


What would it take to establish a take-back scheme for fishing gear?

Insights from a comparative analysis of fishing gear and beverage containers

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Abstract

The problem of marine litter represents a significant global challenge and illustrates the harmful consequences of an economic model that is based on disposability. The seafood sector is not only among the culprits, but is also among the most affected by this threat to the marine environment. Earlier research has pointed to fishing gear take-back schemes as a measure to mitigate the problem, and policymakers have embraced the idea. The Norwegian scheme for beverage containers has been hailed as a benchmark for the application of Extended Producer Responsibility. Through the lens of business ecosystems, we draw parallels between the existing take-back scheme for beverage containers and the latent system for fishing gear to answer the question: “What would it take to establish a take-back scheme for fishing gear?” We elaborate upon four factors that are well established for beverage container take-back schemes, but lacking or unclear in the case of fishing gear: (i) politico-institutional support, (ii) the system’s value proposition, (iii) the system integrator, and (iv) operational factors (i.e., a network of collection points and procedures, and material variety and complexity). Our findings highlight that when innovations are not based on the usual market mechanisms, unconventional conceptualizations of value itself and how value is mapped and distributed are required. Meaningful engagement of the private sector depends upon either explicit articulation of value capture or policy instruments to enforce responsibility; both are currently either unclear or lacking in the context of fishing gear.

KEYWORDS

business ecosystems, extended producer responsibility (EPR), fishing gear, industrial ecology, marine litter, take-back scheme

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1 | INTRODUCTION

Marine waste represents a significant global challenge and illustrates the harmful consequences of disposability (Jørgensen, 2019). The practice of littering is embedded in a complex yet weak governance structure (Dauvergne, 2018) and highlights deficient waste-management systems for both land- and marine-based activities (UNEP, 2005). Estimates from Iceland suggest that each ton of fish caught generates one kilogram of plastic waste, of which 70% can be recycled (Sundt et al., 2018). Likewise, Norwegian studies report that the majority of marine litter is plastic, with products from fishing and aquaculture as crucial contributors (Højman et al., 2022; Mepex, 2020). Deliberate dumping of entire equipment is uncommon, as it represents the loss of expensive items. However, other gear and gear pieces such as rope cutoffs, fishing boxes, buoys, and so on have little if any economic value to fishers after use and can be difficult or expensive to retrieve (Højman et al., 2022; Langedal et al., 2020; Olsen et al., 2020). While the seafood sector is among the culprits, it is also among the most affected by this threat to marine environments. Awareness-raising is imperative but insufficient if not accompanied by appropriate systems and infrastructure (Jørgensen, 2013; Olsen et al., 2020) given the frequent gap between attitude and action—in particular regarding marine litter (Olsen et al., 2020)—that is characteristic of environmentally conscious behavior (Skorstad & Bjørgvik, 2019).

Earlier work has pointed to practical measures to address littering in the seafood sector. Among these measures, we highlight: (i) Improving and standardizing waste-management infrastructure onboard vessels in ports and fish-farming facilities, (ii) marking gear for traceability, and (iii) implementing extended producer responsibility (EPR) for fishing gear (Johnsen et al., 2019a, 2019b; Nordisk Ministerråd, 2006; Sundt et al., 2018; UNEP, 2005; Vangelsten et al., 2019a, 2018, 2019b). Policy actors have also been taking measures to address marine litter (European Parliament, 2019, 2019ab; Miljødirektoratet, 2020), but despite both goodwill and concrete suggestions, a disparity between ambition and reality still exists.

A new European Union directive, which mandates that EPR regulation for fishing gear containing plastic must be operational before 2025 (as depicted in Table 1), represents a meaningful advance.

There are different instruments by which EPR can be operationalized (OECD, 2001), which reflect different understandings of responsibility. EPR can be realized through economic instruments such as advance disposal fees or an upstream combination tax or subsidy. Another approach is to implement EPR through business model innovations such as leasing or servicizing (ibid.). Still, widespread instruments of EPR are take-back schemes, often implemented through producer responsibility organizations (PROs) (Lifset & Lindhqvist, 2008).

For instance, in Iceland, the Act on Recycling Fees (Íslensk lög, 2019) seeks to create economic conditions for reusing and recycling waste, with authorities controlling the flow of plastic—including fishing gear—that enters and leaves the country (Haney, 2019; Langedal et al., 2020). The seafood sector has avoided fees by independently taking up collection and recycling themselves (Langedal et al., 2020). Although Fisheries Iceland reports that approximately 90% of collected gear is sent for recycling, the model is difficult to replicate in countries in which cross-border trade is more difficult to control (Langedal et al., 2020). That is, while the legal instrument enforces EPR through a financial obligation, the responsibility takes the shape of a take-back system in practice.

In Norway, seven product categories currently have EPR requirements, all of which involve physical responsibility for the products' end-of-life through take-backs (Miljødirektoratet, 2021). In all but one case, producers and importers are explicitly mandated to join a PRO (Avfallsforskriften, 2004), and in effect all seven producers or importers have enrolled in one. The Norwegian Environment Agency is now investigating how to address the EU directive. Given the widespread use of this mechanism in other product categories and in light of studies laying the groundwork for take-back scheme implementation for fishing gear in Norway (Aqualine, 2009; Hognes & Skaar, 2017; Olafsen, 2007; Sundt, 2008; Sundt et al., 2018), we reasonably expect that EPR for fishing gear will be implemented accordingly. While earlier studies provide valuable knowledge of the types and flows of materials used and volume estimates, several political and organizational factors challenge the implementation of such a scheme (Wiesmeth & Häckl, 2011). Coordinated collective action requires that multiple actors engage to accomplish an outcome of mutual interest (Olson, 2003).

The purpose of this study is to contribute to this discussion by drawing parallels between Norway's seafood sector and the beverage industry. While the seafood sector is currently discussing ways to operationalize a take-back scheme for fishing gear, the beverage sector has run a successful take-back system for the past 50 years—longer than any other product category. Beverage containers was also the first product category with EPR regulations in Norway, which were introduced in 1993 (Miljødirektoratet, 2021). Like fishing gear today, the emergence of EPR for beverage containers was embedded in concerns with littering and its environmental effects, as well as the extent to which end-of-life responsibility lies with the industry versus individuals. Furthermore, both fishing gear and beverage containers are ubiquitous in their own settings and difficult to be traced back to individuals, increasing the challenge of assigning and enforcing responsibility. By contrasting these two cases, we address the following question: *What would it take to establish a take-back scheme for fishing gear?* This comparison is critical and timely, as it offers new insights into ways in which other sectors address comparable challenges.

Beyond the immediate objective of illuminating the feasibility of take-back systems for fishing gear, this study also contributes to the EPR literature in industrial ecology. As Atasu (2019) highlights, with the growing popularity of the circular economy, EPR has now been applied to various product categories, and experiences on the ground raise operational concerns that prompt scholars to revisit the premises underlying EPR. Our study portrays take-back schemes as functionally structured networks of actors organized around a shared value proposition. In other words, we

TABLE 1 Relevant excerpts from directive (EU) 2019/904

Source	Quote
Paragraph 23	The large percentage of plastic stemming from discarded fishing gear, including abandoned and lost fishing gear, in marine litter indicates that the existing legal requirements (...) do not provide sufficient incentives to return such fishing gear to shore for collection and treatment. The indirect fee system (...) provides a system for removing the incentive for ships to discharge their waste at sea, and ensures a right of delivery. That system should, however, be supplemented by further financial incentives for fishermen to bring their waste fishing gear on shore to avoid any potential increase in the indirect waste fee to be paid. As plastic components of fishing gear have high recycling potential, Member States should, in line with the polluter-pays principle, introduce extended producer responsibility for fishing gear and components of fishing gear containing plastic to ensure separate collection of waste fishing gear and to finance environmentally sound waste management of waste fishing gear, in particular recycling.
Paragraph 24	In the framework of an extended producer responsibility for fishing gear containing plastic, Member States should monitor and assess, in line with the reporting obligations laid down in this Directive, fishing gear containing plastic.
Paragraph 25	While all marine litter containing plastic poses a risk to the environment and to human health and should be tackled, proportionality considerations should also be taken into account. Therefore, the fishermen themselves and artisanal makers of fishing gear containing plastic should not be considered as producers and should not be held responsible for fulfilling the obligations of the producer related to the extended producer responsibility.
Article 3 paragraph 4	(...) "fishing gear" means any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources.
Article 8 paragraph 9	(...) Member States shall ensure that the producers of fishing gear containing plastic cover the costs of the separate collection of waste fishing gear containing plastic that has been delivered to adequate port reception facilities (...) and the costs of its subsequent transport and treatment. The producers shall also cover the costs of the awareness raising measures (...) regarding fishing gear containing plastic.
Article 17 paragraph 1	(...) Member States shall apply the measures necessary to comply with (...) Article 8 by 31 December 2024.

adopt a business ecosystem (BE) approach (Adner, 2013, 2017), which promotes a connection between innovation strategy and industrial ecology. This allows us insight into a tension between take-back schemes, which seek to advance a public good (in the form of environmental interests), and the interests of the private sector, which relies on a logic of private goods and innovations whose value can be captured.

The following section presents the analytical framework of BEs and introduces a typology of goods with which we will analyze distinct types of value associated with EPR programs. Section 3 presents insights from our fieldwork with users of fishing gear. Section 4 compares the contexts of fishing gear and beverage containers. Section 5 concludes with principal lessons learned and theoretical implications.

2 | ANALYTICAL FRAMEWORK

2.1 | Business ecosystems

This article employs an analytical tool borrowed from management studies. In other words, we view the resulting arrangement of EPR policies as a business ecosystem. A BE corresponds to "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017, p. 40). Thus, BEs are vehicles for value creation across organizational boundaries (Oskam et al., 2020), although the ways in which different organizations capture their share of this value may be distinct. One of the main challenges of creating a BE is that its development can challenge the trajectory of individual organizations (Almpanopoulou et al., 2019). As a result, orchestrating diverse interests is essential for creating alignment and cohesion. The way actors organize and align to make the system operational depends on (re)negotiations of power and leadership and the redistribution of responsibilities. Figure 1 illustrates an archetypical BE embedded in its institutional context.

We see take-back schemes as an exemplary case of BEs, as they are often implemented through a PRO, which acts in a symbiotic manner as a system integrator surrounded by other actors. That is, PROs orchestrate operations on behalf of various manufacturers, thus complying with EPR regulation. PROs are often not-for-profit enterprises; their primary purpose is neither profitability nor competitiveness—as is the case with ordinary BEs—but compliance. Thus, the value created by PROs is of a noncommercial nature. This poses challenges for the capture of value, which is not subject to direct appropriation by individual actors. The BE framework serves as a boundary object to structure a comparison between the

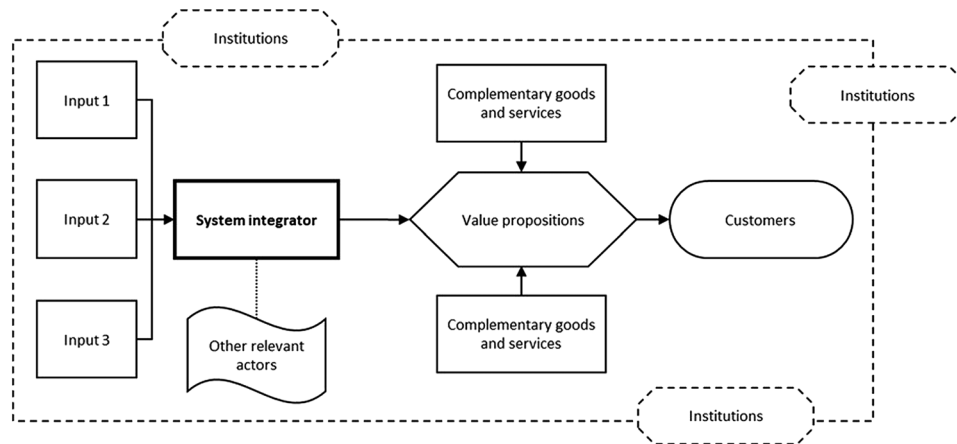


FIGURE 1 Archetypal structure of a business ecosystem (source: inspired by Adner & Kapoor, 2010 p. 309)

existing system organized for bottles and cans and the incipient system for fishing gear. We assess these two contexts by examining four elements: Politico-institutional arrangements, the value proposition, system integration, and operations.

Traditional policy analysis focuses on the policy itself and the governance authority responsible for its implementation. While this approach has its merits, the BE framework allows a shift in focus toward the actors that are subject to regulation. This choice results from the recognition that while legal mechanisms function by setting up an obligation or a prohibition backed by systems of sanctions (Cooter, 1998), a gap exists between the idealization and operationalization of these instruments, and the action of those subject to regulation is an important reason for this gap (Bénabou & Tirole, 2012). Foresight is an immediate problem, as policymakers have limited ability to anticipate and prevent people and firms from finding ways to comply with the letter of the law while deviating from its spirit. Moreover, hidden costs are associated with controlling behavior or adherence to a policy (Falk & Kosfeld, 2006). For example, the effort expended in enforcing rules may produce the opposite of the intended result by crowding out voluntary support (Schmelz, 2021). Furthermore, control involves monitoring, which can quickly become burdensome, demand disproportionate resources, and risk becoming an end in itself (Power, 1999, 2021).

In short, we start from the premise that more than regulation is required to establish a well-functioning take-back scheme for fishing gear. By focusing on firms, this article contributes to the debate from a crucial but overlooked viewpoint from which a stronger alignment between the interests of different actors leads to less costly monitoring and better environmental performance.

2.2 | Questions of value and distinct types of economic goods

Business ecosystems emerge and organize around the creation of joint value propositions. When organizations collaborate to implement environmental regulations rather than to address a business opportunity, unresolved questions remain about how to define value, for whom value is created, and by whom it is captured. In a market-based economy, the possibility of capturing value underlies firms' innovation efforts. In the absence of steering mechanisms, incentives to purposefully create value that cannot be captured are lacking. The notion that value can be captured relies on the properties of subtractability and excludability. In other words, one actor's value capture necessitates the prevention of another's, and restricting other potential beneficiaries from accessing a resource is both possible and cost-effective (Ostrom, 2003). Figure 2 illustrates the fourfold typology of goods that results from the intersection of these properties.¹

Traditional private goods (i.e., excludable and subtractable) allow the possibility to control access, at the same time that consumption of one unit reduces the total available stock of the good or resource. Fishing gear such as a trawl net is a private good because fishers who acquire it can control who may utilize it, considering the limitation on the number of fishers that can use the trawl net simultaneously. In diametrical opposition, public goods (i.e., nonexcludable and non-subtractable) can be freely accessed and enjoyed by anyone without compromising resources' stocks. Clean oceans are an example of a public good. However, the ecosystem services afforded by the oceans—such as fish stocks—are examples of common-pool resources (i.e., nonexcludable but subtractable). This is because restricting and regulating access is difficult or costly, but ungoverned consumption of fish stocks by multiple self-interested actors could potentially compromise the integrity of the entire resource base (Hardin, 1968). Finally, club goods (i.e., excludable but nonsubtractable) are those to which access can be restricted, but which are made artificially scarce as all stakeholders could in principle consume the resource without depleting it in the absence of competitive interests. PROs themselves are an example of a club good, as distinguishing between members and nonmembers is possible, while accepting new member organizations without any loss to existing members is also possible.

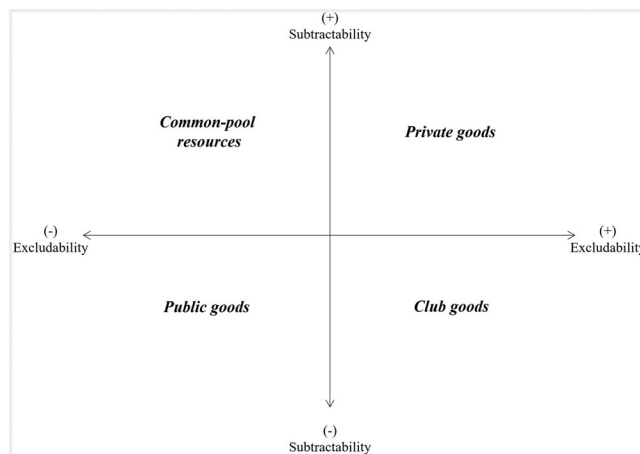


FIGURE 2 Typology of economic goods (source: based on Ostrom, 2010)

This typology matters in this discussion because environmental regulation through economic mechanisms—in this case, through the establishment of a liability system (Panayotou, 1994)—seeks to influence firms' behavior by creating a new threshold for value creation and appropriation. For instance, EPR enforces that end-of-life and waste-handling costs are internalized in the product's price, converting waste from a common-pool liability to a private one. Thus, incentives and prerequisites for value creation and capture are altered, steering firms toward engaging with goods other than private ones. Before analyzing the way in which distinct types of economic goods appear in the two cases, we introduce important considerations regarding waste handling in the context of seafood.

3 | WASTE HANDLING IN THE NORWEGIAN SEAFOOD SECTOR

Even though the modes of operation for fishing boats and fish farming facilities are quite distinct, the equipment used is common across the seafood sector. Secondary sources have identified practical measures to address littering by the seafood sector, as discussed earlier (Johnsen et al., 2019a, 2019b; Nordisk Ministerråd, 2006; Sundt et al., 2018; UNEP, 2005; Vangelsten et al., 2019a, 2018, 2019b). However, there is a knowledge gap regarding the practices and attitudes of users of fishing gear, and this knowledge can illuminate how policies will be met in practice.

To fill this gap, we conducted fieldwork with equipment users and relevant stakeholders (e.g., gear manufacturers, policymakers, NGOs, waste companies) to gain a practice-based view of factors that may enable or hinder a take-back scheme. The self-reported and subjective nature of the data is a limitation. Thus, we do not aim to produce findings that are consistent across the population of seafood actors. Instead, the aim is to explore the problem at hand by comparing it with a benchmark case, from which potential explanatory value can be derived. This is done through semistructured interviews with equipment users and relevant stakeholders, which combined with secondary sources illuminate the issue of interest. Since EPR for fishing gear is still in the planning phase, this approach is suitable for identifying key obstacles. More information on data and methods is available in supporting information S1.²

Fishers report that the loss of fishing gear comes at a high cost, since what cannot be retrieved must be replaced. All waste produced by fishers must be handled first onboard and subsequently in ports or fish-landing facilities. Practices onboard depend on the size of the vessel and the type and area of operations. For example, though vessels and fishing trawlers over 400 gross tons must report both produced and delivered waste, smaller vessels are exempted from reporting. Despite their awareness of the problem, fishers report that they lack the capacity to manage litter occasionally encountered at sea in addition to managing their own waste. Further, choosing to retrieve litter may entail additional challenges, such as incurring fees for delivering waste not generated by the fisher in public Norwegian harbors. Nonetheless, fishers claim that their waste-handling practices have improved under the influence of the increased scrutiny through the media from civil society.

The substantial variability in the quality of waste-management facilities across ports is another common challenge. Fishers point out that systems are not standardized across ports, making it difficult to identify ways to handle waste at an unfamiliar port. In addition, even if fishers sort gear from other waste, they often meet inadequate facilities on land because not all coastal municipalities or ports offer facilities and services for collecting sorted waste despite regulations mandating them to do so. Hence, equipment users underline that adequate infrastructure is essential for preventing littering. Dissatisfaction with waste services for which fishers already pay fees decreases their confidence in return schemes.

One issue particular to fish-farming facilities is abandoned gear—such as cages—which are remnants from companies no longer in business. Removing this gear can be expensive and the equipment can simply be left behind in the case of bankruptcy, as the responsibility for waste removal

remains unassigned. These cases are not numerous, but the lack of mechanisms or procedures to address this issue illustrates the problem of fragmented responsibility.

The creation of a take-back system for fishing gear has been discussed in Norway for nearly 15 years (Olafsen, 2007; Sundt, 2008). Since then, a few initiatives, though limited, have been implemented for items such as gillnets and seines, which are rich in nylon and thus hold a high secondary market value. An example of this recycling value chain is the company Nofir, whose collection of nylon-rich items allows for the simultaneous collection of less profitable items because a large part of the logistical structure is already in place.³ Another example is the government-subsidized program Fishing for Litter, which encourages participating vessels to retrieve litter they encounter during their operations. Finally, ASVO in Lofoten repairs damaged fishing gear, prolonging its use. These initiatives are praised but have limitations, such as a specific geographical context, the need for high volumes of waste, and the fact that they are restricted to the very end of the value chain. Requiring gear producers to take responsibility for end-of-life management promises to deliver a more comprehensive solution, and the success of EPR schemes in other product categories has reinforced this expectation.

Finally, complaints by fishers and fish farmers about the lack of recycled gear in the market are countered by gear manufacturers, who cite the widespread perception that products made from recycled materials are of poorer quality, and thus generate limited demand. Creating supply and demand for recycled products in addition to a marketplace in which to trade these products is necessary. Materials from fisheries and fish farming can also find a second life as alternative products—a process that requires even more market creation and coordination work. With this backdrop, section 4 holds the case of the beverage container take-back scheme as a benchmark for discussing requirements for establishing a take-back system for fishing gear.

4 | ANALYSIS: BUILDING A TAKE-BACK SCHEME FOR FISHING GEAR

Well-functioning take-back systems depend not only on producers, but also on consumers' voluntary engagement with returning products through the right channels. Nonetheless, our analysis focuses on the supply side of a take-back scheme because the impact of stimulating consumers to engage in pro-environmental behaviors before implementation of adequate infrastructure is very limited. Earlier research indicates that such action risks alienating individuals, who may perceive their distributed and small-scale environmental actions as meaningless (Olsen et al., 2020). In the case of take-back of beverage containers, the behavior of returning bottles was already a habit and the introduction of plastic and aluminum containers capitalized on this entrenched behavior. For fishing gear, awareness-building is ongoing and is essential for a take-back system to run properly.

In our analysis, several reasons support our assumption that the latent scheme for fishing gear takes the shape of a PRO. First, the success and popularity of the Norwegian take-back scheme for bottles have led to this model being replicated for fishing gear. Moreover, mitigation of environmental damage in the oceans and the prevention of inadequate disposal are the underlying motives for EPR in the seafood sector. Given this situation, the establishment of industry-wide consortia through a PRO can facilitate the establishment of a system with a strong governance structure. Although PROs have been criticized as cost-ineffective *de facto* monopolies (Lifset & Lindhqvist, 2008; Lindhqvist & Lifset, 2003), they accomplish the task of aligning and leveraging diverse interests toward an immediate shared goal.

While the transferability between the two cases is not absolute, the disparities reflect central issues that must be addressed before a take-back system for fishing gear can be implemented. We elaborate on four aspects that are settled for take-back schemes for beverage containers, but lacking or unclear in the case of potential schemes for fishing gear, as depicted in Table 2 and discussed next.

4.1 | Establishing politico-institutional support

The emergence of the take-back system for beverage containers illustrates the importance of a favorable political environment and the action of institutional entrepreneurs. When beverages were sold in glass containers, the return of containers was driven by material scarcity (Jørgensen, 2013) and cost advantages and did not require external support. However, when disposable containers were introduced, these drivers lost strength and political support became both imperative and difficult to articulate (Jørgensen, 2011). Years of negotiations were required until the current system was established. The industry's intended take-back scheme could only be introduced after an alignment of the industry's ambition and political priorities.

Political articulation and power relationships are crucial to the exercise of building a BE. In the beverage deposit-return scheme, a collaboration between three ministries (Finance, Industry, and Environment) enabled the introduction of an environmental tax that pushed responsibility up the supply chain. Similar ecosystem-building mechanisms are necessary to develop a viable system for recycling fishing gear. The recent EU directive (European Parliament, 2019b) is a landmark initiative in this direction, although much remains to be accomplished by way of political articulation. This is not simply about top-down rulemaking, but about how these rules affect the seafood sector, and how the industry seeks to influence these rules.

TABLE 2 Comparison of key aspects of the existing take-back scheme for beverage containers and the current landscape for a potential take-back system for fishing gear

	Beverage containers	Fishing gear
Status	<ul style="list-style-type: none"> - Operational in its current form since 1999. 	<ul style="list-style-type: none"> - Latent; EU mandates a system must be implemented by 2025.
Politico-institutional support	<ul style="list-style-type: none"> - Very high, albeit mixed in the early days. - System of national scope. - Cross-national system would be desirable but is not imperative. 	<ul style="list-style-type: none"> - Fragmented. - Multiple nationalities share fishing grounds and deliver catch across borders. - Ocean currents carry marine litter across national borders. - Substantial degree of cross-national scope is important for effective operation.
Value proposition and capture (in order of importance in motivating the establishment of the system)	<ul style="list-style-type: none"> - To allow for the inclusion of disposable containers in the beverage sector and substitute the environmental tax with a system for material recycling (i.e., a club good). <ul style="list-style-type: none"> ■ To increase public acceptance and avoid more burdensome regulation. - To mitigate litter (i.e., a public good) by implementing a system for recovering more than 95% of disposable beverage containers in Norway. - Firms capture value through efficiency in production and logistics, and to a smaller extent through the material value of plastic and aluminum (i.e., a private good). 	<ul style="list-style-type: none"> - To mitigate marine litter (i.e., a public good) by establishing a system for adequate disposal of fishing gear (i.e., a common-pool liability). <ul style="list-style-type: none"> - To avoid regulation that can be more costly. - Economic value in material recycling is small compared to the potential costs of the scheme (i.e., absence of private goods). - Possible value capture by the seafood sector in the form of reputational benefits (i.e., a club good), the reduction of instances of ghost fishing, and better waste handling logistics in ports.
System integrator	<ul style="list-style-type: none"> - A PRO, on behalf of the beverage producers and grocers' associations. 	<ul style="list-style-type: none"> - No clear candidate. Fragmented responsibility between manufacturers, port authorities, and waste management actors.
Operations	<p>Network of collection point and procedures</p> <ul style="list-style-type: none"> - All points of sale for beverage products. - Collection happens through reverse vending machines. - Collection system is based upon a deposit, which assigns value to each item. <p>Material variety and complexity</p> <ul style="list-style-type: none"> - Simple material: PET plastic bottles, aluminum cans, and glass bottles. 	<ul style="list-style-type: none"> - Ports, fish-landing facilities, and waste collection points would be relevant collection points. - Technologies to assist collection and assess quality of materials are still emerging, and not mature for large scale deployment. - Many different types of gear (of varying quality) make it difficult to assign deposits. - Some types of gear are better suited for deposits than others. - Involve numerous and diverse products, some of which are made of composite materials.

For instance, widespread agreement does not exist that EPR for fishing gear is a solution to the problem of marine waste. The Norwegian Seafood Federation⁴ has emphasized that measures other than EPR—such as improving documentation of waste practices and promoting eco-design (Sjømat Norge, 2018)—are more relevant. The industry is unsurprisingly resistant to robust rules governing end-of-life responsibilities. Such regulation would internalize the costs of handling waste, and the extent to which the value of material recovery can mitigate this expense is very limited.

As for institutional coordination, the case of beverage containers was organized by a central actor who stood to gain from the system, and thus acted as an institutional entrepreneur. TOMRA is a company that pioneered the technology of reverse vending machines, and one of its founders was pivotal in the emergence of the system we know today (Jørgensen, 2011). A corresponding actor to assume the same role in the case of fishing gear does not exist, just as no company is positioned to benefit as considerably as TOMRA did. In addition, beverage producers were motivated to substitute heavy glass packaging to enable added value capture; establishing a return system was a way to gain acceptance of plastic bottles and aluminum cans without incurring an environmental fee. Manufacturers of fishing gear lack similar incentives to pioneer ecosystem building; thus, the main driver so far has largely been environmental concerns. As a result, policymakers are now developing the basic structures to build the required ecosystem while the industry has remained reactive.

The transnational dimension of the seafood sector is another complicating factor that does not similarly affect beverage containers. Fishers in Norwegian waters and ports are not always nationals, nor have they necessarily acquired their gear in Norway. Also, marine litter transits across national borders. While cross-national integration of EPR systems is desirable for beverage container take-back schemes, it is essential for similar systems for fishing gear. The need for political articulation across borders amplifies the magnitude of this challenge. However, supranational initiatives—such as at the EU level—can facilitate this articulation.

4.2 | Determining the value proposition of the BE

The organizational arrangements of BEs consolidate around a shared understanding of the value BEs offer to the market and stakeholders. When the conditions for value capture (i.e., a certain degree of excludability and subtractability) are not met, the kind and intensity of private sector involvement depends on less conventional conceptualizations of value, and on how this value is allocated to different actors and distributed across the system (Bocken et al., 2015; Oskam et al., 2020).

A two-fold value proposition existed in the case of beverage containers. For beverage manufacturers, the key value was the adoption of disposable containers, enabling cost reductions across the value chain. This value could be captured by individual firms and was thus seen as a worthwhile private good. PROs also exhibit an element of club goods. Beverage manufacturers/importers pay a membership fee to join and a fee to register new products in the scheme. In exchange, the environmental tax is lowered—or waived, if collection exceeds 95%. Hence, more costly regulation is avoided. The value proposition for stakeholders is that, by taking care of reverse logistics and material recycling, the system addresses the problem of littering and creates a public good in the form of a cleaner environment. In short, the same ecosystem appeals to different actors by providing distinct types of value.

For fishing gear, the value proposition of EPR has been defined in the public debate only in terms of common-pool and public goods. The lack of excludability denotes severe limitations in the private sector's ability to capture value, rendering it unappealing for firms to take up voluntarily. While avoidance of more costly regulation could also be framed as a value proposition, because it is framed as preventing a burden rather than facilitating an opportunity, the proposition will be perceived as speculative and difficult to grasp until concrete regulation is implemented. Reputational effects are also a value proposition, though its strength in driving the development of the ecosystem has been minor. Moreover, despite some material value in recycling, the associated costs of recovery (e.g., sorting, cleaning, transport) make the operation uneconomical. Markets for secondary plastics are incipient and influenced by oil prices. Moreover, metals such as copper—present in fishing nets, for instance—are regulated as hazardous waste, creating a liability more than an opportunity for material recovery.

The economic value of recycling beverage containers is somewhat low, and the main advantages for beverage manufacturers in switching from glass to PET and aluminum containers were the significant economic savings associated with handling and transporting lighter materials. Transportation costs were critical, as the beverage industry centralized dramatically after World War II. In contrast, introducing similar changes to production facilities would likely be a hindrance in the case of fishing gear, as this would require recertification of facilities without offering additional cost-saving benefits. Hence, a system for taking back fishing gear cannot rely upon economic value as the main driver. While regulation alone can indeed compel the private sector to assume the responsibility for the end-of-life of products, the robustness and effectiveness of the system can be improved if the industry identifies a way to capture some value from this activity. Voluntary industry engagement would also diminish the cost of enforcing regulations and imposing penalties when regulations are not followed.

Value creation for the industry can be framed in terms of reputation, though this is intangible and thus difficult to quantify. The image of the seafood sector has also been blemished by discussions about sea lice in farmed fish, overfishing, illegal fishing, and other criminal activity associated with seafood (Osmundsen & Olsen, 2017). The industry has responded by positioning itself as environmentally conscious in the pursuit of cleaner seas. Embracing a take-back scheme for fishing gear can contribute to this reputational effort and could provide the baseline for collective action. The challenge with this approach is whether the value of reputation, which is inherently intangible, compensates for the concrete costs of developing

and implementing the system. Environmental certification is one avenue by which the question of reputation becomes tangible. If adherence to a take-back system affects firms' environmental certification, the issue of reputation can translate to higher prices.

4.3 | Finding a system integrator

System integrators play a leading role in building and managing a BE. Integrators are responsible for coordinating both the tangible aspects of the operation and the intangible questions of how value creation and capture are conceived by the diverse partners involved—including the challenge of balancing a triple bottom line that accounts for social, environmental, and financial performance (Bocken et al., 2014; Schaltegger et al., 2016). The actor who assumes the role of system integrator influences the way in which responsibilities are distributed and how the interactions in the ecosystem are governed.

In the case of beverage containers, a new organization was founded (originally Resirk, now Infinitem) that united diverse interests, including those of the grocers' associations and the beverage companies (see supporting information S2). This is a not-for-profit though self-sustaining organization that has the functional role of system integrator. The Norwegian return scheme become a benchmark and claims to have the world's highest rates of return (Infinitem, 2019).

As indicated earlier, one of TOMRA's founders was a precursor to the system integrator and acted as an institutional entrepreneur. It was in TOMRA's best interest to articulate an alignment between the interests of the grocers, the beverage sector, and policymakers. Once political alignment was achieved, the operational integration of the ecosystem was dependent on the PRO, whose monopolistic characteristics ensure a comprehensive system. In the case of fishing gear, Fishing for Litter has acted as a coordinator for collecting marine litter and debris. As an environmentally oriented organization, Fishing for Litter focuses on noncommercial value drivers. Despite advantages to this model, the organization's scope for action is limited and vulnerable to external financing. In contrast, business actors could establish a wider-reaching and more robust take-back scheme.

Nonetheless, many actors have a stake in this context—from fishers, fish farmers, and gear manufacturers to port authorities and public waste-management actors. The question of who holds responsibility for litter and waste from fishing gear is unclear and disputed, indicating that identification of an actor best positioned to champion this system-integration work is difficult. Hence, the absence of an institutional entrepreneur and the fragmented responsibility in the field have been obstacles in identifying supporters of such a PRO.

A key obstacle is that the plurality of actors and their interests currently affect actors' ability to assess what value can be created for themselves (Oskam et al., 2020). As a result, a discussion of the distribution of responsibilities and powers of action is imperative for the emergence of an actor or a consortium that proactively assumes the role of system integrator.

4.4 | Operations

We subsequently elaborate on two operational challenges of take-back schemes: the establishment of a sufficiently wide network for gear collection and the issues of material variety and complexity.

4.4.1 | Designing a network of collection points and procedures

A widespread network of collection points is central to the functioning of take-back schemes. In the case of beverage containers, retailers—who had earlier served as collection points in the returnable glass system—served this purpose. Despite retailers' reluctance to assume this extra task, the network afforded convenience to both consumers and beverage manufacturers as a logistical hub reaching even the most remote locations. With the introduction of TOMRA's reverse vending machines, the work of retailers was greatly simplified, and the availability of this technology was crucial for obtaining the support of retailers. A central lesson from the development of take-back scheme for bottles was the need for convenient collection points. Ease of deposit of the waste generated by fishers is required to incentivize them to collect lost gear they encounter at sea.

Today, waste from fishing and litter collected during operations are delivered to ports, fish-landing facilities, or local municipalities. These facilities could serve as collection points and receive discarded fishing gear. However, the relative power and influence the beverage sector held in relation to retailers was much greater than gear manufacturers have over ports, given the relationship between ports and manufacturers is only indirect. Moreover, the waste-management system is notoriously unstandardized and can vary substantially across ports (Johnsen et al., 2017). In 2016, of the 4,443 registered ports in Norway, only 1,514 submitted a plan for waste reception and handling (EFTA, 2016). Reverse vending machines provided such standardization for beverage containers, but an analogous technology for automatic collection of fishing gear is difficult to implement. The application of artificial intelligence could allow for the automation of receiving stations in ports and thereby increase the effectiveness of the take-back system despite the diversity of items and materials. New methods for tagging and marking gear would facilitate this, as the

traceability of products can allow for EPR implementation in a less labor-intensive manner. However, these technologies are insufficiently mature for widespread deployment.

Another crucial operational difference is that beverage containers have a value assigned in the form of a deposit that incentivizes collection. This is possible due to the small variety of items, which facilitates categorization of products into only two tiers according to volume. While this approach could introduce economic value to fishing gear and create an incentive for returning gear, categorizing and assigning deposits to types of gear is substantially more complex. Different items cannot be compared on a uniform scale (e.g., volume) and the retail price of gear may not be relevant to the value of having it returned. For instance, assigning higher values to less expensive but highly polluting items than for expensive gear that is seldom lost may be relevant. Likewise, damaged beverage containers may be refused by a reverse vending machine, but accepting severely damaged gear is especially crucial, as a system that cannot take back damaged gear offers limited incentive to fishers for returns and is therefore vulnerable to inadequate discarding.

The extent to which a deposit is expected to work depends on the price sensitivity of demand, which likely varies according to the type of gear. The beverage system is tax-based; in recent years, its deposit rate has been adjusted as the incentives provided have lost efficacy—reflected in declining rates of return (Infinitum, 2019). While solutions for automated collection are still unavailable, incentive and deposit structures must be calculated taking into consideration the complexity of collection through serviced stations if a deposit system is to be adopted.

4.4.2 | Untangling the problem of material variety and complexity

The material properties of resources are important in the analysis of the parallels and differences between beverage containers and fishing gear. Beverage containers are made of PET, aluminum, or disposable glass. In contrast, fishing gear is a category encompassing numerous items of complex material compositions (Deshpande et al., 2020). Each type of catch has its own types of gear, so that even if a system were to focus on the most prominent products—gillnets, longlines, and traps (ibid.)—the complexity of the operation would be greater than that of beverage containers. Fishing gear often includes metallic parts, a barrier to economically effective sorting and recycling. These items are considered hazardous waste given the presence of copper in ropes and nets, complicating the transportation of these items across borders in Europe and compromising recycling operations (Kyst.no, 2020). Moreover, advanced designs and modern gear include electric and electronic components. While these components increase gear value—ensuring the equipment is less likely to be lost due to inappropriate care—they also amplify the challenges of recycling the gear (Sundt et al., 2018).

Preparing fishing gear for return demands more complex cleaning procedures, as used gear becomes loaded with substances such as fish oil and dirt (Deshpande et al., 2020). Hence, if the ambition of a take-back scheme goes beyond collecting gear to include recycling gear, the need for special cleaning poses a problem. Depending on fishers to clean gear before returning it would make the system reliant on individual commitment to take on extra work. An alternative is for gear collection in a single stream, with sorting and cleaning at a later stage. This approach would meet the goal of preventing gear from going astray, although the trade-off lies in the effectiveness of material recovery. Early studies on the viability of a take-back scheme for fishing gear observed that the initiative could be funded by trading secondary materials in the recycling market (Sundt, 2008), although the volatility of prices for secondary plastics remains a challenge (Olafsen, 2007). This is indeed the case for beverage containers, since the economic value of material recovery allows the system to be cost-effective and self-sustaining. Hence, if material quality and recycling are compromised by the methods of gear collection, the economics of the system must be redesigned.

In summary, beverage containers flow through a closed system in which old bottles and cans are recycled into new ones. In contrast, the value chain of fishing gear would require additional activities and actors yet to be identified and established. One question concerns whether materials should be recycled into new gear in their subsequent cycles, or whether they should be channeled to other products such as clothing. Involving new actors in new industries creates a considerably more complex system than the one for beverage containers. In addition to the extended value chain, the competitive dynamics between pricing, recycled and virgin resources, and the availability of markets are important considerations. A starting point is to identify which gear to include and to determine whether this choice will be based on market or environmental considerations.

5 | CONCLUDING DISCUSSION

We set out to answer what it would take to establish a take-back scheme for fishing gear, making explicit comparisons between the seafood and the beverage sectors in Norway. This comparison is based upon the premise that well-established beverage container recycling systems can provide lessons for establishing ecosystems that address the significant challenges facing the seafood sector in controlling marine waste. As the marine waste problem is rapidly growing, a considerable need exists for solutions in this sector. Looking to other successful initiatives that aim to manage waste in complex systems is necessary. Our analysis supports that while beverage container recycling systems are a useful aspirational benchmark, substantial differences between the two sectors exist in the material qualities of the waste, the ways in which the boundaries of the systems to be established differ, and how actors articulate value propositions of waste materials.

In short, important limitations exist to adopting established models from other sectors as a blueprint for marine waste without the careful consideration of intangible and contextual characteristics. We have demonstrated how the values of materials, resources, and actor perspectives are not absolute and cannot be taken for granted. At the same time, the introduction of regulations ensuring that producers take responsibility for the end-of-life of products is a considerable achievement as this expresses the importance of socio-environmental values. Reframing economically motivated value propositions to consider environmental values is critical. Preserving clean and living oceanic environments is also in the long-term interest of the seafood sector, including individual fishers.

Policymakers and industry actors must pay close heed to how a shared understanding of value can be articulated, negotiated, and established among heterogeneous actors. Such a process depends simultaneously on technical, social, political, economic, and legal considerations. The history of beverage container-recycling schemes demonstrates that such processes can be established despite challenges. The recent EU directive puts pressure on actors in the seafood sector to establish common ground and overcome weak social institutions that have thus far allowed inadequate disposal of various types of waste. The directive can further lay the grounds for systems that converse on a supranational level.

The EU directive affords policymakers the opportunity to consider new ways to compel manufacturers to engage in eco-innovations. While we focus on EPR as operationalized through take-back schemes, different instruments—such as distinct licensing fees for products that have different environmental impacts—can be combined. Moreover, tying EPR with quality and environmental certification can provide an approach to make the value of EPR more tangible to the seafood sector. Reverse vending machines for bottles were a game-changer, both as a technological innovation and as the solution for the problem of misaligned interests. While the challenge is considerably more complex for fishing gear, the promise of artificial intelligence is also more ambitious. Although artificial intelligence has been introduced to waste management, there is ample room for technology entrepreneurs to apply this technology at greater scales, as well as for the technology itself to mature. Such actors could conceivably play the role of institutional entrepreneurs, similar to TOMRA's coordinating role in the take-back of beverage containers. Policymakers can pave the way for this to happen through mission-oriented innovation policies (Mazzucato, 2018), public procurement and even public enterprises. Finally, take-back schemes for fishing gear may expand on existing initiatives pioneered by the waste-management sector and expand existing logistical networks and selection of materials or items for collection. This selection should represent a mix of products with low value-added but high polluting potential and products with a high degree of economic interest.

Future research can focus on cross-country comparisons to investigate how others are working toward implementing the EU directive. Comparisons between fishing gear and other product categories are likewise relevant. For instance, electric and electronic waste is also characterized by many distinct products and composite materials, and many countries including Norway have EPR policies in place for this product category. Finally, the four domains we outline in the paper can each be investigated in more depth. Much research in waste management has been conducted recently by scholars in technical disciplines. More engagement of historians, political scientists, sociologists, economists, and management scholars can enrich the field and help address the complexity of the challenges we outline in this article.

Further, this article contributes to the strategy literature in which BEs originate (Ritala et al., 2013; Teece, 2016). In contrast to much existing ecosystem thinking, the value driver of this ecosystem is not guided by the competitiveness of either the participants or the ecosystem as a whole; rather, it emphasizes the economic, ecological, and societal impact. More attention to this type of innovation and BEs is vital considering the challenges of our time.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study cannot be made available due to privacy and ethical restrictions.

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NOTES

- ¹We highlight that it is not only the inherent properties of resources that determine their categorization, but also the decisions regarding how they are governed. For instance, knowledge is in principle a common-pool resource, but intellectual property rights set the structures for knowledge to become a private good (Ostrom, 2010).
- ²For the case of beverage containers, we relied on document sources. A description of the acclaimed Norwegian take-back system for beverage containers is available in supporting information 2.
- ³A key difference between Nofir and the proposed EPR is that Nofir is not a producer of gear, but an actor that operates at the very end of the value chain.
- ⁴The Norwegian Seafood Federation represents a wide range of firms in the value chain, from fish farmers to suppliers of equipment, technology, and services to the aquaculture industry.

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SUPPORTING INFORMATION

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