation, products, technologies, services and systems through projects, training, events, networks and information.

[5] Findings relate to unpublished research completed on product circularity and design tools within EC funded ORIENTING project (ORIENTING, n.d).

When implementing ecodesign[6] (or, more specifically, circular design) and CBM-related fishing gear, several key issues need to be considered:

- Functionality: The design of fishing gear should target specific fish, the respective water environment conditions and fishing techniques[7]
- Cost: Fishing operators work to tight margins and global prices for catches fluctuate
- Customisation: The design of fishing gear needs to be tailored to a fishing method and fishing operator activity such as those outlined in (see Table 5.1a Fishing Gear Category and Corresponding Gears and Table 5.1b Indicative classification of Fishing Gear)
- Material selection: Fishing gear needs to survive harsh conditions. Fishing nets and ropes are therefore typically made from nylon, polypropylene and polyethylene (polymers) which are either braided or twisted.[8] Newer plastics, such as Dyneema®[9] has been developed to improve the efficiency and productivity of fishing or to increase the lifespan of the fishing nets and ropes. However, these advanced technical materials raise additional challenges at end-of-life (Plastix n.d).
- Failure modes and effects: Key failures come from tearing and stretching. Durability is key but depends on external factors that cannot be overcome through design, e.g. entanglement of nets in ocean debris, sabotage from competing fishing operators, destructive fishing practices or unskilled fishing operators.

5.5.1 Circular Business Models

Thinking proactively about the development of CBMs for fishing gear amongst producers/assemblers is a new area. It has been primarily fishers (customers) that have been involved in product life extension through repair, but some producers have explored take-back model where they will repair fishing gear and return to fishers.

Below are existing and potential CBMs that might be considered by fishing gear stakeholders: see Tables 5.2 and 5.3. The classification of CBMs is based on Clause 6 ("Guidance on enabling mechanisms and business models") in BS8001:2017 (bsi 2017)—Framework for implementing the principles of the circular economy in organisations—that was further developed to focus on fishing gear in a chapter by Charter and McLanaghan in *Designing for the Circular Economy* (2018). A report

[6] "Ecodesign is the systematic approach which considers environmental aspects in the design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product" (IEC 2019; ISO 2020).

[7] Fishing gear is being increasingly designed to avoid bycatch of unwanted fish through excluders or specific designs.

[8] Fishing lines may be constructed from multiple polymers for specific purposes, e.g. weighted ropes with metal cores.

[9] Dyneema ® is a brand name for rope that uses ultra-high molecular weight polyethylene.

further developed the original thinking, and this is highlighted in Tables 5.2 and 5.3 (Charter et al. 2020).

Table 5.2 highlights existing CBM practices and potential additional opportunities that may be becoming more relevant, particularly given current trends and policy changes. The table highlights potential models related to customisation, e.g. production on demand, product life extension, facilitated reuse and modular design. With emergence of EC legislative recycling requirements from EPR and new CEN guidance standards on circular design, it is likely that these options may be considered with modular design perhaps being a less complex strategy to adopt.

Table 5.3 identifies new CBMs and outlines opportunities and threats. It considers the stakeholders owning and implementing the business model, the opportunities provided by the models, and threats that could hinder the models' introduction. The EC EPR legislation will drive potential opportunities for CBMs, some will be more complex and require, significant organisational change and other will require primarily adaption of design and development processes. Some of the key challenges associated with implementing CBMs will be the change of mindset associated with

Table 5.3 Summary of key targets and dates related to the SUP and PRF Directives

Year	Description
27/06/2019	Entry into force of the revised Port Reception Facilities (PRF) Directive
02/07/2019	Entry into force of the SUP Directive
03/07/2020	Entry into force of implementing acts laying down the format for reporting data on fishing gear (containing plastic) placed on the market and waste fishing gear collected[a]
21/01/2022	Entry into force of implementing acts for PRF Directive[b] that requires the provision of collection facilities for passively fished gear, including ALDFG and "end of life" fishing gear
2022	Member states need to collect and report data on fishing gear placed on the market and on waste fishing gear (containing plastic) collected in the Member State. This will need to be completed annually
2024	Member states will need to report the data and information collected electronically within 18 months of the end of the reporting year for which they were collected (first reporting year: 2022)
31/12/2024	Member states to have established EPR schemes for fishing gear (containing plastic)
07/2027	EC completes an evaluation of the SUP Directive—if appropriate, the EC will propose binding collection targets for waste fishing gear following a study of the feasibility of establishing such binding targets

[a] The Commission Implementing Decision laying down the format for reporting data and information on fishing gear placed on the market and waste fishing gear collected in Member States and the format for the quality check reports was adopted on 31st May 2021. Please see the link here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2021.211.01.0051.01.ENG&toc=OJ%3AL%3A2021%3A211%3ATOC

[b] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0089&from=EN

circularity thinking, potential development costs, e.g. reverse logistics, new collaboration with fishers (and other stakeholders) and (re)training of producer's design/development teams.

Strategies related to—and aimed at improving the business and product circularity of fishing gear—are embedded in the respective tables. The tables have been designed to initiate discussion.

Many of the CBMs outlined in Tables 5.2 and 5.3 are a potentially disruptive and a radical departure from the "business as usual" in the industry. Therefore, any implementation of these CBMs would require extensive research, piloting and testing (Tables 5.4 and 5.5).

5.5.2 Ecodesign

CEN 466 has now started standardisation activities related to the circular design of fishing gear as part of new EC activities covering a variety of other sectors including energy-related products and textiles. At present, ecodesign or more specifically circular design is a new issue for the fishing gear sector. 80% of a product's environmental impact is determined at the design and development stage (Small-piece Trust 1989). However, this figure should be treated as a "rule of thumb": the important point is that consideration of environmental issues at the design and development stage is essential to improve product-related environmental performance throughout the lifecycle of fishing gear. Ecodesign is a process to reduce product-related environmental impacts in design and development and has been practised by leading companies in other industry sectors—outside of the fishing gear—since the 1990s. Other terminology is used worldwide that is equivalent to ecodesign and includes environmentally conscious design (ECD), design for environment (DfE), green design and environmentally sustainable design. The term ecodesign is used below and throughout this report.

Two international standards on ecodesign have been published: IEC 62430:2019 and ISO 14006:2020.

> Ecodesign is the systematic approach which considers environmental aspects in the design and development with the aim to reduce adverse environmental impacts throughout the life cycle of a product
>
> (IEC 62430:2019 (IEC 2019) and ISO 14006:2020 (ISO 2020))

As indicated previously, informal conversations amongst fishing gear producers and assemblers indicated that (fishing gear) design and development often seems to be an informal process based on personal experience and learning of company leaders—rather than formalised design and development process as typically seen in other market sectors. In addition, dialogue has also indicated that neither ecodesign or more specifically circular design has been practised in (fishing gear) design and development. There needs to be further research into this area.

Table 5.4 Existing circular business models and additional opportunities

Circular economy business model	Existing practices	Additional opportunities
Produce on demand (made to order and custom made)		
Producing a product or providing a service only when customer demand has been quantified and confirmed	Fishing gear is often custom made to the needs of individual fishing operators based on their fishing practices	Emerging digital production technologies (e.g. adopted from textile industry) could reduce production times and costs while increasing customisation potential Adopt ecodesign strategies to reduce resource consumption across products' life cycle Combine with other CBMs for additional revenue streams e.g. re-use, repair, remanufacturing and reconditioning
Product life-extension		
New products designed for a long lifetime (durability)	Producers provide fishing operators with a fishing net plan as well as repair patches. Durable materials such as Dyneema® are becoming more common, increasing the lifespan of the fishing gear	Combine with other CBMs for additional revenue streams. Examples: refurbish, repair, remanufacturing and reconditioning services. Combine with modular design and ecodesign strategies to facilitate high quality and commercially viable reuse Adopt ecodesign strategies to reduce resource consumption across products' life cycle
Facilitated reuse		
Reuse with or without repair/ upgrade (supplied, either free of charge or resold)	Producers and fishing operators frequently reuse many of the components of fishing gear such as weights and buoys	Reuse of complete fishing gear systems is high unlikely due to their customised nature. However, there is potential for greater reuse of key components of fishing gear than currently taking place. Commercialising reusable components could be undertaken by the fishing operators, producers, centralised/localised market brokerage and storage or a separate reuse network Combine with other CBMs for additional revenue streams. Examples: refurbish, repair, remanufacturing and reconditioning, recycling, downcycling, upcycling and repurposing or circular business models (e.g. modular design, product life extension) and ecodesign strategies to facilitate high quality and commercially viable reuse
Product modular design		
Products designed to be modular so that components are updated	Fishing gear can be produced so that key components can be easily removed and replaced	Combine with other CBMs for additional revenue streams. Example: repair, remanufacturing and reconditioning Combine with other CBMs (e.g. product life extension) and ecodesign strategies to facilitate high quality and commercially viable reuse

Table 5.5 New circular business models' opportunities and threats

Business models	Opportunities	Threats
Incentivised return		
Incentivises customers to return used/unwanted items to the producer. The producer then either recycles materials or remanufactures the product	Enables producers to meet upcoming SUP and PRF Directives without paying additional EPR fees. This could: • Facilitate an increase in repeat orders for the producer when combined with take back discounts or a deposit scheme • Increase the collection rate of fishing gear thus reducing illegal dumping at sea • Increase the likelihood of fishing gear entering circular resource flows if combined with reuse, remanufacturing and recycling, especially if producers can commercialise circular business models	Producers could incur additional costs due to extra logistics demands, sales discounts or labour and storage demands to handle returning used fishing gear To ensure fishing gear enter circular resource flows producers will require additional resources to undertake diagnostics to assess retainable value

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Table 5.5 (continued)

Business models	Opportunities	Threats
Lease agreement		
Leasing access to a product/service and not selling ownership. This can be on a business to business (B2B) or business to consumer (B2C) basis. In general, an "operating lease" model is likely to be best suited for product service system models in the context of a circular economy, because ownership of the asset is retained by the lessor and can be combined with service or performance-based business models	Enables fishers' access to consistent high quality fishing gear with lower capital investment and potentially a lower lifespan costs when taking depreciation, maintenance and disposal/replacement costs into account. Because the fishing operators lease fishing gear from the producers and pay a regular fee for their use, repair and replacement guaranteeing, they will also have a suitable fishing gear available for use Enables producers to retain ownership of fishing gear enabling them to: Ensure fishing gear are returned at end-of-life to meet SUPD requirements Increase profit from individual fishing gear by product life-extension, modular design, reuse, repair, refurbishing and remanufacturing Obtain additional revenue streams by selling end-of-life fishing gear to recyclers	Requires resources (capital investment) to transfer producer's accounting (upfront sales profit) and sales (bonuses) practices from one-off sales to leasing Fishing operator cash flows, grants, accounting (depreciation) could hinder monthly payments Service contract will require legal clarity on responsibility/liability disputes between producers and fishing operators on maintenance/repair/handling/training etc. Producers underwrite liability of uncontrollable damages, entanglements or misuses etc. which could reduce profitability Insurance will be needed because if the fishers mishandle or don't repair the gear, the producer may face the return of degraded products at the end of the lease Culture and perception of control through ownership amongst fishing operators could result in a low uptake

(continued)

Table 5.5 (continued)

Business models	Opportunities	Threats
Sharing platforms/resources		
Shared access or "collaborative consumption" among users, individuals or organisations, but where some form of transactional arrangement (which could be financial) is provided. Enable increased utilisation rate of products and services by making possible shared use/ownership among consumers. Enabling customers to access a product, rather than owning it outright, and use it only as needed	Enables small scale fishing operators to gain additional revenue streams by renting out their irregularly used, underutilised or port-based fishing gear Enables small scale or start-up fishing operators to reduce costs, removing capital investment by paying per use for irregular used or port-based fishing gear Opportunity for a digital platform to generate revenue (on a % of rental prices) for providing intermediate services between parties, thus reducing the risks to fishing operators Opportunity for a community co-operative to rent port-based fishing gear or end-of-life treatment equipment to local fishing operators	Requires open, collaborative and highly trustful industry culture, which may be a significant challenge in a competitive commercial fishing industry Requires legal clarity on who takes responsibility for incorrect use, maintenance and damages Sharing platforms have potential in regional, artisanal small-scale fisheries where harbours are not too far from each other. It is unlikely to work for industrial fleets who spend weeks to months at sea at a time
Peer to Peer (P2P) lending		
P2P lending of products/services is mainly between members of the public or between businesses, but where no direct financial transaction occurs, or income is secured For B2B lending, business benefits might include reduced costs over directly sourcing the products/services concerned	Enables fishing gear producers to reduce costs by substituting virgin raw materials with recyclate, especially if the producer retains ownership of fishing gear through enacting lease agreements, performance-based pay and incentivised return Additional revenue stream for fishing operators to sell used fishing gear Opportunity for start-up either for collection or recycling used fishing gear	Requires open, collaborative and highly trusting industry culture which may be a significant challenge in a highly competitive commercial fishing industry Requires legal clarity on who takes responsibility for incorrect use, maintenance and damages Challenges could arise if fishing gear is required at the same time, e.g. fishing is tidal based in small ports

(continued)

Table 5.5 (continued)

Business models	Opportunities	Threats
Refurbish, repair, remanufacture and recondition		
Product gets a next life after remanufacturing: the process of restoring the product or part functionality to "as-new" quality; facilitated by design for disassembly. Enables the fishing gear producer to put the products back into the market to earn a second, or subsequent income, from a second or subsequent user	**Refurbish:** aesthetic improvement of a product, component or material, which might involve making it look like new, with limited functionality improvements. Opportunity for a port-based cleaning services by co-operatives or social enterprises Enables fishing operators to reduce fishing gear replacement costs **Repair:** returning a faulty or broken product, component, or material back to a usable state. While some fishing gear producers provide repair services, that are either port-based or at their facilities, and the majority of fishing operators self-repair there fishing gear there is an opportunity for a more joined-up approach to repair in the sector **Recondition:** return of a used product to a satisfactory working condition by rebuilding or repairing major components that are close to failure. Opportunity for port-based or centralised remanufacturing services by co-operatives or social enterprises **Remanufacture:** return a used product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product. Opportunity for additional revenue streams for producers if combined with other circular business models such as product life-extension, modular design, lease agreement, performance-based pay and incentivised return. Enables fishing operators to reduce costs with lower priced fishing gear	**Refurbish:** Low market demand could reduce the potential to cover operational costs. Will require quick turnaround to tie in with fishing operator's downtime **Repair:** Labour intensive work could make repair and reconditioning costs not viable. Will require quick turnaround to tie in with fishing operator's downtime. This could also be a source of additional income for artisanal fishers as they know how to deal with and repair fishing gear **Remanufacture:** Resource-intensive work could increase costs beyond the price of new fishing gear e.g. inspection, storage, disassembly, restoration and replacement of components, testing etc. Hindered by material degradation especially on plastic components Low and sporadic rates of used fishing gear collection could result in an unreliable supply chain

(continued)

Table 5.5 (continued)

Business models	Opportunities	Threats
Recovery of secondary raw materials/by-products		
Creating products through secondary materials from recovered waste	Recycling (closed loop): material is broken down to its chemical components, reproduced and manufactured into the same product, i.e. fishing gear. Enables producers to reduce costs by substituting recyclate with virgin raw materials, especially if the producer retains ownership of fishing gear through enacting lease agreements, performance-based pay and incentivised return. Additional revenue stream for fishing operators to sell used fishing gear Opportunity for start-up either for collection or recycling used fishing gear	Challenges include: Material degradation, irregular collection rates, material toxicity, contamination from salts, moisture, ultraviolet (UV) light, oil spills, chemicals etc. Labour intensive disassembly and material separation High capital investment and operational costs of recycling often cannot compete against low virgin raw materials costs High risks of producing a lower grade material that's not fit for the required performance Unrealistic potential for perpetual recycling due to material entropy Increased costs and red tape required to obtain waste licences to collect, transport and recycle waste fishing gear Large mix of material types
	Downcycling (open circular loops): material is broken down to its chemical components, reproduced and manufactured into the any product i.e. low-grade plastic products like street bollards. Opportunity for a port-based start-ups or centralised system to downcycle fishing gear into low grade fishing related products, e.g. crates, labels etc. Additional revenue stream for fishing operators to sell used fishing gear	

(continued)

Table 5.5 (continued)

Business models	Opportunities	Threats
	Upcycling (open circular loops): material is broken down to its chemical components, reproduced and manufactured into products, e.g. high-grade plastic products such as performance running shoes. Opportunity for port-based start-up or centralised system to upcycle fishing gear into new products, e.g. sunglasses, socks, clothes, footwear, carpet tiles, skateboards, toys and surfing and fishing accessories, etc. Additional revenue stream for fishing operators to sell used fishing gear	
	Repurposing (open circular loops): components are disassembled, and individual materials treated and reformed into new products e.g. keyrings and bags made from fishing nets and ropes. Opportunity for port-based start-up or centralised system to repurpose fishing gear into new products, e.g. bracelets, keyrings, necklaces, dog leashes, bike, garden accessories and mats etc. Additional revenue stream for fishing operators to sell used fishing gear	Challenges include: material degradation, irregular collection rates, material toxicity, contamination from salts, moisture, UV light, oil spills, chemicals etc. Labour intensive disassembly and material separation

Also as indicated previously, EC DG MARE was tasked in the Circular Economy Action Plan in 2015 with initiating European standards development related to circular design of fishing gear. A mandate was delivered to CEN in 2019 and TC466 has been established to take forward standards development. There are three of the key areas for standard development: circular design; CBMs; and recyclability of fishing gear (see earlier section on CEN TC466).

As indicated above, ecodesign and circular design are new concepts in the fishing gear sector. However, there are indications that R&D in circular design of fishing gear is starting. For example, Sotenäs Marine Recycling Centre (SMRC) and its partners have initiated a R&D project related to the circular design of fishing gear (see Chapter 10).

There appears to be a lack of awareness and understanding of the principles of lifecycle thinking that is embedded in ecodesign within the fishing gear sector. As fishing gear is a materials-based product, e.g. non-energy using in the *use* phase, the biggest product-related environmental lifecycle impacts are likely to be associated with the procurement of the materials in the supply chain, e.g. polymers and metals, and waste at the end-of-life. However, fishing gear is often repaired many times by the fishers (in the *use* phase of the gear) despite a lack of 'design for repairability' being included in design and development.

Effective implementation of ecodesign (and within it, circular design) requires increased awareness and understanding of a life cycle perspective that might consider designing for product life extension, e.g. "multiple lives" of fishing gear. However, designing more circular fishing gear will include a range of additional considerations that include:

- Identifying potential trade-offs between material durability and circular material loops such as recyclability
- Assessing commercial viability of using reusable components, given the labour-intensive nature of fishing gear assembly and disassembly, and the unpredictable supply of waste or end-of-life fishing gear
- Determining key components to *make (fishing gear) modular* without impacting on fishing gear performance.

As Circular Economy becomes an increasingly important policy driver in the sector, it will be important—from an environmental and economic standpoint—to extend the life of and retain the value of fishing gear in economic and social systems. Therefore, designing for the *closed loops,* e.g. producers and assemblers developing and implementing *take back* systems for fishing gear to enable the repair and refurbishment of fishing gear will increase. Where *closed systems* do not exist, extracting value from fishing gear in the *open loop* may emerge as entrepreneurs start to see business opportunities (Bakker et al. 2018).

From a product circularity perspective, a key consideration in fishing gear (product) design and development should be how to proactively *design for product life extension* e.g. repairability, durability, etc. Materials recycling should be considered as the final end-of-life stage of fishing gear lifecycle. In this context, product circularity should be thought of as a process to design and develop fishing gear, as a

product/service, to retain the value in fishing gear for as long as possible in economic and social systems.

Thinking about *closed loop* design might lead to contracts between, fishing gear producers and assemblers, and fishers, where the fishing gear is sold as a service rather than as a physical product with, for example, take-back, and repair and modification services built into contracts. Proactive *open loop* design will mean that fishing gear in its 2nd life is designed to be reused in different applications outside of the fishing sector. Such proactively designed systems do not exist at present. Products produced from waste fishing gear in the *open loop* are generally not part of a designed system, as such, with the fishing gear collected and/or procured by designers and entrepreneurs, as end-of-life waste materials from the fishing system. For example, (Verdura n.d) re-uses sections of fishing nets for shoes, (Bureo n.d) recycles polymers from fishing gear into pellets for injection moulding into various products including skateboards, and (Fishy Filaments n.d) turns polymers from fishing gear into filament for 3D printing.

There is a diversity of materials (polymers, metals, rubbers, etc.) that are used in the current design and development, production and/or assembly of fishing gear. Simplifying the types and number of the materials used in the development of fishing gear will enable more effective recycling at end-of-life when product life extension or reuse options are no longer feasible.

There will need to be awareness-raising of the business and environmental benefits of ecodesign (and circular design) targeted at fishing gear producers and assemblers. In addition, new education and training courses will need to be established to help the designers and developers of fishing gear think through design strategies related to improving the product circularity of fishing gear. Tailored grant aid and financial support will also be needed to help increase awareness, understanding and build skill sets within the industry.

As Circular Economy policy increasingly emerges and EPR for fishing gear is implemented in European member states and elsewhere there will be a need to develop improved chemical and mechanical recycling infrastructure, as at present there is only one significant chemical recycler—Aquafil who produce (Econyl, n.d) fibres—and one mechanical recycler—Plastix Global (Plastix, n.d) who produce pellets—in Europe, that specialises in the regeneration and/or recycling of polymers from end-of-life fishing gear.

Implementing EPR in Europe will require all stakeholders to rethink the present way that fishing gear is produced and used through to the final end-of-life once product life extension and reuse has been exhausted. This will take time and money. It will also require significant cultural change and capacity-building amongst all key stakeholders in the fishing gear lifecycle and system. EPR will mean that there will also be the need to be "systems design" of collection, sorting, reuse and recycling of end-of-life fishing gear at regional and national levels.

It is currently unclear how EPR for fishing gear will be implemented in member states. The EC has not clearly set out the methods for calculating a producer EPR fee, and has not, so far, established minimum collection or recycling rates. This may change after the initial evaluation of the SUPD in 2027.

To fully address opportunities and challenges, there will be a need to bring together direct and indirect stakeholders in ports and related coastal areas (from fishing sub-systems) with stakeholders from the business and innovation sub-systems in ports and related coastal areas. Experience from Blue Circular Economy (BCE) stakeholder workshops organised by The Centre for Sustainable Design ® in Ålesund, Norway, and Galway, Ireland indicated the prime benefit of such events was to facilitate networking between role players who had never previously met, stimulating new connections, thinking and perspectives in those regions.

EPR and an increase in Circular Economy practices could result in waste fishing gear being *harvested*, e.g. cleaned and stored into materials banks—presenting an opportunity for start-ups, SMEs, entrepreneurs, co-operatives or social enterprises to develop new products (e.g. clothing) from the materials, new services (e.g. training, cleaning, repair) and new business models (e.g. rental of fishing gear). Combined with advances in technology (e.g. 3D printing) and tapping into local innovation systems, the possibilities could be substantial. Lessons should be learnt from existing leading-edge initiatives, e.g. Sotenäs Marine Recycling Centre in Sweden (see Part III, Chap. 10).

However, not all fishing gear will be reusable and/or recyclable and there is a need to classify and then manage degraded and contaminated gear, materials, components and peripherals. This may highlight further new opportunities for a start-ups or existing businesses. *Green* public procurement could be used by local authorities (that host ports and harbours) to kick-start the demand side and stimulate innovation—for example, incentivising the reuse of waste fishing gear in the *open loop* in building and construction products in coastal areas.

Systems will also need to set up to tackle the significant backlog of fishing gear that needs to be recycled and/or disposed of. There is abundance of usable gear in regional harbours, but unless there is a demand or incentives for repair is unlikely that gear will move back into use.

There is a need to change the mindset from thinking about waste and end-of-life fishing gear to maximising the value in fishing gear, components and materials for as long as possible in economic and social systems. This change in approach will require all key stakeholders to buy into a more holistic strategy that utilises products-services-systems (PSS) strategies, as well as *systems design.*

5.6 Conclusion

National Circular Economy policy development is increasing in Europe, and EPR and the CEN standards on the circular design, CBMs and recycling of fishing gear will come into force in 2024. These developments are likely to present significant challenges for the sector but may highlight new opportunities for the development of new CBMs and ecodesign (including circular design) of fishing gear across its life cycle. In addition, this may present opportunities for further development of products re-using fishing gear and using recycled polymers from waste and end-of-life fishing

gear in new applications within or outside of fishing sector. However, at present, the number of commercial products developed in the *open loop* is limited.

Stakeholders benefiting from changes in the sector are likely to include start-ups, recyclers, SMEs, entrepreneurs, co-operatives or social enterprises focused on new opportunities related to development the recycling infrastructure through European member states, as well as those involved in converting waste and end-of-life fishing gear into products.

To ensure long-term benefits, the fishing gear sector should, ideally, adopt a joined-up, Europe-wide strategy and not just focus on a country and/or regional level approach—although regional and local plans will need to be developed as this is where issues will need to be tackled. It is also recommended that the fishing gear sector—working with other stakeholders—develops a clear vision, strategy and action plan that addresses circularity and EPR. The implementation of EPR in Member States and elsewhere could become a trigger for innovative solutions—including start-ups, SMEs, entrepreneurs, co-operatives and social enterprises focused on more circular solutions for the fishing gear sector. However, there will need to develop new systems to expand recycling systems within Europe related to EPR and to build knowledge around the ecodesign (and more specifically circular design) of fishing gear. Utilising best practice and lessons learnt from initiatives that have already progressed thinking and practice, e.g. Sotenäs Marine Recycling Centre (SMRC) and Steveston Harbour Authority in Canada will be essential. A key lesson learnt from these case studies is to include fishers in discussions from the start. The new business models, design strategies and innovation presented in this chapter provide a useful starting point for stakeholders to consider the next steps in tackling waste and end-of-life fishing gear.

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