Blue Circular Technology

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Blue Circular Technology

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Experts were drawn from the following organisations. Note that the information contained in the report represents the personal views and opinions of the contributor and does not necessarily represent the views or opinions of the organisations they are affiliated with.

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Global Ghost Gear Initiative, Canada
Halpin Centre, Ireland
i-Coats, Belgium
Indigo Waters, Taiwan
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National Cheng Kung University, Taiwan
Ocean Legacy
World Wildlife Fund, Germany

Glossary of terms

The technology field uses many specialist terms and abbreviations. This glossary is provided to help the reader navigate some of the less familiar terms. Two key phrases in this report are:

Blue Circular Technology (BCT): Blue Circular Technology (BCT) is the application of novel 'Industry 4.0' and related technologies to unlock the benefits of the circular economy for the marine environment

Industry 4.0 (I4.0): The term 'Industry 4.0' (sometimes used interchangeably with '4th Industrial Revolution') has its origins in manufacturing and is used to describe smart production facilities based on technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics and automation. These facilities are also known as smart factories, and in these smart factories equipment is capable of autonomously exchanging information machine-to-machine and, together with new industrial processes such as additive manufacturing (3D printing) and bioreactors.

The following table contains descriptions of the key technologies that the authors are including within the scope of BCT:

Key Technologies in BCT	
Term	**Description**
Acoustic / Underwater GPS	Acoustic positioning and navigation systems, often with floating base points, that provide a live GPS position for underwater objects
Additive Manufacturing (3D printing)	The creation of 3D objects through layer-by-layer deposition of metals, polymers, or biological materials
Advanced Analytics	Advanced Analytics are autonomous or semi-autonomous software tools using techniques and tools that go beyond spreadsheets and traditional reporting tools. Advanced Analytics includes many of the so-called Big Data techniques for working with diverse, large datasets
Advanced Materials	Advanced materials are designed with a purpose to have novel or enhanced properties and improve performance over conventional materials in products and processes. Example of advanced materials are reinforced composites, nanomaterials, bio-based materials, and biodegradable materials

Artificial Intelligence (AI)	Systems iteratively trained on large datasets to mimic some aspect of human intelligence. Currently, it is more correct to speak of machine learning and deep learning systems that, for defined objectives, make predictions, recommendations, or decisions
Bio-Based Materials	See Advanced Materials
Biodegradable Materials	See Advanced Materials
Bioreactor	A bioreactor is a device where a biological reaction such as fermentation or growth of an organism is carried out. They are usually a closed and the process can be aerobic or anaerobic
Blockchain	A blockchain is a collaborative, tamper-proof ledger that maintains transactional records. Blockchain is the underlying technology of cryptocurrencies, but is also used for maintaining traceability of physical objects through their life cycle
Chemical Recycling	Chemical recycling is the process of turning any plastic polymer into its original monomers. When the monomers are separated, they can be re-formed into other materials (including new, virgin plastics)
Computer Vision	Computer vision is a field of computer science that enables computers and systems to derive meaningful information from digital images, videos, and other visual inputs
Digital Business Models	Digital business models use digital technologies to either transform or create new businesses, go-to-market approaches, and product and service combinations. This often results in a disruption of value chains
Digital Twin	A digital twin is a digital representation of an object or process that covers its life cycle. Ideally, a digital twin is updated from real-time data gathered from sensors.
Edge Computing	Edge computing is a distributed computing model that brings computation closer to data sources such as IoT devices or other local devices or servers

Integrated Recycling	Integrated process lines that bring sorting and washing of plastic waste, mechanical and chemical recycling, and upcycling into a single system. Integrated recycling systems are of particular interest where mobile solutions are desirable
Internet of Things (IoT) / Machine to Machine Communication (M2M)	Networks of physical devices and machines (things) embedded with special software and sensors, which allow them to connect and share data 'machine to machine'
Mechanical Recycling	Processing of plastic waste into secondary raw materials without significantly changing the chemical structure of the material
Robotics & Automation (including ROVs and AGVs)	Robots are any autonomous machine that can sense its environment, employ algorithms to make decisions, and performing actions in the physical world. Automation is the umbrella term for use of electronics and computer-controlled devices to control of processes and machines. Remotely operated vehicles, or ROVs are underwater machines controlled by a person on a surface vessel. When the control is by means of an AI, these vehicles are called Automated Guided Vehicles or AGVs
Satellites	In this context, a specialised receiver/transmitter that is in orbit around the Earth.
Sensors/Smart Tags	A sensor is a device that detects and responds to input from the physical environment (such as a change in pressure or temperature). Sensors can be 'smart' combining signal conditioning, embedded algorithms, and digital interfaces. Smart tags are a type of sensor that is attached to an object to monitor location and track it in real-time

Side Scan Sonar	Side scan sonar is a type of active sonar system for detecting and imaging objects on the seafloor
Thermal Recycling	Use of thermal conversion methods such as pyrolysis and gasification as a recycling method for plastic polymers

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Introduction

Definitions

This report defines Blue Circular Technology as "Blue Circular Technology (BCT): Blue Circular Technology (BCT) is the application of novel 'Industry 4.0' technologies to unlock the benefits of the circular economy for the marine environment."

Industry 4.0[1] is progressively moving into more and more sectors as a key technological enabler of the circular economy. See Figure 1 for more detail on the relationship between Industry 4.0 and BCT.

Figure 1 Industry 4.0 and Blue Circular Technology (BCT).

Aim and scope of the research

The aim of this report is to identify use of novel technologies in relation to the development of products from waste fishing gear and the recycling of fishing gear (Blue Circular Technology or BCT). Specifically, to share:

- Examples of organisations currently using Industry 4.0 technologies to create products
- How organisations are using Industry 4.0 technologies to build up the recycling value chain
- The broad challenges encountered by these organisations in product development and recycling, and those associated with technology specifically; and

[1] Industry 4.0 (I4.0): The term 'Industry 4.0' (sometimes used interchangeably with '4th Industrial Revolution') has its origins in manufacturing and is used to describe smart production facilities based on technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics and automation. In these smart factories, equipment is capable of autonomously exchanging information machine-to-machine and, together with new industrial processes such as additive manufacturing (3D printing) and bioreactors.

- Emerging trends and future opportunities for further exploitation of Industry 4.0 technologies

The scope of the project is value chain shown in Figure 2.

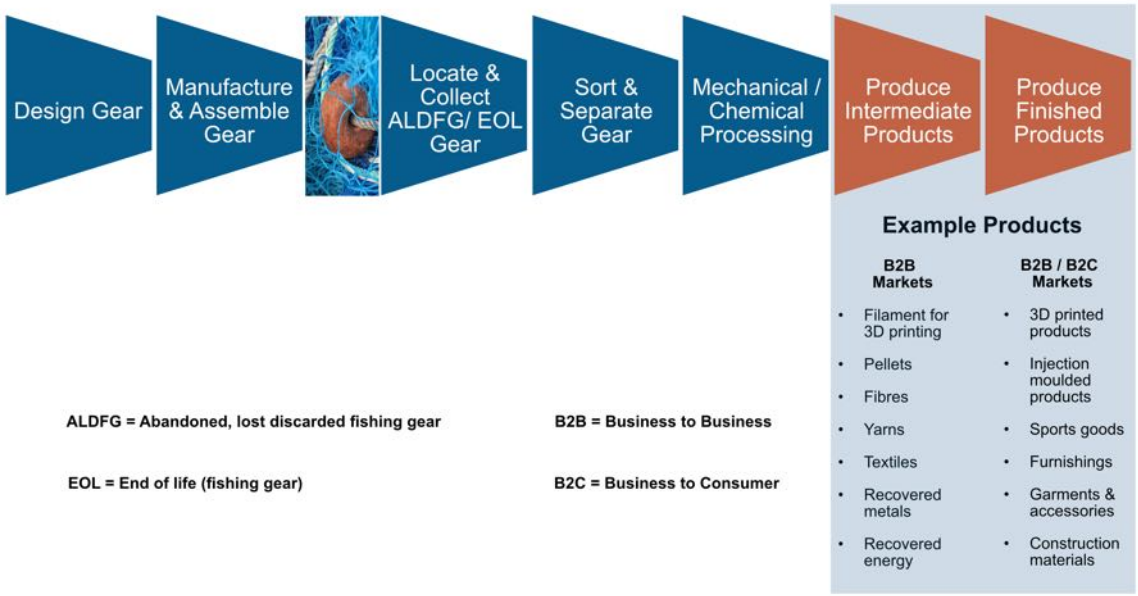

Figure 2 Value chain for the project showing the lifecycle stages and definition of products.

Project approach

Three complementary approaches were used for this project: online searches and follow-on desk research, an international survey, and expert interviews. The results of these are summarised in Figure 3.

Figure 3 Research approach and results.

Although there was strong uptake of the survey, it is important to note that no gear manufacturers or assemblers responded.

Context

There are many statistics about the scale of the issue with end of life (EOL) and abandoned, lost and derelict fishing gear (ALDFG). Irrespective of which numbers you choose to believe, that number is a large one (for example, in 2020 a report from the World Wildlife Fund stated that 5.7 per cent of all fishing nets are lost each year globally[2]). However, and more importantly, a significant proportion of the waste fishing gear either stored in port or harbour areas goes to landfill or is incinerated.

This report does not dwell on the size of the problem, rather it looks to the potential opportunities and the role new technology can have in securing benefits for all in a circular economy. In particular, the role of technology becomes central to success in the context of the circular economy as product markets shift from niche brands and hand-made, limited run items (artisanal markets) to industrial scale and global industry verticals.

Fishing gear has been recycled for many years all over the world but is localised, fragmented and unsystematic at present. The success of companies such as Aquafil (using chemical recycling) and Plastix Global (using mechanical recycling) shows that commercial scale can be achieved for nylon and polyethylene recycling. Yet our research and survey of more than 70 experts reveals continued concern over the viability of gear recycling business models, and the need for innovation in basic areas such as mechanical recycling and low-cost identification of materials.

As big brands in consumer goods, automotive and fashion increasingly demand recycled content with a known provenance, opportunities for all involved in the fishing gear value chain also increases. However, the value chain for fishing gear has slowly evolved over time, rather than being constructed, and this needs to change. Legislative instruments such as the European Directives on Port Reception Facilities and Single Use Plastics (SUP, including Extended Producer Responsibility, or EPR, provisions) are likely to drive behaviour change in a beneficial direction.

In addition, in 2024, the fishing and aquaculture industries in Europe will have new design and lifecycle standards to work with resulting from CEN/TC466 (Sustainable Fisheries Aquaculture and Fishing Gear Technical Committee). These will assist in the circular design of fishing gear and aquaculture equipment.

Industry 4.0

A decade ago, the German government used the phrase "Industrie 4.0" to describe a new way of manufacturing. Today, Industry 4.0 is a catch-all term for wide ranging advances in design, manufacturing, and processing techniques, automation, and data exchange. The focus is on integration across the value chain, rather than on improving individual processes and machines. Decentralisation rather than centralisation.

[2] https://wwf.panda.org/wwf_news/?983716/New-report-from-WWF-says-abandoned-fishing-gear-an-immortal-menace-which-must-be-central-in-the-fight-against-plastic-pollution

Industry 4.0 appears to be a new term in the marine sector and especially in relation to the application of circular solutions for end-of-life fishing gear. The sector is primarily at the Industry 3.0 state and so a complete set of “cyber-physical” technologies have not yet fully emerged. Figure 1 (above) shows the range of technologies that could fall under the Industry 4.0 banner for fishing gear.

The phrase ‘Blue Circular Technology’ encompasses the growing application of Industry 4.0 in marine settings. As with all sector-specific Industry 4.0 applications the drive is for interconnection across lifecycles and value chains, and increasingly intelligent and autonomous systems. Examples of what this could mean in practice for fishing gear are:

- Connecting vessels, nets, buoys, trucks, recycling equipment and product manufacturing together to provide full information transparency. For example, using Radio Frequency ID (RFID) tags and QR codes to track end of life nets from harbour collection through the many steps in recycling to 3D printing filament of known provenance
- Increasing use of robotics and automation to locate, transport, separate, recycle and process gear. For example, using AI to automate underwater, remotely operated vehicles, using robots for retrieval of ghost nets, and automated sorting of materials using spectroscopy and computer vision
- Using technology to improve the way that people interact with each other, the information they need, and the processes they support. This could range from interactive platforms for enhanced collaboration between the various stakeholders involved with planning recycling processes (using specialist tools or Zoom, Microsoft Teams etc), collaborative Computer Aided Design (CAD) systems for gear and product design or simulating process improvements using Digital Twins (virtual models of fishing gear and recycling processes), something already underway at Sotenäs Symbioscentrum in Sweden
- Exploiting real-time data from sensors and tags attached to gear and equipment to make the supply of gear for recycling more predictable, optimise end-to-end recycling processes, and develop nets and materials that are designed for longer life, upgrading, reuse, refurbishment, remanufacture and recycling; and
- Developing both more efficient and effective practices at various points in the lifecycle of fishing gear. For example, through local and regional productive systems that offer stakeholders access to prototyping, test beds and laboratories for recycling using Industry 4.0 technology.

In sectors that are more advanced with Industry 4.0 (such as chemicals and agriculture) novel processing and manufacturing techniques are typically associated with “cleaner” material cycles and circularity (meaning they use more renewable and recyclable resources and less virgin materials). For fishing gear, there are already examples of this in action such as 3D printing using recycled PA6 nylon and energy recovery during recycling. Further, recent articles emphasise the importance of Industry 4.0 in making the circular economy profitable through innovative solutions based on the Internet of Things, 3D printing, blockchain and other novel technologies.

Finally, industry 4.0 is closely aligned with new, digital business, and the wider digitalisation of information and communication technology (ICT) infrastructures through cloud and platform technologies, and the associated economic, commercial, and social impacts.

Industry 4.0 is already re-shaping recycling into “Waste Management 4. 0”: closed-loop, integrated, “cyber-physical” waste management systems. Currently, the reality for fishing gear has been isolated prototypes, proofs of concept and pilot systems. Diffusion of Industry 4.0 is gaining momentum, but there are still barriers in terms of a lack of appropriate skills, clarity about attractive technology use cases, innate conservatism of the sector, and a reluctance to be early adopters.

Despite being at the beginning of the Industry 4.0 journey, this research shows that there are many projects globally (documented in the Annexes). While many are one-off investments for academic research, some have been running for several years and are ready to scale. Perhaps if there had been more input from gear manufacturers, the list might have been even more impressive

The remainder of his report gives practical examples of Industry 4.0 in action in EOL and ALDFG and offers a positive vision for how all involved in the value chain can thrive.

Challenges

At sea and on land

Success with novel technologies is always greater when there is a recognised need or a well-defined problem to be solved. Recycling of ALDFG and EOL fishing gear present many problems that technology can assist with. The following list summarises some of the key challenges that BCT could address:

- How to locate ALDFG as some nets may have been submersed for decades. There is also the question of how to engage a broad range of stakeholders in locating and classifying gear (e.g., divers, beachcombers, harbour masters)
- Missing information on where and what gear is stored on vessels, and in ports and harbours
- Tracking and tracing gear to ALDFG and EOL is currently problematic, with limited transparency and traceability of materials
- Improving efficiency and effectiveness of collection of nets on land and at sea. The infrastructure for collection is often poor, and optimising logistics (including reverse logistics) can be complex in coastal areas with few major roads
- Disassembly of gear that is not designed with that in mind. Eco-design is not commonly used by manufacturers/assemblers (design processes can be informal, and customisation is common)
- Identification and sorting of the types of fishing gear (e.g., need to differentiate between static gear, pelagic and demersal gears as they pose different challenges)
- Classification of materials in the mix can be difficult. Often there are multiple polymers, metals, coatings to be identified and separated and material mix (polymers, metals etc). Large nets cost a lot of money and so are worth repairing, and this may further mix materials
- Poor information on availability and condition of nets for recycling, availability of capacity at specialist recycling facilities[3] and demand from product manufacturers and their customers (for example, big brands)[4]
- Process knowledge gaps and limited access to R&D for SMEs in areas such as material science. Many recycling processes (especially chemical and thermal) are proprietary, and so much current knowledge related to material processing technologies is held as trade secrets by individual companies
- Real-time data capture underwater, and remote monitoring of gear, in general
- Measuring the hazards and environmental impacts of washing systems, chemical and pyrolytic processes[5]

[3] There are few specialist recyclers with appropriate shredding and cleaning equipment for fishing gear. Few general purpose or municipal recycling centres are equipped or designed to handle fishing nets.

[4] This leads to commercial challenges in processing gear. A sustainable business model requires a stable and predictable supply of fishing gear, and access to end markets for recycled raw materials, products etc. Upscaling from pilot projects remains difficult in relation to supply, quantity, certification of both properties and provenance, and logistics.

[5] Cleaning of older nets can be problematic due hazardous coatings, as well as accretions of biotic materials. Aquaculture nets are often contaminated with anti-foulants (greases, metals such as copper). The costs and hazards can become prohibitive enough that gear is shipped to landfill or incinerated rather than recycled.

- Labour intensive activities such as net disassembly, cleaning of gear, sorting and separating net materials, and recovery of nets from the seabed
- Lack of automation through the lifecycle; and
- Capturing data to support reporting on environmental regulatory compliance (an issue likely to be exacerbated with EPR legislation in Europe in 2025).

There are many open questions about the suitability of Industry 4.0 technologies for fishing gear. Favourable outcomes with any new technology require a use case that has proven benefits and incentives for stakeholders, an appreciation of how to mitigate technology risks, and a business case that reflects the economic realities of the technology (i.e., is R&D required? What about long-term costs of ownership?) and the industry itself (e.g., low margins, limited access to venture capital). Where there are current exemplars (e.g., Sotenäs Symbioscentrum and Marine Recycling Centre) these are still building scale and proving technology feasibility.

Many of the end users of technology solutions for fishing gear will be small and medium sized gear manufacturers, specialised recyclers, and fishing cooperatives and, from the expert interviews conducted for this report, there is a lack of awareness of the latest technological developments, and a general lack of availability of skills in designing, developing, and maintaining advanced technology.

There are two broad challenges that BCT needs to help address: the commercial viability of recycling of the gear and accessing and creating markets for the output (whether as pellets, filaments etc, or as finished products). Ultimately, the size of market opportunity, such as demand for recycled plastics in multiple business to business (B2B) sectors), may be the key to unlocking the potential of new technology.

Current business to consumer (B2C) and B2B product markets for recycled fishing gear are relatively low volume or immature. There are few (if any) commercial consumer products of scale made directly from pellets and filaments, and the yarn, fibre and textile markets are still dominated by one or two early entrants, notably Aquafil.

However, as global fashion brands such as Patagonia have shown with NetPlus®, and Prada and Burberry with ECONYL®, there is a powerful movement underway to switch to recycled fibre content from fishing gear with known provenance. For the stakeholders in the gear value chain this B2B market is likely to be the growth market, particularly when there are more advanced materials available (such as technical fabrics and reinforced polymers for structural applications) that will bring in customers in key sectors such as aerospace, automotive and construction.

Building up the recycling value chain

A broader challenge is the variation in maturity of recycling value chains, and low technology maturity generally, for fishing gear in comparison to municipal recycling. To justify investment in new technology there needs to be a system that delivers sufficient and reliable volumes of fishing gear. Looking at successful recycling schemes based in Canada, U.K., U.S.A., Sweden, and Ireland (Steveston Harbour Authority, Odyssey Innovation, Net

Your Problem, Sotenäs Centre of Symbiosis, and Bord Iascaigh Mhara) they have developed different regional models that often use point solutions[6] to address specific problems, rather than developing fully integrated, Industry 4.0 style systems.

In contrast, Nofir and Aquafil offer a more globally integrated model to produce nylon PA6 granules and pellets. However, this is proprietary system that has benefited from substantial investment over several years and so is difficult to replicate for smaller players.

From what is happening in other sectors, such as agricultural recycling, irrespective of whether regional/local or global systems are developed, Industry 4.0 can help in capacity building and resource sharing across the value chain. It is important not see Industry 4.0 as a panacea, but it does provide necessary tools, connectivity, and value chain linkages to enable efficient and effective co-operation. Of course, this all depends on adequate public and private financing and a robust digital infrastructure for circular approaches.

[6] Point solutions are where a technology choice solves a specific problem at a given moment in time. The technology choice is often one of convenience and may be abandoned if a strategic or scale solution is required. It is worth noting that some point solutions can last for many years.

Blue Circular Technology research findings

Understanding the state of the art for BCT

The project approach in Figure 3 yielded:

- 48,000 search results containing 177 applications of BCT across 129 organisations (companies, projects, and NGOs) in 25 lead countries. Examples of applications across the fishing gear lifecycle include:
    - Mitsubishi in Japan developing KILAVIS™RC, a new nylon filament yarn mixed with nylon resin recycled from fishing nets discarded in Japan, and produced in a new mass production system
    - In the US, Hydronet: Underwater networks comprised of acoustic modems and software that provide scalable, high-speed Wi-Fi underwater
    - Novel shredding machines for fishing gear from the Chang Woen company in Taiwan
    - Project Glaukus in the European Union: a complete redesign of the lifecycle to enhance biodegradability and bio recyclability
    - Bluecycle Lab in Greece making pellets for recycled 3D printing filament, and other industrial uses
    - Collecte Localisation Satellites (CLS) in France developing an autonomous underwater robot for locating lost fishing gear at great depths

- 112 academic papers covering key topics such as automated recycling systems, advanced materials, and the relationship of Industry 4.0 to the circular economy. Sample titles include:
    - BERTELSEN, I. M. G. & OTTOSEN, L. M. 2022. Recycling of Waste Polyethylene Fishing Nets as Fibre Reinforcement in Gypsum-based Materials
    - MONDRAGON, G., KORTABERRIA, G., MENDIBURU, E., GONZÁLEZ, N., ARBELAIZ, A. & PEÑA-RODRIGUEZ, C. 2020. Thermomechanical recycling of polyamide 6 from fishing nets waste
    - WEISSBAC, G., GERKE, G., STOLTE, A. & SCHNEIDER, F. 2021. Material studies for the recycling of abandoned, lost or otherwise discarded fishing gear (ALDFG)

- 36 patents for innovations in areas such as net location, pyrolytic processes, spectroscopy, and net design. Sample patent titles include:
    - SYSTEM, APPARATUS AND METHOD FOR IDENTIFYING THE LOCATION OF LOST FISHING GEAR USING IP-RFID
    - INTELLIGENT DEVICE FOR SALVAGING FISHING NETS LOST AND DISCARDED IN OFFSHORE SEABED
    - CUTTING AND SHREDDING DEVICE FOR COASTAL WASTE PROCESSOR

- 71 survey responses from 27 countries covering NGOs, governments, SMEs, academics, individual experts, fishing-related organisations, recyclers, large companies

- 14 expert interviews representing SMEs, standards, start-ups, NGOs, large companies, and academics. These were backed up by an expert discussion of key findings on 27th May 2022.

The full results are contained in the Annexes.

Applications

Online searches were the starting point for locating applications of BCT. Simple searches using a single search engine will typically bring back thousands of off-topic or junk results. To improve targeting of the searches for this project more specialist tools were used.

The main tools used were:

- DevonAgent and DevonThink from Devon Technologies. These are flexible software packages that automate searching across multiple sources at the same time and provide ways to specify tighter searches (for example, the 'near' operator means that search terms must be within 10 words of each other). For example, Bing, Google and Yahoo were all searched simultaneously, with the software following links automatically to return web pages and pdfs that the built in AI analyses and classifies. These tools were also used to search for academic citations in publicly available catalogues and patent searches
- EndNote from Clarivate. This is an academic reference manager with powerful search capabilities for the Web of Science and other academic sources; and
- WIPO PATENTSCOPE, a dedicated search engine for patents.

Annex A contains the 31 searches performed using Bing, Google and Yahoo, and the results obtained.

Query	Notes	Percentage (%)
blockchain NEAR (net* OR "fishing gear")	Blockchain specific search	30%
(3d* or addit*) NEAR (fishing* OR aqua*)	Broad search for 3D printing in fishing or aquaculture	18%
"industry 4.0" AND (marine AND plastic*)	Finds anything with Industry 4.0 close to marine plastics	6%
plastic NEAR (recycl* OR recycl*) NEAR net*	Broad search for plastic recycling and nets	5%
shred* NEAR ("fishing net")	Broad search for shredding of nets	4%
"autonomous recycling"	Generic autonomous recycling search	4%
(technology AND track*) NEAR net*	Broad search for track and trace technology related to nets	3%
digital* NEAR (port OR harb*)	Broad search for digitalisation of ports and harbours	3%
(recycl* OR re-cycl*) NEAR (nets or ropes)	Search with a focus on nets and ropes	3%
"industry 4.0" AND (marine AND litter)	Finds anything with Industry 4.0 close to marine litter	3%
"industry 4.0" AND (fishing* OR aqua*)	Finds anything with Industry 4.0 close to fishing or aqua	3%

Table 1 The 11 searches that yielded 80% of the results.

Table 1 shows that 11 searches that account for 80% of the online chatter. Based on these searches the "hot technology topics" related to fishing gear are:

1. Blockchain and other track and trace technologies
2. Additive manufacturing (3D printing)
3. Industry 4.0
4. Novel recycling processes for plastics (automation and shredding were highlighted)
5. Digitalisation of ports and harbours (also known as smart ports)

From the online searches, the final list of actual applications of BCT were identified manually. Annex B details the individual applications identified in this project, and Annex C contains a matrix of organisations involved by technology and position in the recycling lifecycle.

Country	No. of Applications
United States	25
Spain	21
United Kingdom	18
France	15
Canada	9
Netherlands	9
Italy	8
Sweden	8
Norway	7
Belgium	6
Germany	6
Portugal	6
Taiwan	6
Denmark	5
Greece	4
China	3
Finland	3
Ireland	3
Japan	3
Thailand	3
Australia	2
Chile	2
Fiji	2
Romania	2
India	1
Total	**177**

Table 2 Breakdown of applications by country.

Technology	No. of Applications
Advanced Materials for B2B and B2C Products	26
Other - GIS databases, mobile apps for Citizen Science etc	25
Mechanical Recycling	21
Additive Manufacturing (3D Printing)	15
Robotics & Automation (including ROVs)	10
Blockchain	9
AI	8
Advanced Analytics	7
Acoustic / Underwater GPS	6
Bio-Based Materials for Gear	6
IoT/M2M	6
Satellites	6
Sensors/smart tags	6
Biodegradable Gear	5
Computer Vision	5
Digital Business Models (e.g. platform or app based applications)	5
Chemical Recycling	4
Digital Twin	3
Thermal Recycling	2
Integrated Recycling Technology	1
Side Scan Sonar	1
Total	**177**

Table 3 Breakdown of applications by BCT technology.

Each application identified was also tagged with a stage in the lifecycle from net design to final product (whether for B2B or B2C markets) using the classification approach shown in Figure 4.

Lifecycle																
(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology

Figure 4 Classification approach use to tag applications of BCT to stages of the lifecycle from net design to final product. Note that some applications have cross lifecycle relevance or technology demonstrations with little connection to a distinct stage.

Stage in Lifecycle	No. of Applications
Traceability	29
Finished Goods ("Products")	22
Product Design & Prototyping (based on recyclates)	18
Yarn and Fabric	11
Pellets	10
Collection	10
Recycling Value Chain Reporting	9
Filament	9
Other Recycling Process	8
Shredding	8
Design of Gear	6
Sorting	4
Cleaning	3
Separation	3
Compliance Reporting	2
Grinding and Crushing	2
Total	**154**
Point solutions to validate technology use cases	23
Grand Total	**177**

Table 4 Breakdown of applications by lifecycle stage.

Tables 2, 3 and 4 summarise the number of applications by technology, lifecycle position and country.

The following rules have been applied for allocation of countries in the table:

- For companies, it is where the main office or headquarters are located
- For NGOs, it is where the organisation is registered; and
- For projects and consortia, it is the country of the project leading or co-ordinating company or organisation.

		Lifecycle																
		(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
BCT Technology Area	Total Applications	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Acoustic / Underwater GPS	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1
Additive Manufacturing	15	0	0	0	0	0	0	0	0	6	3	0	0	6	0	0	0	0
Advanced Analytics	7	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	2	1
Advanced Materials (non bio)	26	0	0	0	0	0	0	0	0	1	1	8	9	4	0	0	0	3
AI	8	0	2	1	1	0	0	0	0	0	0	0	0	0	0	1	1	2
Bio-Based Materials	6	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Biodegradable Materials	6	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0
Blockchain	9	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1
Chemical Recycling	4	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0
Computer Vision	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Digital Business Models	5	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2
Digital Twin	3	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
Integrated Recycling	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
IoT/M2M	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	1
Mechanical Recycling	21	0	1	0	1	1	7	2	3	0	3	1	0	2	0	0	0	0
Other - GIS databases, mobile apps etc	27	2	0	0	1	1	1	0	1	0	2	1	8	6	1	0	1	2
Robotics & Automation (including ROVs)	10	0	1	2	0	1	0	0	0	0	0	0	0	0	1	0	2	3
Satellites	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	1
Sensors/smart tags	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2
Side Scan Sonar	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Thermal Recycling	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
No. of Applications by Organisation	180	6	10	4	3	3	8	2	8	9	10	11	21	22	9	2	29	23

Table 5 Heatmap of the number of organisations engaged in specific technologies across the lifecycle. Note that in three cases organisation/application combinations appear at multiple parts of the lifecycle. Hence, total here is 180 compared to 177 in Table 4.

Table 5 is a heatmap of the number of organisations developing or using specific technologies across the lifecycle. Note that there is some overlap between design applications involving bio-based and bio-degradable nets and B2C and B2B products.

Annex D contains an enlarged version of Table 5.

Online survey

The survey was run during April 2022 and attracted 126 visitors of which 71 completed the survey. As mentioned earlier, respondents came from 27 countries and represented NGOs, governments, SMEs, academics, individual experts, fishing-related organisations, recyclers, large companies. However, no gear manufacturers or assemblers completed the survey despite being included in the email sample.

Annex E contains the full survey results, and highlights from the survey findings are given below.

Top five technologies to prioritise for investment in next 3-5 years

1. Novel mechanical separation technologies
2. Low-cost material inspection and testing technologies
3. Novel track and trace technologies
4. Sensors and tags
5. Smart storage that can detect materials

Selected comments on this topic include:

- “Roll out existing mechanical solutions”
- “Develop more storm resilient gear and processes to reduce wear and tear and gear losses”
- “Automate materials identification and sorting”

Top 5 potential areas of application for advanced technology

1. Collection of gear at ‘end of life’
2. Design of gear (e.g., eco-design, design for circularity, modularity)
3. Separation and sorting of gear
4. New materials for fishing gear (e.g., easier to recycle)
5. Tracking and tracing of gear (including abandoned and lost gear

Top 5 barriers to the application for advanced technology

1. Infrastructure investment
2. Political will
3. Viable business models

4. Lack of government grants or tax incentives
5. Market demand

Selected comments on this topic include:

- “Not economically viable. More plastic quantity needed e.g., from other industries”
- “Funding (needed) for actual fishermen and mariners who have been trying to help for years but have been denied and villanized”
- “Finance and investment (not necessarily for research)”

What should be done to ensure advanced technology is successful

1. Stakeholder engagement and management
2. Generate market demand
3. Development of standards
4. Build local producer systems
5. Spend more on R&D

Selected comments on this topic include:

- “Policy support in terms of legislations and regulations”
- “Roll out and strengthen existing solutions”
- “Improve infrastructure (more recycling facilities that can take end of life gear in more places)”

Selected open-ended comments from survey respondents

- “Co-create with fishers and consider local diversity in gears, uses, and fishing traditions. Advanced technologies are nothing without their cooperation”
- “Connect best practice in circular systems for fishing gear with the end consumer”
- “Many of these (technologies) cannot be implemented without others that are ranked lower simply because they are not as high on the priority/to do list, but without them, the whole system of circular fishing gear economy would also not be established”

Themes from expert interviews

A series of one-hour interviews were conducted with 14 experts representing SMEs, standards, start-ups, NGOs, large companies, and academics. These have been distilled into the mind maps in Figures 5 to 8.

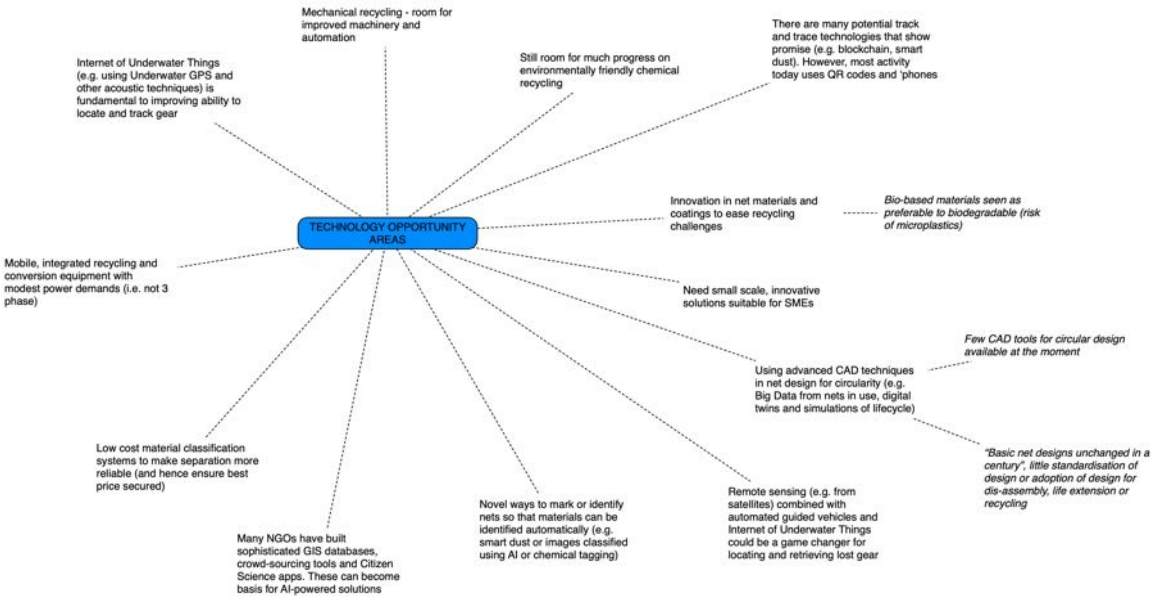

Figure 5 Expert view of technology opportunity areas

Figure 5 shows that the experts confirm some of the key survey findings (such as the need for improvement in mechanical recycling and access to low-cost material classification technology). However, the interviews also highlight some concerns with the more advanced track and trace technologies such a blockchain, and that there is scope for advances in net design.

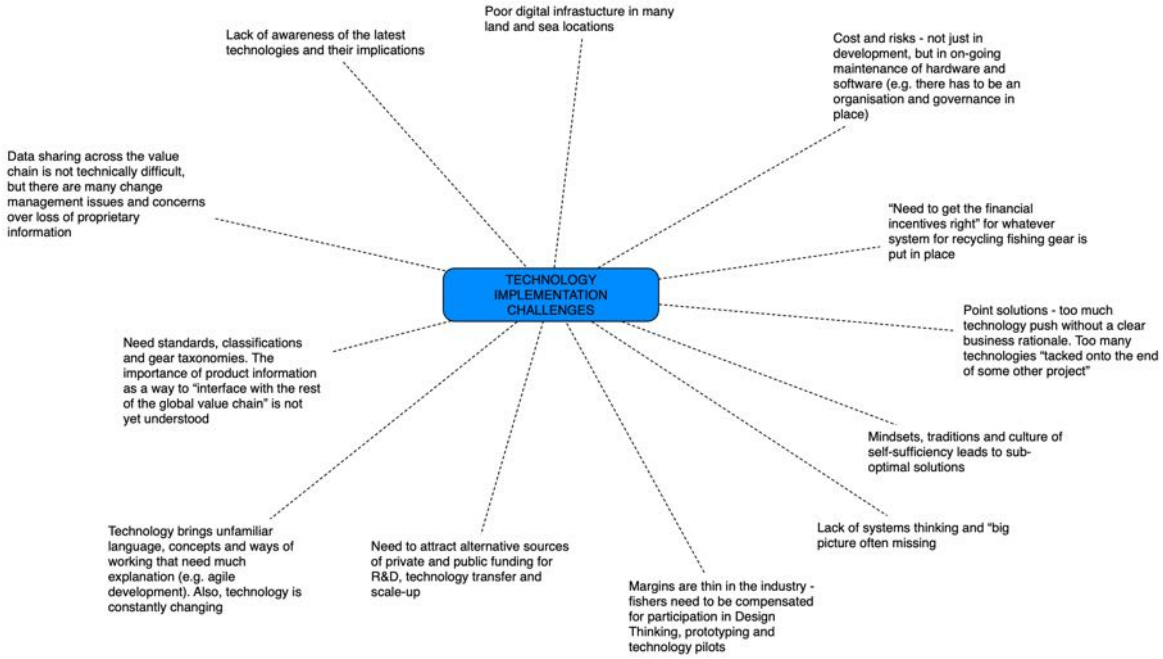

Figure 6 Expert view of technology implementation challenges

Figure 6 presents the interviewees' views on technology challenges. While some of the challenges indicated are technical (such as availability of standards or infrastructure), the majority are cultural and mindset oriented. For instance, the difficulties of collaborative data sharing across the value chain in a culture of self-sufficiency and trade secrecy.

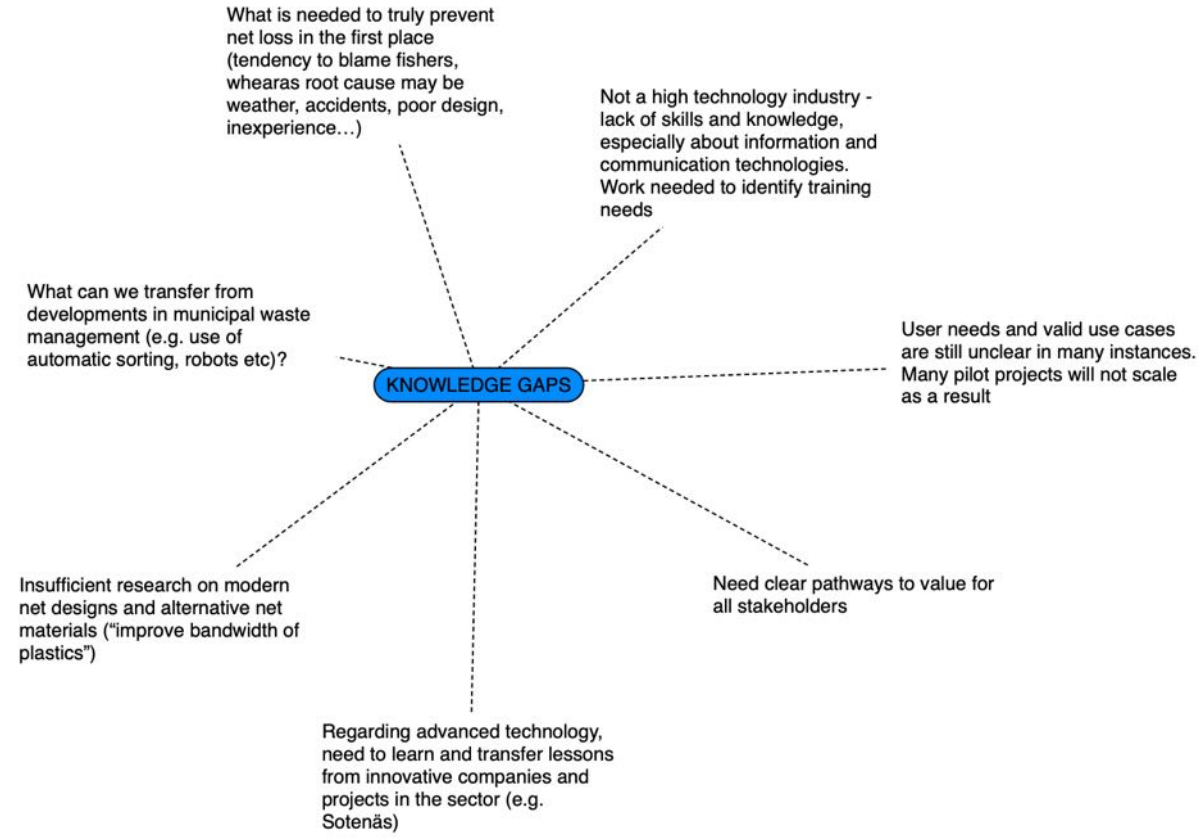

Figure 7 Expert view of technology knowledge gaps

Interviewees also highlighted several knowledge gaps in the industry, and these are shown in Figure 7. The key message here is that there remains much work to be done in engaging with stakeholders in the value chain to build up knowledge about technology capabilities, use cases and benefits.

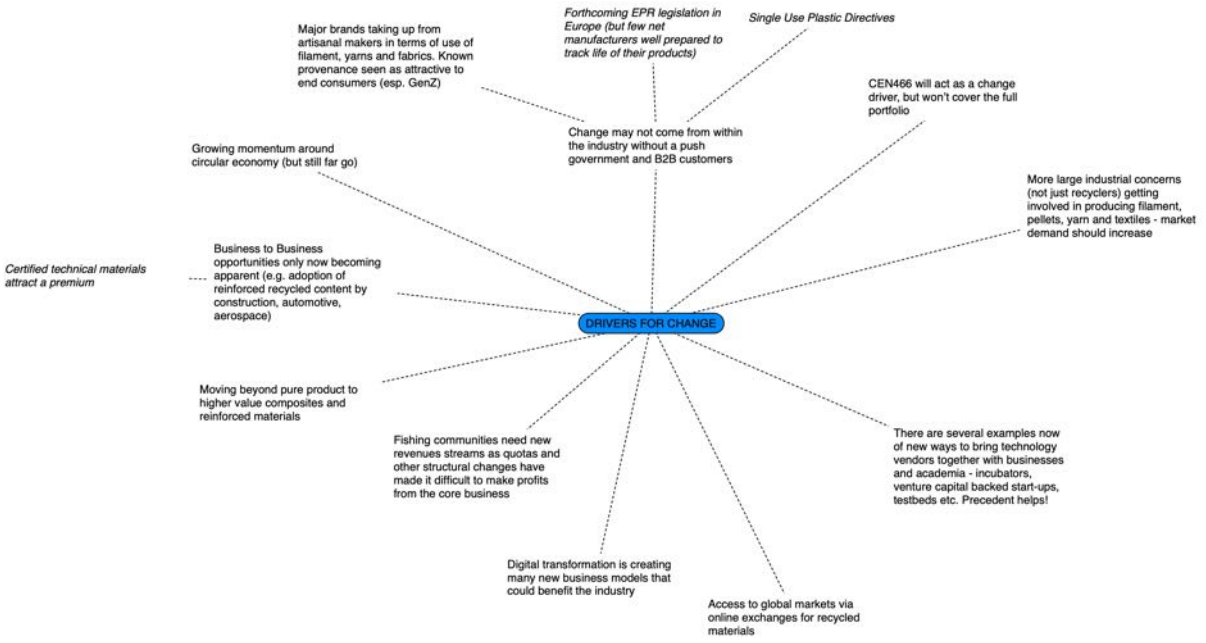

Figure 8 Expert view of technology change drivers.

Figure 8 shows the interviewees' perspectives on how change may come about in the industry. From the various discussions, there was a strong sense that while many in the industry advocate for change, the critical drivers will be external (legislation, large industrial concerns looking for recycled content and major brands responding to their consumers).

Academic research

Annex F contains a list of the 112 academic research papers identified as relevant to this research. Papers were identified by using the same keywords used for the online searches (such as fishing gear near industry 4.0), then grouped into topics based on their contents.

Topic of paper	No. of Papers
Circular economy, digitalisation and Industry 4.0	13
Material innovation (including novel formulations, and Materials 4.0)	10
Waste Management 4.0 (i.e. Industry 4.0 and waste management combined)	8
Reviews of best practices and lessons learnt	7
Advanced analytics	5
Supply chains and logistics (including balancing demand and supply)	5
Remote sensing	5
Business models (including circular)	4
Circular waste management	4
Agricultural waste flows (including nets)	3
Alternative recycling technologies (including automation)	3
Artificial Intelligence	3
Internet of Things	3
Updated models and statistics on supply (and associated misinformation)	3
Additive manufacturing	2
Reviews of chemical and mechanical recycling	2
Gear design	2
Port digitalisation and logistics	2
Recycling strategies	2
Trends (including the uture of chemical and mechanical recycling)	2
Advanced imaging	1
Aquaculture	1
Big Data and waste management	1
Biodegradable nets	1
Blockchain	1
Decision support tools for Circular Economy	1
Detection and prevention techniques	1
Different value chains for gear recycling	1
Digital Twins	1
End of Life	1
Globalisation and waste management	1
Innovation systems	1
Local productive systems	1
Material characterisation	1
Material flows for circular fashion	1
Novel conversion techniques	1
Pre-treatment	1
Programme development	1
Pyrolysis	1
Small island states	1
Sustainability of plastics	1
Systems engineering	1
Thermomechanical processing	1
Types of gear for recycling	1
Total	**112**

Table 6 Analysis of the topics covered by the academic paper searches

Table 6 shows the breakdown of the research papers by topic. The top five research topics are:

1. The intersection of the circular economy, digitalisation, and Industry 4.0
2. Material innovation (including novel formulations, and Materials 4.0)
3. Waste Management 4.0 (i.e., Industry 4.0 and waste management combined)
4. Reviews of best practices and lessons learnt
5. In equal fifth place: Advanced analytics / Supply chains and logistics (including balancing demand and supply) / Remote sensing

Note: Materials 4.0 is the application of selected Industry 4.0 techniques (typically AI) to discovery of new materials and processes.

Patents

Searches using WIPO PATENTSCOPE indicate that there are around 5,000 patents including the term “fishing gear”. However, as noted during an expert discussion held 27th May 2022, many have little technical innovation, or are simply attempts to secure a commercial space for future exploitation.

Of those 5,000 fewer than 50 reference recycling technologies or innovative design methods that could support life extension or recycling.

It is important to note that trade secrecy is the norm in many industries, so a low count of patents should not be taken as an indication that there is a lack of innovation. However, patent registration does provide useful information about intellectual property that is considered to have sufficient value to be worth defending in law.

Annex G contains a list of the 37 patents identified using WIPO PATENTSCOPE as relevant to this research. Tables 7 and 8 show the breakdown by the type of patent and patent office of registration.

Type of Patent	No. Found
Apparatus for Locating Lost Fishing Gear	13
Recycling Devices for Fishing Gear	7
Processes for Recovering Metals from Fishing Nets	6
Methods for Recycling Fishing Gear into New Materials	5
Methods for Preparing Reinforced Polymers from Recycled Fishing Gear	3
Devices for Shredding Fishing Gear	1
Methods for Material Classification	1
Biodegradable Net Materials	1
Design methods for gear	1
Total	**37**

Table 7 Breakdown of patents by type.

Patent Office	No. Found
China Patent & Trademark Office (CPTO)	14
Korean Intellectual Property Office (KIPO)	9
United States Patent and Trademark Office (USPTO)	3
The Office of the Controller General of Patents, Designs and Trade Marks	3
International Bureau Of The World Intellectual Property Organization (WIPO)	3
European Patent Office (EPO)	2
Canadian Intellectual property Office (CIPO)	3
Total	**37**

Table 8 Breakdown of patents by patent office.

Discussion of findings

Start of the journey

This research shows that use of certain individual Industry 4.0 technologies (such as 3D printing and blockchain) in the context of recycling of fishing gear has been underway for a few years:

- Fishy Filaments (UK), Fab&Fil (France) and ValorYeu (France) recycling fishing nets into filament for 3D printing
- Ocean Tech Hub LDA, Peniche Ocean Watch (Portugal), working with blockchain provider Empower AS (Norway) for logging and tracking fishing gear once it has been collected; and
- The CircularSeas grant-funded project (Spain) using 3D printing technology to make high performance plastic-based spare parts for the Maritime Industries.

However, wider adoption of BCT is patchy, with many developments running in isolation and without an overarching sector vision for the future of the value chain, or how to integrate these technologies. It is also unclear how much networking, knowledge transfer and collaboration is taking place between businesses and projects.

The survey and expert interviews do show that the industry recognises that innovation is needed. For example, the desire for more innovation in mechanical recycling highlighted by the survey does seem to be in progress as there are developments in cutting blade materials for shredding as one just one example.

However, Industry 4.0 technologies that are well advanced in other industries, such as AI, digital twins, computer vision, industrial automation, and robotics, are less common or appear as proof of technology projects in this sector/area, e.g:

- CIDCO Development Center for Ocean Mapping (Canada) developing new AI methods to recognise and detect underwater objects (such as lost gear) in real-time side-scan sonar data imagery streams (see glossary)
- Sotenäs Symbioscentrum (Sweden) working with start-up Respace to create digital twin of the material flows through their system, potentially as a foundation for an EPR reporting system in the future
- Project NetTag (Portugal) developing new technologies to track fishing gear, including low cost, miniature acoustic tags and acoustic transceivers together with an automated, short-range robotic recovery system

Also, as is consistently reported in Industry 4.0 literature, the benefits of many advanced technologies comes when several are integrated into a broader system. This requires a step-up in terms of capital and skills, as well as change management. To date, there are few examples of more integrated approaches of this nature. Sotenäs is one of the few examples where there is an overall vision for technology integration in line with Industry 4.0 principles can be observed, even though they are progressing towards it project by project.

A lack knowledge about Industry 4.0 may account for the lack of vision, and possibly there have not been sufficient incentives to make the investment in time and money required to develop more integrated approaches. Also, more integrated approaches Industry 4.0 is more likely to be feasible where the digital infrastructure is well-developed (for example, where nations and private owners have developed smart ports).

However, with the arrival of EPR in Europe for fishing gear there will be a strong regulatory driver for change, and as global B2B markets for recycled materials of known provenance expand there will be commercial drivers too. Signs that the higher value B2B markets for products such as technical fibres, yarns and textiles are expanding include:

- The MARNET grant-funded project (Spain) developing with technical applications from functional recycled PA yarn blend
- Nanovia (France) developing a nylon filament reinforced with carbon fibres from the aviation sector
- Carvico (Italy) investing in R&D to develop innovative new fabric blends based on ECONYL® yarn
- Academic research in Hokkaido University (Japan) and DTU Denmark (as part of the Circular Ocean project) to create a market for using recycled nylon fibre from ALDFG as reinforcement in polymer cement mortar in construction beams

The commercial opportunity is only likely to grow further as the circular economy become more of a reality, and as the next wave of consumers (GenZ) make greater demands for sustainable products.

Design for circularity requires manufacturers to invest

Experts consulted for this research have highlighted that gear manufacturers are already looking at improvements in gear design, including action towards circularity (e.g., single polymer nets). However, it is unclear how much structured R&D is happening to support this (e.g., only one patent was identified in this area), and with a few exceptions such as Eurocord no national or international industry associations for discussion of cross-cutting issues such as circularity (or sustainability more generally) in relation to fishing and aquaculture gear development, although CEN TC466 has initiated discussion on European standards.

More generally, the experts interviewed for this report identified that there is a problem with funding R&D: moving from grant-funded pilot project to large scale, integrated technology solutions in this industry is difficult, which makes companies and investors cautious. Looking at how agriculture has progressed with Industry 4.0, it required:

- Large food and agrochemical companies to supplement government funded R&D for the benefit of themselves and their downstream supply chain partners (fishers and gear manufacturers). For these multinational companies investment in R&D is usually measured as a percentage of turnover, and so volume and revenue are key drivers in making investment decisions; and

- Increased entrepreneurial activity supported by investors with specialist knowledge about the sector so they can make more informed assessments about risks and likely returns.

Regardless, an increase in R&D activity for fishing gear almost certainly requires aggregating waste streams to make a viable industry in the eyes of investors.

Regulatory pressure is often an incentive for R&D activity as well, and the approaching deadline for European EPR legislation (December 2024[7]) may spur gear manufacturer R&D activities (and other developments) in support of circularity.

Innovation isn't evenly spread

One of the curious features of the findings is how innovation, technology transfer and piloting is distributed.

For example, of the 177 applications found, half come from just four countries (The United States, Spain, the United Kingdom, and France). The US applications are mostly from major NGOs based there, whilst the others appear to be leveraging public finances (e.g., grants) to drive projects forward.

When it comes to the nature of the technologies involved, again, half come from just four types of technology (advanced non-bio materials, GIS[8] databases and mobile apps for Citizen Science, mechanical recycling, and additive manufacturing). Only one example of fully integrated recycling technology was identified.

There is a similar story with the distribution of applications across the lifecycle from net design to product. Product design, prototyping and finished goods manufacturing (e.g., consumer products made by moulding, extrusion and 3D printing from recycled fishing gear) account for 30 of the 177 applications, while there are only six applications for design of gear. 23 of the applications did not seem to have a clear linkage to the lifecycle, rather being early-stage point solutions to test out a technology or as temporary fixes to a problem.

Academic papers offer another window into the unevenness of innovation. They act as a lead indicator of the likely direction novel technologies will take. In contrast to the survey findings and expert opinions, the intersection of the circular economy, digitalisation and Industry 4.0 is the number one research area (closely followed by material science research, which does align with the expert views). Also, research into the combination of waste management and Industry 4.0, Waste Management 4.0, is in the top three research areas. While Waste Management 4.0 is primarily focused on municipal waste practices, the implications for technology developments in recycling fishing gear in the future are clear.

[7] Some countries are ahead of schedule: Sweden recently adopted Ordinance 2021: 1001 which introduces extended producer responsibility (EPR) for fishing gear. The new law will come into force on 1st January 2023.
[8] Geographic Information Systems.

The limited patent information gives yet another perspective. The most striking feature of the patent activity is how much is concentrated in China and Korea. From a technology viewpoint, apparatus for locating lost fishing gear (e.g., smart buoys) is the number one, reflecting the fact that traceability is a top topic.

Promising use cases

From the number of applications found, there are many potential use cases for new technology. However, as the expert interviews highlighted, there are many open questions about the suitability of each technology for marine environments and use by the various players in the value chain. In many instances the applications examined could be viewed as projects to test feasibility and evaluate risks – technical, process, data, financial, political – and to get stakeholder engagement.

The research also highlights some of the similarities and differences between technology use cases for existing ALDFG and EOL gear, and for new gear (especially post EPR). There is also a question for each use case concerning sources of potential funding. For example, many monitoring and tracking use cases desired by NGOs and governments are likely to be an additional cost for fishers and gear manufacturers. Who pays?

Some of the most commercially attractive and technically feasible use cases are listed below.

For existing gear:

- Locating lost gear such as Project MarGnet's high resolution acoustic mapping, data analysis and algorithms for predicting locations (Italy)
- Coastal and ocean retrieval (remotely operated vehicles or ROVs, machine vision underwater) e.g., Halma PLC's Deep Trekker ROVs (Canada)
- AI techniques for extracting maximum value from existing databases (e.g., GIS data on location of ALDFG)
- Providing additional financial incentives for recycling, such as Plastic Bank have done for several years with marine litter (their blockchain platform, Alchemy, offers a reward and banking capability for collectors)

For new nets:

- Modernising net designs and materials i.e. design for greater durability and circularity (recyclability and re-use), simplification of disassembly (and potentially the automation of disassembly) e.g., graphene reinforcement, development of knotless designs by various net manufacturers, Project INdIGO developing new designs based on bio-based green chemistry where you can grow materials and structures from algae (and seaweed, bacteria, enzymes, mycelium, yeast proteins etc), and bio-degradable materials
- Product Lifecycle Management, Computer Aided Design (CAD), and integration with material selection tools (such as MatMatch), to improve the design process and facilitate the creation of product information and digital twins for fishing gear. This is

likely to become an important use case once EPR legislation is in place as demonstration of compliance will necessitate much more detailed record keeping on net construction (Bureau Veritas already offer a “Digital Classification” service based on digital twins of vessels and this could be a model for fishing gear in the future once CEN466 standards are available)

- Establishing chains of custody (to support product claims) and tracking and tracing fishing gear and materials though-out the lifecycle. A wide variety of approaches are currently being trialled: smart dust (minute, ultra-low-cost communication and sensing devices), blockchains, sea-bed imaging, smart beacons and buoys, surface satellite trackers, underwater acoustic tags e.g., Project USMART has already demonstrated the feasibility of producing underwater acoustic communication devices with a range of 1km underwater known as "nano-modems" with a low-cost manufacturing cost and long life from small batteries
- Marking gear so that materials can be easily identified and separated by automated equipment e.g., using chemical markers, QR codes, smart dust

And across both:

- Developing more integrated Industry 4.0 systems that deliver higher value raw materials and products. This means scaling and integrating multiple technologies into systems that support appropriate operating models for fishing gear e.g., local producer systems, networks of hubs, micro-factories etc
- Increasing the scale of additive manufacturing capabilities
- Discovering a wider range of polymer blends, formulations and composites based on recycled fishing gear for technical, engineering and construction use. This can be accelerated using AI-based, Material 4.0 techniques[9]
- Developing digital business models and connecting with B2B markets thorough integration with blockchain-powered platforms such as Textile Exchange’s eTrackit (this tracks the physical movement of certified materials from fibre producer to brand using Fibercoin blockchain tokens, and the GS1 framework)
- Automation of data transfer to certification and regulatory systems
- Lowering the cost of material identification technology by developing handheld and smartphone devices based on the latest chipsets and algorithms[10]
- Incremental and radical improvement to washing (e.g. anaerobic digestion), shredding and other forms of processing (e.g., pyrolytic), in particular automated and mobile recycling systems (“recycling in a box” systems (along the lines of the MiniWiz concept for municipal waste) is a common ambition)

Maturing the value chain

This research has highlighted the relative immaturity of the end-to-end value chain for recycling fishing gear. Addressing this in the long term may require, as the survey and

[9] Materials 4.0 is computational materials design. Market pressure for improved product performance and sustainability is driving innovation for materials at a pace that traditional laboratory methods cannot address.
[10] The most likely spectroscopy approaches are Fourier Transform Infrared (FT-IR), hyperspectral, and Near Infrared (NIR).

interviews revealed, a combination of political will and public investment to build-up national and transnational flows and digital infrastructure. It also will require market demand to attract greater scale engagement with the private sector (especially recyclers who may view fishing gear as a marginal segment). Increased demand is likely to come from multiple sources. For example, maturing B2B markets for textiles driven by large fashion and retail brands, and as a consequence of greater fin and shellfish consumption (especially in South East Asia) leading to an expansion of fishing and hence net availability for recycling.

However, some of the supply chain issues highlighted can be addressed more directly by borrowing technology proven concepts from industries such as agriculture andfast moving consumer goods. In the last decade, advanced analytics and AI have been used in these sectors together with off the shelf and legacy technologies to:

- Improve demand and supply forecasting integrating many and varied information sources (including less obvious ones such as social media, weather data)
- Optimise collection, transportation, warehousing, and reverse logistics, especially where many different service providers and routes are involved
- Trade directly via B2B eCommerce portals, improving margins through techniques such as dynamic pricing; and
- Connect supply chain actors together using Electronic Data Interchange (EDI), blockchains and more. Working Group 5 in ISO TC323 is already working on product circularity datasheets.

Maturing value chains requires best practice supply chain management, and these bullet points represent areas where best practice supply chain management has existed for several years in other sectors. Each of these is as much an enabler of circularity of fishing gear as the more technical applications of BCT to net design or producing yarn. It is tempting to think of these as more suited to large enterprises, but this is mistaken: the rise of cloud-based platforms and service providers for many of these technologies has driven down the costs and the learning curve.

Where are the start-ups?

Advances in novel technologies involves commercial risk, so in many industries progress is increasingly driven by venture-backed start-ups. This has certainly been the case in agriculture where “AgTech” and “Smart Farming” are well established, attracting some of the largest funds in the world as well as support from major technology companies.

Start-ups and scale-ups benefit from specialist support via incubators and accelerators[11] designed to grow technology businesses quickly. However, this research shows that there are few with a focus on fishing gear or “BluTech” more generally. Exceptions include:

[11] Incubators support entrepreneurs for periods of up to five years to flesh out their concepts for growth in the long term. In contrast, accelerators help businesses with established models make progress in the short term (less than six months). Typically, both are run as programmes offering combinations of mentorship, office space, access to specialised equipment, funding, and development support.

- The European CircularSeas Project (which is promoting the Green Economy in the Atlantic Area by using Circular Economy principles) has access to a business incubation centre that offers integrated environments for 3D printing tailored to maritime environments
- The BlueSwell Incubator Program (USA), a dedicated, early-stage BlueTech incubator (and a partnership between SeaAhead, Inc., and the New England Aquarium); and
- INEX (USA). This is an IoT incubator that partners with start-up IoT tech companies, helps them develop the technology in the lab, then finds small and midsize fishing businesses as pilots

One reason, highlighted in the expert meeting, for the lack of private start-up investment, is the lack of industry knowledge in the analyst community to evaluate opportunities in this area. However, globally, there does not seem to be a shortage of public funding sources for projects in this area (e.g., Blue Economy is in top four public investments for the EC, and the US State Department and others appear to offer generous grants for this area).

Encouraging start-ups may well be one of the most effective ways to bring commercial success with the latest technologies for recycling fishing gear. There is a suggestion that it can be difficult to attract start-ups to some remote locations, or that the industry is not as attractive to entrepreneurs as, say finance. However, agricultural sector shows this is not the case - if entrepreneurs are made aware of the opportunities and are supported appropriately, they will come.

Looking forward

Achieving scale with BCT

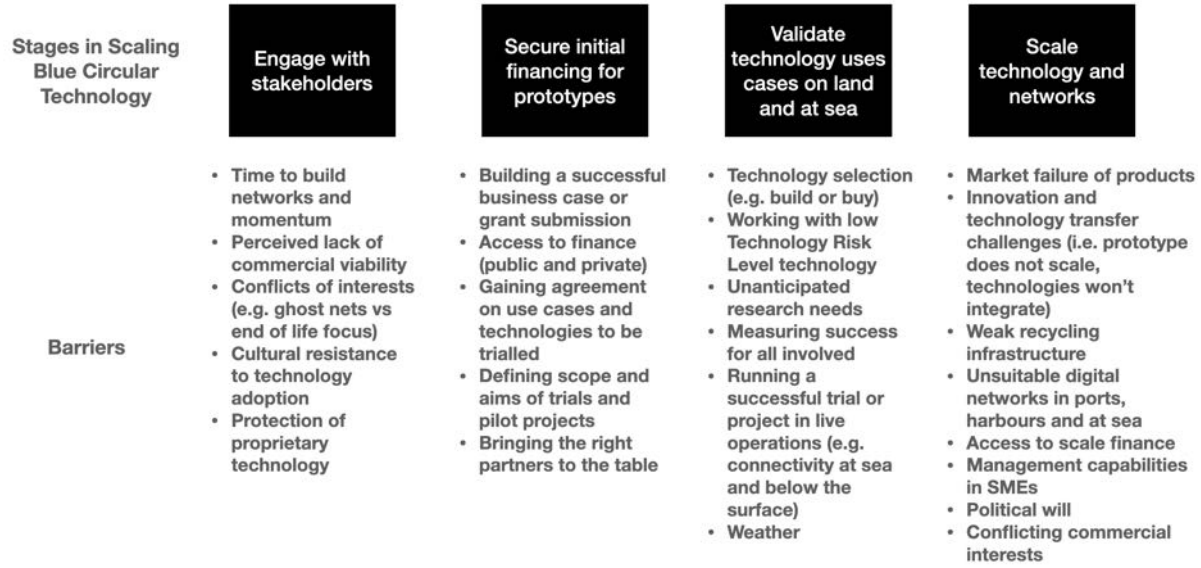

Figure 9 Barriers to establishing Blue Circular Technology as an industrial system that uses novel technologies to implement circular strategies for end of life (EOL) and abandoned, lost, and derelict fishing gear (ALDFG).

Increasing recycling rates and volumes is desirable to clean-up oceans and prevent useful materials going to landfill or incineration. Regulation and grant-funded projects play an important role, but so does large scale innovation and BCT, and that requires access to bigger and more profitable markets for recycled materials.

To date, there have been relatively few products made from recycled gear. Those that have made the headlines have come from start-ups, artisan makers, and small production runs, typically converting the polymers in gear recycled into pellets and filament, then moulding or printing a final product. Greater recycling volumes makes it feasible to produce more mass market products from recycled gear in sectors such as fashion and furnishings (as has been happening with ECONYL® regenerated nylon for several years).

This research suggests that a shift from small to large scale will be associated with an increasing focus on B2B partnerships and transactions. An example is Bureo's strategic realignment from consumer goods (skateboards etc) to B2B partnerships based on supply of NetPlus material.

Inevitably, this increase in scale will attract larger businesses into both the recycling process (such as multinational chemical companies and larger recyclers) and the production of products that incorporate at least some recycled fishing gear material. These larger businesses bring benefits in terms of process execution, depth of capability, and access to capital, but it can also be disruptive for existing players. As an example, at the expert discussion held on 27th May 2022, the case of Mitsubishi entering the market was discussed. Their approach was characterised as a disruptive set of acquisitions and disposals of

companies in the gear recycling value chain over a couple of years to structure the market to their advantage.

How scale volumes in recycling and the flow of industrial and consumer goods are achieved matters, too. If increased volumes employ value chains based on the linear "take-make-dispose" mindset, then environmental and social harms likely increase too. The digital transformation that Industry 4.0 offers is a key enabler of more circular value chains and more effective, high productivity alternatives to centralised mass production such as networks of local production systems.

This research shows that while there are many small, independent technology projects across the entire lifecycle, this does not guarantee successful transformation of value chains at scale. Success requires:

- A critical mass of organisations in the value chain that have adopted circular principles
- Strong international cooperation and networks
- Effective knowledge transfer from academia and pilot projects
- Public-private capacity building programmes; and
- An integrated approach to using Industry 4.0.

Figure 9 highlights some of the key barriers to scaling identified in this research. Many of the technologies discussed in this report are unproven at scale, and achieving scale requires substantial upfront capital investment beyond what has been made so far, and alignment of a broad range of stakeholders' goals to minimise technology (and other) risks. For example, fishing gear producers/assemblers will need to work with polymer and other materials suppliers to integrate circular design considerations. Scaling and maturing technology is a team sport.

Success at scale also requires rigorous business analysis and understanding of user requirements. Extensive data modelling is usually required up front too. None of this is straightforward as the language of IT and fishing are worlds apart. As one expert said, "it is a challenge getting IT guys talking to companies in fishing – you need a facilitator or someone who can explain challenges back to the developers."

Running a grant-funded pilot project to see how technology can help with, say, EPR, will help to clarify needs and gaps, but once that technology is adopted at scale it becomes core to doing business. As BCT becomes more business critical in the fishing gear there is a need for organisational formality in areas such as IT service management (ITSM) and IT asset management (ITAM). Budgets need to address on-going development and maintenance costs, as an example. Questions such as "who pays" year after year become very important to resolve.

Then there are dependences that may be out of the direct control of those in the industry such as:

- Availability of common standards that enable development of systems such as those that will come from TC466
- The pace of digitalisation of port and harbour infrastructure; and
- Availability of technology skills, and access to education

Conclusions

Overall, the sector appears to have been slow to digitalise and adopt advanced technology at scale across the lifecycle of gear (e.g., compared to agriculture). The research also suggests that circular design / eco-design of gear is still in the early stages of awareness and understanding in the sector.

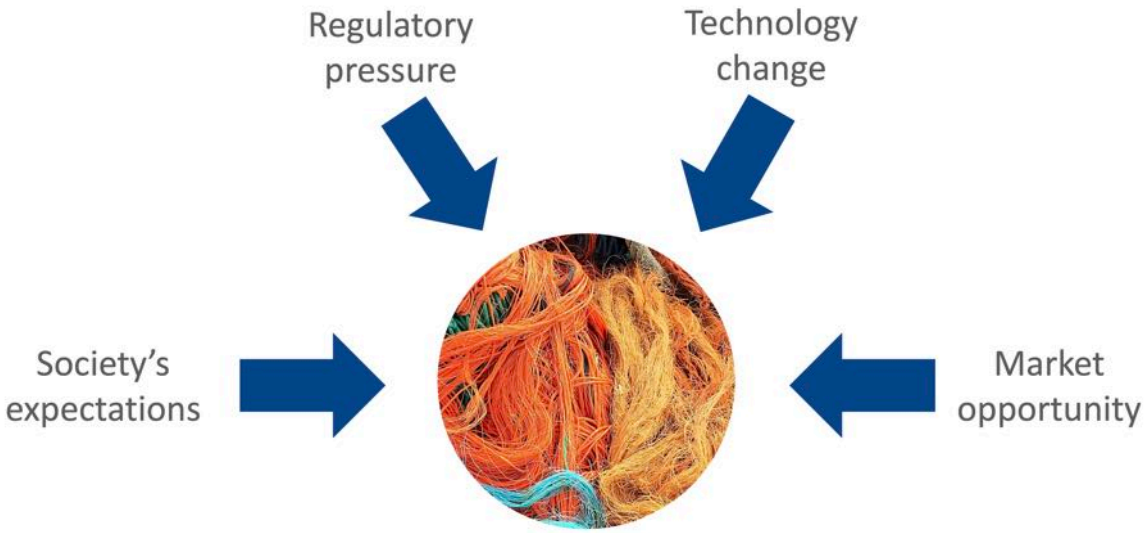

Figure 10 Drivers for systemic change.

There is a build-up of pressure for change from several quarters, as shown in Figure 10.

In particular, the pace of adoption BCT may pick up soon as the industry in Europe responds to the 2024 dates for CEN TC466 standard publication and European EPR legislation becoming mandatory. And as was the case for Waste Electrical and Electronic Equipment (WEEE) and End of Life for Vehicles (ELV), Europe acted as a testbed and others soon followed.

Stimulus for innovation in marking gear, and associated tracking and tracing using BCT, is also likely to follow the International Maritime Organisation (IMO) decision to make marking of fishing gear mandatory through MARPOL Annex V (the conclusion reached at Marine Environment Protection Committee 78 in June 2022).

There is a fragmentation of policy approaches to ALDFG and EOL gear worldwide, and the spread of EPR schemes for fishing gear has the potential to be a powerful driver for greater international alignment and consistency more generally. This is especially important for

those gear manufacturers and recyclers who operate in global supply chains, for whom BCT may be the most cost-effective choice for delivering regulatory compliance.

Looking further ahead, only with the right incentives for all the stakeholders will there be widespread investment in circular design and BCT. From the applications identified, the industry is in an R&D/technology transfer phase for many technologies and there is still a need to identify the use cases across the gear lifecycle that are financially viable. Despite examples of significant public investment, BCT is characterised by many small, disconnected projects. For the future, there are several promising use cases, but each needs substantial investment: prioritisation is required.

Finally, lessons from other industries show that integrated approaches are needed to deliver more substantial business cases. This is more than just about the technology itself; it involves aggregation of waste streams and market demand for products too. In academic and research discussions of fishing gear, Industry 4.0 is frequently associated with broader concepts such as digitalisation of ports and harbours and Waste management 4.0 that are also relatively new. In the sector, Industry 4.0 seems to be a new concept with relatively little concrete discussion at present, and this should be a priority to address. However, progress on a common vision or approach may be hindered by the lack of national and transnational producer/assembler organisations.

Predicting for the future for BCT is difficult but watching how some of the organisations identified in this report act going forward, may be instructive. Ones to watch are:

- Where the global chemical companies such as BASF (Germany) and Mitsubishi Chemical Corporation (Japan) on the B2B marketplace for recycled gear
- Expansion of Healix and DSM's portfolios of recycled-based polymers (Netherlands)
- How innovators such as Bureo (USA), Fishy Filaments (UK) and Fil & Fab (France) choose to expand (local vs regional vs global)
- Future innovations in integrated recycling from companies such as Gangsu Machinery (China) and KOWIN (Taiwan) among others
- The growth in commercial blockchain-based solutions such as those from Verifact (Ireland) and Empower (Norway)
- The effectiveness of projects such as Coopération Maritime's RECYPECH (France) and the Sotenäs Symbioscentrum digital twin project (Sweden) in addressing EU EPR legislation
- Potential developments with AI analysis of underwater video, for example at IndigWaters (Taiwan); and
- Can projects such as USMART (UK) grow into a viable internet of underwater things?

ANNEX A

Search Results

These following queries were developed by the project team to identify relevant applications of advanced technologies in relation to fishing gear recycling.

Each was input to a specialist web crawler that queries Bing, Google, and Yahoo simultaneously. It will follow links one level from the landing page automatically, and up to 100 results are returned per search engine.

The tool uses machine learning to classify the results, which then can be further refined by hand.

Note: the NEAR operator means that the search terms must be within 10 words of each other.

Note: "yield" is a measure of how Bing, Yahoo and Google perform against the query. Higher numbers mean that the search is more accurate (and did not contain as many off-topic results).

Query Ref	Query	Notes	# of Files returned by search engine	Filtered by query	Yield	Percentage (%)
M	blockchain NEAR (net* OR "fishing gear")	Blockchain specific search	2773	918	33%	30%
N	(3d* or addit*) NEAR (fishing* OR aqua*)	Broad search for 3D printing in fishing or aquaculture	2139	548	26%	18%
C	"industry 4.0" AND (marine AND plastic*)	Finds anything with Industry 4.0 close to marine plastics	1051	183	17%	6%
J	plastic NEAR (recycl* OR recycl*) NEAR net*	Broad search for plastic recycling and nets	2434	149	6%	5%
AA	shred* NEAR ("fishing net")	Broad search for shredding of nets	1170	112	10%	4%
AD	"autonomous recycling"	Generic autonomous recycling search	360	111	31%	4%
L	(technology AND track*) NEAR net*	Broad search for track and trace technology related to nets	4280	105	2%	3%
R	digital* NEAR (port OR harb*)	Broad search for digitalisation of ports and harbours	2651	95	4%	3%
F	(recycl* OR re-cycl*) NEAR (nets or ropes)	Search with a focus on nets and ropes	1010	93	9%	3%
B	"industry 4.0" AND (marine AND litter)	Finds anything with Industry 4.0 close to marine litter	1210	93	8%	3%
A	"industry 4.0" AND (fishing* OR aqua*)	Finds anything with Industry 4.0 close to fishing or aqua	475	79	17%	3%
AE	"fishing net" AND 3d AND filament	Broad search for 3D printing filament based on nets	2641	76	3%	<3%
O	(chemical or mechanical) NEAR (net* AND tech*)	Broad search for chemical or mechanical processing of nets	4868	70	1%	<3%
E	(recycl* OR re-cycl*) AND ghost	Similar to D, but with focus on ghost nets	916	61	7%	<3%
U	washing NEAR fish* AND net*	Very broad search for washing of nets	3525	58	2%	<3%
X	"circular" NEAR "fishing gear" AND tech*	Broad search for circular anything near to fishing gear and technology	783	46	6%	<3%

H	“waste management” NEAR “fishing gear”	Finds waste management near fishing gear (may also find Waste Management 4.0)	666	38	6%	<3%
T	(sorting or collection) NEAR (nets OR ropes)	Very broad search for collection and sorting of ropes and nets	1936	36	2%	<3%
Q	(“internet of things” or IOT) NEAR (fishing* OR aqua*)	Broad search for IOT in fishing or aquaculture	1356	31	2%	<3%
I	technology NEAR nets NEAR (abandoned OR lost)	Finds anything to do with technology and abandoned or lost nets	1415	26	2%	<3%
AC	inspection OR test* NEAR (polymer AND net* OR “fishing gear”)	Finds inspection and test of gear and nets	3422	26	1%	<3%
P	“artificial intelligence” NEAR (fishing* OR aqua*)	Broad search for AI in fishing or aquaculture	1007	23	2%	<3%
G	(recycl* OR re-cycl*) NEAR “fishing gear”	Similar to D, but with broader scope	503	21	4%	<3%
Y	robot* NEAR “fishing gear”	Robot specific search	1015	17	2%	<3%
Z	“computer vision” NEAR “fishing gear”	Computer vision specific search	408	11	3%	<3%
K	“circular design” NEAR polymers NEAR tech*	Broad search for circular design technology and polymers	795	9	1%	<3%
D	(recycl* OR re-cycl* AND tech*) NEAR (fishing* OR aqua*)	Similar to A, but with focus on recycling technology	1347	7	1%	<3%
AB	(repair* OR refurb*) NEAR “fishing gear”	Finds repair and refurbishment of gear and nets	419	3	1%	<3%
S	(ecodes* OR eco-des*) NEAR (fishing* OR aqua*)	Broad search for eco design	534	0	0%	<3%

The classification tool (used automatically) narrowed the ~48,000 results to ~3,000 “on topic” results. These were then manually refined before being re-classified and tagged by the tool. This yielded 177 applications, documented in Annex B.

Step in Analysis	Process / Calculation	No. of Search results	Notes
A	Total No. of Files	47750	web pages, images and pdfs
B	Relevant Hits	3045	Note: queries evaluated left to right
C	Yield (B/A)	6%	
D	Manual sort - 1st pass	600	Note: still includes duplicates and off topic items
E	Yield (E/C)	20%	Compared to relevant hit number at B above
F	Further classification and tagging	177	Part machine / part human
	Yield (F/C)	29%	Compared to manual sort at D above

ANNEX B

Applications

The following list is extracted from the online searches performed for this project. In the case of projects highlighted in the list, the emphasis is on currently active projects, but some recently closed ones are included where knowledge transfer or follow-on activity is occurring.

The following rules have been applied for allocation of countries in the table:

- For companies, it is where the main office or headquarters are located
- For NGOs, it is where the organisation is registered
- For projects and consortia, it is the country of the project leading or co-ordinating company or organisation

The table includes a small number of companies or projects found in online searches that do not fully meet the BCT criteria used but are seen as significant in terms of the capabilities they demonstrate and their potential for application more widely to fishing gear. These are not included in the application counts presented in this report.

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
AddiFab	Denmark	Inventors of Freeform Injection Moulding, a new process that utilises 3D printing to produce injection moulding inserts. Examples include using Marine Nylon® filament from Fishy Filaments to make buttons for UK brand Finisterre.	Additive Manufacturing	Product:Manufacturing	https://www.addifab.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Adidas	Germany	Working together with Parley for the Ocean developing, testing, and implementing new materials. Also founding partner for the Parley Institute for Material Science. The Institute identifies, evaluates, and funds material replacements for plastic and other harmful, toxic, or exploitative materials.	Advanced Materials	Design:Product Design	https://news.adidas.com/made-with-recycled-materials/five-years-of-working-with-parley-to-end-plastic-waste/s/40d88ae9-a487-4dbf-af48-9ebb16882247
Adriatic Network for Marine Ecosystem (ADRINET)	Italy	The overall objective of ADRINET is to improve a joint coastal management system and create governance plans to preserve biodiversity and coastal ecosystems inside the Programme area. ADRINET involves investments in technologies to endow fishing boats with RFID and GPS systems to map fishing routes and ghost-nets, monitoring sea pollution, tracing fish caught and preventing over exploitation of the fish stocks. The project includes three ghost net removal campaigns (Italy, Albania, Montenegro) and a common traceability system using RFID. All results are accessible to scientific and local communities. Project co-ordinator is University of Bari.	Sensors/smart tags	Other:Traceability	https://adrinet.italy-albania-montenegro.eu/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
AIMPLAS	Spain	OCEANETS European OCEANETS project is developing technology and methods to prevent the loss of nets, facilitate their recovery and reuse, and make it feasible to recycle into new, high value-add textile products. ECOALF provide chemical recycling of nets into PA pellets. A geolocation tool has been implemented by the Port of Vigo Shipowners' Cooperative (ARVI) and the Asociación Vertidos Cero to prevent loss. Also researching the feasibility of including an additive in PA pellets as a tracker. Sintex have produced sample sportswear fabrics that show the traceability technology works. Next steps are in innovations in mechanical recycling. The aim is to recover polyester and PE fishing nets and to manufacture woven and non-woven products. Note: AIMPLAS also lead the REPESCALPAS project focused on more general marine litter (not fishing gear). This project has developed novel a management system to recover the plastic fraction from marine litter that could possibly be applicable to gear.	Chemical Other Mechanical	Product:Pellets Other:Traceability Recycling:Grind or Crush	https://www.aimplas.net
AssetLink Global	United States	Provides remote monitoring and tracking solutions, based on satellite IoT, for fishing vessels and maritime users such as The Ocean Cleanup project. Also provides a sensor monitoring platform for environmental science users. Primary focus is on geofencing and preventive maintenance	IoT/M2M Satellites	Other:Traceability Other:Traceability	https://assetlinkglobal.com/solutions/smart-maritime/commercial-fishing-fleet/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		(e.g., of vessels and gear). However, wider application of the platform for fishing gear is possible.			
B4Plastics	Belgium	Scale-up with proprietary polymer architecture technology for creating bio-based and biodegradable products (FortePlastics technology platform). Technology is based on a library of BioBased Building Blocks (B4) that can be combined in different ways to make materials with the desired properties i.e. fine-tuned between strength and degradation. Biodegradability is achieved with cleavable linkages in the polymer structure that micro-organisms or enzymes can break easily. Fishing gear has been one of their focus areas (see Project Glaukos entry).	Biodegradable Bio-Based	Product:Manufacturing Product:Manufacturing	https://b4plastics.com
BASF	Germany	Have invested in a start-up, trinamiX GmbH, that is focused on innovative sensing technologies used in both classifying and recycling. Recyclers using trinamiX Mobile NIR Spectroscopy to scan plastic and determine what they are and how they can be recycled. Fishing net recycling - used, old and torn nets, fishing lines and other gear can be sorted.	AI	Recycling:Separation	https://www.basf.com/us/en/media/smart-scientists/recycling.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Benthos Buttons	United Kingdom	3D printing and injection moulding of buttons using Benthos Fishy Filaments' premium 3D printing filament called "Porthcurno."	Additive Manufacturing	Product:Finished Goods	https://benthosbuttons.com/manufacturing
BIOFILET	France	The objective of the project is to obtain feedback on the characteristics of prototype biosourced and compostable mussel nets, their reaction with the marine environment, the behaviour of the net during use, and information on the degradation of these bioplastics in industrial composting. Co-ordinator is SMIDAP (Syndicat Mixte pour le Développement de l'Aquaculture et de la Pêche).	Bio-Based Biodegradable	Design:Product Design Design:Product Design	https://www.smidap.fr
Blue Ocean Gear	United States	Silicon-valley start-up that makes a smart buoy that can be attached to nets, lobster traps and longline fishing lines. The Farallon Buoy also contains a microprocessor; a GPS chip; an accelerometer; water temperature and depth sensors; plus, Iridium satellite and long-range open-band radio modules. Power is provided by a nickel-metal hydride battery.	Satellites	Other:Traceability	https://newatlas.com/environment/farallon-buoy-lost-fishing-nets/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Blue Room Innovation	Spain	Specialist technology innovation company, with a focus on circular economy and new technologies such as blockchain. Whilst not fishing gear specific, they are developing a blockchain-based waste management solution for ports, and WastePassport to track waste from port reception to recycling plants. May also develop will develop a new token as a secondary market incentive. Has the potential to be transferred to gear. Support and funding from GALATEA, and support of Port of Palma.	Blockchain	Recycling:Collection	https://www.blueroominnovation.com/en/trazabilidad-y-gestion-de-los-residuos-en-puertos-con-blockchain/
BLUECYCLE LAB	Greece	A model lab for processing many fishing gear and other marine plastic waste, based in Piraeus. Offers a certified process for making pellets for recycled 3D printing filament, and other industrial uses. Materials are collected by partner organisations, from the marine litter collection stations by Aegean Rebreath in various locations in Greece, and from the network of co-operating manufacturers / suppliers / consumers of fishing and marine equipment. Materials involved are: • Nylon 6 • Nylon 66 • Polyester (PES) • Polypropylene (PP) • Polyethylene (PE)	Additive Manufacturing Additive Manufacturing Additive Manufacturing	Product:Pellets Product:Finished Goods Product:Filament	https://bluecycle.com/en/about/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		• High density polyethylene (HDPE) • Ultra high molecular weight polyethylene (UHMPE) The lab is a collaborator with: UrbAct: EU Program sharing the know-how for the operation of tech hubs in European cities, Plastic Busters MPAs (pilot to prevent and reduce waste from fishing and aquaculture activities in the Thermaikos Gulf, GGGI, and Playroom for children's toys recycling.			
BLUENet	Spain	The BLUENET consortium brings together partners of the Basque Country (AZTI, GAIKER, ITSASKORDA) and Italy (NTT). Co-ordinated by the AZTI Foundation. The sources to be investigated are aquaculture and fisheries, with a focus on Abandoned, Lost or Discarded Fishing Gear (ALDFG). An objective is the waste characterisation, pellets production at lab-scale and their processability to obtain multifilament yarns. These are then used in product prototypes and compared with conventional products. For example, developing recycled rope prototypes and validating their performance in aquaculture applications at sea	Advanced Materials	Product:Yarn or Fabric	https://www.bluenetproject.eu
BlueSwell Incubator Program	United States	New England's first dedicated, early-stage bluetech incubator. A partnership between SeaAhead, Inc., and the New England Aquarium. The program is designed to support the creation and growth of start-ups with solutions that have the potential for significant impact on ocean health, sustainable ocean industries and global resilience.	Computer Vision Acoustic	Other:Other Other:Other	https://blueswell.sea-ahead.com/cohort-1

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		Relevant start-ups in first cohort in 2020 include: SeaDeep: Enhanced 3D sea-floor ocean imaging, data visualisation and analytics for better environmental characterisation. Hydronet: Underwater networks comprised of acoustic modems & software that provide scalable, high-speed Wi-Fi underwater.			
Bureau Veritas	France	Offer Digital Classification as a means of bringing design review into the digital age. Uses a digital twin of a ship or asset (e.g., fishing gear). This eliminates the need for 2D drawings and provides a faster, safer way to conduct design review.	Digital Twin	Design:Product Design	https://marine-offshore.bureauveritas.com/digital-classification
Bureo	USA	Bureo is both a trailblazing product design and manufacturing company (skateboards, sunglasses and more) and a materials and recovery business that operates its own net recycling programme across South America. Founded in 2015, Bureo is the only Certified B Corporation in the list, and one to watch. The recent introduction of NetPlus® nylon yarn (developed in conjunction with Tin Shed Ventures®, Patagonia's venture capital fund) is one way that Bureo is scaling their operation and is included as a leading example of how the B2B market for yarns and fabrics is developing through network business models and partnerships with large consumer brands. Although NetPlus® hasn't been classified as an 'advanced material', B2B customers of Bureo such as Futures (a surf fin maker), together with 3M, are starting to incorporate NetPlus® alongside carbon fibre in their products.	Not included in the application count	Product:Yarn or Fabric	https://bureo.co/pages/netplus

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Carvico	Italy	Has invested in R&D to develop innovative fabrics blends based on ECONYL® yarn.	Advanced Materials	Product:Yarn or Fabric	https://www.carvico.com/en/nature-voice/recycled-fabrics/
Chang Woen	Taiwan	Chang Woen specialises in innovative, shredding machines, including new-style machines for fishing gear (patented).	Mechanical	Recycling:Shredding	http://demo.changwoen.com.tw
CIDCO - Development Center for Ocean Mapping	Canada	Developing new AI methods to recognise and detect underwater objects in real-time side-scan sonar data imagery streams. One application is ghost fishing gear retrieval.	AI Computer Vision	Recycling:Collection Recycling:Collection	https://arxiv.org/pdf/1909.07763.pdf
CircularSeas	Spain	Project co-funded by the European Regional Development Fund (Interreg Atlantic Area Programme). The co-ordinator is Leartiker S. Coop. País Vasco, Spain. Also involves the Halpin Centre, at the National Maritime College, Cork Institute of Technology, University of Plymouth UK, Communauté d'Agglomération de La Rochelle Université de La Rochelle, France, Universidad de Vigo Spain (lead technical partner), and CDRSP. IPLeiria Portugal. Circular Seas promotes the development of eco-innovative green products and components through the combination of 3D printing technology and the use of recycled ocean plastic waste and new biodegradable, renewable and high-performance polymers. There are multiple work packages under this banner, with work package 6 focused on technical, economic and environmental viability of the manufacturing of new green products. Leartiker S. Coop in Spain is a polymer partner, taking nylon monofilament nets as input and producing nylon monofilament as final product for 3D printing into a variety of end products.	Other Additive Manufacturing Other	Recycling:Cleaning Product:Filament Design:Product Design	https://circularseas.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		Communauté d'Agglomération de La Rochelle Université de La Rochelle are mechanically recycling PE sourced from oyster farming, and will prototype surfboard fins as the end product. University of Vigo in Spain, working with Ecoalf, have recycled plastics from the fishery sector back into fish tags as a product. At the Good Fish (Ireland) facility they have prototyped components for processing machinery e.g. for repair and maintenance of conveyor belts. Technology innovations include photogrammetric capture of the 3D mesh for 3D printing from a 2D image using a mobile scanning app and off the shelf software. Also exploring anaerobic digestion and ultrasonics to clean organics off plastics. However, investment case was not met.			

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
CLAIM	Greece	CLAIM is a project with potential implications for fishing gear but is not solely focused on gear (the focus is marine litter). The CLAIM consortium consists of 20 Partners, coming from 15 countries around the Mediterranean and Baltic Seas. The partners are representing SMEs, Research Organisations and Universities, experts in the fields of litter regarding development of prototypes, models, litter characterization, environmental impact assessment, socio-economics, market-up take and science communication. Co-ordinator is HCMR - Hellenic Centre for Marine Research. CLAIM will prove 5 new marine cleaning technologies. One of the technologies involved has potential application for gear: a pyrolyzer. The small scale pyrolizer developed by IRIS exploits plasma-fuelled high temperature for transforming solid waste into syngas, and a recyclable solid residue. The process does not produce dioxins and furans, an issue with many thermal processes. The very small scale, up to 100kg of waste per day, makes the device suitable for mounting on small boats that can work closer to shore and collect marine litter nearer the point of entry.	Thermal	Recycling:Processing	http://www.claim-h2020project.eu

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Claire Potter Design	United Kingdom	Circular economy design studio and member of the Global Ghost Gear Initiative. Active member of the working group, Replicating Solutions. Project Precious Plastics (Open Source Injection Moulding Machine) Working directly with local Brighton fishers and designers, ALDFG to be subjected to a series of innovative, small scale, fast re-manufacturing methods. Project Net-Worth and follow-on activity Working on transferring knowledge from project Net-worth (see below) to a wider range of products made from recycled PP trawl nets, both in the UK and abroad. Previously led Project Net·Worth, a feasibility and product design investigation together with The Centre for Sustainable Design and MCB Seafoods, co-funded by Innovate UK. Project explored how ALDFG can be remanufactured locally in design/make hubs around the coast of the UK.	Other	Design:Product Design	http://clairepotterdesign.com/researching/
CleanAtlantic Consortium	Spain	Project to protect biodiversity and ecosystem services in the Atlantic Area through improved capabilities to monitor, prevent and remove marine litter. Co-ordination team is Centro Tecnológico del Mar – Fundación CETMAR. Main objectives are: 1. To describe the current situation, existing knowledge, data and initiatives in the Atlantic regions and definition of gaps	Advanced Analytics	Other:Traceability	http://www.cleanatlantic.eu

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		2. Review current systems to monitor and record marine litter, and to deliver protocols, tools, and indicators to fill monitoring needs 3. Development of modelling tools to predict the origin, circulation, and fate of marine litter, and elaboration of regional maps of hotspots of accumulation using models, remote sensing technologies, and aerial, surface, and underwater unmanned systems 4. To address prevention by developing best practices to reduce inputs from fishing and port sectors 5. To tackle removal of marine litter by implementing initiatives of fishing for litter, to reduce the presence of "abandoned lost and otherwise discarded fishing gears" on the seabed, and to develop best practices for routine beach litter clean-up by local authorities 6. To deliver training and awareness activities and to transfer project outputs to competent authorities and key stakeholders <u>DELIVERABLE 5.1- Development of sustainable tools (Database and software) for Marine Litter Data management</u> Project partner ifremer (national integrated marine science research institute in France) developed a Dali POSTGreSQL database and R scripts for transforming and visualising the data. The CleanAtlantic R Shiny dashboard is a piece of software developed to facilitate the automated reporting on marine litter data. It was primarily developed with focus on seafloor marine litter and beach litter.			

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
CleanSea	Netherlands	CleanSea is an EU project closed in 2015. The aim was to generate new information on the impacts of marine litter, develop novel tools needed to collect and monitor litter and protocols needed for monitoring data (litter composition and quantities). Relevant to the current project, one of the work packages investigated novel methods for identifying plastics in marine litter, including fishing gear. Techniques investigated included Direct Analysis in Real Time Mass Spectrometry (DART-MS), Fourier Transform Infrared Spectroscopy (FT-IR) and Coherent Anti- Stokes Raman Spectroscopy (CARS).	Advanced Analytics	Recycling:Sorting	https://cordis.europa.eu/project/id/308370/reporting
Collecte Localisation Satellites (CLS)	France	CLS design and deploy space-based solutions. Currently leading a consortium of fishers from the Var department of France, together with associations Planète Mer and ReSeaclons, to develop satellite tracking of fishing gear. This involves development of mini, surface satellite trackers and underwater acoustic tags. They have also developed a compact, lightweight, autonomous underwater robot for locating lost fishing gear at great depths. Recycling of located nets is performed by ReSeaclons.	Satellites Robotics & Automation Acoustic	Other:Traceability Other:Traceability Other:Traceability	https://www.cls.fr/en/supporting-small-scale-fishers-fighting-against-plastic-waste-groundbreaking-innovations/
Comberplast	Chile	Operates an entire recovery process, from shredding and cleaning to the extrusion and injection moulding of new product.	Mechanical Mechanical	Product:Finished Goods Recycling:Shredding	https://www.lindner.com/comberplast

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		There have been innovations in adapting the shredding technology of Lindner's Micromat 1500, equipped with an optimised cutting system, to make it suitable for the materials are usually heavily loaded with abrasive substances. The fishing nets, lines and other discarded plastic materials are recycled and converted into innovative new products, for example for the agricultural and mining industries, or green pallets for an international brewery.			
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia	Note: not fishing gear, but sufficiently relevant to justify including. An automated system for identifying and monitoring litter along rivers. AI processes images from cameras under bridges and ensures high-quality data about volumes and categories of material. AI developed in partnership with Microsoft and its Azure cloud computing services. Has been applied in Hobart (Tasmania), London (England) and Dhaka (Bangladesh).	Computer Vision AI	Other:Other Other:Other	https://blog.csiro.au/dr-denise-hardesty/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Coopération Maritime's RECYPECH project	France	Project RECYPECH was launched towards the end of 2020 and was financed by the Agence de la Transition (ADEME), the Ministry of the Sea (MMer) and the Ministry of Agriculture and Food (MAA), France Filière Pêche and Maritime Cooperation. The goals was to create an optimised EPR collection and processing system for PE and PA. The project was in three parts: R&D (identification of material recovery/recycling outlets for used fishing gear), "Preparing the eco-organization" relating to the development of a detailed business model designed in collaboration with marketing stakeholders, and support at the local level for a pilot of pre-collection and selective sorting. In addition, the project presented an opportunity to make the approach known to French fishermen as well as well as to local port players.	Other	Other:Other	https://www.pechpropre.fr/
CuRe Technology	Netherlands	Proprietary scalable technology for creating a fully circular polyester chain. The process works with any used polyester by removing the colour and converting it into clear pellets. The pellets have the same properties as virgin grade polyester. There is a pilot plant in Emmen (Netherlands) for rapid scale-up and technology transfer.	Chemical Mechanical	Recycling:Processing Product:Pellets	https://curetechnology.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Deep Trekker (now part of Halma PLC, UK)	Canada	Manufacturer of Remotely Operated Vehicles (ROVs) for underwater inspection.	Robotics & Automation	Other:Other	https://www.deeptrekker.com/
Dive Technologies	United States	Note: now acquired by defence technology company Anduril Industries (Feb 2022). Dive Technologies developed DIVE-LD, a modular and customisable Autonomous Underwater Vehicle (AUV) AUV that can be used for long-range oceanographic sensing, seabed mapping and infrastructure health monitoring. The AUV itself is of novel construction using 3D printing (https://www.compositesworld.com/articles/large-format-3d-printing-enables-toolless-rapid-production-for-auvs).	Robotics & Automation Sensors/smart tags	Other:Other Other:Other	https://www.anduril.com/article/anduril-industries-acquires-dive-technologies/
DSM	Netherlands	DSM have formulated a range of unfilled and glass-reinforced polyamide materials using discarded fishing nets. These mechanically recycled plastics are offered as resins suitable for moulding and extrusion. The recycle-based polyamide Akulon RePurposed. We use the material recovered from the fishing nets collected along the coastlines of India. Akulon RePurposed is used in high-end applications in the sports and leisure segment, such as for surfboard accessories. It can also be used in a wide variety of other applications, including furniture and industrial applications.	Advanced Materials	Product:Pellets	https://www.dsm.com/engineering-materials/en_US/products/akulon/akulon-repurposed.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Ecoalf	Spain	Foundation, fashion brand and B Corp that has invested in R&D to develop the technology to transform the plastic collected from the bottom of the ocean into high-quality yarn. Sources nylon yarn from Aquafil.	Advanced Materials	Product:Finished Goods	https://ecoalf.com/en/pages/materiales
eOceans	Canada	A mobile app and digital platform for collaborative, real-time, and multi-dimensional ocean tracking, including ALDFG.	Digital Business Models	Other:Reporting	https://www.eoceans.co
			Advanced Analytics	Other:Reporting	
Epsotech	Denmark	Has developed a plastic sheet product (Sea Plastics) together with Plastix.	Advanced Materials	Design:Product Design	https://epsotech.com/en/sea-plastics.html
Faculty of Engineering, Gipuzkoa, University of the Basque Country UPV/EHU	Spain	Research to analyse the potential of thermomechanical recycling of polyamide 6 (PA6) from fishing nets waste	Thermal	Recycling:Processing	https://www.ehu.eus/en/en-home
Fil & Fab	France	Producer of Nylo®: 100% mechanical recycled nylon powder granules from fishing nets. A local social enterprise (Les Genêts d'or) does mechanical crushing. Now work with 40 ports, and over 200 fishers across France. Nets are sorted by colour and state, cleaned, dismantled separate different plastics and to recycle rope separately.	Additive Manufacturing	Product:Pellets	https://www.fil-et-fab.fr
			Mechanical	Product:Pellets	

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Fishy Filaments	United Kingdom	Recycles fishing nets into engineering grade filament for 3D printing.	Additive Manufacturing	Product:Filament	https://fishyfilaments.com
Formossa Taffeta Co	Taiwan	Specialist yarn and textile company that has developed a proprietary system for making recycled polyester and polyamide fabrics from fishing nets and other marine litter sources.	Advanced Materials	Product:Yarn or Fabric	http://www.ftc.com.tw/newftc/en/product_view.php?id=2
Gangsu Machinery Co	China	Manufacturer of integrated washing and mechanical recycling machines (grinding, crushing, and shredding) for fishing nets, filaments, and ropes. Output is suitable for granulation.	Mechanical	Recycling:Processing	https://www.gangsuplas.com/p/fishing-net-washing-machine-line/
GEP Ecotech	China	Design and manufactures mobile shredding and pre-shredding machines that integrate feeding, shredding, conveying and separation. No indication that these have been used exclusively for fishing gear, but is indicative of the areas of technological innovation in mechanical recycling.	Mechanical	Recycling:Shredding	https://www.gepecotech.com
Glaukus	Belgium	Four-year EU-funded project (2020-2024) to develop innovative and environmentally sustainable textile fibres and coatings to reduce the carbon and plastic footprint of fishing gear and clothing.	Advanced Materials Bio-Based	Other:Other Design:Product Design	https://cordis.europa.eu/project/id/887711

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		The project includes developing a novel approach to scaling up production of polymer building blocks from bio-based feedstocks. Funding comes from the Bio-Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme. Project involves a complete redesign of the lifecycle to enhance biodegradability and bio-recyclability. The products that will be prototyped in Glaukos, are fishing nets and technical textiles. There are two key concepts: bio-recycling as a sustainable end-of-life solution and biodegradability to mitigate micro plastic pollution. Co-ordination is by Bio Base Europe Pilot Plant Vzw in Belgium. Participants are: Universiteit Maastricht, Forschungszentrum Julich Gmbh, B4plastics, Universidad De Vigo, Quantis, Fva Sas Di Louis Ferrini & C0, Eurocord, Bundesverband Der Deutschen Sportartikel-Industrie (Bsi) Ev, I-Coats, Van Beelen Group, Novozymes A/S, Nexis Fibers A.S., Pak Gida Uretim Ve Pazarlama Anonim Sirketi			
Global Fishing Watch	United States	Using AI to profile high-seas vessels by flag state and gear type from satellite and vessel registry datasets.	AI	Other:Legal Reporting	https://globalfishingwatch.org/our-technology/
			Satellites	Other:Legal Reporting	
Global Ghost Gear Initiative® (GGGI)	United States	Amongst many other activities, GGGI has built the largest database of ALDFG. Gathered in one place, publicly available as their Data Portal. Now trying to move into tracking and tracing of nets through their lifecycle. Using existing data portal requires people to track and feed data in manually. Blockchain also being trialled to provide chain of custody, but	Advanced Analytics	Other:Reporting	https://www.ghostgear.org/projects
			Blockchain	Other:Traceability	

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		this has not been widely deployed. Also some satellite tracking being used to track nets being deployed, but not (yet) to track them through their lifecycle.			
Goodwood Plastic Products	Canada	Turns ghost gear (ropes and nets) into synthetic lumber using an innovative shredding technique. Innovation funding came from the Canadian Government.	Mechanical	Recycling:Shredding	https://www.cbc.ca/news/canada/nova-scotia/n-s-company-finds-new-life-ghost-gear-1.5609337
Green Ideas Group	Sweden	Business specialising in the commercialisation and adaptation of technical solutions for the environment. The focus is on municipal waste, but they are involved with projects to recycle fishing gear. The company has a proprietary pyrolysis technology which uses low temperatures and does not require a catalyst. The process is particularly suited to inputs that are mixed plastics which would otherwise be incinerated. Outputs can be further processes into environmentally friendly fuels, new plastics, or petrochemical end products.	Other	Recycling:Processing	https://greenideasgroup.com/pyrolysis/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Gulf of Maine Lobster Foundation	United States	Project involving side scan sonar technology in the Gulf of Maine to identify accumulations of ghost gear. Project also provides a forum for divers to share equipment and pool knowledge about recovery methods. Ocean Conservancy's Global Ghost Gear Initiative Inaugural Small Grants Program awardee (Jan 2021).	Side Scan Sonar	Other:Traceability	https://www.ghostgear.org/news/2021/4/23/awardees-of-ocean-conservancys-gggi-inaugural-small-grants-program-announced
Havep	Netherlands	Workwear and protective gear company. Has created an innovative stretch textile blend that includes Econyl® nylon thread (bought via IBQ Fabrics). This material is used for the knee area in workwear trousers.	Advanced Materials	Design:Product Design	https://www.havep.com/en/blog/circular-together%C2%A0-nylon-made-from-recycled-fishing-nets
Healix	Netherlands	Born out of a Hackathon, Healix is a performance textile company that collects, sorts, shreds, washes and reprocesses used twines, ropes, nets and other plastic fibre waste into polymers for the global supply chain. Healix® circular polymers is a family of branded polymers made from fishing gear.	Advanced Materials	Product:Yarn or Fabric	https://healix.eco/
Hitta Mig2 /Find Me	Sweden	Funded by Vinnova, and co-ordinated by RISE. Developing a cost-effective underwater identification and location method for fishing gear through localisation based on hydroacoustics in combination with a persistent IoT (internet of things) for traceability.	Acoustic IoT/M2M	Other:Traceability Other:Traceability	https://www.ri.se/en/what-we-do/projects/hitta-mig2-find-me

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		Aim is to support the transition to a circular economy related to fishing gear logistics and plastic waste.			
Hokkaido University, Sapporo	Japan	Academic research in the School of Engineering to evaluate feasibility of using recycled nylon fibre from ALDFG as reinforcement in polymer cement mortar for the repair of corroded concrete construction beams.	Advanced Materials	Other:Other	https://mdpi-res.com/d_attachment/materials/materials-13-04276/article_deploy/materials-13-04276.pdf
i-Coat	Belgium	Innovators in coatings and application methods for ropes and high-performance nets. Since 2021 offers bio-based (5-30% of blend) and biodegradable coatings. Involved in Project Glaukus (see entry).	Biodegradable	Product:Manufacturing	http://www.i-coats.be/
			Bio-Based	Product:Manufacturing	
IBQ Fabrics	Spain	Part of Holistex. Yarn and textile company, with extensive R&D capabilities. Working with Seaqual and Aquafil to include recycled fishing gear into innovative new materials.	Advanced Materials	Product:Yarn or Fabric	https://ibqfabrics.com/en/ecoibq/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Impact Laboratories Ltd	United Kingdom	Impact has developed a novel method of material separation for recycling called NetCycle. This is a low footprint, water-based separation technology suitable for portable or decentralised situations. Netcycle builds on a technology Impact have already commercialised called BOSS (Baffled Oscillation Separation System). The aim is to enable recyclers to gain access to a completed new feedstock and giving fishing companies and authorities a route to dispose of their broken or end of life fishing nets. UK Research & Innovation (UKRI) funded a feasibility study for the project (NetCycle).	Other	Recycling:Separation	https://www.impact-solutions.co.uk/netcycle-the-solution-to-ghost-nets/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Impossible Plastics	Sweden	Mass customisation manufacturer that will make products for industrial-scale production according to individual needs. Inputs sourced from landfills, oceans (incl. fishing gear), and material on the way to incineration. Patented technology provides the market with environmentally sustainable products that bind up to four times its own weight in carbon dioxide. Ongoing collaborations exist with Sotenäs Symbioscentrum, Peniche Ocean Watch and the Swedish Environmental Protection Agency. Products are third-party tested.	Other	Product:Manufacturing	https://www.impossibleplastics.com/
INdIGO	France	The EU Regional Development Funded INdIGO project has two main objectives: to develop the first fishing gear with a controlled lifespan that is biodegradable in the marine environment and to improve the recycling of fishing gear at the end of its life. The INdiGO project covers all aspects of net development including the supply chain, manufacturing, prototype development, testing and technical and economic analysis. A lifecycle analysis will also be performed. INdIGO also includes an educational aspect through the development of a mobile application to locate gear already lost, related to fishing and aquaculture activities. This will enable the mapping of pollution in the cross-Channel zone area and will raise awareness of plastic pollution among	Advanced Materials Biodegradable	Design:Product Design Product:Filament	http://indigo-interregproject.eu/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		divers, walkers, and fishermen. Work package 2 concerns the development of the prototype of the new fishing gear for the fisheries and aquaculture sectors. The first step is the development of the formulation from biodegradable plastics. This formulation will then be transformed in order to make semi-products: a monofilament and multifilament. These semi-products will then be used for the design and manufacture of prototype nets on an industrial scale. The INdIGO project brings together 10 French and English partners. Co-ordinator is UBS - Université Bretagne Sud. 6 research institutes: the University of Southern Brittany, Ifremer, the technical centre Synergie Mer Et Littoral, CEFAS, the University of Portsmouth and the University of Plymouth. 4 industrial partners are also associated to the project: NaturePlast, Filt, IRMA and Marine South East. UBS, via the ComposiTIC technical platform, is the project leader.			
Indigo Waters	Taiwan	Using underwater cameras (optical wavelengths) to detect derelict oyster chord nets. Formosa recycle this chord. Piloting on the West/South coast Taiwan where there are lagoons used for oyster aquaculture fields. Much oyster chord is abandoned (PA6 nylon). Visibility is low, so dangerous for divers and hence little knowledge of how much chord buried at sea bottom. Using video cameras and a diving torch, with a human operator locating and identifying the chords, as a safer, low-cost solution. Future development may include AI for analysing the video feeds, and an ROV.	Computer Vision AI	Other:Traceability Other:Traceability	https://www.indigowaters.org

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
INEX	United States	INEX is an IoT incubator. It partners with start-up IoT tech companies, helps them develop the technology in the lab, then finds small and midsize enterprises to pilot the projects in the field. Farms and fishing businesses are the living labs. Unclear as to whether any of the living labs in New Bedford, Massachusetts, USA, are focused on fishing gear.	IoT/M2M	Other:Other	https://iotimpactlabs.com
KOWIn (KO WIN YANG INDUSTRIAL CO., LTD).	Taiwan	Manufacturers of integrated, turn-key washing and recycling lines for fishing net scraps (PA, PP, PE and other plastic materials). Using this equipment it is possible to produce higher value final products such as recycled fishing net flake, which is directly available for extrusion-pelletising, producing fibre or other recycled plastic products.	Mechanical	Recycling:Processing	https://www.kowinrecycle.com/Fishnet-Waste-Turn-Key-Washing-Recycling-Line.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Leartiker S. Coop (CircularSeas)	Spain	Technological Centre specialising in Food Technology and Polymers Technology. Their Multifocalised Technology Centre is a leading centre for polymer research and technology transfer, including activities related to ocean plastic waste from fishing gear. Leartiker are the overall project co-ordinator for CircularSeas an Interreg Atlantic Area (ERDF funded) project with partners in areas such as polymer science, 3D printing and design, business incubation, software engineering, and maritime services/operations. The project aims to promote the Green Economy in Atlantic Area by using Circular Economy principles., performing waste analysis and are developing an integrated environment for 3D printing tailored to maritime environments. Among other activities, the project is using 3D printing technology to make plastic-based parts for the Maritime Industries. The inputs combine ocean plastic waste and new biodegradable, renewable and high-performance polymers. Innovations in software and hardware integration focus on off the shelf technologies.	Additive Manufacturing	Product:Finished Goods	https://www.leartiker.com/project/43
LIDEM Construcciones Mecánicas S.L	Spain	Specialist developers and manufacturers of rotary shredding machines. Have invested to make machines suitable for fishing gear.	Mechanical	Recycling:Shredding	https://www.lidem.com/ing/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
MAELSTROM	Italy	The EU-funded MAELSTROM project brings together key stakeholders – from research centres and recycling companies to marine scientists and robotic experts – to leverage the integration of complementary technologies for the sustainable removal of marine litter in different European coastal ecosystems. Co-ordinator is CNR-ISMAR - Marine Science Institute of the Italian National Research Council. The project will design, manufacture and integrate scalable, replicable and automated technologies, co-powered with renewable energy and second-generation fuel, to identify, remove, sort and recycle all types of collected marine litter into valuable raw materials. WP3 delivers a key technology: an underwater cable robot to be developed by TECNALIA and CNRS-LIRMM as an upgrade of the COGIRO cable robots used in industrial plants. This will be adapted to marine underwater activities. There will also be an app for recycling operators that will allow them to identify the materials being collected, and follow each step in the transformation process. Countries involved are: Netherlands, Malta, Spain, United Kingdom, France, Denmark, and Portugal. Project partners are: Stichting Deltares - The Great Bubble Barrier B.V. - Netherlands Universita Ta Malta - Malta International Sustainable Development Initiatives (I.S.D.I.) Group Limited - Malta Gees Recycling Srl - Venice Lagoon Plastic Free - Centro Internazionale In Monitoraggio Ambientale - Fondazione Cima -Servizi Tecnici Srl- Italy Fundacion Tecnalia Research & Innovation - Spain Alpha Consultants (Uk) Ltd - Uk Ciimar - Centro Interdisciplinar De Investigacao Marinha E Ambiental - Portugal Makeen Power	Robotics & Automation AI	Recycling:Collection Recycling:Collection	https://www.maelstrom-h2020.eu/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		A/S - Denmark Centre National De La Recherche Scientifique Cnrs - France.			
MarGnet	Italy	ECEASME/EMFF funded project. Objectives of the "MarGnet" project are to set up and test multi-level solutions to monitor, map, prevent, remove and recycle marine litter and ghost gear from sea-based sources present on the seafloor at two pilot sites located in the Northern Adriatic: the Venice Lagoon in Italy, and the Cres-Lošinj Archipelago in Croatia. Technical innovations include: monitoring the presence of marine litter and ghost gear through combined multi-sensor high resolution acoustic mapping and data analysis; development of a predictive model, able to stimulate the dispersion of sinking marine litter; improvement of the environmental sustainability and efficiency of the recycling process by engineering a prototype that exploits low temperature pyrolysis Co-ordinatior is LP-CNR-ISMAR - Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine.	Acoustic Advanced Analytics	Other:Traceability Other:Traceability	http://www.margnet.eu

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
MARLISCO	Denmark	A project initiated in 2012 by Plastix (with support of EuPR / EUPC) to develop an advanced technology to break, crush and sort different plastic fractions from fishing nets and compress the material again for more clean plastic particles. Same for steel/ The processed plastic and steel can be sold again to new production. Stakeholders involved were Plastix, Green Wave Plastics WasteFreeOceans, Frandsen Industri Produktion ApS EFD, Induction, F.L. Teknik, Schnoor Plast, and Aalborg Universitet.	Mechanical	Recycling:Separation	https://www.marlisco.eu/separation-and-recycling-of-materials-from-fishing-trawl-and-nets-denmark.en.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
MARNET	Spain	The MARNET project is funded by Generalitat Valenciana and FEDER Valencia region operational programme. It focuses on developing innovative textile yarns based on polyamide fibre sourced from recycled fishing nets. The results of the project will be truly novel, as sustainable, circular economy fabrics will be developed with technical applications from functional recycled PA yarn blends and natural fibres. Examples of technical applications include formulations based on additives to recycled PA: UV (to improve the resistance of materials to ultraviolet rays), UPF (to protect the skin from ultraviolet rays), FR (to retard flame propagation), FIR (to reflect the far-infrared waves emitted by the body providing therapeutic effects to the cells), NI (to release negative ions producing numerous benefits for the wearer). In addition to contributing to the cleanliness of the seas and oceans, the project will enhance the competitiveness of Valencian companies, enabling them to offer new products with an added-value factor. The co-ordinator is AITEX - Textile Research Institute.	Other	Product:Yarn or Fabric	https://www.aitex.es/portfolio/marnet-research-into-functionalised-polyamide-fibre-from-recycled-fishing-nets-for-technical-applications/?lang=en

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Mitsubishi Chemical Corporation	Japan	Has developed KILAVIS™RC, a new nylon filament yarn mixed with nylon resin recycled from fishing nets discarded in Japan and established a mass production system. This new nylon filament yarn is a blend of REAMIDE™ (recycled nylon resin made by REFINVERSE, Inc. from raw material newly regenerated from collected fishing nets discarded after use), and KILAVIS™, their own nylon filament yarn, using special fibre spinning technology.	Advanced Materials	Product:Yarn or Fabric	https://us.mitsubishi-chemical.com/mitsubishi-chemical-launches-sales-of-nylon-filament-yarn-using-resin-recycled-from-fishing-nets/
Multipack Global	India	Rope manufacturer. Includes re-cycled HPE, PE, PP. Some content from fishing gear, but not specified.	Other	Product:Finished Goods	https://www.multipackglobal.com
Nagami Designs	Spain	Specialist in 3D printing and robotic manufacturing. Have worked with Parley for the Oceans to develop self-contained fabrication units.	Advanced Materials	Design:Product Design	https://nagami.design/en/
Nanovia	France	Nanovia is collaborating with Coopération Maritime's RECYPECH project, and Fil & Fab in Brittany, France to develop PA6 nylon filament for thermoplastic extrusion 3D printing. Two filaments: PA6 R and PA6 CF R, a nylon filament reinforced with carbon fibres from the aviation sector.	Additive Manufacturing	Product:Filament	https://nanovia.tech/en/recycling-fishing-nets-for-3d-printing/
NaturePlast	France	Specialist company involved in providing support in developing products using bioplastic materials. Involved in INdIGO as leader of R&D operations for the formulation and compounds production based on bioplastics featuring biodegradation ability, together with Filt and UBS.	Biodegradable Bio-Based	Product:Filament Design:Product Design	http://natureplast.eu/en/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Net Your Problem (NYP)	United States	A Seattle-based company whose goal is recycling end of life fishing gear into new products. NYP is working with Washington CoastSavers and the National Marine Sanctuary Foundation to sort out certain plastics, warehouse them and then transport them to the Ocean Legacy Foundation, which has been working for several years on commercialising a recycling process for marine debris. NYP is also working with Western Washington University's Plastics and Composites Engineering Program and Washington SeaGrant on improved mechanical recycling processes. Future developments could include brokerage services for these materials.	Mechanical	Recycling:Shredding	https://www.netyourproblem.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Net-Works	United Kingdom	A collaboration between global carpet tile manufacturer Interface Inc., the Zoological Society of London (ZSL), global synthetic fibre manufacturer Aquafil and local partners. Part funded by the Darwin Initiative (DI), a UK government funding initiative that helps to protect biodiversity and the natural environment through locally based projects worldwide. Operations in 40 communities in the Philippines and Cameroon, with expansion to Indonesia underway. Locally collected and cleaned raw materials are bought by Net-Works and recycled into high quality nylon yarn and sold globally. A key innovation is a mechanical baling machine that operates without electricity. Innovative and inclusive business model based on a community based supply chain. Also, setting up community banks and providing access to financial services, using the Village Savings and Loan Association (VSLA) model.	Chemical Digital Business Models	Product:Yarn or Fabric Other:Other	https://net-works.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
NetTag -Tagging fishing gears and best-practices	Portugal	Funded by the European Maritime and Fisheries Fund (EMFF) and supported by the Executive Agency for Small and Medium-sized Enterprises (EASME). Centro Interdisciplinar de Investigação Marinha e Ambiental (Portugal) (CIIMAR). NetTag is a project promoting waste free fisheries through tagging fishing gears and enhancing on board best-practices in Portugal and Spain. Scientists, engineers, and the fisheries industry are involved. The approach used combines two different types of preventive measures: (i) new technology to prevent lost gears (a miniature acoustic transponder (or tag); and (ii) awareness actions to promote best-practices for on-board waste management. NetTag will develop new technologies to track fishing gears in case gears get lost, including low cost, miniature and environmental friendly acoustic tags and acoustic transceivers for localisation (with fisher's personal ID) of lost gear, and an automated-short-range robotic recovery system. See also: USMART - smart dust for large scale underwater wireless sensing	Digital Business Models	Other:Traceability	https://cinea.ec.europa.eu/featured-projects/nettag_en

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Nofir AS	Norway	Collects and recycles fishing and aquaculture gear from around Europe and Turkey. Covers PA6, PE and PP, lead and steel. Now acquired by Aquafil. Collected material is transported to the factory in Lithuania or Turkey where it is dismantled, classified and prepared for recycling. Nofir work in partnership with Aquafil in Slovenia to turn the recycled nets into regenerated polymers which are then used in textile products such as socks and swimwear, and carpet tile.	Advanced Analytics	Recycling:Collection	https://nofir.no/en/
Nordic Comfort Products (NCP)	Norway	Collect worn-out fishnets, ropes, and pipes from local fish farming companies, Kvarøy Fiskeoppdrett and Nova Sea. Started with research in 2017 collaboratively with Sintef Raufoss Manufacturing. Aim of study was to investigate how to recycle plastic waste from fishing and aquaculture and return it to standard production processes. NCP design and manufactures and has invested in equipment for injection moulding furniture using pellets from end of life fishing gear.	Other Other	Design:Product Design Product:Finished Goods	https://ncp.no/en/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Norwegian University of Science and Technology (NNTU)	Norway	Multiple projects in adjacent areas as well as directly relevant to fishing gear. Project SWARMs (Department of Marine Technology) The primary goal of the SWARMs project (Smart and Networking Underwater Robots in Cooperation Meshes) is to expand the use of underwater and surface vehicles (AUVs, ROVs, USVs), making autonomous maritime and offshore operations a viable option for new and existing industries. The SWARMs platform targets to integrate, coordinate and improve the functionalities of the different AUVs/ROVs, and to exchange information with each other by means of a communication network, during the execution of a specifically configured underwater operation regardless its complexity. SWARMs platform is distributed among the different elements taking part in a mission. http://www.swarms.eu/approach.html#technicalapproach NTNU AMOS - Centre for Autonomous Marine Operations and Systems Multiple research projects focused on intelligent ships and ocean structures, autonomous unmanned vehicles (under water, on the sea surface, in air and space) and robots for high-precision and safety-critical operations in harsh environments. Fishing gear is not explicitly cited, but many of the technologies look relevant.	Robotics & Automation	Other:Other	https://www.ntnu.edu/amos/about-amos

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Ocean Tech Hub LDA, Peniche Ocean Watch	Portugal	Circular Ocean is part of Ocean Tech Hub LDA's Peniche Ocean Watch (POW) initiative creating a blue circular economy model for waste fishing gear. A collaboration across ports in Portugal with Docapesca (Portugal's national fishing port authority). Also involves collaboration with Norwegian blockchain provider Empower AS for logging and tracking fishing gear once it has been collected. Goal is to develop a local handling and mechanical recycling process to shred, wash, and grind and extrude nets into pellets for large scale additive manufacturing in Ocean Tech Hub's 2Rodas microfactory in Peniche. Sculpture Ocean Project: Sculptur Ocean is a collaboration among partners Ocean Tech Hub LDA, NarWave AB, and Sculptur AB. The project is focused on developing the local production of new products from marine waste using the emerging technology of large scale additive manufacturing (3D printing). The production is planned to take place in POW's 2Rodas microfactory in Peniche. The project will investigate high-performance marine structures using formulations including graphene. https://www.penicheoceanwatch.com/sculptur-ocean	Blockchain	Other:Traceability	https://www.penicheoceanwatch.com/circular-ocean
			Mechanical	Product:Pellets	
			Additive Manufacturing	Product:Finished Goods	
			Integrated Recycling	Other:Other	
			Advanced Materials	Product:Filament	
Ocean Winnowers	United States	Ocean Winnowers have adapted ideas from a mobile marine gasification system for ocean plastic debris (PACMAN or Particularly Adept Contraption Managing Aquatic Nuisances). This was originally conceived as a floating, automated, integrated ocean harvesting system for plastics from seabed to surface. The design comprised mechanical grabs and a waste separation system, with residual heat power generation to power the operation and minimise carbon footprint.	Mechanical	Recycling:Collection	https://www.facebook.com/OceanWinnowers/
			Digital Business Models	Recycling:Collection	

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		Now re-imagined as a marine debris "on demand" service model using a fleet of small catamarans that leave a "hive" daily to collect the plastic which is returned to the barge where it is processed.			
Oceanworks	United States	Oceanworks® is the largest online sourcing platform for responsible plastic. Their global materials network is backed by shore- to-shelf traceability. Oceanworks® offers digitised blockchain-based traceability, material quality assurance, global logistics and marketing support. BASF Venture Capital GmbH are an investor.	Blockchain	Other:Other	https://oceanworks.co
Odyssey Innovation	United Kingdom	Employ a series of centralised drop-off points where ALDFG can be stored for collection. These materials are then transported from ports to reception facilities to be prepared for processing. The material is then sent to Plastix Global for recycling. Upon return, some of the material is made into kayaks.	Other	Product:Finished Goods	https://www.seafish.org/responsible-sourcing/tackling-marine-litter-and-end-of-life-fishing-gear/odyssey-innovation-developing-a-circular-solution-to-give-recycled-gear-a-new-life/
Orthex	Finland	Company designs and manufactures a range of products from recycled materials that includes those fro marine sources (under the trademark SmartStore™ Ocean). For example, their bucket is made completely from recycled plastic, material for the container is derived from old fishing nets and the handle is made from post-consumer recycled plastic.	Advanced Materials Other	Design:Product Design Product:Finished Goods	https://www.orthexgroup.com/products/bio-and-recycled/recycled-material

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		The wash bowl and scoop are made of 70 % old fishing nets and 30 % regular polypropylene.			
Parley for the Oceans	United States	NGO that co-ordinates a global clean-up network, including ghost net retrieval from shore and at sea. They claim to have developed the first global supply chain for upcycled marine plastic debris. From recovered materials they have funded material science to develop a range of Ocean Plastic® materials that can be used by leading brands (e.g. Dior). Working with innovation leader ABB Robotics and 3D printing experts Nagami, Parley has unveiled the next stage in the evolution of their self-contained AIR Stations at COP26 in Glasgow. These are end-to-end solutions for the plastic waste problem on islands and in remote regions. Intercepted marine plastic debris is sorted, cleaned, and processed on-site to create 3D printed Parley Ocean Plastic® furniture, objects, and building structures which then can support local communities and schools.	Advanced Materials Additive Manufacturing	Design:Product Design Product:Finished Goods	https://www.parley.tv/updates/parley-ocean-plastic
Plastic Bank	Canada	The Plastic Bank reintroduces coastal marine litter (including some beached fishing gear) into global supply chains as Social Plastic feedstock. Their blockchain platform (Alchemy) offers end-to-end traceability. The platform also offers a reward-incentive / banking capability for collectors (i.e., monetises the waste).	Blockchain	Recycling:Collection	https://plasticbank.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Plastic Energy	United Kingdom	Plastic Energy has a chemical recycling solution for high- and low-density PE and for PP. Their patented technology works on mixed, contaminated, multi-layered waste streams, as well as plastics that can no longer be mechanically recycled. Technical partners include Loughborough University (UK) and Siemens. The key patent is for Thermal Anaerobic Conversion (TAC) technology to convert end-of-life plastics. This complements traditional mechanical recycling efforts and energy recovery activities. The process converts end-of-life plastic waste into a new feedstock (TACOIL) to create clean recycled plastics. Much of the processing is currently from sources other than marine. However, they have collaborations with Waste Free Oceans, who partner with recyclers, converters, and brands, and who have some experience with fishing gear recycling (although their focus is floating and beached waste).	Chemical	Recycling:Processing	https://plasticenergy.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Plastic@Bay	United Kingdom	InnovateUK supported project to design an affordable and low-tech extrusion line and die capable of recycling fishing nets and ropes into plastic lumber. The project has added pre-processing steps to enable use of a lower power shredder that does not require a fixed, industrial housing and power supply. Future plans involve a Mobile Shredding Unit (MSU), comprising a purpose build unit, which will fit onto a flatbed trailer. Within the unit sits a 20.7 kW shredder with generator, conveying system and pre-processing area. The MSU will only shred materials that are clean, have no bio-fouling on them and have all non-recyclable components removed. The product will be shredded plastic, sorted by polymer and type (hard plastic versus fibres).	Mechanical	Recycling:Processing	https://www.plasticatbay.org/?v=79cba1185463
Plastix Global	Denmark	Mechanical recycler of PE and PP. Has developed proprietary mechanical recycling, grinding and extrusion capabilities. The operation is fully automated. Plastix's process transforms fishing nets, trawls, and ropes into recycled high-density polyethylene (rHDPE) or recycled polypropylene (rPPC), both of which are branded OceanIX. This recyclate is available in pellet form. They operate within a global network of partners for collection. At their facility, they can clean, separate, shred and recycling several different net materials.	Additive Manufacturing Mechanical	Product:Pellets Recycling:Grind or Crush	http://plastixglobal.com/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Project Blue	United Kingdom	UK based business with manufacturing facilities in Tuscany, Italy. Makes eco-chic products for pets from ALFDG. Serves global markets with a direct-to-consumer business model. Partners with the Danish recycling company Plastix Global to convert nets. Process starts by sourcing fishing nets, trawls and ropes from several ports, net makers, and plastics collectors globally. Plastix sorts the nets and divides them into types of plastics and colours. They are then shredded, washed, separated, and converted into pellets. Project Blu then mixes pellets with other plastic waste and uses injection moulding for the end product. Investors are Mars, R/GA and Michelson Found Animals.	Other	Design:Product Design	https://projectblu.co/pages/about-project-blu
			Other	Product:Pellets	
Qualy	Thailand	Qualy is a Thai design brand with a focus on community and environment. Qualy purchases discarded fishing nets collected by the local fishing villagers under the “Net free Seas” project operate by the Environmental Justice Foundation (EJF), to use as a raw material to create every day, creative products, home decorative items. Once the nets are collected they are cleaned using salt water, compressed into blocks, and transported to the partner recycling factory Teamplas Group). Here, they are made into pellets and sold to end-user companies which make them into useful products.	Other	Design:Product Design	https://qualydesign.com/international/
			Mechanical	Product:Finished Goods	
R3-IoT	United Kingdom	Uses satellite technology to transmit data about conditions in specific pens from remote fish farms to the cloud. This includes net condition.	IoT/M2M	Other:Reporting	https://r3-iot.com
			Satellites	Other:Reporting	
			Sensors/smart tags	Other:Reporting	

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
RadiciGroup	Italy	RadiciGroup is a global player in the polymer market (fibres, yarns and performance plastics). Renycle® is a range of sustainability-oriented engineering PA6 blends for injection moulding (i.e., typically containing 30% glass fibre reinforcement) from post-industrial and post-consumer sources. Although not obviously using fishing net inputs currently, that waste stream could potentially be included.	Advanced Materials	Product:Manufacturing	https://www.radicigroup.com/en
Recy Technologies	Italy	Designers and manufacturers of innovative, integrated washing lines for all type of fishing nets. All polluting materials present in the product are eliminated.	Mechanical	Recycling:Cleaning	https://recytechnologies.it/macchine/
Release Project	Japan	Blockchain-based social commerce platform that combines Big Data with Blockchain & AI. Aims to address logistics and supply chain inefficiency and the lack of efficient communication among buyers and sellers involved in agriculture and fishing ecommerce (services, skills, products). Fishing gear is not explicitly referenced, but there is clear scope for B2B gear transactions with full traceability.	Blockchain	Other:Traceability	https://www.globenewswire.com/news-release/2020/10/02/2102700/0/en/The-Release-Project-uses-advanced-technology-cryptocurrencies-and-blockchain-to-transform-the-logistics-of-agriculture-and-fisheries-around-the-world.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Resqunit	Norway	Has developed a flotation device fastened to fishing gear (Backup Buoy) that allows lost gear to be retrieved. The device uses an Electronic Time Release mechanism that is maintenance free and self-operated.	Robotics & Automation	Other:Traceability	https://www.resqunit.com/our-products/
Robot Industries	Romania	Specialists in integrated robotic systems for a number of Industry 4.0 and Waste Management 4.0 scenarios. Has developed an innovative Waste Robotics Autonomous Recycling (WAR) technology that integrates advanced waste handling processes, computer vision, deep learning algorithms and state-of-the-art robotic technologies to enable smaller, more precise, safer and more profitable waste recycling. No current fishing gear applications, but the technology is indicative of how automated waste sorting and processing is developing in niche applications.	AI Robotics & Automation	Recycling:Sorting Recycling:Sorting	https://www.robotindustries.ro/ro/roboti-reciclare-si-selectare-deseuri

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Safetynet Technologies Limited	United Kingdom	This project will develop and test an acoustic tag solution called MyGearTag. It will have 3 components: the tag, a deck hub and a smartphone App. Operationally MyGearTag will be passive and not transmit until it receives a unique signal from the deck hub, avoiding sound pollution. The deck hub will be fitted on the vessel and deployed as required. A smartphone App will be developed to allocate the tags to specific gears and provide the interface for communicating with the tags and pinpointing their location. Pilot test sets and trials will be carried out on commercial mobile and static gears in the UK, including potters, netters, and trawlers.	Sensors/smart tags	Other:Traceability	https://sntech.co.uk
Schijvens Corporate Fashion	Netherlands	Schijvens collects corporate customers' old clothing, shreds it and mixes the textile fibres with shredded PET-polyester ones from sportswear, fishing nets and bottles. This is the raw material for their circular yarn (typically 50% of the mix comprises recycled PET polyester from bottles, fishing nets and polyester clothing). The yarn falls into class A of the Made-By benchmark.	Mechanical	Product:Yarn or Fabric	https://schijvens.nl

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Schoeller Allibert	Netherlands	Leading supplier of returnable transit packaging. Partnered with Waste Free Oceans (WFO) conducted multi-year research on plastic blends to produce the WFO-box OceanIX, made largely from recycled fishing gear, that still meets strict quality requirements. Currently scaling up use of discarded fishing gear in products.	Advanced Materials	Product:Finished Goods	https://schoellerallibert.com/us/sustainability/recycling/
Sea Synergy	Ireland	Funded by the Environmental Protection Agency (EPA), MARplas employs a Design Thinking process for the circular economy that encourages and utilises co-design to develop and demonstrate innovative and novel approaches to the re-use of nets MARplas considers the full net re-use process: collection, cleaning, segregation, reprocessing, and new products. This will involve prototyping as a means to assess routes to market. This will contribute to the development of new disruptive p2p business models for re-use processes. The project will also prototype development of new materials / prototypes for an Irish context based on LCA phase.	Other Digital Business Models	Design:Product Design Design:Product Design	https://www.seasynergy.org/marplas/
Sea2see	Spain	Designer and producer of eyewear and watches in, entirely made with recycled marine plastic. Manufacturing takes place in Italy and Switzerland. Produce UPSEA(TM) PLAST upcycled plastic (plastic pellets of polyamide). Company has Cradle to Cradle Gold Certification. Exact proportion from fishing gear is not reported.	Other Other	Design:Product Design Product:Finished Goods	https://www.sea2see.org

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		Company organises marine debris collection by fishermen in Spain, France and West Africa.			
Sealive	Spain	Developing bio-based fishing nets made from green alternative materials such as micro-algae. Co-ordinator is ITENE is the Spanish specialist Technological Centre in R&D in packaging, logistics, transport, and mobility. SEALIVE brings together 24 partners and five linked third parties from 13 different countries across Europe (Austria, Belgium, Cyprus, Czech Republic, Denmark, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain) and South America (Argentina). The consortium consists of 10 Small to Medium Enterprises (SMEs), 2 Universities, 4 Research and Technology Organisations (RTOs), 3 Non-Profit Organisation (NPO) and 4 large companies.	Advanced Materials Bio-Based	Design:Product Design Design:Product Design	https://sealive.eu
SEAQUAL INITIATIVE	Spain	SEAQUAL INITIATIVE works with the waste management and recycling industries to transform marine litter into SEAQUAL® MARINE PLASTIC. It is unclear how much of the recycling involves fishing gear. Seaqual is made by spinning melted polyester chips. This produces fibre ready to be spun into yarn. The material is certified to Oeko-Tex Standard 100 and GRS. Antex and VICA are licensed manufacturers of Seaqual yarn (both are in Spain). Antex makes continuous filaments and VICA creates short, staple fibres.	Advanced Materials	Product:Yarn or Fabric	https://www.seaqual.org

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
SeeAhead	United States	See also BlueSwell Incubator Program. SeeAhead offer a Bluetech start-up platform to drive open innovation, Business Angel investing (Blue Angels) and an early stage venture fund. SeeAhead appear to be a key promoter of Bluetech, and focus on application of emerging technology to sustainable aquaculture, fisheries management, the offshore wind supply chain, coastal resilience, plastic alternatives and the future of ports and shipping. Currently, they are home to more than 70 startups https://sea-ahead.com/startup-members).	Other	Other:Other	https://sea-ahead.com/what-we-do

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
SenseOCEAN	United Kingdom	SenseOCEAN is a Collaborative Project funded by the European Union Seventh Framework Programme. It draws together world leading marine sensor developers to create a highly integrated multifunction and cost-effective in situ marine biogeochemical sensor system. Although not currently directly applicable to fishing gear, innovations will be combined with state-of-the-art sensor technology to produce a modular sensor system that can be deployed on many platforms. Prototypes will be optimised for scale-up and commercialisation. These will be tested and demonstrated on profiling floats, deep-sea observatories, autonomous underwater vehicles, and fishing vessels. Ultimately the developed sensors will be launched as commercially available products. Lead organisation is the National Oceanography Centre in the UK.	Sensors/smart tags	Other:Traceability	https://senseocean.eu
SINTEF Ocean	Norway	SINTEF Ocean conducts research and innovation related to ocean space. Simulation One research focus is information and communication technology for fishing gear design and simulation. Project CAGEREPORTER	Computer Vision Robotics & Automation	Other:Other Other:Reporting	https://www.sintef.no/en/ocean/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		The CageReporter project adapts the use of autonomous and tether-less underwater vehicles as a carrier of sensor systems for data acquisition, where the data are transferred from sea-based fish cages to a centralised land base. Examples of areas of applications include net inspection. The project idea is based on using low-cost technology for underwater communication, vehicle positioning, and camera systems for 3D vision.			
SOFAR	United States	Note: Demonstrates a planetary-wide infrastructure capability that could be exploited for fishing gear location, tracking and tracing. Company provides a mesoscale ocean Big Data platform i.e., currently the largest, global ocean sensor network. Data is collected from thousands of smart, open ocean buoys ("spotters"). Data is provided to customers via APIs. Focus is primarily on weather, route optimisation and similar marine tasks. However, the company has a mission to support broader scientific research. Was supported as a start-up by s2gventures (https://www.s2gventures.com/oceans-seafood).	AI	Other:Other	https://www.sofarocean.com
			Satellites	Other:Other	
			Sensors/smart tags	Other:Other	
Sotenäs Symbioscentrum	Sweden	Original vision was to develop an integrated, end-to-end waste management system based on three projects: a biogas facility, a wastewater treatment plant, and recycling of waste and "end of life fishing gear and marine litter from beaches. In a case study for BCE this is described as a "circular economy-based rejuvenation programme involving job creation, upskilling, investment, added-value and more efficient, greener use of local resources." In 2018 the Sotenäs Marine Recycling Centre (SMRC) was	Digital Twin	Other:Traceability	http://symbioscentrum.se
			Digital Twin	Other:Reporting	
			IoT/M2M	Other:Traceability	

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		established. This is a small factory to disassemble fishing gear, sort the different materials and prepare materials for reuse and recycling (any large-scale processing is by Plastix Global in Denmark). The factory has small-scale mechanical recycling capabilities (i.e., a shredder), and injection moulding, extrusion, and 3D printer capabilities suitable for prototyping. Nets are collected from all over Sweden at local hubs, the transported to the SMRC. SMRC has developed a Testbed Ocean Waste (TOW) to encourage innovation in upcycling/reuse/recycling of marine waste. In the test bed are mainly innovators, start-ups and small companies that develop their ideas near the raw material (analysed and characterised by RISE in Gothenburg). There are connections to other test beds across Sweden, including the one for plastic recycling run by RISE. They host testing and analysis equipment, plus large-scale 3D printing, fibre spinning, injection moulding and extrusion machines (for pellets). Products being made from plastics from TOW include furniture, interior design objects, clothing and accessories, and automotive components. <u>IoT Project</u> Vinnova funded IoT project for track and trace through tagging raw materials. Project tacks materials from end-to-end (the start of the supply chain to the point of manufacture) using QR codes at each stage (collecting, sorting etc). Essentially a central platform for data sharing. <u>Digital Twin Project</u> Digital Twin is based on the material flow between hubs in the			

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		network, and includes fishing gear. The Digital Twin has been built and connected to the marine recycling centre by Swedish start-up, Respace (spun out from Chalmers by two University Professors, and based in Sotenäs). Data model allows for fishing gear to be divided into different types of gear, then the individual materials (i.e. there is an implicit taxonomy). Could be basis for an automated reporting system for EPR, and connection to EU EPR system is being developed (reports are only available as mock-ups at the moment). Sorted materials go to RAMBO, Plastix, other recycling facilities (e.g. municipality), local test bed for ocean plastics, STENA. Also has a simple front-end ordering system so companies can specify what recycled materials they are looking for (12 companies in different sectors, currently. Limited traceability currently, with lower level tracking / more detailed tracking in future. Other future areas for investigation: automatic sensors, more actors in network, and blockchain for Material Passports and to secure data flows.			

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Teamplas Group	Thailand	Recycler with projects together with EJF that involve chemical recycling of nylon nets as input materials for injection moulding and other processes (also known as Ocean Bound Plastic). In addition, Teamplas offer an Ocean Plastic series of resin products, including PA6. These are produced in an integrated supply chain for traceability, and are certified by global institutes (e.g., Global Recycle Standard, GRS).	Advanced Materials	Product:Finished Goods	https://teamplasgroup.com
Techmer Polymer Modifiers	United States	Global leader in materials design. Designed an industry-first metallic silver using 100% Envision Ocean Bound resin for packaging applications. Partners with Plastix and using Techmer's proprietary Techsperse® compounding technology that allows end users to use 100% recycled materials (such as OceanIX) while maintaining physical properties and achieving their colour and appearance targets. Techmer's exclusive track-and- trace program will also enable brand owners to validate their packaging claims to the consumer, regulatory agencies, or to anyone interested in confirming their commitment to sustainability.	Advanced Materials	Design:Product Design	https://www.techmerpm.com/techmer-pm-expands-its-sustainable-solutions-portfolio/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Teem Fish	Canada	A project to create a Dungeness Crab lost gear e-reporting tool in British Columbia, Canada. The project aims to enable near real-time reporting of lost fishing gear; and integrate their software into the annual lost gear retrieval program operated by Ecotrust Canada and the Area A Association. Ocean Conservancy's Global Ghost Gear Initiative inaugural Small Grants Program awardee (Jan 2021).	Other	Other:Reporting	https://www.ghostgear.org/news/2021/4/23/awardees-of-ocean-conservancys-gggi-inaugural-small-grants-program-announced
Testbed ocean waste	Sweden	Sotenäs municipality has established a test bed for upcycling/reuse/recycling of marine waste. The test bed is available for physical tests and supplemented with an innovation environment where the business approach of the testers is to be developed. The testbed will also build a network to other related testbeds. The test bed primarily targets smaller actors, such as innovators, start-ups, and smaller companies.	Digital Business Models	Other:Other	https://www.vinnova.se/en/p/testbed-ocean-waste/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Textile Exchange	United States	Developing eTrackit as an alternative traceability mechanism to track the physical movement of certified material and process transformation from fibre producer to brand or product. Textile exchange are working with the TextileGenesisTM traceability platform, which is tailored for the textile ecosystem. Uses Fibercoin blockchain tokens, and GS1 framework for automated upload of value chain data, at article level from site-to-site across the textile value chain.	Blockchain	Other:Traceability	https://textileexchange.org/etrackit/
Thünen Institute of Baltic Sea Fisheries	Germany	Pursuing multiple projects to change the materials and design of gear to improve abrasion resistance. A key project is DropS intended to reduce plastic waste from beam trawl fishery through gear modifications. Long term aim is to eliminate the need for "dolly ropes" made form polyethylene.	Advanced Materials	Other:Other	https://www.plastic-network.org/thunen-institute-of-baltic-sea-fisheries/
Tiong Liong	Taiwan	Recycled nylon fishing net fabric supplier and manufacturer. Has developed MARINYLON® recycled nylon fishing net yarn. Sources locally. Has invested in multi-year R&D in core textile techniques including weaving, dyeing, and finishing, functional treatment and coating, and lamination.	Advanced Materials	Product:Yarn or Fabric	https://www.tiongliong.com/en/product/MARINYLON-Recycled-Nylon-Fishing-Net-Fabric/marinylon-recycled-fishing-net-fabric.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
TraSeable Solution	Fiji	Company working on solutions that could be adapted for fishing gear. Their solutions leverage and integrate Internet of Things (IoT) technology and provide regulators with the means of verifying and validating end-to-end traceability of seafood and agriculture products.	IoT/M2M	Other:Traceability	https://www.traseable.com
Trimara	United Kingdom	Make the AutoBoss; an automatic net washing machine for aquaculture.	Robotics & Automation	Recycling:Cleaning	http://www.trimaraservices.com
TU Delft	Netherlands	Project Spoilt - Ocean Cleanup Research project looking at mathematical models for the logistics of recycling of marine litter. Although the focus is on floating litter, the algorithms are applicable to any marine logistics challenge. The researchers have evaluated alternative logistics chains to accommodate ocean plastic waste recycling by connecting transport with data collection and advanced data analytics. The analysis shows that more complicated logistic structures (i.e., where waste is converted to consumer products) can lead to sustainable business models for cleaning up the Oceans.	Advanced Analytics	Other:Other	https://repository.tudelft.nl/islandora/object/uuid%3Ac216f32e-015d-4771-8de2-80ec0dca88aa

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
USMART - smart dust for large scale underwater wireless sensing	United Kingdom	The aim of this UK EPSRC-funded project is to create a smart underwater sensing framework based on ultra-low-cost underwater communication and sensing devices ('smart dust'). Pilot studies at Newcastle University have demonstrated the feasibility of producing underwater acoustic communication devices known as "nanomodems" using novel approaches to signal processing. This vastly reduces hardware complexity, size, and cost (a manufacturing cost of £50), very low receiver power consumption (enabling long life from small batteries), and tiny dimensions. Data transfer and positioning capabilities equal those of much more expensive devices, over distances up to 1km through water. The project will focus on three main demonstrator scenarios in close collaboration with industry and end users: subsea asset monitoring (e.g., condition of subsea cables, risers, seabed installations); marine environment / biodiversity monitoring - chemical or biological parameters; and sensor nets for underwater security - detecting sound emitted or magnetic disturbances from underwater threats. The novel contributions of this project will be: Disruptive, low-cost technology enabling mass deployment with battery life of several years; large scale underwater monitoring (>100 devices) with high spatial resolution; rapid deployment and online data delivery; and intelligent, adaptive sensing to maximise resource utilisation and fully exploit large scale. To maximise the impact of the project, an open test-bed will be created near the Northumberland coast. Potential end-users (including users of fishing gear) will be invited to take part in a series of workshops to identify new opportunities in distributed underwater sensing, which will be prototyped and evaluated via trials using the testbed. Newcastle University have the lead, with project partners: Proserv (Nautronix), Subsea 7 Limited, and TechnipFMC plc (UK).	Acoustic	Other:Traceability	https://research.ncl.ac.uk/usmart/

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
ValorYeu	France	Business recycling of fishing nets into filament for 3D printing. Filament is 100% recycled PA6, and available with antimicrobial properties. Recovery of used fishing nets in La Rochelle, Le Croisic and Île d'Yeu. For the ports, the operation is free of cost. Also has a social mission - developing economic activity on the island of Yeu. Other institutions involved include - Landry - ICAM - Port de La Rochelle - Mairie de l'Île d'Yeu - Port de l'Île d'Yeu - Port des Sables d'Olonne - ADEME - Ministère de la transition écologique.	Additive Manufacturing	Product:Filament	https://www.valoryeu.com
Vecoplan AG	Germany	Designers and manufacturers of recycling equipment, including shredding machines with innovations relevant to fishing gear. Has supported WWF ghost gear initiatives in the Baltic (PP and PA nets).	Mechanical	Recycling:Shredding	https://vecoplan.com/en

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Verifact	Ireland	Net360 Novelplast Teoranta (plastic recycler) and Verifact (traceability blockchain for fishing gear) collaborating on net provenance and traceability using Hyperledger Fabric. QR codes are used to track collection dates at each step. The blockchain scope limited but intended to include reporting for regulators and ecolabel producers as a response to SUP/EPR. The approach is also influenced by the EU Directive on Port Reception Facilities (PRF) as the waste gear scheme is within the scope of PRF. Project is still being scoped. In terms of technology, the project is still at the design/wireframe stage for project, with ongoing discussion over which data fields to include. Many stakeholders involved in net supply chain e.g. in Donegal alone they are working with 12. AquaEye Current Verifact project for aquaculture together with European Space agency (ESA). AquaEYE sensors are installed on participating certified aquaculture production units and data is transmitted through satellite and GPRS technology to monitor water quality. Has potential to be adapted for monitoring/tracking gear. The following two projects are not fishing gear specific, but sufficiently adjacent to be included. Seafood blockchain project Since 2019, Verifact have been working with Donegal Catch (part of Green Isle Foods) on a sea to plate blockchain project,	Blockchain	Recycling:Collection	https://vfact.com

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
		supported by BIM funding. Scope is seafood chain of custody aligned with Global Dialogue on Seafood Traceability (GDST) and FAO. 63 commercial buyers involved – retailers, food service etc. Verifish Verifish: Seafood traceability back to catch / farming. Aldi and Verifact (as Verifish) are now participating in a pilot project with BIM, funded under the European Maritime and Fisheries Fund. Aim is to validate buying policy for sustainably sourced Irish seafood. Value chain is fishing co-op, processor, and retailer (ALDI). 12 product lines.			
Wilson School of Design at KPU	Canada	Student project. Dr. Victor Martinez supervised project NetGain aimed at recovering fishing nets and turning them into filaments for 3D printing. Demonstrated a 40:1 increase in value from net-as-waste to filament.	Additive Manufacturing	Product:Filament	https://www.kpu.ca/research/blog/catching-fish-3d-printing-recycling-fishing-nets-netgain-wilson-school-design

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
World Wildlife Fund partnered with ConsenSys and SeaQuest Fiji	Fiji	Implementing a blockchain system that verifies where, when, and how tuna fish were caught. A traceability system was built by integrating blockchain on top of the existing digital traceability system. Using TraSeable's tablet-based application, fishermen on boats in the sea and regulators on shore enter data into the blockchain system. Could also be extended to register types and quantities of nets so authorities can track whether boats return to port with the number of nets they left with.	Blockchain	Other:Traceability	https://www.sciencedirect.com/topics/social-sciences/world-wildlife-fund
WWF Deutschland	Germany	Collaboration to trial a novel material recycling pathway for ALDFG in the context of European Interregional project MARELITT Baltic. WWF together with recycling company Toensmeier AG collected ghost fishing gear from the Baltic Sea. This was sent to the recycling equipment manufacturer Vecoplan, where several pre-treatment steps, including sorting, shredding, density separation and cleaning were conducted. Process data were collected, and a material flow analysis was performed. Samples of the cleaned synthetic fibres were sent to the plastic pellet producer EREMA to determine potential applications.	Other Other	Product:Pellets Recycling:Shredding	https://www.recovery-worldwide.com/en/artikel/vecoplan-r-supports-ghost-net-recycling-with-its-processing-technology_3368500.html

Company, Organisation or Project Name	Lead Country / Head Office	Description	Technology Application	Lifecycle	URL
Yangzhou Haili Precision Machinery Manufacturing Co., Ltd	China	Largest manufacturer of fishing net machines in China. 30-year history of innovations in knotless, single, and double knotted net making machines. Advanced net designs developed using 3D CAD modelling software.	Other	Design:Product Design	http://m.chinanetmachine.com/about-us
ZenRobotics	Finland	Intended for municipal waste processing, and no known applications to fishing gear waste sorting, but they show a potential future direction. Company makes AI-powered robots that can recognise and sort waste fractions of various shapes, weights, and sizes from light packaging waste to big and bulky objects from construction sites. The robots sort materials like plastics, metals, wood, and fibres.	Robotics & Automation	Recycling:Sorting	https://zenrobotics.com

ANNEX C Organisations involved across the lifecycle

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
AI		CIDCO - Development Center for Ocean Mapping MAELSTROM	Robot Industries	BASF											Global Fishing Watch	Indigo Waters	Commonwealth Scientific and Industrial Research Organisation (CSIRO) SOFAR
Acoustic / Underwater GPS																Collecte Localisation Satellites (CLS) Hitta Mig2 /Find Me MarGnet NetTag -Tagging fishing gears and best-practices USMART - smart dust for large scale underwater wireless sensing	BlueSwell Incubator Program

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Additive Manufacturing									BLUECYCLE LAB CircularSeas Fishy Filaments Nanovia ValorYeu Wilson School of Design at KPU	BLUECYCLE LAB Fil & Fab Plastix Global			AddiFab Benthos Buttons BLUECYCLE LAB Leartiker S. Coop Ocean Tech Hub LDA, Penich Ocean Watch Parley for the Oceans				

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Advanced Analytics		Nofir AS	CleanSea											eOceans Global Ghost Gear Initiative¬Æ (GGGI)		CleanAtlantic Consortium MarGnet	TU Delft
Advanced Materials (non bio)									Ocean Tech Hub LDA, Penich Ocean Watch	DSM	BLUENet Carvico Formossa Taffeta Co Healix IBQ Fabrics Mitsubishi Chemical Corporation SEAQUAL INITIATIVE Tiong Liong	Adidas Epsotech Havep INdIGO Nagami Designs Orthex Parley for the Oceans Sealive	Ecoalf RadiciGroup Schoeller Allibert Teamplas Group				Glaukus Hokkaido University, Sapporo Thünen Institute of Baltic Sea Fisheries

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
												Techmer Polymer Modifiers					
Bio-Based Materials	BIOFILET Sealive											Glaukus NaturePlast	B4Plastics i-Coat				
Biodegradable Materials	Glaukus INdIGO								INdIGO NaturePlast				B4Plastics i-Coat				
Blockchain		Blue Room Innovation Plastic Bank Verifact														Global Ghost Gear Initiative (GGGI) Ocean Tech Hub LDA, Penich Ocean Watch Release Project	Oceanworks

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
																Textile Exchange World Wildlife Fund partnered with ConsenSys and SeaQuest Fiji	
Chemical Recycling								CuRe Technology Plastic Energy		AIMPLAS	Net-Works						
Computer Vision		CIDCO - Development Center for Ocean Mapping														Indigo Waters	BlueSwell Incubator Program Commonwealth Scientific and Industrial Research Organisation (CSIRO) SINTEF Ocean
Digital Business Models		Ocean Winnowers										Sea Synergy		eOceans			Net-Works Testbed ocean waste
Digital Twin												Bureau Veritas		Sotenväs Symbioscentrum		Sotenäs Symbioscentrum	

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Integrated Recycling																	Ocean Tech Hub LDA, Penich Ocean Watch
IoT/M2M														R3-IoT		AssetLink Global Hitta Mig2 /Find Me Sotenäs Symbioscentrum TraSeable Solution	INEX
Mechanical Recycling		Ocean Winnowers		MARLISCO	Recy Technologies	Chang Woen Comberplast GEP Ecotech Goodwood Plastic Products LIDEM Construcciones Mecánicas S.L Net Your Problem (NYP) Vecoplan AG	AIMPLAS Plastix Global	Gangsu Machinery Co KOWIn (KO WIN YANG INDUSTRIAL CO., LTD). Plastic@Bay		CuRe Technology Fil & Fab Ocean Tech Hub LDA, Penich Ocean Watch	Schijvens Corporate Fashion		Comberplast Qualy				

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Other - GIS databases, mobile apps etc	Claire Potter Design Yangzhou Haili Precision Machinery Manufacturing Co., Ltd			Impact Laboratories Ltd	CircularSeas	WWF Deutschland		Green Ideas Group		Project Blu WWF Deutschland	MARNET	CircularSeas Claire Potter Design Nordic Comfort Products (NCP) Project Blue Qualy Sea2see Sea Synergy Yangzhou Haili Precision Machinery Manufacturing Co., Ltd	Impossible Plastics Multipack Global Nordic Comfort Products (NCP) Odyssey Innovation Orthex Sea2see	Teem Fish		AIMPLAS	Coopération Maritime's RECYPECH project SeeAhead
Robotics & Automation (including ROVs)		MAELSTROM	Robot Industries ZenRobotics		Trimara									SINTEF Ocean		Collecte Localisation Satellites (CLS) Resqunit	Deep Trekker (now part of Halma PLC, UK) Dive Technologies Norwegian University of Science and Technology (NNTU)

BCT Technology Area	Lifecycle																
	(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Satellites														R3-IoT	Global Fishing Watch	AssetLink Global Blue Ocean Gear Collecte Localisation Satellites (CLS)	SOFAR
Sensors/smart tags														R3-IoT		Adriatic Network for Marine Ecosystem (ADRINET) Safetynet Technologies Limited SenseOCEAN	Dive Technologies SOFAR
Side Scan Sonar																Gulf of Maine Lobster Foundation	
Thermal Recycling								CLAIM Faculty of Engineering, Gipuzkoa, University of the Basque Country UPV/EHU									

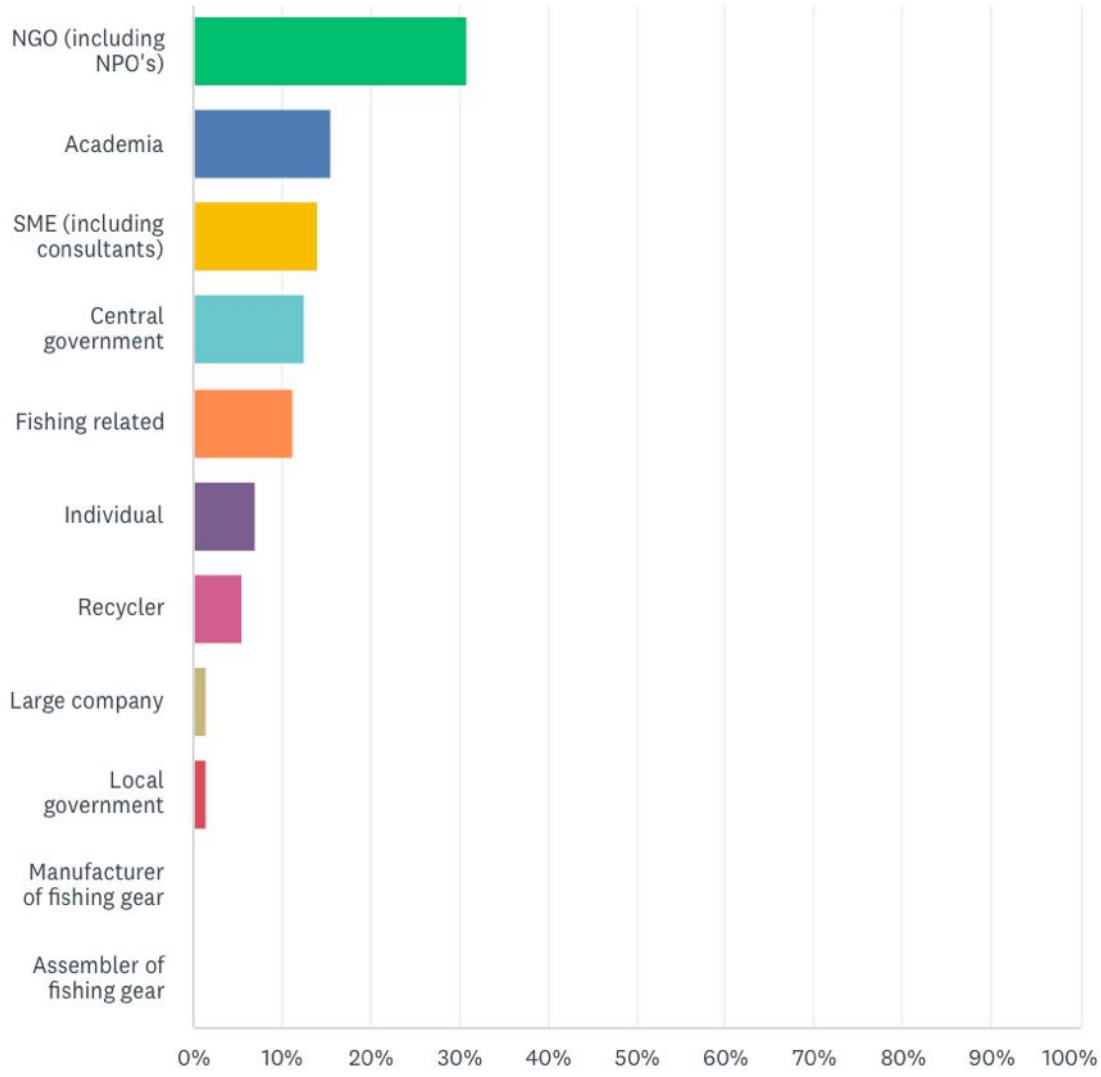
ANNEX D Heatmap of the number of organisations engaged in specific technologies across the lifecycle

Note that in a small number of cases (three) there are applications that are relevant to two parts of the lifecycle. This occurs for bio-degradable design activities which are applicable to both nets and products, and for some of the more generic technologies (categorised as 'other'). Hence a total of 180 entries for 129 discrete organisations.

		Lifecycle																
		(Re)Design of Gear	Recycling							Product (B2C and B2B)					Cross Lifecycle and Point Solutions			
BCT Technology Area	Total Applications	Design of Gear	Collection	Sorting	Separation	Cleaning	Shredding	Grind or Crush	Other Processing	Filament	Pellets	Yarn or Fabric	Industrial and Consumer Product Design & Prototyping	Finished Goods	Value Chain Reporting	Compliance Reporting	Traceability	Point Solutions to Validate Technology
Acoustic / Underwater GPS	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1
Additive Manufacturing	15	0	0	0	0	0	0	0	0	6	3	0	0	6	0	0	0	0
Advanced Analytics	7	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	2	1
Advanced Materials (non bio)	26	0	0	0	0	0	0	0	0	1	1	8	9	4	0	0	0	3
AI	8	0	2	1	1	0	0	0	0	0	0	0	0	0	0	1	1	2
Bio-Based Materials	6	2	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0
Biodegradable Materials	6	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0
Blockchain	9	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1
Chemical Recycling	4	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0
Computer Vision	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
Digital Business Models	5	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2
Digital Twin	3	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
Integrated Recycling	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
IoT/M2M	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	1
Mechanical Recycling	21	0	1	0	1	1	7	2	3	0	3	1	0	2	0	0	0	0
Other - GIS databases, mobile apps etc	27	2	0	0	1	1	1	0	1	0	2	1	8	6	1	0	1	2
Robotics & Automation (including ROVs)	10	0	1	2	0	1	0	0	0	0	0	0	0	0	1	0	2	3
Satellites	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	1
Sensors/smart tags	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2
Side Scan Sonar	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Thermal Recycling	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
No. of Applications by Organisation	180	6	10	4	3	3	8	2	8	9	10	11	21	22	9	2	29	23

ANNEX E Survey results

Q: Which of the following best describes you or your organisation? (Select one)
N=71



Q: Where are you based?
N=71

United States	16.90%	12
Ireland	14.08%	10
United Kingdom	14.08%	10
Canada	8.45%	6
France	5.63%	4
Belgium	4.23%	3
Brazil	2.82%	2
Germany	2.82%	2
Italy	2.82%	2
Kenya	2.82%	2
Netherlands	2.82%	2
Angola	1.41%	1
Argentina	1.41%	1
Barbados	1.41%	1
Cyprus	1.41%	1
El Salvador	1.41%	1
Ghana	1.41%	1
Greece	1.41%	1
Japan	1.41%	1
Malaysia	1.41%	1
Mexico	1.41%	1
Norway	1.41%	1
Pakistan	1.41%	1
South Africa	1.41%	1
Spain	1.41%	1
Trinidad and Tobago	1.41%	1
Vanuatu	1.41%	1

Q: Thinking of repair, reuse, refurbishment and recycling of waste and "end of life" fishing and aquaculture nets, ropes, components and peripherals, which advanced technologies would you prioritise for investment in the next 3-5 years? (Select up to 5)
N=71

ANSWER CHOICES		RESPONSES	
Novel mechanical separation technologies		53.52%	38
Low-cost material Inspection and testing technologies		39.44%	28
Novel track and trace technologies such as blockchain		38.03%	27
Sensors and tags		36.62%	26
Smart storage that can detect materials		35.21%	25
Novel thermal processes (incl. pyrolysis)		32.39%	23
Process automation		28.17%	20
Novel chemical separation technologies		28.17%	20
3D printing		22.54%	16
Something else - this counts as 1 of your 5 choices (please specify)	Responses	22.54%	16
Artificial Intelligence		19.72%	14
Systems that can make sense of images and videos		18.31%	13
Bioreactors		9.86%	7
Virtual models of fishing gear (sometimes called "digital twins")		9.86%	7
Robots		8.45%	6
Automated guided vehcles		7.04%	5
Internet of Things		4.23%	3
Total Respondents: 71			

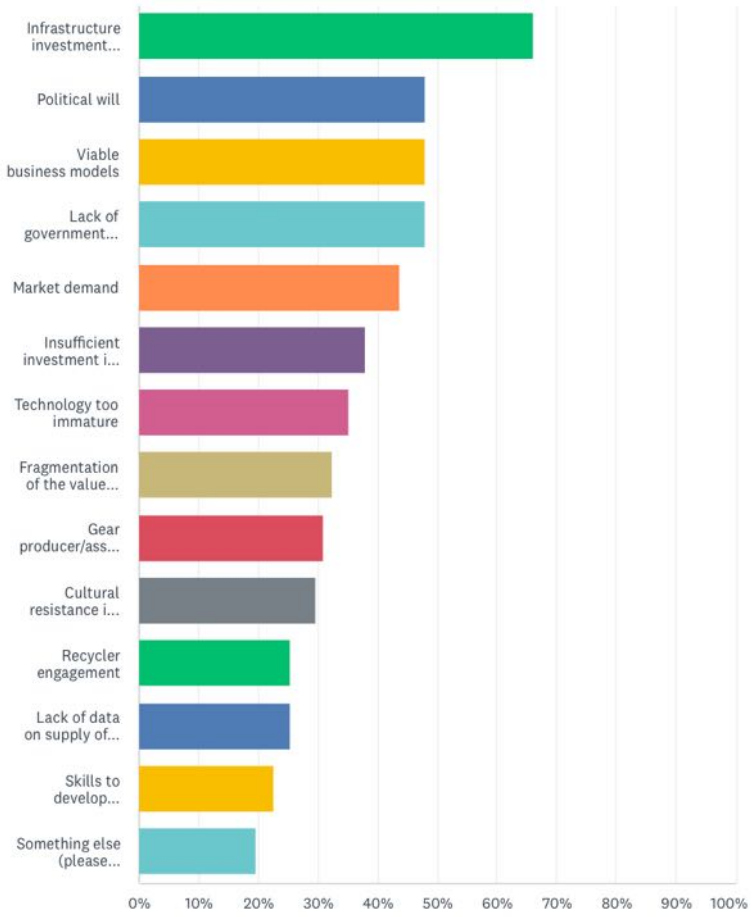
Note that this question allowed for free text responses, and these are listed below, verbatim:

- Automated materials identification and sorting
- Developing more storm resilient gear and processes to reduce wear and tear and gear losses.
- Developing more storm resilient gear and processes to reduce wear and tear and gear losses
- Recycling of plastic material into building materials
- Environmentally friendly plastics
- Training platforms and/or technologies for seafood harvesters
- Smart systems are needed to encourage sign up by fishers and other retrieval schemes plus member of the public to bring the stuff ashore - smart storage systems needed above all else!
- Help {redacted name} complete their now advanced design of capture and waste to energy at sea. Facebook page
- Alternative materials
- In SIDs may have to think low cost and what is practical in a tropical setting
- Biodegradable materials – composting

- Just noting that it's not immediately clear to me how some of these technologies will relate to repair, reuse, refurbishment, and recycling of FNRCs in particular, so this was a harder question to answer than initially anticipated.
- Low-tech recycling
- roll out existing mechanical solutions
- carbon footprint of circular approach to recycling
- Search and rescue of abandoned gear automation

Q: Thinking of advanced technology in relation to circular solutions to waste and "end of life" fishing and aquaculture gear, please rank the following in terms of potential areas for application from 1 to 11, with 1 as greatest potential and 11 as least.
N=71

Q: Thinking of advanced technology in relation to circular solutions to waste and "end of life" fishing and aquaculture gear, which of the following do you see as the greatest barriers to successful implementation? (Select all that apply)
N=71

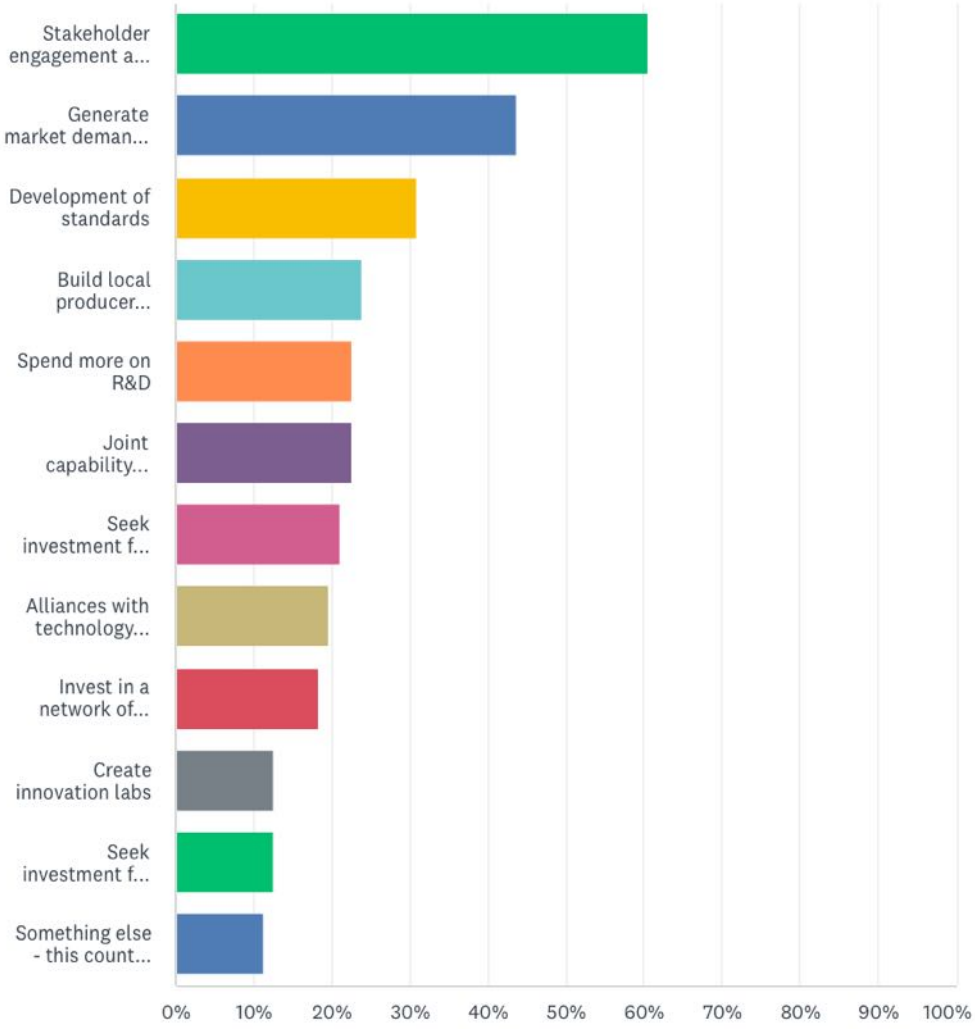


Note that this question allowed for free text responses, and these are listed below, verbatim:

- Insufficient certainty on availability of gears to recycle
- Fishing gear may last decades and will be used thousands of times to categorise this as single use plastic is idiotic.
- Not economical viable. More plastic quantity needed e.g., from other industries.
- Use recycled material in existing products (-volumes) and provide useful documentation (process and properties, data)
- Fisher engagement is key, and it is all too easy to dump gear at sea
- Funding for actual fishermen and mariners who have been trying to help for years but have been denied and villanized
- Lack of feasible substitute materials
- No solution for too small waste streams to be industrialised
- Lack of political guidance/mandates
- Noting the way the question is framed, it's hard to connect advanced tech specifically to some of these challenges.

- Lack of available market volume (less <1-2% of polymer use)
- Cost to the environment vis GHG production
- Ignorance
- Finance and investment (not necessarily for research)

Q: In the context of circular solutions to waste and "end of life" fishing and aquaculture gear, what should be done to ensure advanced technology is successful? (Please select your top 3)
N=71



Note that this question allowed for free text responses, and these are listed below, verbatim:

- This plastic is not waste it’s a resource and should be seen as such
- If everything collected is turned into quality plastic granules/powder there wouldn't be a need for more than that other than making it available on the market at the same price and quality as existing plastic powder.
- Track and trace from purchase to end of life systems
- Policy support in terms of legislations and regulations

- Work with {name redacted} and the fishing/mariner community
- Dedicated material producer investments/budget
- Roll out and strengthen existing solutions (Aquafil & Plastix)
- Improve infrastructure (more recycling facilities that can take end of life gear in more places)

Q: Any final comments? (Listed verbatim).

- Connect best practice in circular systems for fishing gear with the end consumer - MSC standards strengthened; Harbour recognition for recycling good practices. Accelerate data collection systems to monitor material flows.
- These responses represent my personal opinions and do not necessarily represent the views or priorities of the US government. I found some of these terms unfamiliar. It would be good to have definitions or examples of what you mean. For example, internet of things or digital twins.
- Plastic can be recycled over and over and should not be treated as waste but a resource
- Concerning question 5: I gave up. Numbers change in other boxes every time I put a number in one of the boxes. Concerning question 7: There seems not to be a need for more plastic standards than those in place. But the recycling industry needs to be able to process more plastic types, and more dirty plastics, than they are able to today. The main issues for the market operators/manufacturers are purity, price and enough quantity (the latter is less important if the recycled product is plastic powder of the same quality as other plastic powder on the market today).
- A strong barrier in Italy is the lack of a clear procedure to be followed by fishers when they need to throw away old nets and fishing gear. Laws and infrastructures need to be improved and clarified.
- Start at grass roots identifying the problem and why gear gets lost and dumped in the first place. This is a fundamental barrier and advanced systems will be wasted without getting resource input sorted.
- Co-create with fishers and consider local diversity in gears, uses, and fishing traditions. Advanced technologies are nothing without their cooperation
- We would love to see the PACMAN model developed, by Ocean Winnowers (go to face book page), it has now evolved to have small catamarans that leave the hive daily to run the windrows and collect the plastic then return it to the barge where it is processed and we can still travel to the Islands in the winter when the plastic is hard to collect due to {unknown word - ed} and the depth the plastic sinks to. Involve the people who live and work on the ocean and depend on her for sustenance. Stop blocking everyone who is not academia from funding sources, work together.
- Great Project Initiative! Well done :)
- in my opinion, recycling fishing nets (turning into other products) is just postponing the arrival of these nets in the environment, since sooner or later, those products that were made with these nets will reach the end of their useful life. and will either be discarded or else will have to be recycled forever.

- Question 5 ranking is not really useful: many of these cannot be implemented without others that are ranked lower simply because they are not as high on the priority/to do list, but without them, the whole system of circular FG economy would also not be established.
- We are involved in the development of a biodegradable fishing net. I am happy to share information.
- Cross industry cooperation and a joined responsibility to make it successful
- Marking or fishing gears and development of country specific legal framework
- Need to address the long term culture in the fishing industry of disposal of used and damaged materials in the ocean.
- have a real look at the polymer volume brought this (niche) market. Yes, it is partly still a serious EoL issue yet implementation of a real effective EPR (including minimum mandatory recyclate content for example) and adding value to CO2 savings (i.e. 150 Euro or more) when replacing virgin plastics with recyclates evolving from this industry will be far more effective than looking at new technologies for a niche
- Communication with and training of stakeholders is key to the successful rollout of the EPR scheme in the EU.

ANNEX F Academic Search Results

Note that all references either directly concern recycling of fishing gear or were citations from papers or articles concerning recycling of fishing gear (e.g., although Waste Management 4.0 papers typically focus on municipal waste and Industry 4.0, articles on the future of gear recycling reference them as indicative of a development direction for the industry).

Paper	Relevance
ADAMI, L. & SCHIAVON, M. 2021. From Circular Economy to Circular Ecology: A Review on the Solution of Environmental Problems through Circular Waste Management Approaches. *Sustainability,* 13.	Circular Waste Management
AL-OBAIDI, A., AL-ALI, K., RABIA, M., AL-KHUFFASH, K., QAROOT, Y., SALEH, K., LAMONT, L., AL-HAJERI, E., EL-CHAAR, L. & KARKI, H. 2012. Novel Autonomous Recycling System. *SPE Middle East Health, Safety, Security, and Environment Conference and Exhibition.*	Automated recycling systems
AMADEI, A. M., SANYÉ-MENGUAL, E. & SALA, S. 2022. Modeling the EU plastic footprint: Exploring data sources and littering potential. *Resources, Conservation and Recycling,* 178**,** 106086.	Simulation of plastic supply
ARMSTRONG, N. S. 2020. Plastics Derived From Derelict Fishing Gear in the Arctic: Looking at Sustainable Fisheries for a Strategy of Mitigation, Remediation and Prevention in Iceland and Alaska.	Detection and prevention techniques
BARON, O., ROMERO, G., ZHANG, Z. & ZHOU, S. 2021. Innovative Business Models in Ocean-Bound Plastic Recycling. *Rotman School of Management Working Paper*.	Business models
BATISTA, T., CANSADO, I. P., TITA, B., ILHÉU, A., METROGOS, L., MOURÃO, P. A., NABAIS, J. M., CASTANHEIRO, J. E., BORGES, C. & MATOS, G. 2022. Dealing with Plastic Waste from Agriculture Activity. *Agronomy,* 12.	Recycling agricultural waste
BELLANDI, M. & PROPRIS, L. 2021. Local Productive Systems' Transitions to Industry 4.0+. *Sustainability,* 13**,** 13052.	Local productive systems
BERTELSEN, I. M. G. & OTTOSEN, L. M. 2022. Recycling of Waste Polyethylene Fishing Nets as Fibre Reinforcement in Gypsum-based Materials. *Fibers and Polymers,* 23**,** 164-174.	Material innovation
BEZAMA, A. & AGAMUTHU, P. 2019. Addressing the big issues in waste management. *Waste Management & Research,* 37**,** 1-3.	Circular Waste Management
BONIFAZI, G., PALMIERI, R., SERRANTI, S., MAZZIOTTI, C. & FERRARI, C. R. 2017. Hyperspectral imaging based approach for monitoring of microplastics from marine environment. *OCM***,** 193.	Advanced analytics

BORCHARD, R., ZEIS, R. & RECKER, J. 2021. Digitalization of waste management: Insights from German private and public waste management firms. *Waste Management & Research*.	Industry 4.0 and waste management
BRUNILA, O.-P., KUNNAALA-HYRKKI, V. & INKINEN, T. 2021. Hindrances in port digitalization? Identifying problems in adoption and implementation. *European Transport Research Review,* 13.	Port digitalisation
BURMAOGLU, S., OZDEMIR GUNGOR, D., KIRBAC, A. & SARITAS, O. 2022. Future research avenues at the nexus of circular economy and digitalization. *International Journal of Productivity and Performance Management,* ahead-of-print.	Digitalisation as an enabler of Circular Economy
CHAMBERS, K. J., F; POWELL, K 2021. Policy Options for Fishing and Aquaculture Gear in the UK. Phase 1: Gear Inventory. *End-of-life fishing and aquaculture gear policy options - ME5240.* UK: DAERA, Defra, Marine Scotland, Welsh Government.	Types of gear for recycling
CHARTER, M. 2017. Summary of the findings of port-related feasibility studies related to the collection and recycling of waste fishing nets and ropes in Greenland, Ireland, Norway and Scotland.	Different value chains for gear recycling
CHARTER, M., SHERRY, J. & O'CONNOR, F. 2020. Blue circular economy: opportunities for circular business models and circular design related to fishing gear (version 2).	Circular business models
CHAUHAN, A., JAKHAR, S. K. & CHAUHAN, C. 2021. The interplay of circular economy with industry 4.0 enabled smart city drivers of healthcare waste disposal. *Journal of Cleaner Production,* 279**,** 123854.	Circular economy and Industry 4.0
CHEN, W.-Q., CIACCI, L., SUN, N.-N. & YOSHIOKA, T. 2020. Sustainable cycles and management of plastics: A brief review of RCR publications in 2019 and early 2020. Elsevier.	Sustainability of plastics
COLE, G. P., K; CHAMBERS, K; JARVIS, F 2021. Policy Options for Fishing and Aquaculture Gear in the UK. Phase 3: Economic assessment. *End-of-life fishing and aquaculture gear policy options.* UK: Defra, Welsh Government, Marine Scotland, DAERA.	Business models for gear recycling
OSPAR COMMISSION, 2020. OSPAR scoping study on best practices for the design and recycling of fishing gear as a means to reduce quantities of fishing gear found as marine litter in the North-East Atlantic.	Gear design
CORVELLEC, H., STOWELL, A. & JOHANSSON, N. 2021. Critiques of the circular economy. *Journal of Industrial Ecology*.	Circular Economy
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ANNEX G Patent search results

Note that all searches were using WIPO PATENTSCOPE.

For country coverage: https://patentscope.wipo.int/search/en/help/data_coverage.jsf

Patents – Novel design methods

8.113515790 INTERACTIVE CUSTOMIZATION METHOD AND SYSTEM FOR FISHING GEAR
CN - 19.10.2021
Int.Class G06F 30/12Appl.No 202110785856.4Applicant HARBIN INSTITUTE OF TECHNOLOGY Inventor CHU DIANHUI
The invention discloses an interactive customization method and system for a fishing gear, and the method comprises the following steps: S1, carrying out the modularized interactive design of the fishing gear according to the composition structure of the fishing gear, and generating a design drawing; S2, submitting the design drawing generated in the step S1, and performing auditing by a system administrator; S3, generating a bill of material of the fishing gear according to the successfully checked fishing gear design drawing; S4, entering a production link according to the BOM of the fishing gear; and S5, enabling the fishing gear design drawings which are formally produced in batches to enter a historical product library, so that the next design and reuse are facilitated. Interactive design can be carried out according to the structure of the fishing gear, the system simulates the design process of the fishing gear, a user can participate in the whole fishing gear customization process such as fishing gear design and fishing gear production, a design drawing is generated after the fishing gear design is completed, a bill of material (BOM) is generated according to the design drawing, then the quotation of the fishing gear is generated, production is carried out according to the BOM, and finally, the customer accepts and accepts.

Patents – Apparatus for Locating Lost Fishing Gear

1.1020120030965 LOST FISHING GEAR POSITIONING SYSTEM WHICH PERFORMS WIRELESS INTERNET PROTOCOL COMMUNICATION USING AN INTERNET PROTOCOL RADIO FREQUENCY IDENTIFICATION TECHNIQUE, AN APPARATUS, AND A METHOD THEREOF
KR - 29.03.2012
Int.Class G01S 5/02Appl.No 1020110094509Applicant DONG-A UNIVERSITY RESEARCH FOUNDATION FOR INDUSTRY-ACADEMY COOPERATION Inventor CHOI, HYUNG RIM
PURPOSE: A lost fishing gear positioning system, an apparatus, and a method thereof are provided to monitor the location of a lost fishing gear on a real time basis using an IP-RFID(Internet Protocol-Radio Frequency Identification) tag, thereby providing corresponding location information to an administrator. CONSTITUTION: A lost fishing gearpositioning system(100) is detachably mounted on a fishing gear floated on the sea. The lost fishing gear positioning system includes an IP-RFID(Internet Protocol-Radio Frequency Identification) tag(10) for transmitting lost fishing gear information through wireless IP communications. A smart point(200) communicates with the lost fishing gear positioning system through the IP communication. The smart point receives the lost fishing gear information from the lost fishing gear positioning system. A management terminal(300) processes the lost fishing gear information by receiving the information from the smart point. COPYRIGHT KIPO 2012

2.WO/2012/039579SYSTEM, APPARATUS AND METHOD FOR IDENTIFYING THE LOCATION OF LOST FISHING GEAR USING IP-RFID

WO - 29.03.2012
Int.Class G01S 5/02Appl.No PCT/KR2011/006947Applicant DONG-A UNIVERSITY RESEARCH FOUNDATION FOR INDUSTRY-ACADEMY COOPERATION Inventor CHOI, Hyung Rim
The present invention relates to a system, apparatus and method for identifying the location of lost fishing gear using an IP-RFID. The apparatus for identifying the location of lost fishing gear according to the present invention comprises an IP-RFID tag which is detachably mounted on fishing gear installed at the sea, and which comprises a wire connected to the fishing gear and transmits information regarding the lost fishing gear to a smart point via wireless IP communications when the fishing gear sinks below the surface of the sea and the IP-RFID tag is separated from the fishing gear. The smart point is installed at the sea near the apparatus for identifying the location of the lost fishinggear in order to perform IP communications with the apparatus and receive information regarding the lost fishing gear from the apparatus. A management terminal performs wireless communications with the smart point over a network, and receives information regarding the lost fishing gear from the smart point and processes the received information. Here, the IP-RFID tag of the apparatus, mounted on the fishing gear, may collect information on the area of sea in which the relevant fishing gear is installed, and provide the management terminal located in a remote place with the collected information via IP communications, thus enabling a manager to effectively and remotely manage the fishing gear installed at the sea using the management terminal.

4.WO/2019/147781 DETECTION OF DERELICT FISHING GEAR
WO - 01.08.2019
Int.Class A01K 69/06Appl.No PCT/US2019/014916Applicant BLUE OCEAN GEAR LLCInventor OPSHAUG, Kortney, Noell
The location of lost or entangled fishing gear, known as derelict gear, is detected. The motion or change of position of a buoy attached to fishing gear is determined via sensors mounted on the buoy and compared to typical buoy motion. If the buoy has moved beyond a threshold value from its original location, an alert is sent to the fisherman. The available sensor data will be used to determine the likelihood of loss or entanglement. This alert facilitates recovery of lost or entangled gear by identifying where immediate retrieval efforts should be focused. The number of traps lost to the ocean that otherwise would continue to trap or entangle marine life may be reduced.

5.2993555 DETECTION OF DERELICT FISHING GEAR
CA - 24.08.2018
Int.Class A01K 69/06Appl.No 2993555Applicant BLUE OCEAN GEAR LLC Inventor

The location of lost or entangled fishing gear, known as derelict gear, is detected. The motion or change of position of a buoy attached to fishing gear is determined via sensors mounted on the buoy and compared to typical buoy motion. If the buoy has moved beyond a threshold value from its original location, an alert is sent to the fisherman. The available sensor data will be used to determine the likelihood of loss or entanglement. This alert facilitates recovery of lost or entangled gear by identifying where immediate retrieval efforts should be focused. The number of traps lost to the ocean that otherwise would continue to trap or entangle marine life may be reduced.

6.20180244354 DETECTION OF DERELICT FISHING GEAR
US - 30.08.2018
Int.Class B63B 22/18Appl.No 15882002Applicant Blue Ocean Gear LLC Inventor Kortney Noell Opshaug
The location of lost or entangled fishing gear, known as derelict gear, is detected. The motion or change of position of a buoy attached to fishing gear is determined via sensors mounted on the

buoy and compared to typical buoy motion. If the buoy has moved beyond a threshold value from its original location, an alert is sent to the fisherman. The available sensor data will be used to determine the likelihood of loss or entanglement. This alert facilitates recovery of lost or entangled gear by identifying where immediate retrieval efforts should be focused. The number of traps lost to the ocean that otherwise would continue to trap or entangle marine life may be reduced.

7.3745853 DETECTION OF DERELICT FISHING GEAR

EP - 09.12.2020

Int.Class A01K 69/06Appl.No 19743334Applicant BLUE OCEAN GEAR LLC Inventor OPSHAUG KORTNEY NOELL

The location of lost or entangled fishing gear, known as derelict gear, is detected. The motion or change of position of a buoy attached to fishing gear is determined via sensors mounted on the buoy and compared to typical buoy motion. If the buoy has moved beyond a threshold value from its original location, an alert is sent to the fisherman. The available sensor data will be used to determine the likelihood of loss or entanglement. This alert facilitates recovery of lost or entangled gear by identifying where immediate retrieval efforts should be focused. The number of traps lost to the ocean that otherwise would continue to trap or entangle marine life may be reduced.

8.20200239108 DETECTION OF DERELICT FISHING GEAR

US - 30.07.2020

Int.Class B63B 22/18Appl.No 16848076Applicant Blue Ocean Gear LLC Inventor Kortney Noell Opshaug

The location of lost or entangled fishing gear, known as derelict gear, is detected. The motion or change of position of a buoy attached to fishing gear is determined via sensors mounted on the buoy and compared to typical buoy motion. If the buoy has moved beyond a threshold value from its original location, an alert is sent to the fisherman. The available sensor data will be used to determine the likelihood of loss or entanglement. This alert facilitates recovery of lost or entangled gear by identifying where immediate retrieval efforts should be focused. The number of traps lost to the ocean that otherwise would continue to trap or entangle marine life may be reduced.

9.1020200048683 SMART BUOY DETECTING LOSS OF FISHING GEAR

KR - 08.05.2020

Int.Class A01K 75/04Appl.No 1020180131024Applicant RCN CO., LTD .Inventor CHOON SIK YIM

The present invention relates to a smart buoy detecting the loss of a fishing gear. More specifically, the present invention relates to a smart buoy for determining whether a fishing gear is lost by a sensor included in the buoy, when the fishing gear is lost from the smart buoy in which the fishing gear is combined. COPYRIGHT KIPO 2020

12.1020190052197 SYSTEM AND METHOD TO MANAGE FISHING GEAR USING AUTOMATIC FISHING GEAR IDENTIFICATION DEVICE

KR - 16.05.2019

Int.Class A01K 69/06Appl.No 1020170147079Applicant (주) 지씨에스씨 Inventor NAM, GYEUNG TAE

The present invention relates to a fishing gear management system using an automatic fishing gear identification device, and a method thereof. The fishing gear management system using an automatic fishing gear identification device comprises: an automatic fishing gear identification device which is able to manage the current state of fishing gearby regularly receiving and analyzing fishing gear information to determine whether the fishing gear like a catching net or a fish trap for catching targets like fish is normal or lost, and

regularly and wirelessly transmits fishing gear information including the identification information and position information of fishing gear by being attached to the fishing gear to quickly perform management such as fishing gear collection when an abnormal condition occurs in the fishing gear; and a control server of a land control station which analyzes fishing gear information regularly received from the automatic fishing gear identification device, registers the analyzed information in a database, and determines the state of the fishing gear by the analysis of the fishing gear. COPYRIGHT KIPO 2019

14.202121006125 GHOST NET DETECTION SYSTEM

IN - 19.02.2021

Int.Class A61K /Appl.No 202121006125Applicant Prashant Vemra Inventor Prashant Verma
ABSTRACTGHOST NET DETECTION SYSTEMA ghost net detection system capable of tracking and disintegrating a lost, abandoned or discarded fishing gear, partially or in totality, in water body is proposed. The system consists of a variety of net capsule (200) capable of inflating a balloon, sending acoustic signal or cutting the net thread (102), in different combination, attached to the net thread (102) inseparably. The net capsules (200) are mounted in a specific pattern to achieve fishing net disintegration in to smaller pieces. A master capsule (300) attached to the rope or lead line (101) of the fishing net (100) is an active tracking device, transmitting an acoustic signal in water and LORA signal in air. The combination of net capsule (200) along with master capsule (300) is used to track, recover or disintegrate the fishing gear lost in water. Figure 1

16.1020200050608 SMART BUOY AND CONTROL SYSTEM-BASED FISHING GEAR MANAGEMENT SYSTEM

KR - 12.05.2020

Int.Class G06Q 50/02Appl.No 1020180133398Applicant RCN CO., LTD. Inventor CHOON SIK YIM
The present invention is for managing a fishing gear used in the ocean. The present invention relates to a fishing gear management system which can manage whether a fishing gear is lost by using a sensing value of magnetic strength which can determine an amount of change in location information of a smart buoy fastened to the fishing gear and fastening strength of the smart buoy with the fishing gear. COPYRIGHT KIPO 2020

19.110127002 INTELLIGENT DEVICE FOR SALVAGING FISHING NETS LOST AND DISCARDED IN OFFSHORE SEABED

CN - 16.08.2019

Int.Class B63C 7/18Appl.No 201910458406.7Applicant SHANGHAI OCEAN UNIVERSITY Inventor MA JIAZHI
The invention relates to an intelligent device for salvaging fishing nets lost and discarded in an offshore seabed, and belongs to the technical field of fishing gear equipment. The intelligent deviceincludes a hull, a winch is arranged at the tail of the hull, the winch is electrically connected with a control panel, the winch is connected with a hoisting ring by a tow rope, a connecting shaft is arranged on the lower part of the hoisting ring, and a double-layer hook is connected with the lower part of the connecting shaft. According to the intelligent device for salvaging the fishing nets lost and discarded in the offshore seabed, the fishing nets are prevented from sinking to the seabed for a long time and resulting in the death of a large number of marine life, the marine ecological environment can be effectively protected, and metal garbage of the seabed can further be salvaged ashore.

34.1020190121489 LOW POWER WIDE AREA COMMUNICATION-BASED SMART BUOY AND FISHING GATEWAY SYSTEM AND METHOD THEREOF

KR - 28.10.2019

Int.Class H04L 29/08Appl.No 1020180044861Applicant MOKPO NATIONAL MARITIME UNIVERSITY INDUSTRY-ACADEMIC COOPERATION FOUNDATIONInventor SEONG REAL LEE
The present invention relates to a low power wide area communication-based smart buoy and fishing gateway system. More particularly, the present invention relates to the system which enables a control system to determine a location of a smart buoy and whether or not a fishing gear is lost by transmitting data including coordinate information and missing information from the smart buoy using low power wide area communication. COPYRIGHT KIPO 2020

Patents – Biodegradable Net Materials

26.602/KOL/2011 BIODEGRADABLE RESIN COMPOSITION FOR FISH NET AND METHOD OF MANUFACTURING FISH NET BY USING BIODEGRADBE RESIN COMPOSITION
IN - 19.10.2012
Int.Class A01K 75/00Appl.No 602/KOL/2011Applicant REPUBLIC OF KOREA (NATIONAL FISHERIES RESEARCH AND DEVELOPMENT INSTITUTE)Inventor PARK, SEONG WOOK
A biodegradable resin composition for a fish net that is formed a mixture resin of a poly butylene succinate (PBS) resin that has excellent strength and low extension coefficient and a poly butylene adipate-co- terephthalate (PBAT) resin having low strength and excellent extension coefficient compared to the PBS resin in order to maintain the same catchability as that of a conventional non-biodegradable nylon fishnet even when a fish net is formed of a biodegradable resin, and methods of manufacturing fish nets by using biodegradable resin compositions, in which since a material that is naturally decomposed in sea water is used to form a fishing gear with a fish net, damage generated by contamination of coastal zones due to lost fishing gears and ghost fishing is minimized, and simultaneously, strength, flexibility and elastic recovery of the fishing gear are ensured, and a method of manufacturing a fish net by using the biodegradable resin composition.

Patents – Recycling Devices for Fishing Gear

1.106892066 MARINE DEBRIS RECYCLING DEVICE
CN - 27.06.2017
Int.Class B63B 35/32Appl.No 102017000230975Applicant YIN KANGKANG Inventor YIN KANGKANG
The present invention relates to the field of marine debris disposal, specifically to a marine debris recycling device, including a base, a transmission unit, a sorting unit, a fishing net collection unit, a taking and replacing mechanism and a storage box. The base is mounted on a foredeck of a hull through bolts; the transmission unit is mounted on the base and extends out of the hull, and is used for collecting debris floating on the sea; the sorting unit is used for classifying debris to facilitate the classified storage of debris while the transmission unit works; the fishing net collection unit is used for collecting fishing nets floating on the sea; the taking and replacing mechanism is used for taking out the fishing nets from the sea; and the storage box is used for storing the collected debris. The marine debris recycling device can salvage small debris like glass bottles, plastic bottles and plastic caps in the sea, and perform sorting while performing salvage, so that the debris recycling efficiency is improved; and meanwhile, the marine debris recycling device can also perform arranged salvage on the fishing nets so as to facilitate transportation of the fishing nets.

2.209997294 FILTERING DEVICE FOR PREPARING REGENERATED PARTICLES FROM WASTE FISHING NETS
CN - 31.01.2020
Int.Class B01D 33/11Appl.No 201920418116.5Applicant LIANYUNGANG YONGTAI PLASTIC INDUSTRY CO., LTD.Inventor ZHANG WENQIANG

A filtering device for preparing regenerated particles from waste fishing nets comprises a filtering support, a rotating shaft is transversely arranged on the filtering support, a circular-truncated-cone-shaped filtering cylinder is arranged on the rotating shaft in a sleeving mode, and the filtering cylinder is fixedly connected with the rotating shaft through a supporting frame; wherein the small-opening end of the filter cartridge is an inlet end, the large-opening end of the filter cartridge is an outlet end, a filter screen is arranged on the filter cartridge, a plurality of filter holes matched with the filter screen are uniformly formed in the filter cartridge, a water collecting tank is arranged under the filter cartridge, and a material collecting tank used for containing broken fishing nets is further arranged on the outlet end side of the filter cartridge. The filtering device is simple in structure and high in filtering efficiency, cleaning water is dynamically filtered through rotation of the filtering cylinder, and the recycling efficiency is greatly improved while the recycling effect of broken fishing nets in the cleaning water is guaranteed.

3.100869063* APPARATUS FOR SORTING SPENT FISHING-NETS, CAPABLE OF SEPARATING NYLON AND OTHER COMPONENT AFTER CUTTING AND CRUSHING THE SPENT FISHING-NETS

KR - 11.11.2008

Int.Class B65G 33/00Appl.No 1020080076947Applicant CELLBIO CO., LTD. Inventor SHIM, IL JOO

PURPOSE: An apparatus for sorting spent fishing-nets is provided to separate nylon and other component after cutting and crushing the spent fishing-nets by recycling each raw material extract from the spent fishing-nets. CONSTITUTION: An apparatus for sorting spent fishing-nets comprises as the follows. A housing, which is installed to be inclined so that an input hole higher than a discharge hole, is formed with a nylon discharge hole and a rest discharge hole. A cylinder screening device extracts polypropylene, polyester, nylon, and rest. The transfer conveyor(140) transfers the nylon piece passing through the discharge hole to the nylon discharge hole. A driving part rotates the cylinder screening device. The cylinder screening device includes a protrusion formed in an inner surface of the cylinder screening device and increases the extracting efficiency by delaying the passage in the cylinder screening device. ©KIPO 2009

11.211440752 WASTE FISHING NET RECYCLING DEVICE

CN - 08.09.2020

Int.Class B29B 17/04Appl.No 202020026493.7Applicant CHAOHU CITY FANGTAI FISHING GEAR CO., LTD.Inventor XU HONGWEI

The utility model discloses a waste fishing net recycling device. The device comprises a crushing box, box doors are arranged at the positions, close to the two sides, of the top of the smashing box.Handles are fixedly connected to the tops of the two box doors; two flow guide plates are arranged in the crushing box; the two flow guide plates are both fixedly connected with the inner side wall ofthe crushing box, a crushing disc is arranged between the two flow guide plates, the crushing disc is slidably connected with the flow guide plates, a plurality of crushing teeth are fixedly connected to the inner side wall of the crushing disc and distributed in an annular array, and a driving disc is arranged in the crushing disc. According to the fishing net crushing and mixing device, waste fishing nets and improvers can be efficiently crushed and mixed, production operation of reutilization is facilitated, resources are saved, and a certain protection effect on the environment is achieved.

12.209105995 INTELLIGENT SUSPENSION FISHING NET DEVICE WITH SIGNAL SIGN

CN - 16.07.2019

Int.Class A01K 69/00Appl.No 201821550749.3Applicant EAST CHINA SEA FISHERIES RESEARCH INSTITUTE, CHINESE ACADEMY OF FISHERY SCIENCES Inventor TANG FENGHUA

The utility model relates to an intelligent suspension fishing net device with a signal sign. The device comprises a net cage, a floating ball and a heavy hammer, a plurality of fish inlets are formedin the net cage, guide anti-escape nets are arranged at the fish inlets, the floating ball is connected with the top of the net cage, the heavy hammer is connected with the bottom of the net

cage, colored flags are arranged at the top of the floating ball and fixedly installed on the floating ball through vertical rods, and signal lamps are arranged on vertical rods of the colored flags. The fishing net device can be quickly positioned during fishing and recycling, fishing operation can be carried out in the daytime or at night, the signal lamp can remind a ship to avoid a fishing net at night, the structure is simple, use and operation are convenient, the fishing efficiency is high, and living body fishing of fishing catches is achieved.

8.211440752 WASTE FISHING NET RECYCLING DEVICE
CN - 08.09.2020
Int.Class B29B 17/04Appl.No 202020026493.7Applicant CHAOHU CITY FANGTAI FISHING GEAR CO., LTD. Inventor XU HONGWEI
The utility model discloses a waste fishing net recycling device. The device comprises a crushing box, box doors are arranged at the positions, close to the two sides, of the top of the smashing box.Handles are fixedly connected to the tops of the two box doors; two flow guide plates are arranged in the crushing box; the two flow guide plates are both fixedly connected with the inner side wall ofthe crushing box, a crushing disc is arranged between the two flow guide plates, the crushing disc is slidably connected with the flow guide plates, a plurality of crushing teeth are fixedly connected to the inner side wall of the crushing disc and distributed in an annular array, and a driving disc is arranged in the crushing disc. According to the fishing net crushing and mixing device, waste fishing nets and improvers can be efficiently crushed and mixed, production operation of reutilization is facilitated, resources are saved, and a certain protection effect on the environment is achieved.

14.110521683 AUTOMATIC UNHOOKING AND RECYCLING DEVICE FOR CRAB CAGES
CN - 03.12.2019
Int.Class A01K 74/00Appl.No 201910942244.4Applicant ZHEJIANG OCEAN UNIVERSITYInventor FENG WUWEI
The invention provides an automatic unhooking and recycling device for crab cages, and belongs to the technical field of fishing gear equipment. The automatic unhooking and recycling device solves thetechnical problems that existing crab cages cannot be recycled automatically. The recycling device comprises a mounting frame, the mounting frame is provided with a vibration box and a vibrator, a fixed pulley and unhooking blocks are arranged above the vibration box, the mounting frame is provided with a driving motor, the unhooking blocks are located at one side of the fixed pulley and over thevibration box, main ropes for crab cage breeding are provided with hooks, and the crab cages are hung on the hooks and can be separated from the hooks under the extrusion of the unhooking blocks whena driving motor drives the main ropes to move; the two sides of the vibration box are provided with a first trolley for containing crabs and a second trolley for containing empty crab cages respectively, the vibration box and the first trolley are communicated with each other through an oblique recycling pipeline, and the vibration box and the second trolley are communicated with each other through an oblique sliding plate. The device can automatically recycle the crab cages and the crabs and is convenient to use, stable and efficient.

Patents – Processes for Recovering Metals from Fishing Nets

5.WO/2018/117978A PROCESS FOR OBTAINING COPPER FROM WASTE FISHING NETS
WO - 28.06.2018
Int.Class C22B 7/00Appl.No PCT/SI2016/000029Applicant AQUAFILSLO D.O.O.Inventor JAHIC, Denis
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid, wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing, such that the NaOH concentration in the water is up to 20 %. The suspension of the washing liquid, sludge and other impurities, resulting from the washing step, is led to a separation step. The sludge

obtained in the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium, such as H2SO4, HNO3, HCl, a mixture of strong mineral acids or a mixture of one or several strong mineral acids with H2O2. Then, the non-dissolved sludge is separated from the solution of copper ions Cu2+ in the acidic medium, the solution of copper ions Cu2+ in the acidic medium is led to electrolysis, wherein elementary copper having a purity of more than 94 % is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor, where the residual paraffins and co-polymers are removed at a temperature ranging from 500 °C to 900 °C. The remaining ash may contain up to 30 % by weight of copper compounds based on the weight of the ash, particularly in the form of copper(II) oxide CuO, less in the form of copper(I) oxide Cu2O and copper phosphates Cu(H2PO4)2, Na6Cu9(PO4)8. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets, such that not only pure polyamide is obtained from the nets but also elementary copper, which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material, moreover, the quantity of copper in final waste is reduced, consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

6.3559289 A PROCESS FOR OBTAINING COPPER FROM WASTE FISHING NETS
EP - 30.10.2019
Int.Class C22B 7/00Appl.No 16847611Applicant AQUAFILSLO D O OInventor JAHIC DENIS
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid, wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing, such that the NaOH concentration in the water is up to 20 %. The suspension of the washing liquid, sludge and other impurities, resulting from the washing step, is led to a separation step. The sludge obtained in the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium, such as H2SO4, HNO3, HCl, a mixture of strong mineral acids or a mixture of one or several strong mineral acids with H2O2. Then, the non-dissolved sludge is separated from the solution of copper ions Cu2+ in the acidic medium, the solution of copper ions Cu2+ in the acidic medium is led to electrolysis, wherein elementary copper having a purity of more than 94 % is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor, where the residual paraffins and co-polymers are removed at a temperature ranging from 500 °C to 900 °C. The remaining ash may contain up to 30 % by weight of copper compounds based on the weight of the ash, particularly in the form of copper(II) oxide CuO, less in the form of copper(I) oxide Cu2O and copper phosphates Cu(H2PO4)2, Na6Cu9(PO4)8. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets, such that not only pure polyamide is obtained from the nets but also elementary copper, which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material, moreover, the quantity of copper in final waste is reduced, consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

7.3046131 METHOD FOR RECOVERING COPPER FROM WASTE FISHING NETS
CA - 28.06.2018
Int.Class C22B 7/00Appl.No 3046131Applicant AQUAFILSLO D.O.O.Inventor
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid, wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing, such that the NaOH concentration in the water is up to 20 %. The suspension of the washing liquid, sludge and other impurities, resulting from the washing step, is led to a separation step. The sludge obtained in the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium, such as H2SO4, HNO3, HCl, a mixture of strong mineral

acids or a mixture of one or several strong mineral acids with H2O2. Then, the non-dissolved sludge is separated from the solution of copper ions Cu2+ in the acidic medium, the solution of copper ions Cu2+ in the acidic medium is led to electrolysis, wherein elementary copper having a purity of more than 94 % is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor, where the residual paraffins and co-polymers are removed at a temperature ranging from 500 °C to 900 °C. The remaining ash may contain up to 30 % by weight of copper compounds based on the weight of the ash, particularly in the form of copper(II) oxide CuO, less in the form of copper(I) oxide Cu2O and copper phosphates Cu(H2PO4)2, Na6Cu9(PO4)8. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets, such that not only pure polyamide is obtained from the nets but also elementary copper, which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material, moreover, the quantity of copper in final waste is reduced, consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

8.110114483 A PROCESS FOR OBTAINING COPPER FROM WASTE FISHING NETS
CN - 09.08.2019
Int.Class C22B 7/00Appl.No 201680091752.0Applicant AQUAFILSLO D O OInventor JAHIC DENIS
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid, wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing, such thatthe NaOH concentration in the water is up to 20 %. The suspension of the washing liquid, sludge and other impurities, resulting from the washing step, is led to a separation step. The sludge obtainedin the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium, such as H2SO4, HNO3, HCl, a mixture of strong mineral acids or a mixture of one or several strong mineral acids with H2O2. Then, the non-dissolved sludge is separated from the solution of copper ions Cu2+ in the acidic medium, the solution of copper ions Cu2+ in the acidic medium is led to electrolysis, wherein elementary copper having a purity of more than 94 % is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor, where the residual paraffins and co-polymers are removed at a temperature ranging from 500 DEG C to 900 DEG C. The remaining ash may contain up to 30 % by weight of copper compounds based on the weight of the ash, particularly in the form of copper(II) oxide CuO, less in the form of copper(I) oxide Cu2O and copper phosphates Cu(H2PO4)2, Na6Cu9(PO4)8. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets, such that not only pure polyamide is obtained from the nets but also elementary copper, which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material, moreover, the quantity of copper in final waste is reduced, consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

9.201917027225 A PROCESS FOR OBTAINING COPPER FROM WASTE FISHING NETS
IN - 06.09.2019
Int.Class C22B 7/00CAppl.No 201917027225Applicant AQUAFILSLO D.O.O.Inventor JAHIC, Denis
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing such that the NaOH concentration in the water is up to 20 %. The suspension of the washing liquid sludge and other impurities resulting from the washing step is led to a separation step. The sludge obtained in the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium such as H2SO4 HNO3 HCl a mixture of strong mineral acids

or a mixture of one or several strong mineral acids with H2O2. Then the non-dissolved sludge is separated from the solution of copper ions Cu2+ in the acidic medium the solution of copper ions Cu2+ in the acidic medium is led to electrolysis wherein elementary copper having a purity of more than 94 % is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor where the residual paraffins and co-polymers are removed at a temperature ranging from 500 °C to 900 °C. The remaining ash may contain up to 30 % by weight of copper compounds based on the weight of the ash particularly in the form of copper(II) oxide CuO less in the form of copper(I) oxide Cu2O and copper phosphates Cu(H2PO4)2 Na6Cu9(PO4)8. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets such that not only pure polyamide is obtained from the nets but also elementary copper which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material moreover the quantity of copper in final waste is reduced consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

10.20190316265 PROCESS FOR OBTAINING COPPER FROM WASTE FISHING NETS
US - 17.10.2019
Int.Class C22B 15/00Appl.No 16471691Applicant AquafilSLO d.o.o.Inventor Denis Jahic
The invention refers to a method for recovering copper from waste fishing nets. The method of the invention includes washing of nets in a washing liquid, wherein an antifouling coating and other impurities are removed from the surface of the nets to a largest extent possible. The washing liquid is water; NaOH can also be added into the water in order to improve the efficiency of washing, such that the NaOH concentration in the water is up to 20%. The suspension of the washing liquid, sludge and other impurities, resulting from the washing step, is led to a separation step. The sludge obtained in the separation step is led to the dissolution step in an acidic medium. A strong mineral acid is selected as the acidic medium, such as H_2SO_4, HNO_3, HCl, a mixture of strong mineral acids or a mixture of one or several strong mineral acids with H_2O_2. Then, the non-dissolved sludge is separated from the solution of copper ions Cu^{2+} in the acidic medium, the solution of copper ions Cu^{2+} in the acidic medium is led to electrolysis, wherein elementary copper having a purity of more than 94% is deposited on the cathode. The non-dissolved residual sludge can be optionally led to thermal treatment to the reactor, where the residual paraffins and co-polymers are removed at a temperature ranging from 500° C. to 900° C. The remaining ash may contain up to 30% by weight of copper compounds based on the weight of the ash, particularly in the form of copper(II) oxide CuO, less in the form of copper(I) oxide Cu_2O and copper phosphates $Cu(H_2PO_4)_2$, $Na_6Cu_9(PO_4)_8$. This ash is then led to dissolution in the acidic medium and to further steps of the method. The proposed method of the invention improves the method for recycling waste nets, such that not only pure polyamide is obtained from the nets but also elementary copper, which has a double benefit: elementary copper in a sufficiently pure form is a useful raw material, moreover, the quantity of copper in final waste is reduced, consequently a negative impact on the environment is reduced and the cost of waste disposal of the method is reduced as well.

Patents –Methods for Recycling Fishing Gear into New Materials

1.107056625 RECYCLING METHOD OF POLYAMIDE-66 FISHING NET WASTES
CN - 18.08.2017
Int.Class C07C 209/62Appl.No 102017000423517Applicant CHAOHU DINGSHENG FISHING GEAR CO., LTD. Inventor WEI ANSONG
The invention discloses a recycling method of polyamide-66 fishing net wastes. The recycling method comprises the following operation steps that firstly, the polyamide-66 fishing net wastes are washed again by means of a citric acid solution; secondly, the polyamide-66 fishing net wastes treated through the first step are added into sulfuric acid, then acetic anhydride is added, after the mixture is heated to 75-85 DEG C, heat preservation is conducted for 2-4 hours, then the mixed liquid is subjected to ultrasonic treatment, cooling and crystallization

are conducted, and a filtrate is obtained after filtration; thirdly, barium sulfate is added into the filtrate for mixing and stirring to be uniform, then calcium hydroxide is added for reacting for 10 min, the mixture is heated to 60-70 DEG C, heat preservation is conducted for 2 hours, then filtrate is obtained after filtration, the filtrate is subjected to reduced pressure distillation, and hexanediamine is prepared. According to the recycling method of the polyamide-66 fishing net wastes, the operation steps are simple, the time required for recycling is short, continuous scale production can be achieved, the recycled hexanedioic acid and hexanediamine are high in purity, the yield is high, and the fishing net recycling industry development is greatly promoted.

2.101407081* METHOD FOR MANUFACTURING INJECTION MOLDING RAW MATERIAL PELLET USING WASTE FISHING GEAR

KR - 05.06.2014

Int.Class B29B 17/00Appl.No 1020130046750ApplicantInventor 조선옥

The present invention has a purpose of recycling a waste fishing gear comprising a rope and a net which is discarded, and using the same as a raw material for injection molding of various industrial products. The main composition of the present invention for achieving the purpose comprises the steps of: collecting a waste fishing gear; removing a foreign matter attached to the waste fishing gear; cutting the waste fishing gear; washing the fishing gear; drying; melting the waste fishing gear; and processing the melted product to a pellet, wherein. the cutting length is 1-20 centimeters in the step of cutting the waste fishing gear which has the foreign matter removed and the water content is 0-3% in the drying step. COPYRIGHT KIPO 2014

3.113604895 METHOD FOR REINFORCING AND RECYCLING WASTE FISHING NET THREADS

CN - 05.11.2021

Int.Class D01F 1/10Appl.No 202111006247.0Applicant CHAOHU XIANGYU FISHING GEAR CO., LTD.Inventor HU HUIMIN

The invention discloses a method for reinforcing and recycling waste fishing net threads, and belongs to the technical field of fishing net processing. The method comprises the following steps of (1) cleaning; (2) melting treatment; (3) crushing and sieving; (4) flame-ultraviolet coupling treatment; (5) melt spinning; and (6) twisting. According to the method for reinforcing and recycling the waste fishing net threads, the waste fishing net threads are recycled and subjected to reinforcing and modifying treatment, a specially-made reinforcing agent is added, and the fishing net threads prepared after the waste fishing net threads and the reinforcing agent are jointly melted again still have good mechanical performance and chemical corrosion resistance.

4.111978594 METHOD FOR RECYCLING WASTE POLYVINYL CHLORIDE FISHING NET THREADS

CN - 24.11.2020

Int.Class C08J 11/08Appl.No 202010942300.7Applicant CHAOHU CITY FANGTAI FISHING GEAR CO., LTD.Inventor XU HONGWEI

The invention discloses a method for recycling waste polyvinyl chloride fishing net threads, and belongs to the technical field of fishing net thread recycling. The method comprises the following steps: (1) crushing treatment; (2) dissolving treatment; (3) extraction treatment; and (4) drying treatment. The method is simple in overall process, high in polyvinyl chloride recycling rate, good in recycling effect, safe and environmentally friendly.

5.107118418 PROCESS FOR RECYCLING WASTE FISHING NET

CN - 01.09.2017

Int.Class C08L 23/06Appl.No 201710389129.XApplicant CHAOHU DINGSHENG FISHING GEAR CO., LTD.Inventor WEI ANSONG

The invention discloses a process for recycling a waste fishing net. The process comprises the following steps: (1) preparing a recycled raw material; (2) retreating the recycled raw material; (3) performing hot-press forming treatment. In a machining process, the features of a polyethylene

recycled raw material are improved, so that the compound property of the polyethylene recycled raw material is improved in secondary use; finally, the mechanical property of a wood-plastic composite material prepared from the polyethylene recycled raw material and other raw materials such as wood powder is improved well; an effective direction and technical support are provided for recycling of the waste fishing net.

Patents – Devices for Shredding Fishing Gear

1. KR10182697200000* - CUTTING AND SHREDDING DEVICE FOR COASTAL WASTE PROCESSOR

Title
(EN) CUTTING AND SHREDDING DEVICE FOR COASTAL WASTE PROCESSOR
(KO) 해안폐기물 처리기용 절단 파쇄장치
Abstract
(EN) The present invention relates to a cutting and shredding device for a coastal waste processor to process a large amount of coastal waste in a short time since the device is not stopped when cutting and shredding coastal waste by cutting plastics, nets, ropes and waste fishing gears stacked on the coast while the waste is pressurized and fixed, and preventing the cut coastal waste from getting scorched when shredding. COPYRIGHT KIPO 2018
(KO) 본 발명은 해안폐기물 처리기용 절단 파쇄장치에 관한 것으로 연안에 적체되어 있는 비닐류, 그물, 밧줄, 양식자 폐어구류를 가압 고정된 상태에서 절단시키고 아울러 절단된 해안폐기물을 파쇄시 눌러붙지 않도록 구성함으로써, 해안폐기물 절단 파쇄시 장치가 멈춤되지 않아 짧은 시간안에 많은 양의 해안폐기물을 처리할 수 있도록 구성된다.

Patents – Methods for Preparing Reinforced Polymers from Recycled Fishing Gear

1.105463612 GRAPHENE QUANTUM DOT REINFORCED POLYARMIDE FIBER AND PREPARATION METHOD THEREOF
CN - 06.04.2016
Int.Class D01F 6/90Appl.No 201510953167.4Applicant CHONGQING INSTITUTE OF GREEN AND INTELLIGENT TECHNOLOGY, CHINESE ACADEMY OF SCIENCESInventor CHU JIN
The invention provides graphene quantum dot reinforced polyarmide fiber and a preparation method thereof. The mechanical property of PA6 fiber is improved through the molecular template effect of graphene quantum dots and the staggered effect between graphene quantum dots and a PA6 texture structure; the high-strength and high-modulus PA6-GQD compound fiber with tensile strength of 0.72-1.05 GPa and initial modulus of 8-11 GPa is prepared through a traditional mature PA6 melt spinning process. Compared with traditional high-strength and high-modulus PA6 fiber, the graphene quantum dot reinforced polyarmide fiber has the advantages that the mechanical performance is more excellent, the technological process is simple, environment pollution is small, cost is low, the fiber is suitable for being produced on a large scale, an existing PA6 melt spinning process device does not need to be changed, the prepared PA6-GQD fiber has excellent mechanical performance, and the fiber can be used for the fields of tire curtain wires, industrial cloth, clothes, fishing nets and military war industry.

2.2021103849 A PREPARATION METHOD TO SYNTHESIZE GRAPHENE QUANTUM DOT REINFORCED POLYAMIDE FIBER
AU - 12.08.2021
Int.Class D01F 6/90Appl.No 2021103849Applicant Southwest UniversityInventor Chu, Jin
Polyamide 6 (PA6) is one of the most widely used synthetic fiber products. It has excellent properties such as high strength, good resilience, fatigue resistance, dyeability, corrosion

resistance, and insect resistance, and its density is lower than most fiber varieties. In this patent, we propose a method for preparing graphene quantum dot (GQD) reinforced polyamide fiber utilizing the molecular template effect of graphene quantum dots and the dislocation effect formed between the PA6 texture structure to improve the mechanical properties of PA6 fibers. High-strength and high-modulus PA6-GQD composite fibers with a tensile strength of 0.72~1.05GPa and an initial modulus of 8~11GPa were prepared by traditional PA6 melt spinning process. It is suitable for large-scale production with simple process, low environmental pollution and low cost, compared with the traditional PA6 fiber. The prepared PA6-GQD fiber has excellent mechanical properties and can be used in tire cord, industrial cloth, clothing, fishing nets, national defense and military industry, and other fields.

3.111321486 HIGH-TEMPERATURE-RESISTANT AND ANTI-BENDING COMPOSITE MONOFILAMENT AND PREPARATION AND APPLICATION THEREOF
CN - 23.06.2020
Int.Class D01F 8/14Appl.No 202010179818.XApplicant FUJIAN HUAFENG NEW MATERIAL CO., LTD.Inventor ZHUO LIQIONG
The invention belongs to the technical field of textile industry yarns, and more specifically relates to a high-temperature-resistant and anti-bending composite monofilament and preparation and an application thereof. The high-temperature-resistant and anti-bending composite monofilament comprises a skin material and a core material; the skin material is PBT and the core material is PA6; and the usage ratio of the skin material to the core material is (1-6): (9-4). The high-temperature-resistant and anti-bending composite monofilament provided by the invention can be used as a base material for upper materials, home textile articles, fishing gear materials, filter nets, mesh cloths or belts. According to the high-temperature-resistant and anti-bending composite monofilament provided by theinvention, the PBT is used as the skin material and the PA6 is used as the core material, the high strength and high temperature resistance characteristics of the PBT skin and the softness and high elastic properties of the PA6 core are fully utilized, the performance complementation of all component materials is fully realized from the process, and the composite monofilament with the skin-core structure with high tensile strength, thermal stability and bending resistance is prepared, and the breaking strength of the composite monofilament is 4.2-5.7CN/D, the elongation at break is 45 to 55%,and the bending strength is up to 300 million times.

Patents – Methods for Material Classification

1.101674915* METHOD FOR CLASSIFYING PLASTICS BY MATERIAL USING ATR FT-IR SPECTROSCOPY AND RBFNN PATTERN CLASSIFIER
KR - 22.11.2016
Int.Class B07C 5/342Appl.No 1020160040352Applicant 수원대학교산학협력단 Inventor 오성권
The present invention relates to a method for classifying plastics by material using an ATR FT-IR spectroscopy and an RBFNN pattern classifier. More particularly, the present invention relates to a method including: (1) a step in which spectrum data by plastic material is obtained using the ATR FT-IR spectroscopy; (2) a step in which the spectrum data by plastic material obtained through the step (1) is pre-processed; (3) a step in which the data pre-processed through the step (2) is inputted to the RBFNN pattern classifier, and the RBFNN pattern classifier learns characteristics by plastic material; and (4) a step in which a randomly inputted plastic is classified by the material, using the RBFNN pattern classifier learned through the steps (1)-(3), for the randomly inputted plastic. According to the method for classifying plastics by material using an ATR FT-IR spectroscopy and an RBFNN pattern classifier suggested in the present invention, the inputted plastics including a black plastic can be classified more accurately and rapidly by the material, by obtaining the spectrum data by plastic material using the ATR FT-IR spectroscopy and making the RBFNN classifier learn the characteristics by plastic material by inputting the data obtained by the plastic material. COPYRIGHT KIPO 201

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