Chapter 10
Sotenäs Marine Recycling Centre in Sweden: A Case Study Related to Waste Fishing Gear

Martin Charter and Paul Whitehead

Abstract The chapter is a case study on the development of a Sweden's first recycling centre focussed on waste fishing gear and other marine plastics based in Sotenäs. Key to the development of the centre has been a longer-term vision and commitment from the local municipality and the fishermen's association. Working with partners across Sweden and locally, the centre has also developed an innovation testbed that is developing new test for polymers from waste fishing gear and aims launch new circular products. The chapter provides favourable learning for any organisation that will be tasked with establishing recycling infrastructure in relation to extend producer responsibility (EPR) requirements for fishing gear that will come into force across the European Union in 2025.

Keywords Fishing gear · Sweden · Circularity · Recycling · Circular design · Extended producer responsibility

10.1 Introduction

Waste fishing gear is now being recognised as a major contributor to marine plastic waste and is in the spotlight for European policymakers. Other drivers include increased media interest in marine plastic pollution, pressure group activity, new European standards related to circularity of fishing gear, and importantly a forthcoming European Commission (EC) Directive covering Extended Producer Responsibility (EPR) that will be implemented in December 2024 (Charter 2023). This means that the fishing gear sector will need to consider sustainability and specifically circularity of their activities.

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At present, the infrastructure for the recycling of fishing gear is limited worldwide with few established and scaled recyclers of fishing gear. This is a potential challenge in Europe with all member states and fishing gear producers needing to have schemes in place by January 2025.

This chapter is a case study focussed on the development of the Sotenäs Marine Recycling Centre (SMRC), Sweden. The case study was prepared based on interviews with key stakeholders involved in SMRC during 2021. Extensive research completed within the Circular Ocean (Circular Ocean n.d. and CfSD n.d) and the Blue Circular Economy (Blue Circular Economy n.d and CfSD n.d) projects and dialogue with the Global Ghost Gear Initiative (GGGI) indicated that current best practice in recycling fishing gear is very limited. SMRC emerged as an interesting case study from dialogue in expert workshops organised by DG MARE at European Commission. In addition to recycling of fishing gear, SMRC also provides testing services and aims to develop new circular products derived from waste fishing gear and other marine plastics through an innovation testbed—'Testbed Ocean Waste' (TOW). With the growing interest worldwide in tackling waste fishing gear and emerging EPR legislation in Europe, this case study provides an example of the development of recycling infrastructure for fishing gear. The chapter also includes lessons learnt and conclusions that will be of interest to an international audience.

10.2 Sotenäs Symbioscentrum (Sotenäs Centre of Symbiosis)

Sotenäs is a small coastal municipality with a strong fishing and marine culture. The town has a population of about 9000, which increases, through tourism, to more than 50,000 during the summer months. The municipality is located 122 km north of Gothenburg, Sweden.

In 2015, the Sotenäs Municipality in Sweden established the Symbioscentrum (Sotenäs Centre of Symbiosis) as an organisation to implement industrial symbiosis in Sotenäs. The goal was to apply industrial symbiosis principles to strengthen the local economy socially, economically, and environmentally through designing an integrated system that viewed waste as a potential opportunity and covered many different types of waste produced by the municipality including fishing gear.[1]

Symbioscentrum aims to develop synergies between industrial players involved in renewable energy, food production, aquaculture, algae production, marine technology and innovative products, upcycling waste heat, fish industry waste, and other wastes from the neighbouring sea to create jobs (many of them green), value-added products and processes, and improvements in material and energy efficiency in the region. The creation of new jobs and encouraging the setting up of new companies is a key part of the strategy (Fig. 10.1).

[1] Industrial symbiosis is the process by which wastes, or by-products of an industry or industrial process become the raw materials for another (Chertow 2000).

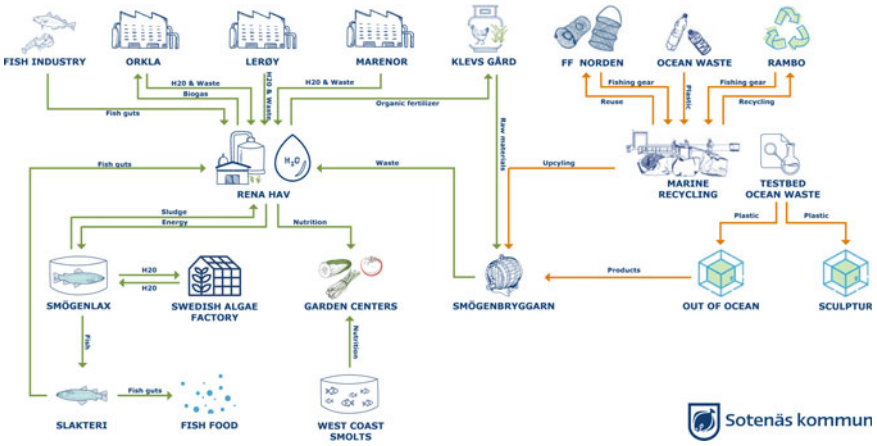

Fig. 10.1 Symbioscentrum system
Source: Sotenäs Symbioscentrum, Sotenäs Municipality, Sweden, 2022

10.2.1 Symbioscentrum's Vision

Symbioscentrum stated vision was to develop a system encompassing three core projects: (I) a biogas facility, (II) a wastewater treatment plant (WWTP) managed by Rena hav, and (III) recycling of ghost and end-of-life fishing gear (and plastic beach litter). The starting point was tackling biowaste and wastewater from the local fish processing industries to produce biogas, recycling of fat from restaurants to produce bio-diesel (no longer in operation) and plastic recycling together with Fiskareföreningen Norden (FFN) (also known as Nordic Fishermen Association (NFA)). In parallel, there were ongoing 'fishing for litter' and beach cleaning initiatives. When the activities started, the ideas for recycling ocean plastics locally were at an early stage of conceptualisation and development (Fig. 10.2).

The initial vision also included producing local food and manufacturing products in a self-supporting, financially viable closed loop circular system. What evolved was the vision of a circular economy-based rejuvenation programme involving job creation, upskilling, investment, added-value and more efficient, 'greener' use of local resources.

In 2018, Symbioscentrum brought different projects together under one 'roof'. This included an EC funded Interreg project called 'Ren Kustlinje' ('Clean Coastline') and a nationally funded project to clean beaches from ocean waste aiming to reduce the problem of plastic from the fishing and other industries. With these projects as a base, Sotenäs Marine Recycling Centre (SMRC) was established by Symbioscentrum. Initially, SMRC was designed as a small factory to disassemble fishing gear, sort the different materials, and prepare materials for reuse and recycling.

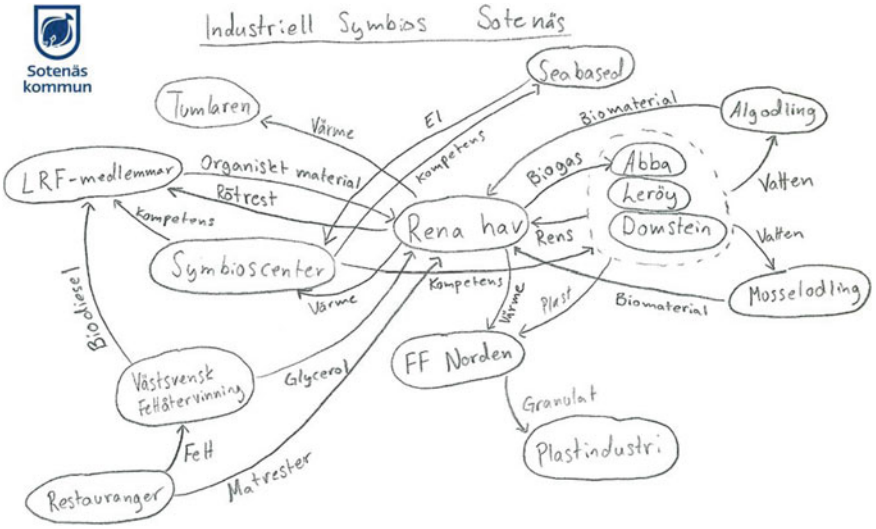

Fig. 10.2 First symbiosis map of Sotenäs
Source: Sotenäs Symbioscentrum, Sotenäs Municipality, Sweden, 2022

Management Structure

Symbioscentrum is coordinated through a manager, who reports (as at November 2021) to Director of Sotenäs Municipality, who has full responsibility for SMRC (Symbioscentrum 2020). Another key role in Symbioscentrum is the municipality's, as well as Symbioscentrum's development strategist.

A steering group was established by Symbioscentrum in 2015 to drive its evolution via project development. As at November 2021, the group comprised the Director of Sotenäs Municipality and representatives from three large companies (Orkla, Leröy, and Marenor) an SME (Rena hav), University West, Innovatum Science Park, a venture capital organisation and local politicians. The steering group was led by two project developers (now based at Chalmers Industriteknik[2] (CIT)), one of whom was subsequently involved in the start-up phase of SMRC, i.e. setting up the structure and arranging the supporting finance. The current CIT project developer was originally employed by the municipality as a project developer at Symbioscentrum, before joining CIT to support the development of SMRC and other projects. SMRC has been, and still is, financed by a mix of internal resources and a number of externally funded projects.

[2] CIT is involved in different projects related to SMRC, design of circular fishing gear and the testbed project.

10.3 Sotenäs Marine Recycling Centre (SMRC)

10.3.1 Background

SMRC was founded in 2018 as part of Symbioscentrum and has been, since its inception, backed by strong political will and engagement from the fishing community. The SMRC vision was to be a flagship for innovation and knowledge related to ocean plastics and waste fishing gear that works with the whole value chain from design to collection and recycling. SMRC is Sweden's first marine recycling centre and also aims to develop new circular products.

Starting-up SMRC included a range of tasks: securing funding, establishing small-scale sorting, building a network, facilitating the development process, and arranging logistics and material analyses. SMRC now focusses on collecting and processing ocean marine plastics including waste fishing gear. The end-of-life fishing gear processed by SMRC includes nets, cages (including lobster pots), and marine plastics found on the beaches. In addition, through its innovation testbed, TOW—working with a series of partners—it aims to identify those polymers that are best suited for use in manufactured products.

Until September 2021, SMRC employed a project developer and a project manager of TOW (Symbioscentrum 2020). Both SMRC project developer and the TOW project manager reported to Director of Sotenäs Municipality. In June 2021 as part of the development of SMRC, the municipality hired a site manager. There is now a growing team working at SMRC and the TOW innovation testbed drawn from different departments within Sotenäs Municipality (Fig. 10.3).

As previously mentioned, SMRC processes discarded and end-of-life fishing gear, e.g. nets, cages, etc. (including lobster pots) and marine plastics from beaches of the coastal area around Sotenäs. It was initially established to help tackle the problem of what to do with the large quantities of stockpiled discarded fishing gear left in harbours that were not being processed due to lack of recycling infrastructure. Fishing gear stockpiled in ports due to a lack of recycling infrastructure is a problem in many parts of the world, and Sotenäs is no exception.

The prime waste management route for end-of-life and retrieved ghost gear in Sotenäs and many other countries has, traditionally, been sending it to landfill. However, beach cleaning and the sorting of marine plastics had been carried out by Sotenäs Municipality and volunteers for decades before SMRC was founded. More recently, NFA became a promoter of cleaner seas and beaches and began to supply the Sotenäs Municipality, and SMRC specifically, with end-of-life and ghost fishing gear.

As highlighted earlier, SMRC's origins were based on a series of funded projects[3] that aimed to address the recycling of plastics from waste fishing gear and marine waste that involved various organisations from Sweden, Denmark, and Norway. One

[3] Project example: 'Ren Kustlinje'.

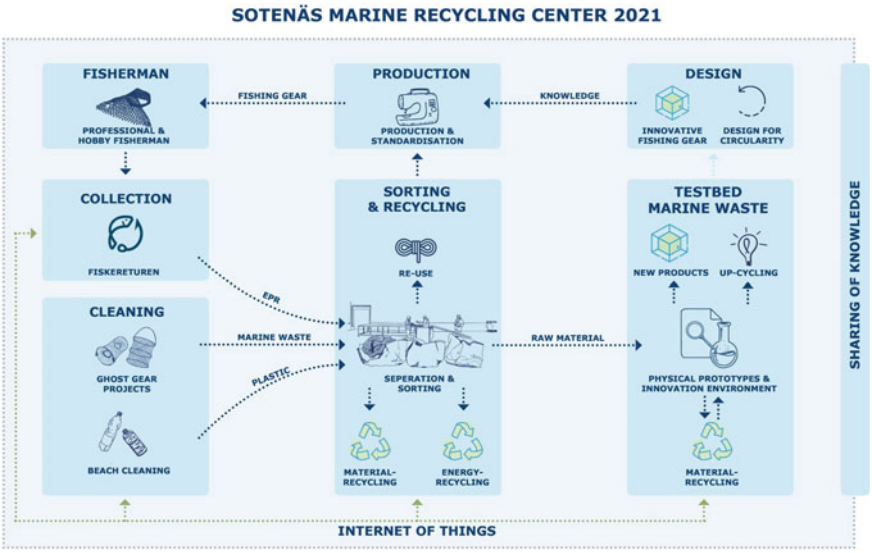

Fig. 10.3 Sotenäs Marine Recycling Centre (SMRC)
Source: Sotenäs Symbioscentrum, Sotenäs Municipality, Sweden, 2022

of those projects was the Interreg funded Clean Coastline[4] project that had different work packages including different areas of R&D. Sotenäs Municipality supported SMRC and R&D projects through funding some of its employees and providing facilities which included buildings, boats, and equipment.

10.3.2 Polymers and Metals

SMRC focusses on the three most commonly occurring polymers used for fishing gear (mainly polyethylene (PE)), monofilament nets (mainly polyamide (PA), e.g. nylon), and ropes (mainly PE and polypropylene (PP)). The types of gear collected include pelagic trawls[5] and other, smaller fishing net types. The polymers collected from ghost and end-of-life gear, and beach cleaning provides SMRC with the opportunity to increase their use in industrial scale recycling via participating manufacturers. Applications for the polymers have been identified as including furniture, building materials, footwear, and clothing.

[4] A 'spin off' of the Clean Coastline programme was the creation of a beach cleaning map of West Sweden.

[5] *Pelagic* trawls are cone-shaped nets that are towed behind one or two vessels and are designed to catch fish in the mid and surface water.

Table 10.1 SMRC: plastics and metals fractions as at November 2021

Plastics
• Combustible black (> 1.5 m: very dirty, mix PA and PET etc.)
• Combustible blue (< 1.5 m: very dirty, mix PA and PET etc.)
• PP mix (very little)
• PP ropes, blue lines
• PE nets, green
• PET (nets, ropes)
• PA nets
• Mixed ropes (PP and PE, not PA)
• PE nets, mixed
Metals
• Iron
• Lead
• Lead, mixed
• Lead ropes
• Stainless steel
• Copper

Source SMRC, 2021

A range of metals and plastics are recycled. The precise mechanism for sorting, or which fractions to be sorted, has not been finally decided at the time of the research, and trials were due to be completed during 2022 (Table 10.1).

'Floats and objects that can be reused are sorted separately', highlighted the SMRC project developer. 'We have around 20-30 different fishing gear components and sub-components that can be recycled after sorting by polymer type. They include buoys, balls, floats, and metal parts, e.g. shackles. Typically, they are 'waste' that can be reused in some capacity'.

Metals from the waste gear are also processed (sorted, broken up, and compressed) by SMRC and include lead (pure), lead (dirty), lead lines, mixed metal (which is the main percentage), and stainless-steel wires.

Fishing gear that is heavily contaminated—by bioaccumulation, sand, seashells, etc.—and that cannot be recycled or upcycled, is transported to an incinerator in Uddevalla located 60 km east of Sotenäs, where the material is used for the generation of heat and electricity for use in the Uddevalla district heating scheme. Metal parts are removed for recycling or upcycling. The contaminated mixed polymer ropes, polyvinyl chloride (PVC), and broken objects are used as 'feedstock' for the incinerator.

In the past, most of the *clean* polymers were exported to Plastix Global in Denmark for shredding and mechanical recycling into pellets for use by manufacturers in Europe and elsewhere. However, the CIT project manager highlighted that a shift in mindset started in 2021, 'we are seeing a shift now, where more and more polymers

are being used in Sweden, not going abroad, with different companies using different types of polymer'.

The majority of polymers come from Sweden's 'industrial scale' fishing fleets—rather than from ghost gear (WWF 2020)—because it is easier and cost less to obtain end-of-life gear from them than to scour the seas for ghost gear. However, ghost gear has not been forgotten.

In Sweden, retrieval of ghost gear and ghost lobster pots is carried out by the voluntary actions of divers and fishers as well as retrieval programmes that are funded by various organisations such as the European Maritime and Fisheries Fund (Jordbruksveret n.d) and Sweden Agency for Marine and Water Management (SwAM). SwAM has a larger government project related to the collection and recycling of lost and discarded fishing gear (SwAM 2022). The programmes include a Sotenäs Municipality-led project—funded by a mix of the national government, agencies, and the municipality—which hires fishers and divers to retrieve lost gear (Fishsec 2022). It is a collaborative effort between Sotenäs and the neighbouring municipalities of Tanum and Lysekil with retrieval work completed by the volunteer divers and fishers.

SMRC is now accepting end-of-life gear from other coastal regions of Sweden, as a result of funding from the Swedish Agency for Marine and Water Management's department that aims to establish a nationwide collection initiative called Fiskereturen (or 'Return of Fishing Gear'). The initiative, started in December 2019, is a joint partnership between Sotenäs Municipality, NFA,[6] Båtskroten Boat Scarp Service, and Keep Sweden Tidy Foundation ('Håll Sverige Rent').

> In Sotenäs, we accept various fishing gears because it has nowhere else to go in terms of what can be done with it. We now have people, mainly fishers and divers - a mix of volunteers and paid people - bringing ghost and other fishing gear from all over Sweden to us for disposal and recycling (interview with SMRC project developer).

10.3.3 Lobster Pots

In the waters in the Sotenäs area, several hundred ghost lobster pots are retrieved each year. To put that in context, ghost lobster pots have been gathering on Sweden's seabed for decades, with the result that there are an estimated tens of thousands of them, many still trapping sea life. Those retrieved and in a useable condition are sold directly to fishers and via the Sotenäs municipality's 'Secondhand Store'. Some are cleaned and given minor repairs at the recycling centre before being sold.

'They sell quickly', highlighted the SMRC project developer, adding, 'we are also looking at collaborating with a company that is interested in carrying out more comprehensive repairs and including innovative solutions to reduce entrapment of fish, crabs, and lobsters in case the recycled pots are lost again'.

[6] Fishers and fishing gear producers locally established in the municipality (NFA, n.d).

10.3.4 Hubs

Hubs are typically located where fishers get their fishing nets repaired by fishing gear producers, although many fishers will repair and patch their own nets. The producers and fishers repair and adjust gear for best performance and to extend product life of the fishing gear whilst adhering to the appropriate technical regulations.

During 2020, it is estimated that SMRC processed more than 170 tonnes of waste and end-of-life fishing gear that was collected locally and from elsewhere through a series of recycling hubs located in the different regions of Sweden. There are around 10 hubs in total, located in fishing villages and ports, from where fishing gear is transported by truck to SMRC.

Fishers who do not plan to repair nets themselves drop their gear off at the hubs. In some cases, gear is collected from the fishers by Fiskereturen ('Return of Fishing Gear' project) and taken to a hub, at no cost to the fishers.

10.3.5 SMRC Testbed

SMRC's innovation testbed—'Testbed Ocean Waste' (Sotenäs Symbioscentrum 2021) (TOW)—carries out different tests on the material derived from the processing of waste fishing gear and beach litter that is beyond reuse, repair, or upcycling. The tests use different production methods and consider different applications for the polymers. The goal is to support participating companies with their own innovation, for example, by advising them how to apply the tests and the results to new 'circular products'.

'That goal supports an aim of SMRC to 'Keep it all in Sweden'. A circular economy model keeps, or helps to keep, material/value locally, in Sweden, rather than it going overseas', highlighted SMRC project developer.

TOW is partly funded by Vinnova, the Swedish government's Innovation Agency, and is run by Sotenäs Municipality and testbed partners. The partners include CIT, who provide academic expertise and consultancy related to energy, materials, digitalisation, design, and project management, and other support related to circular economy thinking and practical application; Research Institute of Sweden (RISE n.d); NFA and University West.

TOW is a part of a network of testbeds in Sweden that includes the testbed for plastic recycling run by RISE in Gothenburg. RISE has a huge variety of instruments and research equipment including a large-scale 3D printer, fibre spinning, larger injection moulding, and extrusion machines, for the production of pellets, and equipment for analyses and tests managed by RISE. RISE also performs different tests on the materials to determine the properties of the polymers.

The motivation for companies to use TOW comes from a growing interest in transforming waste to value by incorporating marine plastic in products by upcycling or reuse, or by recycling polymers to produce pellets prior to manufacturing final

products or product parts. Companies participating in the TOW project co-finance through providing in-kind funding related to staff time and other contributions to the value of 100,000–200,000 SEK per company.

Nine companies are participating in TOW and a further two are in the process of joining. They range from small start-ups to large and global organisations and include producers of furniture, interior design objects, clothing and accessories, and automotive components. The companies are Sculptur—3D printing furniture; Out of Ocean—interior design and building material; XV Atelier—fashion; Scandinavia Form—interior design; add: north—3D filaments; Rewyld—accessories; Store Enso—Biocomposites; Appelviken watches—watches; and IAC Group—automotive components.

TOW uses SMRC owned equipment that includes a large and a small shredder (that creates fibres/flakes, from which pellets are made by RISE and other external partners, via its compounder); an oven; a customised compression press; a small scale/prototype scale injection moulding machine; extrusion machine; and small scale 3D printer along with handheld tools and machinery. The equipment, processes, and analyses are complemented by RISE's polymer recycling laboratory in Gothenburg.

The SMRC project developer highlighted that 'tests carried out at TOW and, where necessary, at RISE, are driven by the requirements of the participating companies and partners. In some instances, companies want information on the specific properties of a plastic, for example, to help them decide if additives need to be added to a plastic to help optimise the final consumer or business to business product. New product prototyping is primarily carried out on the companies' own production lines'.

Tests, analyses, sorting, and the use of equipment at SMRC are provided free of charge for participating companies but they are expected to give feedback to SMRC and TOW for development purposes (as part of the companies' in-kind in the project). Other benefits to companies are consultancy related to circular business development and innovation provided by Symbioscentrum, and the opportunity for companies to join Symbioscentrum's larger network of companies, institutes, and research organisations.

The tests provide a data-led basis for innovation. 'The testbed is customer-led and so responds to requirements and requests from the participating companies. It started from a clean sheet, not knowing what the companies would be interested in, or what methods, fine-tuned to each of them, they required. But we quickly adapted, in close partnership with them' highlighted the CIT project developer.

The SMRC project developer highlighted also that, TOW's participating companies come from throughout Sweden. That is good, but overall, we prefer at least some makers to be more local as we look to job creation in the circular economy in Symbioscentrum.

'Some of the companies have successfully tested and developed products with the help of TOW and are soon to launch new products. The next challenge, which we are working on, is to secure a larger scale production and flow of material to and from SMRC, all within Sweden'.

To summarise, TOW is developing and applying tests, and this process is indicating which tests perform most closely to participating companies' needs. The tests

also provide a data-led basis for innovation for the participating companies. In addition, TOW is producing a number of prototype circular products. The work at TOW and lessons learned is helping SMRC to get more involved in developing European standards for the circular design of fishing gear and other areas—see the section on 'Standards' in this chapter.

10.3.6 Social

There is a strong social element to SMRC. The municipality's work training programme includes trainees from: (i) the local unemployed, who gain work experience and (ii) migrants and refugees who benefit from becoming better acquainted with Swedish culture and language, developing social skills, and better understanding the Swedish work environment. All trainees receive an income from the municipality.

The trainees' work covers separating and sorting fishing gear and beach plastic. In addition, they help to clean the beaches and coastal area of the municipality when the weather allows for it—primarily, but not exclusively, in the summer. This way they gain experience of both indoor and outdoor work whilst making a positive contribution to cleaner beaches and improving their prospects for re-entering the workforce locally or elsewhere in Sweden.

10.4 Challenges

10.4.1 Funding

> An early challenge was gaining funding. The resources required to do what we are doing needs funding because SMRC was not a commercially viable entity, although multiple benefits can be leveraged from it, highlighted the CIT project coordinator, further adding, key for an operation like SMRC is public funding with the long-term aim of achieving commercial viability via the supply to businesses of recycled and other post-processed raw materials of high value.

10.4.2 Bringing Fishers on Board

Engaging fishers in the recycling of fishing gear is essential. The SMRC project coordinator added 'a perceived early-stage challenge was getting fishers and producers to work with us. However, the fishers did not really present much of a challenge to engage because they were keen to help and in fact were a key partner—as represented by the NFA—from the beginning. Members even voluntarily gathered fishing gear together, at their own docks, for several years before SMRC was started. The NFA

has been supporting the centre and been a driving part of it from day one'. So, the challenge actually became an opportunity due to the leadership displayed by NFA.

10.4.3 Different Stakeholders, Different Responsibilites

Another major challenge faced by SMRC was working with a variety of different stakeholders, each with their own, different, responsibilities but all being unsure over what to do with marine waste. A big problem was identifying who was responsible for marine waste in government, because it fell between different bodies. That means that even waste fishing gear—for example—was the same, whether it is in the ocean, has floated ashore, or was lying in harbours, the question of which agency should do what with the waste was generally not addressed.

'Historically, that created confusion and wasted time, but now SMRC is helping to coordinate things more effectively', highlighted the CIT project developer.

The agencies involved—with their responsibilities are in brackets—include the Swedish Environmental Protection Agency (SEPA) (waste on land/beaches), Swedish Agency for Marine and Water Management (SAMWM) (waste in water), Swedish Transport Agency (waste in docks), and municipalities (waste in the local environment/local beaches). SEPA and SAMWM provide funding to SMRC.

The issue illustrated above is not just a Swedish challenge but is also true in other countries in Europe and worldwide as marine plastics and waste fishing gear are increasing being recognised as a horizontal issue. Developing a cross-cutting policy development and coordination that works across different government ministries would perhaps start to address some of the duplications and complexities. This will be increasing important with the emergence of EPR legislation in Europe and other emerging policy development associated with marine plastics globally.

10.4.4 Persuading Businesses to Start up in Sotenäs

A further challenge has been persuading businesses to start up in Sotenäs, and for early stage and established businesses, to be able to deal with the availability of fluctuating volumes of polymers from waste fishing gear for production. 'We are having successes with established businesses—for example, with an interior design and building materials company, Out of Ocean, that was set up in Sotenäs (Out of Ocean n.d), but our main focus is supporting start-ups in an early development stage and attracting them to be based in Sotenäs as part of Symbioscentrum. For example, Impossible Plastics are in the process of setting up a facility in the municipality', indicated the CIT project developer. The approach aims to support start-ups applying innovation to waste fishing gear to develop circular products that then generate 'green' jobs in the municipality or elsewhere.

10.4.5 Provenance and Traceability—Track and Trace/ The Internet of Things

Traceability is another challenge as with increasingly environmental and climate change anxieties, businesses and consumers are becoming more concerned about the genuine provenance of raw materials and finished products and demanding higher quality proof. Provenance is all about proof of authenticity of origin (Woodham 2021).

Increasing traceability of fishing gear components used in manufactured products will be beneficial to all stakeholders. By developing processes that enable tracking and tracing of fishing gear, this will give more confidence to customers and other stakeholders in what the sector of the provenance of discarded fishing gear at the end of life.

A Vinnova funded project based on Internet of things (IoT) has been set by CIT in association with SMRC to help us develop a best of breed 'track and trace' system through tagging raw materials and auto-tracking them, end-to-end from the start of the supply chain to the point of manufacture.

The CIT project developer explains 'increasing demand by consumers for transparency, and the facts about provenance of materials are driving the need for higher quality traceability. IoT provides the means to track and trace fishing gear throughout the lifecycle. We have had a simple system with name tags on materials in the different stages of the value chain (collecting, sorting, etc.). The data related to the tags are then fed into an IT system. In the future, we might use QR-codes and equipment, such as scales for weighing fishing nets, directly connected to the IT system'.

10.4.6 Extended Producer Responsibility

EC Extended Producer Responsibility (EPR) legislation will place responsibility on fishing gear producers for the financing, collection, and recycling of end-of-life disposal of fishing gear throughout Member States. The system is an all-embracing recycling system including reporting to the agencies, collection, transportation, and recycling, and in parallel, a European standardisation process has started.

SMRC is already preparing for EPR rollout across the EU in early 2025. SMRC project developer highlighted that SMRC's experience will be useful in the future EPR development in Sweden. 'We are involved in a project with SEPA and SAMWM which aims to involve different stakeholders that will be affected by the EPR to implement and test the system before it becomes legislation in 2024'. The main focus of this project is to test and develop the EPR system nationally, with one element also focussing on the standardisation process.

Standards

A new project on *design for circularity of fishing gear* has been set up at SMRC. It is led by CIT, working closely with NFA and SMRC. 'Together, we are looking to create standards for how gear can be designed for circularity. Circularity, as it applies to fishing gear and beyond, is a key element of Symbioscentrum's ethos', says CIT project developer.

In November 2021, the European Standards body (CEN) started a technical committee TC 466 to development a series of standards related to circular design, circular business models, and digitalisation of fishing gear. 'We are at an early stage in our thinking about standards, but we believe that standards will evolve at a European and Swedish national level. To that end, we are collaborating with Swedish Institute for Standards (SIS) and others as the project develops to ensure that we are inputting our knowledge and influencing the process'.

Lessons learned at SMRC and TOW will be helpful for stakeholders in the fishing industry in Sweden, and across Europe and elsewhere, because EPR and circular design will force a rethink by all parties, e.g. fishing gear designers, manufacturers, etc., about their post-sales responsibilities.

'Historically, fishing gear has not been designed to be easy to disassemble and/or recycle. Design for circularity overcomes the problem of the complex work, and therefore, time involved in separating the component parts of ghost and end-of-life gear, and then reusing and/or recycling them'.

The CIT project developer highlighted that

> It is highly desirable to have gear that is designed specifically for easy disassembly and with the parts easier to recycle. Historically, gear has used three different types of plastic where, today, just one type could in theory be used, making life easier for us and therefore product manufacturers (Charter et al. 2020).

The SMRC project developer comments, separately, SIS has set up a Swedish technical committee related to waste fishing gear that includes SMRC and others, which means that SMRC is involved in forthcoming European standardisation work on 'sustainable fisheries, aquaculture, and fishing gear' (CEN TC 466). The technical committee's start-up meeting was in November 2021 which means that SMRC and other Swedish stakeholders will be engaged in the future meetings.

10.5 Key Findings: SMRC and Its Work

There are a number of key findings from the development and operation of SMRC that are listed below. These findings are important for stakeholders that are in the process of establishing the infrastructure for the recycling of fishing gear.

10.5.1 Local Support and Funding

The involvement of the local municipality, specifically its funding, buy-in, and political support was essential to establishing SMRC in Sotenäs. Funding from central government and the engagement from local organisations including NFA has also been key factors in SMRC development.

It is uncommon for a municipality in Sweden to become so involved in a project like SMRC, but its support has been vital to kick-start the project and keep the momentum going.

10.5.2 The Role of External Partners and Companies

Different projects require different partnerships with different expertise. Sotenäs Municipality has built expertise at collaboration, identifying potential projects, and finding funding. Where specific skills are needed, the execution of a project is often carried out by one of the partners. The collaboration provides expertise, flexibility, and 'agility' at lower cost or more cost effectively. The municipality collaborates with external partners because—as is typically the case with a municipality in Sweden—it does not have all expertise in-house; and if it did, it would be at a high cost.

The support of CIT and other academic partners—that provided expertise and manpower—has also been important to the project. CIT continues supports the municipality with expertise in industrial symbiosis, circular economy, innovation management, logistics, resource mapping and analysis, etc. The input and engagement with fishers via NFA were essential to the development of SMRC and TOW, as they have deep knowledge about fishing gear, its components, and why different materials are used.

10.5.3 Vision

It is essential to have a vision and guiding principles to support future direction. The key players—Symbioscentrum and NFA—both developed visions that were aligned to support the overall development of recycling of fishing gear with SMRC have developed a more specific vision.

Symbioscentrum's vision (see 10.2.1**).** The vision started with the recycling of fishing gear and has evolved to consider the circular design of nets and the creation products from polymers from end-of-life gear.

NFA vision. NFA developed a vision 15 years ago that incorporated sustainability in its working practices, when it recognised that it had to become more sustainable

to survive. 'NFA began to see the benefits of using more selective fishing[7] gear and started to collect end-of-life gear to prevent it from becoming ghost gear—and to recycle rather than dump it in landfill', highlighted the SMRC project manager.

NFA subsequently invested considerable time and expertise in recycling fishing gear. The founder and Chairman of the Board of NFA highlighted that fishers 'should have a holistic view and not leave anything behind in the sea', and further added:

'SMRC allows us to demonstrate to the fishing industry, in an informed way, the benefits of picking up all the nets and all the rubbish dropped into the sea and the importance of keeping the seas clean and the fish healthy' (Symbioscentrum 2020).

It was recognised early which is there must be no cost to fishers to engage with fishing gear recycling, e.g. if there is a cost to fishers, they will not be interested in participating.

SMRC vision: SMRC vision is to be a flagship for innovation and knowledge for ocean plastics and fishing gear that works with the whole value chain from design, collection, and recycling to the development of new circular economy products. This is to be achieved through:

- Creating and developing a value chain related to polymers and other materials arising from waste fishing gear
- Creating a world class research centre lab for ocean plastic waste in Sotenäs, e.g. to be a 'centre of excellence' for research, development, and networking related to ocean plastics
- Acting as a testbed for sorting and recycling of fishing gear
- Contributing to the development of standards development relevant to EPR and the circular design of fishing gear
- Having a digital twin of the facility, through creating transparent tracking of the entire system via IoT
- Sharing the model with other countries to help: (i) increase the reuse and recycling of ocean plastic, (ii) increase value of the materials, and (iii) help clean the oceans globally by working 'glocally'—working globally and locally.

10.5.4 Project Development

Since SMRC was founded, several projects of different sizes have been carried out that contributed to its development. Some of these have been funded through EU funded Interreg projects, Swedish government innovation projects and other financial support programmes as well as regional and locally financed projects. The ability to join up the separate, individual projects, and build on the knowledge and learning has helped SMRC move forward despite a lack of strategic core funding.

[7] Selective fishing gear is a process that has been developed and used by NFA to reduce by-catch and the 'wrong' catch by using parts in their nets that let unwanted fish out. It also allows fishers to capture only the size of catch they want (SLU 2021).

10.5.5 Best Practice

SMRC is developing examples of best practice related to the recycling of fishing gear that includes collection, sorting, circular design, and testbed development. At present, this has not been documented or published. The goal is to share knowledge and experience in Sweden, Europe and/or the rest of world particularly related to: (i) test methodologies, e.g. the use testing of a different types of polymers for possible use in the manufacture of new products, (ii) technology methodologies, e.g. manufacturing methodologies, and (iii) sharing of the findings of how to set up and manage a fishing gear recycling system with interested parties.

10.6 Key Lessons Learnt and Insights

There have been two key learnings that have been crucial for the development of SMRC: (i) gaining the local political will from Sotenäs Municipality to invest in SMRC and related initiatives and (ii) getting fishers' and volunteer marine waste collection groups' buy-in to the project. Fishers, via NFA, have been highly instrumental in the success to date of SMRC. The success includes the creation—driven by SMRC—of regional hubs throughout Sweden that feed end-of-life fishing gear and ghost gear to the centre.

SMRC:

- Is developing a model, aligned to its vision—that could be duplicated elsewhere in the world—for an end-to-end, closed loop system starting with circular designed fishing gear, locally-based manufacturing and services, and related work experience, training, and job creation
- Will potentially act as a magnet for new businesses that align to the goals of Sotenäs Symbioscentrum, in which SMRC is playing the leading role related to waste fishing gear
- Is sharing best practice, knowledge, and information, in order to help accelerate change in fishing gear recycling and circular economy thinking elsewhere
- Is engaging in standards development related to the recycling and circular design of fishing gear, e.g. design to increase the speed and ease of disassembly and improved recyclability. SMRC is now involved in providing inputs into European standards development in relation to EPR legislation that will impact on the fishing industry in Europe starting in 2025.

10.7 Conclusions

SMRC—under the umbrella of Symbioscentrum—has come a long way since it emerged as an idea from an EU funded Interreg project that aimed to help prevent marine waste involving partners from Sweden, Denmark, and Norway.

SMRC's progress has been built on a close working relationship with NFA (fishers) and with CIT (research and innovation). The collaborative relationship with CIT has fostered critical thinking and work, related to circularity, testing, IoT-based tracking, and initial standards development.

These collaborations demonstrate that partnerships can help make things happen at a regional or local level, and more speedily, because typically, a local municipality will not have all necessary resources in-house to do all the work itself. It is simply too costly. Partnering has also allowed for greater flexibility and greater business agility.

SMRC is showing that its local model for the retrieval and processing of waste fishing gear and ocean waste can be expanded to include an entire country via remote hubs; and can, with its parent, Symbioscentrum, be part of something transformative: strengthening and deepening a local economy through circularity and innovative thinking.

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