Fostering Circular
Blue Economy
in the Mediterranean

A Circular Blue Economy for the Mediterranean:

Current practices and opportunities

Prepared by:
SwitchMed, Blue Growth Community

switchmed

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Interreg Mediterranean BLUE GROWTH

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1 Foreword



This report aims to describe the state of play in the development of circular economy in some blue sectors in the Mediterranean, also providing some keys to strengthen such developments and foster the transfer process across the sea basin territories.

This report is prepared in the framework of two EU-funded initiatives, the Interreg MED Blue Growth Community and the SwitchMed programme. More particularly, it was originated by the willingness of two entities to join forces to explore a common topic: the Conference of Peripheral Maritime Regions of Europe (CPMR) – through its Inter-Mediterranean Commission (IMC), as a partner of the Blue Growth Community, and of the United Nations Environment Programme/Mediterranean Action Plan (UNEP/MAP) Regional Activity Centre for Sustainable Consumption and Production: MedWaves. Plan Bleu also contributed to the elaboration of the report.

The Interreg MED Blue Growth Community horizontal project (2019-2022) is the continuation of the Interreg MED InnoBlueGrowth horizontal project (2016-2019). The project relies on the Blue Growth Community (BGC), gathering all the Interreg MED projects (modular, integrated and strategic), dealing with Blue Growth issues, as well as other relevant "blue" stakeholders. BGC's main objective is to promote sustainable Blue Economy in the Mediterranean region, assist and coordinate the BGC's projects in their communication and capitalisation activities, create and ensure internal and external synergies, and transfer projects' results and outputs to other Mediterranean territories.

This report is part of the project's capitalisation activities/Work Package (WP5) related to circular economy in blue sectors, led by Plan Bleu. The main objective of BGC's capitalisation activities is to coordinate the transfer, mainstreaming and capitalisation of knowledge expertise and tools developed in the framework of the implementation of the community projects, including relevant stakeholders, and ensuring long-term sustainability of the community's results. A key activity in this context is the Development of strategic documents for mainstreaming of project results in key regional, national or EU policies and programmes.

This report capitalises on results and tools developed by relevant projects and initiatives, potentialities and best practices, including those coming from the Blue Growth Community, for example the BLUEfasma project that implements circular economy principles in fishing/aquaculture in order to empower the innovation capacity of SMEs, maritime clusters/networks and public authorities in the Mediterranean area.

The SwitchMed programme is funded by the European Union and implemented by the United Nations Industrial Development Organization (UNIDO), the United Nations Environment Programme (UNEP) Economy Division, the United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP) and its Regional Activity Centre for Sustainable Consumption and Production: MedWaves. SwitchMed is conducted in close coordination with the Directorate-General for Neighbourhood and Enlargement (DG NEAR). The initiative was launched in 2013 to speed up the shift to sustainable consumption and production patterns in the Southern Mediterranean, through the promotion of circular economy approaches. The programme aims at achieving productive, circular and sharing economies in the Mediterranean by changing the way goods and services are consumed and produced so that human development is decoupled from environmental degradation.

Recently, a specific component of SwitchMed dedicated to Blue Economy and funded by DG MARE was added and is focusing on different aspects: enabling policy frameworks at the national and regional levels, sustainable entrepreneurship within Blue Economy sectors, improvement of the sustainability of the seafood, fish and aquaculture value chain and networking among key stakeholders. This report is the starting point of the activities under Output 7.3, aiming at integrating circular economy principles in Blue Economy sectors at the regional level, and in particular within the Barcelona Convention framework.

This Report has been officially validated and endorsed by the member regions of the Intermediterranean Commission (IMC) of the Conference of Peripheral Maritime Regions of Europe) on 10 June 2022.

2 Introduction



2.1 Circular Economy: definition and background

The circular economy is a model of production and consumption, that involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.

Circular economy is based on three principles, driven by design: (i) eliminate waste and pollution, (ii) circulate products and materials (at their highest value), (iii) regenerate nature (Ellen MacArthur Foundation). It is underpinned by a transition to renewable energy and materials. It seeks to rebuild capital, whether this is financial, manufactured, human, social or natural. The objectiveis to maintain the value of products, materials and resources for as long as possible by returning them to the product cycle at the end of their use while minimising the generation of waste. The fewer the products being discarded, the less materials being extracted, the better for the environment (Eurostat).

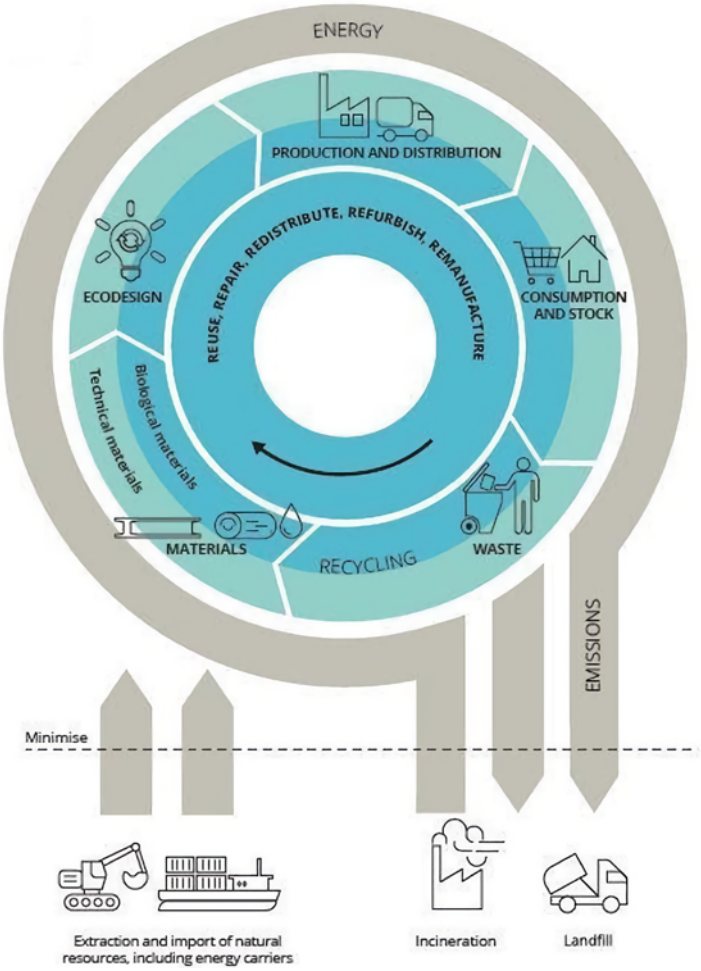


Figure 1. Circular economy system diagram, Source: EEA 2020.

This ensures enhanced flows of goods and services. The system diagram (Figure 1) illustrates the continuous flow of technical and biological materials through the 'value circle'. In such a way, circular economy decouples economic activities from the consumption of finite resources. It is a resilient system that is good for business, people and the environment

A circular economy comprises two cycles: a biological cycle and a technical one (Figure 2). Biological materials - represented in green cycles on the left side of the diagram - are those materials that can safely re-enter the natural world once they have gone through one or more use cycles, where they will biodegrade over time, returning the embedded nutrients to the environment.

Technical materials - represented in blue on the right-hand side - cannot re-enter the environment. These materials, such as metals, plastics, and synthetic chemicals, must continuously cycle through the system so that their value can be captured and recaptured.

Such a circular system aims at maximising the use of pure, non-toxic materialsand products designed to be easily maintained, reused, repaired or refurbishedto extend their useful life, and later to be easily disassembled and recycled into new products, with minimisation of wastage at all stages of the extraction-production-consumption cycle.

Recycling and the circular economy. Recycling is the action or process of converting waste into reusable material. In the face of current environmental challenges, recycling won't be enough to overcome the sheer amount of waste we produce (Ellen MacArthur Foundation). The circular economy aims to prevent waste and pollution from being created in the first place. In fact, regarding recycling, the World Economic Forum states that "In a properly built circular economy, one should rather focus on avoiding the recycling stage at all costs. It may sound straight forward but preventing waste from being created in the first place is the only realistic strategy".

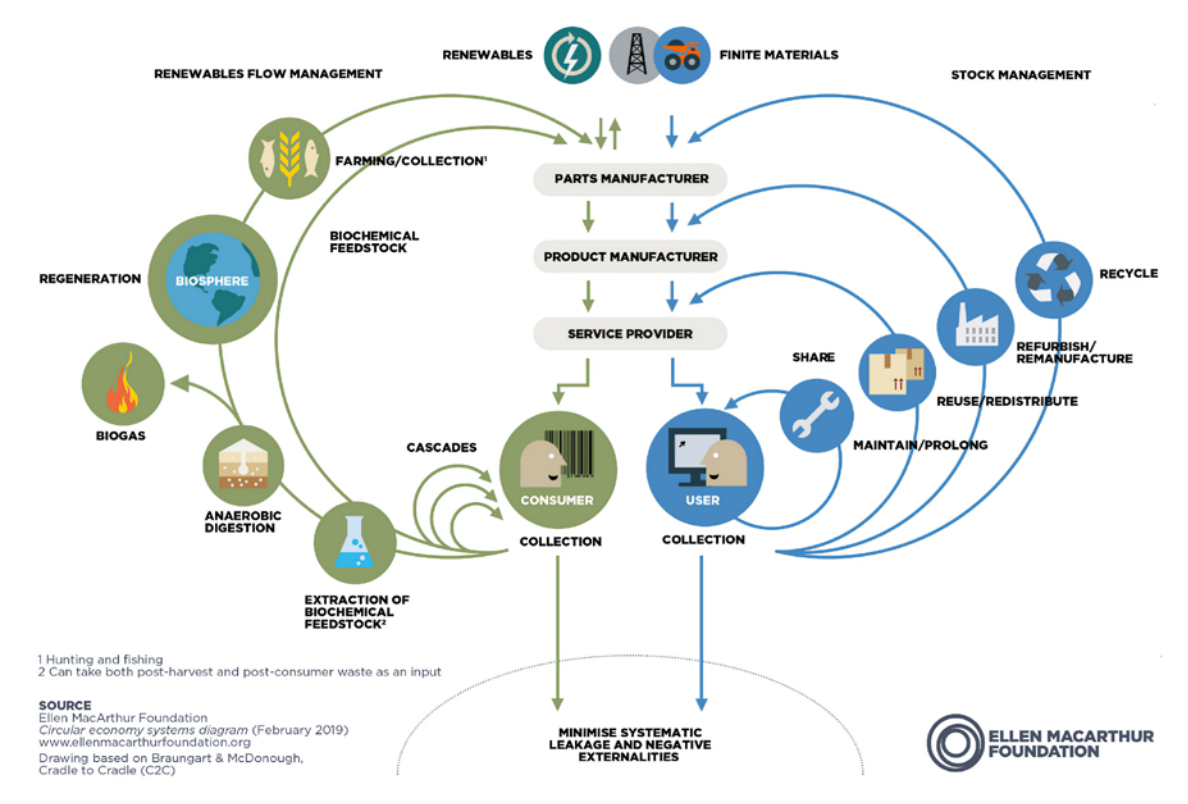


Figure 2. Circular economy system diagram, Source: Ellen Mac Arthur Foundation.

Design phase is key for a circular economy. Today, in industries like fashion and plastics packaging, products and systems are designed in such a way that more than 80% of material flows are destined for landfill, incineration or leaked into natural environments (Ellen Mac Arthur Foundation). Once things are designed, it's hard to reverse production processes.

Design decisions often lead to long-term investments that lock us into a certain model for years to come. Over 70% of a product's life-cycle costs and environmental footprint is determined during its design phase (Radjou and Prabhu 2014).

With circular design (**Figure 3**), we can prevent the creation of waste and pollution right at the start. Circular design can be defined as the practice of applying circular economy principles at the design stage of everything (Ellen MacArthur Foundation). The linear structure design focuses on the product itself and how it is packed. Traditionally, design has not considered product impact during its birth and use, or what happens when it is not in use anymore and thrown away. Products were not designed to last, allowing for new models to come fulfil the needs and temptations of consumers. The emphasis was laid on product aesthetics and attractiveness, and brand promotion by applying smart marketing, leading to massive resource consumption and waste (Fifield and Medkova 2016). Circular design challenges a generation of products and materials in a way that minimises the primary raw materials used. Circulardesign begins with the resources' economic potential optimisation through new business models. At the same time, emphasis is on resource restoration and quality of life (Circular Product Design 2016).

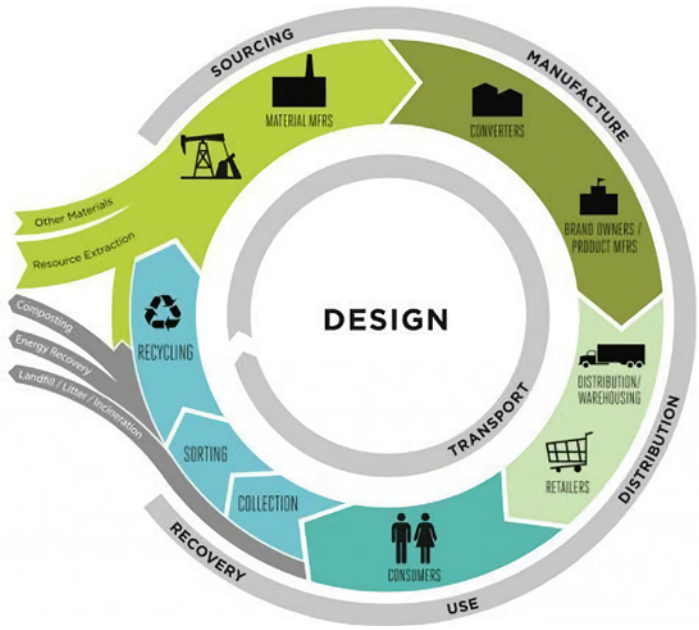


Figure 3. Centrality of design phase in circular economy. Source: Perella 2016.

Circular business models. Circular business models can create environmental value by transforming ecological challenges into economic opportunities and by reducing environmental impacts. In order to make this happen, the main approaches to be deployed are eco-innovation and life-cycle thinking. Eco-innovation can be developed under different perspectives (Mosangini and Tuncer 2020):

- **Process eco-innovation.** Production processes are modified to significantly improve resource and energy efficiency, in order to save resources and prevent pollution. Existing processes and technologies are improved without changing the final product. For instance, in the shipbuilding industry, a vessel could be built using less raw materials and energy and producing less waste

- **Product eco-innovation.** The innovated solutions change the main characteristics of the product or service. New processes and technologies transform the final product, for example, shifting from conventional vessels to zero emissions vessels.

- **System eco-innovation.** Here, eco-innovation implies transformations at the system level in the value chain and regarding consumption patterns. This is where radical business model innovation is required. System eco-innovation embraces complex changes, usually involving non-technological transformations and various stakeholders.

A business model is a document or strategy that outlines how a business or organisation delivers value to its customers, integrating different aspects such as business strategy, technological capabilities and business innovation processes. A "business model innovation" focus on the process in which an organisation adjusts its business model encompassing a fundamental change in how a company delivers value to its customers, whether that's through the development of new revenue streams or distribution channels. Business model innovation is often the result of external factors (e.g. competition law, labour market legislation, environmental legislation) and an essential step in going from process/product level to system level that could potentially lead to more environmental value creation. Circular business models could be the missing link between changes at the level of individual companies and systemic changes triggered by various companies adopting business model innovation. A combined adoption of eco-innovation and life cycle thinking approaches can lead to alternative, sustainable business models for the companies of the future.

To date, business models can be grouped into five main business strategies (Mosangini and Tuncer 2020). See below:

Prevent pollution and save resources

The **bussines models** to implement this strategy:

- Cleaner and Reasorce Efficient Rroduction
- Zero-waste production

Extend resource use and reduce disposal

The **bussines models** to implement this strategy:

- Design for Durability, Long Lasting and Modularity
- Collection and Recycling
- Repairing and Upgrading
- Reuse and reselling

Recover resources after disposal

The **bussines models** to implement this strategy:

- Design for disassembly, reassembly and recycling
- Collection and Recycling
- Upcycling

Increase resource utilisation rate

The **bussines models** to implement this strategy:

- Rental - subscriptions
- Leasing - subscriptions
- Servitization - selling the functionality.

Increase resource utilisation rate

The **bussines models** to implement this strategy:

- Alternative low impact fibre or recycled material driven value chains.
- Slow living products and services with full control over the value chains (eco-design brands, slow food brands, slow fashion brands, slow cities)

2.2 Policy frameworks - Circular Economy in Blue Economy sectors

In the following paragraphs, some relevant policy frameworks at the EU, regionaland national level, promoting, strengthening or just linked to circular economy are exemplified. They provide a foundation for circular economy practices to be developed or improved.

2.2.1 European Union

Over the last few years, the European Union has adopted plans, strategies and measures to promote the adoption of principles of circular economy, in particular vis-a-vis the food and plastic industry.

In December 2015, the EU adopted the "Circular Economy Package and Action Plan", which envisages a set of actions to reduce food waste, legally recognise organic and waste-based fertilisers, foster eco-design for improved energy efficiency, reparability, durability and recyclability of products, and limit landfill to a maximum of 10% of municipal waste by 2030.

In March 2020, the European Commission adopted the "New Circular Economy Action Plan" to support the implementation of the European Green Deal by building on the work done since 2015. It is one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth. The EU's transition to a circular economy aims to reduce pressure on natural resources and to create sustainable growth and jobs. It is also a prerequisite to achieve the EU's 2050 climate neutrality target and to halt biodiversity loss.

Additional steps have been undertaken at the EU level to promote the adoption of circular principles in the plastic and food industry:

- In January 2018, the "EU Strategy for Plastics in the Circular Economy"was launched with the aim of innovating the way in which plastic products are designed, produced, used and recycled. In particular, the Strategy highlighted the need to reduce the impact of fishing gear and single-use plastics (together they account for 70% of marine litter) in our seas and oceans. The "Single-Use Plastics Directive" is a crucial step forward in this direction by tackling the 10 most common single-use plastic items for which more sustainable alternatives are available and affordable.

- The Single Use Plastics (SUP) Directive (2019/904), which addresses 10 of the most common single-use plastic items found on European beaches, as well as end-of-life fishing gear and ALDFG, foresees the introduction of Extended Producer Responsibility for fishing gear starting 31/12/2024. Within this Directive, producers of fishing gear containing plastic will have to take on the responsibility (and costs) for separate collection, transport, treatment and awareness-raising measures of fishing gear. This has been brought in to reduce port costs for fishers, particularly in small fishing ports, and potentially accelerate the development of a dedicated waste stream for fishing gear waste.

- In May 2020, the EU Communication "A Farm to Fork Strategy - for a fair, healthy and environmentally-friendly food system" was issued with the objective to promote circular business models in food processing and retail also through the potential, largely untapped, of bio-based economy including the use of algae and fish waste. The strategy has 27 concrete actions to transform the EU's food system by 2030, including a reduction by 50% in sales of antimicrobials used for farmed animals and aquaculture.

- In May 2021 the new Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030 were adopted by the European Commission. They aim to support the development of the sector and stimulate its contribution to the European Green Deal and to the Farm to Fork Strategy. Competitiveness, resiliency and environmental and climate sustainability are the key aspects the guidelines want to promote for the benefit of the sector. The guidelines also aim to support the increase of organic aquaculture through sustainable feed systems that are respectful of ecosystems and biodiversity; this implies limiting feed producers' relianceon fish meal and fish oil taken from wild stocks and use of alternative protein ingredients (e.g. algae or insects or the waste from other industries).



Figure 4. Transition to a sustainable food system

- At the end of March 2022, the European Commission adopted a package of legislative and non-legislative measures along the entire life cycle of products according to the circular economy action plan. The aim is to improve EU products' circularity, energy performance and other environmental sustainability aspects. The measures aim to ensure the sustainable production and consumption of textiles, harmonised technical standards for marketing construction products as well as adequate information to consumers about the durability and reparability of the products they plan to purchase.

With the Communication on a new approach for a sustainable blue economy in the EU - Transforming the EU's Blue Economy for a Sustainable Future (COM/2021/240 final), the European Commission stresses that a sustainable blue economy should create tangible opportunities for new jobs and businesses and mitigate the detrimental impacts on oceans and coasts. This means that those businesses based on renewable resources able to preserve marine ecosystems and reduce pollution while building resilience to climate change must be incentivised.

The promotion of a circular economy approach in the current models of production and consumption not only generates new business opportunities for all the Blue Economy sectors, but also greatly benefits marine ecosystems currently impacted by human activities. A circular economy approach also reduces the negative impacts on the seas and oceans caused by land activities (DG-MARE 2021).

To tackle the main sources of pollution in European seas and to promote recycling solutions, the Commission will:

→ take action to halve plastic litter at sea, nutrient loss into the sea and the use and risk from chemical pesticides by 2030;
→ restrict intentionally added micro-plastics and develop labelling, standardisation, certification and regulatory measures on the unintentionalrelease of micro-plastics, including measures to increase the capture of micro-plastics at all stages of the product lifecycle;

→ ensure that litter caught in fishing operations is reported at port, and that fishing gear made from plastic is collected and recycled after its use. The Commission will prepare the relevant implementing acts and has asked industry standardisation bodies to develop standards for recyclable fishing gear;

→ propose revising the ship recycling Regulation and the EU requirements for decommissioning offshore platforms to ensure proper protection of the marine environment.

2.2.2 Mission Starfish 2030: Restore our Ocean and Waters

In 2020 the EU Mission Board on Healthy Oceans, Seas, Coastal and Inland Waters proposes a Mission Starfish 2030: Restore our Ocean and Waters by 2030, setting up five overarching objectives to be achieved by 2030: (i) filling the knowledge and emotional gap, (ii) regenerating marine and freshwater ecosystems, (iii) zero pollution, (iv) decarbonising our ocean, and waters (v) revamping governance. Circular economy is indicated as a means to reach the Mediterranean sea basin lighthouse target regarding zero plastic generation.

2.2.3 The Barcelona Convention and its Protocols

The Barcelona Convention is a multilateral legal framework for the protection of the marine and coastal environment and the sustainable use of their resources in the Mediterranean. In February 2016, the Contracting Parties of the Barcelona Convention adopted the "Mediterranean Strategy for Sustainable Development 2016-2025", a document that aims to adapt international commitments to regional conditions and to guide national strategies and stimulate regional cooperation in the achievement of sustainable development objectives.

Objective 5 of the strategy (Transition towards a green and blue economy) calls for an economic model that rests on, among other things, circular economy as a way to pursue not only environmental sustainability but also poverty eradication through job creation and social inclusion. Circular economy can give credible responses to the sustainability challenges by indicating the way to decouple prosperity and use of (marine and coastal) resources. The Strategy was complemented by the 2017 "Regional Action Plan on Consumption and Production in the Mediterranean", which addresses two key blue sectors: fisheries and tourism.

In December 2021, during COP22 in Antalya (Turkey), the Contracting Parties of the Barcelona Convention adopted a set of twelve Regional Measures to support the development of sustainable businesses and to strengthen the demand for sustainable products in the Mediterranean. The measures target four groups (entrepreneurs and SMEs, policymakers, business support organisations and financial actors) depending on their role in the sustainable business ecosystem. One of the 3 transversal measures adopted aims to create an "enabling framework for sustainable and inclusive businesses within sectors of the Blue Economy". The one related to the development of sustainable alternatives to Single-Use Plastics is also highly relevant in the context of this report.

The recently-amended (2021) Regional Action Plan for Marine Litter prevention strengthens the measures to be implemented at the regional level towards the circular economy, as a key action to tackle the issues of marine pollution from plastics. Foreseen actions include: establishment of targets to phase out production and use of non-reusable, non-recyclable, and non-compostable plastic products; promotion of the use of recycled plastics and disincentivise the use of plastic, resins and additives that hinder products' recyclability; implementation of standards for product labelling (including on packaging) to provide consumers with clear and reliable information on sustainable choices.

In 2021, Plan Bleu has coordinated the preparation of a roadmap for the sustainable development of the aquaculture sector in the Mediterranean, through a participatory process with the establishment of a multi-stakeholder group of about one hundred representatives from the private sector, local,national and regional authorities, NGOs, researchers and international organisations working in the sector. The Mediterranean Blue Growth Community and Biodiversity Protection Community have also participated in this process.

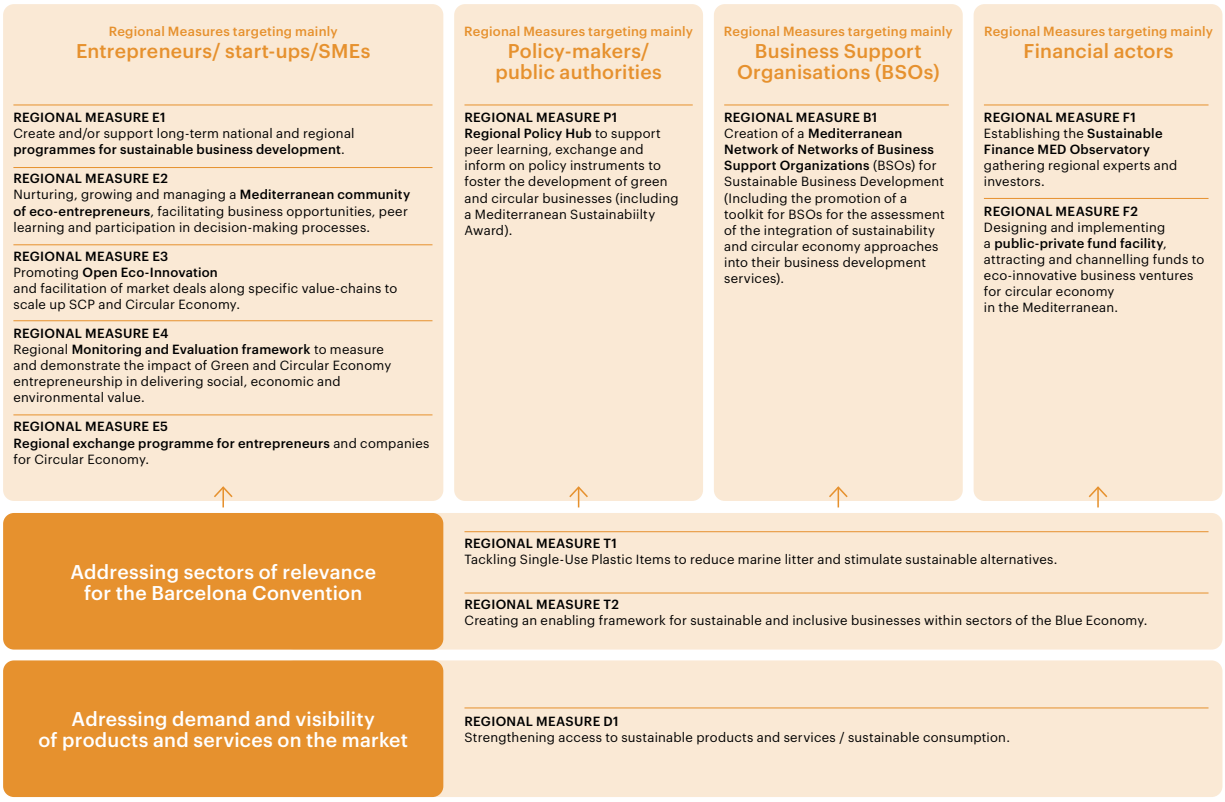


Figure 5. Barcelona Convention set of measures towards to support the creation and development of green and circular businesses in the Mediterranean.

2.2.4 The Union for the Mediterranean

Building on the first Union for the Mediterranean (UfM) Ministerial Declaration on Blue Economy (Brussels, November 2015), the 2nd UfM Ministerial Declaration on Sustainable Blue Economy was adopted by the 42 Euro-Mediterranean countries on February 2nd, 2021. The objective of this ambitious Declaration is to reinforce the existing process, expand the areas of cooperation, call for new joint actions to speed up recovery of blue economy sectors in the Mediterranean, as well as ensure long-term sustainability. The Declaration identifies the following priority areas for cooperation by the 42 UfM member countries:

- → Governance and the future of sea basin strategies in the Mediterranean region
- → Marine research and innovation, skills, careers and employment
- → Sustainable food from the sea: fisheries and aquaculture
- → Sustainable, climate-neutral and zero-pollution maritime transport and ports
- → Interactions between marine litter and the blue economy
- → Coastal and maritime tourism
- → Maritime Spatial Planning and Integrated Coastal Zone Management
- → Marine renewable energies
- → Maritime safety and security of blue economy activities
- → Sustainable investment in the blue economy.

The Ministerial Conference was accompanied by a video summarising the achievements since the adoption of the 1st UfM Ministerial Declaration on Blue Economy (2015) and explaining the new commitments and areas of joint cooperation related to new Ministerial Declaration on Sustainable Blue Economy. In parallel, the UfM published the milestone report, Towards a Sustainable Blue Economy in the Mediterranean region – 2021 Edition, that assesses the state of the art of blue economy sectors at the Mediterraneanlevel following the Ministerial priorities and with a specific focus on: (i) employment for youth and women, (ii) the analysis of employment trends, blue skills, careers and jobs across blue economy sectors; and (iii) investments related to the sectors most affected by the pandemic (i.e. tourism, maritime transport, and fisheries). The report – delivered in English, French and Arabic – also presents key figures and data and highlights operational tools for future development, including initiatives, programs, and projects.

Following the adoption of the 2021 UfM Ministerial Declaration on Sustainable Blue Economy and as a key step forward in their joint cooperation, the UfM member countries agreed to elaborate a Roadmap for the implementation of said Ministerial Declaration with a view to producing an overview and analysisof the joint needs, gaps and opportunities for future support, funding, and implementation for each thematic priority, also including an easy-to-handle-and-understand monitoring system of the implementation of the Roadmap. The Roadmap is a living document, which will be progressively updated over time.

2.2.5 The WestMED Initiative

The WestMED initiative is a sub-regional platform composed of ten countries in the western Mediterranean region. The initiative aims to move towards the development of a smart and resilient blue economy through the involvement of public institutions, academia, local communities, and SMEs from both sides of the Western Mediterranean in local and regional maritime projects. The initiative pays particular attention to the adoption of circular economy principles in the aquaculture sector.

2.2.6 The EU Strategy for the Adriatic-Ionian Region

The participating countries work together on areas of mutual interest with high relevance for the Adriatic-Ionian countries. Blue growth is a pillar of the strategy, and the countries of the region focus on blue technologies, fisheries and aquaculture, and maritime and marine governance. Although the blue circular economy is not explicitly addressed, the strategy pursues a sustainable seafood production and consumption.

2.2.7 Examples of national policy frameworks

Circular economy is intrinsically cross-sector and so are the policies that are relevant for its implementation. Mediterranean countries are gradually starting to introduce circular economy in their strategic and legislative frameworks. When available, these strategies also refer to specific sectors, but their scope is not focused on blue economy sectors, although they are sometimesmentioned among others. On the other side, national blue economy policies and strategies are focused on the development of sectors. They may include elements for environmental sustainability but are not focused on circular economy. Sectoral policies in the fields of fishing, aquaculture and tourism include several elements regarding environmental sustainability, these elements are sometimes also relevant for a circular transformation of the sectors' economy.

Generally, we can highlight the need for developing interconnections between circular economy and blue economy policy frameworks, as well as single blue sector policies. Moreover, the link between environmental sustainability, efficient use of resources and circular economy could strengthen motivation of sectors in targeting objectives and could stimulate the approach to other aspects of circularity as well. Some examples of policy instruments containing elements directly or indirectly supporting circular economy in blue sectors are provided here below.

The **Tunisian Maritime Cluster** was established in 2019. It brings together twenty-three founding members specialised in the various public and privatemaritime sectors. In 2020, a partnership agreement was signed between the Tunisia Maritime Cluster and the Italian cluster Blue Growth facilitated by the WestMED initiative. Such cooperation will allow the two clusters to facilitate relations between their members in order to set up projects in many related fields, including the promotion of technological approaches for a circular economy in fisheries and aquaculture.

The **Spanish Strategy for the Circular Economy** represents a good example of national strategy because it adopts a comprehensive approach, identifying a number of key economic sectors: construction, farming, fishing and forestry, industry in general, consumption goods, tourism, and textile and garment sectors.In the farming sector, the challenge identified is to make it possible to produce better quality foodstuffs at affordable prices, guaranteeing sustainable use of natural resources, ecosystem and biodiversity conservation, waste reduction, valorisation of waste whenever possible and the development of sustainable food models.

Regarding tourism, extensive use of water resources, high wastelevels in tourist areas and the challenges of managing this issue with a lesser level of waste separation at origin, as well as the continuous growth of an inland tourism associated to nature, are the fundamental issues recognisedby the Strategy. The Strategy does not target the Blue economy sectors with specific measures or indicators.

Nautical tourism in Spain is consolidating its growth regardless of the pandemic effect. The sector is addressed within the **Spanish National Strategic Policy for Tourism**. The strategy stresses the need to move the sector towards the precepts of the circular economy. The interest in opportunities for circularity in nautical tourism is exemplified by the activities of the chair for Blue Economy of the Conselleria d'economia sostenible de la Generalitat Valenciana, holding symposia, circular economy consumption channels (rental, shareduse, use from sports schools and social entities), as well as creative and innovative advances in reuse and recycling in the sector, also through prizes and competitions.

In the **French Roadmap to Circular Economy** (2019), blue economy sectors are not specifically highlighted, but some actions are of relevance for them. This is particularly the case in the fight against food waste, including the deployment of biowaste sorting at the source by councils, and the recycling of all high-quality biowaste. These measures, although not specifically focused on fisheries and aquaculture, can foster development of circular practices in those sectors.

The recent **French Strategy for Recyclability, Recycling and Reincorporation of Materials** (2021) identifies cross-cutting measures, applicable to different sectors, including in the Blue economy. For example, the strategy calls for development and improvement of production processes for raw materials and recycling composite waste. This topic includes actions of relevance for the blue economy sectors, for example, in the field of glass-fibre and carbon-fibre composites where the Strategy aims to identify and assess the recycling potential offered by the substitution of non-recyclable resins by recyclable resins in the various composite applications. However, it should be noted that neither strategy includes specific references to the Blue economy.

The French Ministry of Ecological Transition published a decree in 2019 designating a national body (APER) in charge of the creation and management of the **French National Network for Pleasure Boat Collection and Deconstruction**. The objective of this law is to deconstruct between 20 and 25,000 boats from 2019 to 2023. To achieve this, the nautical industry and the government jointly decided on an equivalent increase in eco-contribution and a quota of the taxation of boaters (DAFN).

Blue economy is one of the new areas of intervention identified by the **Italian National Strategy for Circular Economy** (2021), together with eco-design, bioeconomy and critical raw materials. The Strategy recognizes some priority lines of action: collection and dissemination of best practices in the field of green and sustainable mobility, developing projects and activities aimed at the concrete realisation of the principles of environmental, economic and social sustainability; redesign of products and processes; dissemination of knowledge on opportunities offered by innovative fuels and alternative traction; development of 'territory logistics' and forms of 'reverse logistics'; dissemination of experiences of rail/road/sea inter-modality to facilitate the integration of mobility infrastructure; enhancement of the role of ICT as enabling factor for innovation and sustainability.

In November 2021, a bill was approved to allow fishermen in Italy to land plastic that has accidentally ended up in their nets. Until now, they were forced to throw it back into the sea because otherwise they would have committed the crime of illegal waste transport, thus they would be considered waste producers and obliged to pay for its disposal. The waste will now be taken to the ports where collection points will be set up and reward mechanisms will be introduced for fishermen.

The **Italian National Strategy for Aquaculture**, despite not calling explicitly for circular economy, contains many elements towards environmental sustainability, some of which are relevant for circularity too, such as integrated multi-trophic aquaculture (IMTA) and recirculating aquaculture systems (RAS).

The **National Greek Action Plan on Circular Economy** was published in 201 to help the country set out on a path towards the long-term (2030) adoption of circular economy principles. In the short term, the plan is expected to achieve a radical reduction of the per capita waste produced and increase the reuse and recycling of waste with a separate collection of recyclable waste and of bio-waste. In the long term, the goal is to support circular entrepreneurship by promoting "industrial symbiosis" and circular business clusters.

The **Israeli National Resource Efficiency and Environmental Innovation Program** was introduced in 2018, aiming at encouraging companies to implement circular model applications. The program called for an annual investment of about €756 million in environmental-promoting projects, of which €143 million would be invested directly in the circular economy. According to the available literature (Flanders Investment and Trade 2019), a national program for circular economy in industry should be in preparation, in collaboration with the Ministry of the Environment, the Manufacturers Association, the Israeli Green Building Council, the Heschel Center for Sustainability and the Innovation Authority. The Israeli Circular Economy Platform is recognised by the European Circular Economy Stakeholder Platform as an Israeli actor on national, regional and international levels to integrate new resource strategies and circular-based business models with Israeli innovation capabilities.

Fishing activities contribute significantly to ensuring Morocco's food security and it is one of the most job-creating and fastest-growing economic sectors in the country. The **Moroccan Halieutis Strategy** was launched in 2009 as a development and competitiveness strategy for maritime fishing to ensure the sustainability of the activity through the preservation of fish resources and addressing globalisation challenges by meeting higher standards. The strategy rests on three pillars: sustainability, performance and competitiveness.

Also, the **Government of Algeria** is making progress on the elaboration of the National Strategy for the Blue Economy. Once finalised, it will provide a view of the conditions of exploitation, regulation and management of the maritime space and its resources and create synergies among the interlinked marine and maritime economic sectors.

2.3 A report on Circular Economy in Blue Sectors

The objective of this report is to illustrate the degree of development of circular economy in blue sectors in the Mediterranean and to highlight the challenges hindering further developments and the actions that could help overcome the present barriers. In addition, the report aims to display case practices of circular economy (mainly from the Mediterranean, but also beyond) that can be transferred or spread and developed further.

A preliminary analysis of practices available for the established blue sectors (European Commission 2020) was conducted considering:

- → Marine living resources
  - fisheries
  - aquaculture
- → Marine non-living resources
  - oil and gas
  - other minerals
- → Marine renewable energy
- → Port activities
- → Shipbuilding and repair
- → Maritime transport
- → Coastal and maritime tourism

Specific aspects of the blue economy sectors in the Mediterranean have been assessed (see the table below) and used as a basis for selecting those of greater interest for the present study.

Sector		Opportunities for circular economy	Labour intensity	Potential for SMEs involvement
Fisheries and aquaculture		Good opportunities and several practices available	High	High
Marine non-living resource		Not sustainable sector	Low	Low
Marine renewable energy		Some, but still in development	Low	Low
Port activities		Opportunities, practices documented mostly outside the Med	High	Medium
Maritime transport		Some, but still in development	Medium/ High	Low
Shipbuilding and repair		Good opportunities and some practices available	Medium	Medium
Coastal and maritime tourism	Bathing	Opportunities mostly limited to accommodation	High	High
	Cruising	Some practices available	High	Low
	Marinas	Practices available	High	High
	Boating and yachting	Practices available	High	High

Marine non-living resources have been excluded from the analysis because they are considered a highly unsustainable sector and, being capital intense, less important for SMEs. On the other hand, fisheries and aquaculture are significant employers and offer great opportunities for adopting circular economy principles. Likewise, coastal and maritime tourism is an important source for growth and jobs, especially for youth, migrant workers, part-time workers as well as female workers (58% of people employed in core tourism activities are women) (UfM 2021). Shipbuilding used to be labour intensive, though firms tend to reduce costs by means of digital solutions.

Considering the elements above, this report focuses on the following sectors:

→ **Fisheries** and **aquaculture**
→ **Port systems**, including **ship building** and **ship repair**
→ **Nautical tourism**, including **marinas**, **recreational boating** and **yachting**.

These sectors represent an important economic part of blue economy in the Mediterranean region. They are already addressed by the Blue Growth Community and they have a high potential for improvement in terms of sustainability and circularity. Most of them are also relevant for the development of local communities and SMEs.In this report, practices are collected and briefly described to exemplify available experiences of circular economy in blue sectors in the Mediterranean.

The following **field of actions**, according to a circular economy approach, have been identified, and all the practices outlined in the report are associated with one of them:

→ **Eco-design** (e.g. biodegradable fishing/aquaculture gear; recyclable composite/fibres; integrated aquaculture farming)

→ **Repair** (e.g. find second-hand, end-of-series and destocking parts for pleasure boats)

→ **Re-use** (e.g. of waste from fishery and aquaculture, of end-of-life boats)

→ **Reduce** (e.g. greenhouse gases emissions in ports/marinas)

→ **Up-cycle** (e.g. use old sails and fabric scamps for new products)

→ **Recycle** (e.g. marine litter collected during fishing operations, oil in marinas, waste in ports, glass fibre products, parts and components from end-of-life boats)

→ **Digitalisation** as an enabler of circular economy (e.g. in marinas to save energy consumption)

3 Implementation of Circular Economy in Blue Economy sectors



3.1 Fisheries and aquaculture

Fisheries and aquaculture are key maritime activities in the Mediterranean. Landings from capture fisheries in the Mediterranean reached their height in the 1990s and in the first decade of the 2000s, with peaks of more than one million tonnes. After that, landings started to drop, reaching a minimum of 760,000 tonnes in 2015, slightly increasing to 780,000 tonnes in 2017. On the other hand, aquaculture exhibits an opposite trend: the total aquaculture production in Mediterranean, considering all species and all environments, has increased substantially during the last 20 years. Production in 1996 was estimated at 509,678 tonnes, while in the last ten years production has increased from more than 1,198,000 tonnes in 2006 to more than 2,082,800 tonnes in 2016 (an increase of 73.8%, with an annual growth rate of approximately 7.4%) (UNEP/MAP and Plan Bleu 2020).

Combined, fisheries and aquaculture provide an economic output close to USD 12 billion per year, including both the value at first sale and the wider economic impact along the value chain. The sector is estimated to provide direct and indirect employment for at least one million people, including at least a quarter of a million people directly employed on board capture fishing vessels (UNEP/MAP and Plan Bleu 2020). Considering only the production of marine species in Mediterranean countries, the production in 2016 was estimated at 1.616.041 tonnes (UNEP/MAP and Plan Bleu 2020).

These two sectors can exert pressure on the environment in a number of ways, including:

- → Over-exploiting targeted fish-stocks
- → Disrupting the ecosystems of non-targeted and farmed species
- → Contributing to marine/aquatic pollution
- → Consuming finite fossil fuels and in so doing generating harmful emissions to power boats and for the energy needs of fish auctions and other buildings used to receive the catch.

Opportunities to reduce the environmental impact of these activities are linked to the adoption of a circular economy approach.

There are examples and practices where production processes allowed for a lower ecological footprint (FARNET, 2019) by improving the energy efficiency of the machines and equipment used, the design of products, including packaging, and the use of waste materials for generation of new products.

In this regard, the Interreg MED project BLUEfasma targeted mainly SMEs and the public sector to transfer knowledge, approaches and tools for the adoption of a circular economy in the fishing and aquaculture sectors.

Considering the socio-economic relevance of these sectors and the existing challenges in the production chain (ghost gear, by-catch, discharge and waste of sea-food products, waste generated from transportation and packaging, etc.), the opportunity to develop circular economy initiatives in the Mediterranean is great and would largely benefit both the economy of the sectors and the marine environment.

Circular economy opportunities are distributed along the entire value chains of seafood products. However, in order to implement changes in the circular economy direction, it is essential to fully understand the specificities of fisheries and aquaculture industry, including the different segments (small-scale and large-scale fisheries, but also possibly for a single species/product) not only at country level, but also at the sub-national/local level. A general value chain for the sector is exemplified in **Figure 6.**

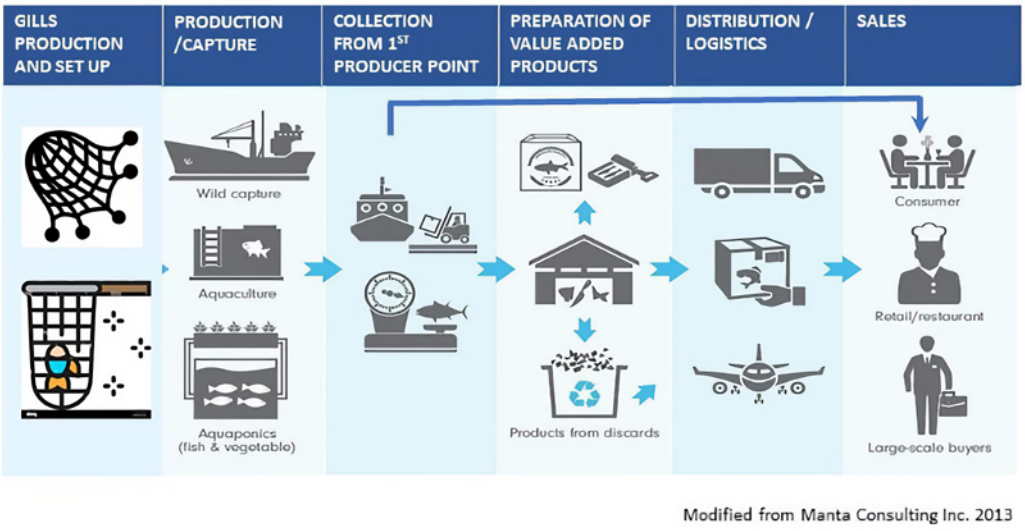


Figure 6. Fisheries and aquaculture general value chain

3.1.1 State of play of circular economy practices and best available technologies

Fisheries and aquaculture are particularly reliant on plastic (for gear, equipment, fish crates, packaging, etc.) and therefore the search for viable alternatives to plastic is imperative. Solutions at design stage are being assessed, for example,for shellfish aquaculture devices made of biodegradable materials (e.g. natural materials for spat collectors; cotton-based mussel ropes). Moreover, since forever, increase of the lifetime of fishing nets is practiced in some way around the Mediterranean through traditional reparation techniques.

Fishing gear and aquaculture devices have detrimental impacts on marine ecosystems and associated biodiversity when lost or abandoned. In most cases, the loss of gear is unwanted by the fishermen, but in some cases fishing gear is intentionally discarded to avoid the waste management cycle and its related costs. Considering recycling, the collection, treatment and industrial regeneration of nylon yard from end-of-life fishing nets represents a well-established practice in some territories of the region, with good economic impact and market opportunities. This practice requires industrial chemical plants and wide and well-organised collection and sale network.

Marine aquaculture seems to be a lively sector in the region, not only for its growing trends but also on the sustainability front. In this regard, it is relevant to mention the recommendations towards environmental sustainability and circularity, included in the “Roadmap for a sustainable aquaculture sector in the Mediterranean region” under finalisation by Plan Bleu. Many practices addressing circular economy are running throughout the Mediterranean basin, both in terms of mariculture and of cultivation of marine species on land, aiming to maximise efficiency and transform waste into valuable inputs. Aquaponics, Integrated multi-trophic aquaculture (IMTA), recirculating aquaculture systems (RAS), and bio-floc echnology are technologies addressing a circular approach from the design stage (see paragraph 3.1.2 for definition and description). These systems have been developed in a circular perspective and can be further explored and exploited. In fact, notwithstanding these encouraging experiences, their implementation for large-scale production of market-sized fishes is still extremely low.

Seafood transformation generates a large quantity of waste (shells, heads, bones, skin), not to mention that a massive portion of the total harvest from fishing activities remains unused or poorly used due to unattractive colour, small size, high fat content, etc. The valorisation of discards and effluents of the fish processing industry - fish washing, degutting, salting, fermentation, drying, and smoking - represents a promising business area. Indeed, seafood processing produces 50-70% by-products. Circular business opportunities are being developed, producing industrial high-value end products out of seafood industry waste: fishmeal for aquaculture and biogas from fish waste and sludge are to date the most common practices. Shells from shell-fish farming and fishing industry are now widely recognized as good substrate for natural banks regeneration, natural engineering and agricultural soil additives. Such waste offers plenty of opportunities as high-value marketable by-products rich in nutrients, minerals, collagen, enzymes, and bioactive peptides that could be used in different fields including pharmaceuticals and cosmetics.

Fishing-for-litter related practices have become quite common in the region, with initiatives involving fishermen and local communities. Although similar initiatives fall under the category of "waste management solutions" rather than under "circular economy practices", countries are gaining growing awareness that fishermen are crucial to addressing marine pollution and triggering a virtual circle. In this direction, production of fuel from litter collected from the sea, which is currently being experimented with in the Mediterranean, could be developed more. Production of a variety of objects from plastics collected at sea has become popular in the region. Although this practice definitively does not represent the best solution to marine litter pollution, it is a better alternative to the disposal of waste collected during fishing operations. But, at least for now, it is only partially attractive for investors due to the characteristics of recycled plastic, which is fit only for producing very simple material with limited value.

On top of that, a change of paradigm in business models of these sectors is key to achieving tangible results towards circularity. The BLUEfasma project is working on empowering the innovation capacity of SMEs, maritime clusters and networks in Mediterranean islands and coastal areas to support blue circular economy in fishing and aquaculture. A Circularity Self-Assessment tool is available to registered users as a decision-support tool to measure the readiness of SMEs and their willingness to invest with respect to circular economy principles. In addition, Living Labs, as tools to change the current thinking in circularity and the way businesses perform towards blue CE, have been successfully tested. The Labs identified recommendations for developing circular economy approaches, which are included in the Key points illustrated in chapter 5.

Opportunities towards circularity can also be introduced in the sea-food production and transformation sector. As highlighted in a recent report (FAO, CIHEAM and UfM 2021), blue foods are an essential part of the Mediterranean diet and present a unique opportunity to promote local, healthy and sustainable food and improve food security and nutrition in the region.

Summing up, fishing and aquaculture are blue economy sectors with a huge potential for moving towards circularity. Improvement can be done at all stages of a product's life. Key challenges in the sector have been identified by the Bluefasma project and are summarised in the following points:

Eco-design	→ Reduce energy consumption and carbon emissions through better-insulated cooling rooms or boat engines that are less dependent on fossil fuels → Find alternatives to plastics by replacing single-use plastic bags with plastic from recycling or reusable bags
Production	→ Create added value for waste → Use discarded fish/shellfish in other phases of the production cycle → Link with other sectors (agriculture)
Production	→ Share or mutualise large equipment and boats → Repair and reuse discarded nets/ropes/cages/ boxes and crates
Production	→ Share or mutualise large equipment and boats → Repair and reuse discarded nets/ropes/cages/ boxes and crates

BLUEfasma Toolbox

BLUEfasma online platform links to five tools aiming at enhancing circularity in fisheries and aquaculture.

BLUEfasma Circular Economy Knowledge Base identifies and systematises already developed, innovative best practices, tools, solutions, and methods related to the Circular Economy (CE) in order to deliver a well-organised online library to relevant SMEs and maritime clusters/networks assisting them to improve their innovation capacity on CE in fishing/aquaculture.

BLUEfasma e-network has been established to facilitate experience exchange and networking among all actors of the sectors.

MED Circular Economy Data is a report for policy makers including data related to the readiness & willingness of Mediterranean SMEs and maritime clusters/networks related to fishing and aquaculture to invest in CE.

BLUEfasma Circularity Self-Assessment Tool is a tool that measures SMEs' (working in the value chain of fishing and aquaculture sectors) readiness and willingness to invest in CE and proposes personalized recommendations in order to implement CE principles.

BLUEfasma Capacity Building Instrument integrates financing, mentoring and coaching opportunities for R&I business investment in the fishing and aquaculture sectors, in order to support SMEs and enterprises in twinning/entering the blue CE market.

3.1.2 Integrated aquaculture farming processes

In the Mediterranean, aquaculture is a growing sector that plays a leading role in achieving food security, creating employment and boosting economic development while reducing dependence on overexploited wild stocks. This rapid growth, however, poses significant doubts concerning the capacity of the sector to operate in an environmentally responsible manner.

Multiple initiatives have been launched to address such concerns. The Mediterranean is now a laboratory experimenting with innovative technologies and approaches with the aim to maximise efficiency and transform waste into valuable products.

Integrated Multi-Trophic Aquaculture (IMTA)

It is similar to polyculture, where two or more organisms are farmed together.This system, practiced for centuries in fresh water, farms multiple marine aquatic species from different trophic levels in an integrated fashion to improve efficiency, reduce waste, and provide ecosystem services, such as bioremediation.

Species at the lower trophic level (usually plants or invertebrates) use waste products such as faeces and uneaten feed from the higher trophic species (typically finfish), as nutrients. The lower trophic species can then be harvested in addition to the fish to give the farmer more revenue, or even to be fed back to the fish.

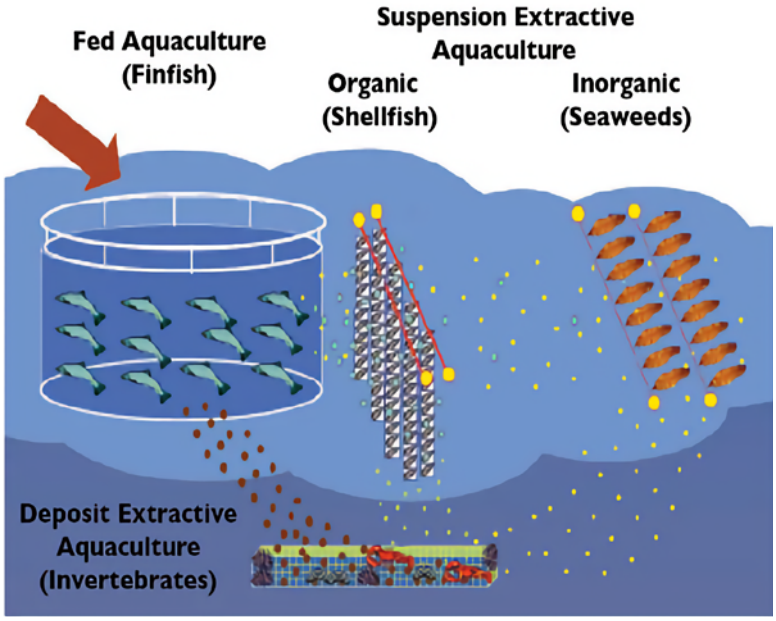


Figure 7. Conceptual approach for Integrated Multi-Trophic Aquaculture. Source: Global Aquaculture Alliance.

Although the potential benefits of IMTA are well understood, its implementationin Europe, especially in the Mediterranean region, is still scarce, despite a growing commercial interest, consumer interest, environmental urgency and policy drivers for a larger adoption of IMTA. Beyond the practical experiences highlighted, it is worth pointing out several IMTA pilot actions in Italy, Cyprus and Israel[1] .

1 Pilot sites in the framework of the EU Research Project IDREEM (Increasing Industrial Resource Efficiency in European Mariculture), http://www.idreem.eu/

Recirculating Aquaculture System (RAS)

RAS is essentially a technology for intensive farming of fish, or other aquatic organisms, by reusing the water in the production (FAO). The method, applicable to any species grown in aquaculture, operates by filtering water from the fish/shellfish tanks so it can be reused within the tank. This dramatically reduces the amount of water and space required to produce seafood products.

The RAS includes solids, ammonia and CO2 removal as well as oxygenation.Biological filtration controls and degrades waste compounds that would otherwise accumulate in the water. The elimination of such compounds thanks to specific groups of microorganisms allows the recycling of the sea water in the tank. Moreover, the system collects and digests solid waste products that are derived directly from the fish or by the accumulation of uneaten feed to fuel additional microbial processes whose activities result in the production of methane gas, which can be captured and used as a source of energy[2].

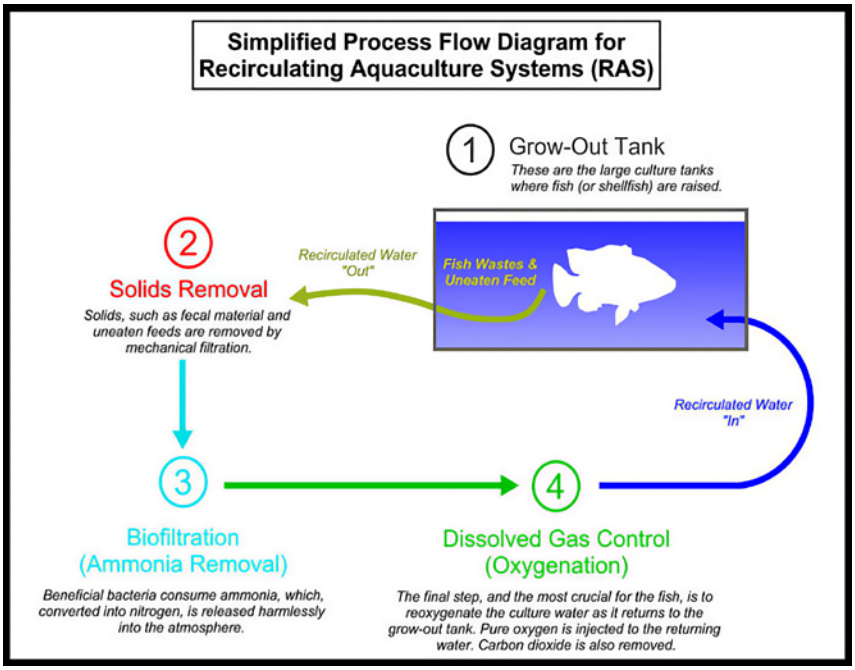


Figure 8. Flow diagram for Recirculating Aquaculture Systems. Source: Blue Ridge Aquaculture.

Today, more than ten species are produced in RAS[3] , and while maximum sustainable yields of many aquatic wild stock species have been or will soon be reached, and many species are already overfished, RAS is considered a key technology that will help the aquaculture sector meet the needs for aquatic species over the coming decades and overcome specific challenges (e.g. eutrophication).

RAS is a complex, capital-intensive aquatic production system built on physical, chemical and biological interactions. Such interactions, as well as the relationships between the fish in the system and the equipment used, are crucial to predict changes in water quality and system performance. In this regard, there are many parameters to determine water quality in aquaculture, but only a few are those traditionally controlled in the recirculation processes: dissolved oxygen, ammonia, biosolids, carbon dioxide, total gas pressure, nitrate and alkalinity[4].

2 Pilot sites in the framework of the EU Research Project IDREEM (Increasing Industrial Resource Efficiency in European Mariculture), http://www.idreem.eu/

3 C.A Espinal, D. Matulic “Recirculating Aquaculture Technologies”, 2019.

4 Ibid

Currently, most functional RAS facilities operate in a freshwater environment. It is true that the number of facilities operating in a saline water environment is gradually increasing, though they still have to be consolidated when it comes to commercialising large-scale production of market-size fishes.

Aquaponics

Aquaponics is a method that integrates the recirculating aquaculture system and the cultivation of plants without soil (hydroponics) in one production system. In aquaponic units, water from the fish tanks is recirculated through filters to feed beds of plants, and then back to the fish tanks. The great advantage of aquaponic farming is that it enables the plants to recover dissolved waste nutrients from fish tanks, thus reducing both water use and discharges to the environment. At the Mediterranean level, this method is still in its infancy even if there is great interest and excitement around it as witnessed by national (e.g. Greece, Albania), bilateral (e.g. Italy-Tunisia) and EU initiatives (e.g. SIMTAP EASY, CoolFarm and ECOFISH).

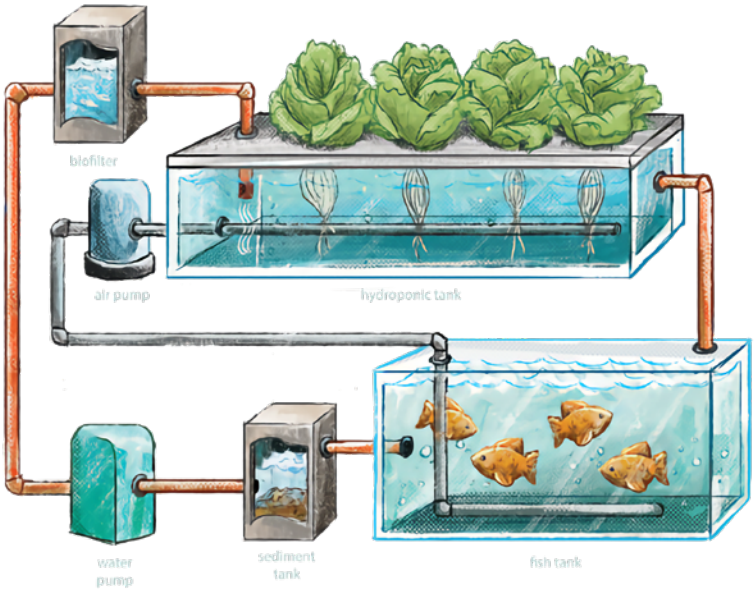


Figure 9. Flow diagram for Aquaponics. Sources: Earth.org

Bio-floc Technology

Although largely implemented in North America, South America and Asia for shrimp farming, the bio-floc technology (BT) is not very developed in Europe. Like IMTA and aquaponics, bio floc technology is based on ecological and regenerative principles to recover and use waste. Originally conceived as a natural way to clean water, it turned into a popular low-cost means of cleaning the culture water while providing an additional source of feed.

This innovative waste management and nutrient retention technology uses microbial biotechnology to increase the efficacy and utilisation of fish feeds by treating toxic materials such as nitrogen components and converting them into supplementary feed for the fish and crustaceans. Bio-floc systems rely on photosynthesis to convert uneaten feed, faeces and excess nutrients into food. While breaking down toxic ammonia and nitrates, autotrophic and heterotrophic bacteria multiply to attract an ever-growing host of organisms (diatoms, fungi, algae, protozoans and various types of plankton) loosely bound by bacterial mucus.

These floating clumps, or “flocs”, are microscopic and a delicacy for fish and shrimp[5]. Bio-floc systems, however, are still far from making a significant contribution to global aquaculture production, mainly because it is a complicated aquaculture concept that requires specific skills.

Algae cultivation

This activity has a great strategic potential, being recognized by the European Commission with the recent launch (February 2022) of a platform to promote production and use of algae in Europe. The stakeholder platform, called EU4Algae, aims to accelerate the development of a European algae industry and promote algae for nutrition and other uses among consumers and businesses in the EU.

Macroalgae production still depends on harvesting from wild stocks (68% of the macroalgae producing units), but macroalgae aquaculture (land-based and at sea) is developing in several countries in Europe, currently representing 32% of the macroalgae production units. France, Ireland and Spain are the top 3 countries in number of macroalgae production units, while Germany, Spain, and Italy stand as the top 3 for microalgae. Seaweed production in Europe (considering both harvesting from wild stocks and aquaculture) is primarily concentrated in the Atlantic region, with very few companies producing macroalgae in the Mediterranean area (Araújo et al. 2021). This is related to the geographical distribution, the larger extension of the intertidal area and a higher abundance and dimension of seaweed species traditionally exploited at an industrial scale on the Atlantic coasts. These factors historically facilitated the expansion of an algae industry based on the mechanical and manual harvesting of wild resources. Some companies are cultivating species that are native to the Mediterranean (e.g., Ulva sp., Gracilaria sp.), but these units correspond to a minority of the European production. Some initiatives at the European and regional level are now trying to identify the factors limiting the expansion of this activity in the Mediterranean and discussing measures that could promote the cultivation of seaweeds in this area (Araújo et al. 2021).

Innovative microalgae production can be linked to aquaculture developments. For example, AlgaEnergy (IES) has arranged research with different Universities and with the Spanish Institute of Oceanography (IEO), thanks to which it has cultivation protocols that allow it to produce various strains of microalgae that, certified with the PREMIUM quality seal, ensure outstanding properties, be it for the food of fish larvae, for the nutritional improvement of the fish feed, or for its use in the “green water” technique.

5 The Fish Site, 2019 https://thefishsite.com/articles/ten-easy-steps-towards-biofloc-production-of-shrimp-or-tilapia

Sufficient Integrated Multi-Trophic Aquaponic System

Objetive(s):	To define, design, set up and test an innovative food production system that drastically reduces, on one side, the required fish feed inputs (e.g., fishmeal, fish oil, soybean, etc.) and the consumption of resources (water, energy), and, on the other side, the production of waste and pollution.
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Italy, Germany, France, Malta and Turkey
Description:	The project moves from the IMTA approach towards an innovative self-sufficient integrated multi-trophic aquaponic system (SIMTAP) for small-scale, labour intensive and environmentally friendly marine fish and halophytic plants production adapted to the typical socio-economic and climatic condition of Mediterranean areas. SIMTAP can be coupled with the re-use of the effluents from greenhouse soilless cropping systems, in a cascade effect acting both as a bioremediation of wastewater (run-off) from greenhouse cultivations, and as a recycling of the nutrients still contained in the same wastewater, thus helping the SIMTAP cycle. Moreover, the project aims to evaluate the effectiveness and performance of SIMTAP systems in terms of food production and use of energy, water and other resources. The Life Cycle Assessment (LCA), analysis of energy consumption and energy assessment of SIMTAP will be performed to quantify and compare the potential environmental impacts with the conventional hydroponic and aquaculture systems. Another crucial issue of this project is the economic assessment: the identification of possible payment streams (e.g. emission certificate, etc.) to realize projects in a bankable form. This action and Life Cycle Cost (LCC) studies will be specifically linked to the technical proposal for achieving reasonable prized solutions for low-medium technological level countries.
Promoter:	Horizon 2020, Consortium led by the University of Pisa, Italy
Sources:	www.simtap.eu

Wireless Aquaponic Farming In Remote Areas: A Smart Adaptive Socio-Economic Solution (WAFRA)

Objetive(s):	To develop wireless aquaponics systems for remote areas
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Euro-Mediterranean
Description:	The project will develop a photovoltaic-powered remote wireless sensing platform to monitor nutrients (nitrogen and phosphorous compounds), fish odour, and other operational parameters. Secondly, microbial electrochemical technologies will be applied to adjust nutrient concentration in the aquaculture tank effluent to serve hydroponics. The resulting platform will include a cost-benefit analysis module and will allow aquaculturecompanies,hydroponic/aquaponicfarmownersortechnologyproviders operating their aquaponics systems in an efficient and sustainable way.
Promoter:	ERANETMED programme, Consortium led by the University Ains Shams (Egypt)
Sources:	https://eg.linkedin.com/in/wafra-eranet-4829b8183

NORAY

Objetive(s):	To promote sustainably-farmed shrimp
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Spain
Description:	Noray has developed what they refer to as a “hybrid bio-floc system”. The precise details of this system are an industrial secret. In general terms, it is about a technique using zero water exchange in the system over the 90-day grow-out phase and the water quality is maintained by the control of the bacteria in a nitrifying way.
Promoter:	NORAY (private company)
Sources:	https://www.norayseafood.es/es/

Shrimp Cultivation Research Center



Objetive(s):	To raise shrimp in salty water using biofloc technology
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Algeria
Description:	Raising shrimp in the desert seemed impossible due to the fact that the little water available there is too hot, with unstable salinity levels. The Korea-developed biofloc technology helped to make it possible. The Algerian government, in collaboration with the Korean National Institute of Fisheries Science and the International Cooperation Agency, launched the shrimp-farming project. In 2015, the Shrimp Cultivation Research Center, a shrimp farm of about twelve hectares, was built in the Ouargla Province. The farm produced its first shrimp in January 2016. Algeria can now produce up to 100 tons of shrimp every year, and more farms are planned in the area by the end of 2025, where underground water is available.
Promoter:	Korea's National Institute of Fisheries Science in collaboration with the Algerian Government
Sources:	https://www.seafoodsource.com/news/aquaculture/shrimp-farm-operation-finding-success-in-the-sahara-desert

TAPAS project

Objetive(s):	To consolidate the environmental sustainability of European aquaculture
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	European Union
Description:	The project aims to develop tools, approaches and frameworks to support EU Member States in establishing a coherent and efficient regulatory framework, implementing the Strategic Guidelines for the sustainable development of European aquaculture and delivering a technology and decision framework for sustainable growth. This EU Horizon 2020 project ran a critical analysis of existing tools and technologies (e.g. regulations and license practices, carrying capacity assessment, EIA, etc) to provide a base to develop new models and decision systems appropriate for farm, water body, and regional scale studies. It carries out an assessment of nutrient retention of fish farm effluent and a site assessment for the feasibility for an Integrated Multi-Trophic Aquaculture system (IMTA). The activities were split into three phases: 1) the distribution of suspended solids from the fish farm was studied through the collection and analysis of samples; 2) a method to identify the best site for IMTA was tested by stocking selected extractive organisms in the identified locations. The project placed an invertebrate rack system and examined the water quality through eight sedimentation traps along the boundary of the fish farm so as to measure the amount of collected suspended organic material and identify predominant current patterns.
Promoter:	AquaBioTech Group, Malta
Sources:	http://tapas-h2020.eu/case-studies/malta-case-study/

IMPAQT



Objetive(s):	To promote intelligent management systems for integrated multi-trophic aquaculture (IMTA).
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	European Union + Turkey, United Kingdom and China
Description:	The project aims to i) design and implement new/emerging efficient and cost-effective technologies in monitoring and management systems for IMTA production; ii) validate systems and models both in situ and in laboratory; iii) demonstrate an optimal sustainable IMTA development in a holistic perspective based on ecosystem services and circular economy principles; iv) promote an effective transfer of knowledge derived from IMPAQT activities to the EU aquaculture stakeholders. The project pursues the implementation of a more efficient IMTA practice. First, at the planning phase, the advanced IMTA model will select the optimal site and the optimal spatial configuration for various aquaculture components. Impacts and interactions will be specifically assessed at an ecosystem scale, rather than just at the scale of individual farms. Second, at the operational phase, the project will assess the current status and respond to production and environmental challenges in a timely way at the scale of an IMTA farm.
Promoter:	Horizon 2020, Consortium led by Marine Institute, Ireland
Sources:	https://impaqtproject.eu/

REMEDIA LIFE

Objetive(s):	To reduce the environmental impact of intensive mariculture in floating cages
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Italy
Description:	Waste from mariculture plants negatively impacts the surrounding ecosystems, since the cages, located in the sea, cannot be conveyed to recycling and abatement plants like those located on land. In most fish farming systems, metabolic by-products, feed residues, faecal material and residues of prophylactic and therapeutic compounds are discharged without any treatment, thus causing deterioration of water quality and the appearance of diseases of farmed species, as well as possible infections in humans. These negative environmental impacts are particularly evident in production plants located near the coast, in confined areas where the diluting effect of marine circulation is lower. The project aims to develop innovative integrated multi-trophic aquaculture with higher potential to mitigate the impacts of mariculture plants in a confined marine environment, with the use of a new set of bioremediation organisms (e.g. polychaeta, sponges and micro algae) that have proved to be more efficient than shellfish alone in removing suspended waste material. The project is expected to improve the breeding performance with an increase in the quality of the biomass of the fish produced within the system while providing additional economic advantages through the marketing of the non-edible biomassproduced during the process that may turn into by-products with high commercial value.
Promoter:	Life Project coordinated by the University of Salento – DiSTeBA
Sources:	https://remedialife.eu/

NORCANTABRIC

Objetive(s):	To launch the first on-land Atlantic salmon farm in Spain
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Spain
Description:	Salmon is a local product on the Atlantic coast of Spain. The recirculating aquaculture system (RAS) facility is located in the northern region of Cantabria. It is a 32 million EUR project that will create approx. 50 jobs. The facility will produce salmon with an average weight of 4.5-5kg. Its anticipated output of 3,000 tons a year at full capacity represents 5% of the total volume of Atlantic salmon consumed in Spain. The Danish company Alpha Aqua has provided the RAS technology for the project.
Promoter:	Norcantabric
Sources:	https://norcantabric.com/

Macroalgae Cultivation In Natural Environments



Objetive(s):	To produce algae biomass from the sea without any energy or fertiliser consumption
Field of action:	Reduce: Extensive production of macroalgae biomass in natural conditions, without energy use nor fertilisers supply.
Geographic scope:	Bizerte, Tunisia
Description:	The enterprise Selt Marine produces food thickeners from macroalgae cultivation in a lagoon near Bizerte, in Tunisia. They cultivate red algae on an industrial scale, being able to increase the initial biomass harvested from the sea tenfold. Algae are cultivated in the lagoon natural environment, within cylindrical nets. The algae are dried in the sun on large tables and then transported to the factory where they will become texturisers, gelling agents or food thickeners such as agar-agar or carrageenan. This type of product is gradually replacing gelatine of animal origin. Red algae are also beginning to find a place in the cosmetics and pharmaceutical sectors. Nowadays, Asia is the leading producer and exporter of red algae, but the Mediterranean lagoons, like the one in Bizerte, present an ideal climate for this cultivation, and this production promotes the presence of shrimp, small fish, oysters or mussels. This kind of production also absorbs nitrogen and phosphorus from the water, preventing eutrophication. Whether grown locally or imported, Tunisia has great know-how in transforming algae into different products. A variety of innovative uses are being studied: biodegradable bottles, noodles or vegetarian nuggets.
Promoter:	Selt Marine
Sources:	www.seltmg.com

Fish Farming Project In The Village Of Tonakt



Objetive(s):	To encourage aquaculture in the desert applying circular economy approaches
Field of action:	Innovative design: Integrated farming processes
Geographic scope:	Village of Tonakt, Governorate of Tataouine, Tunisia.
Description:	A small project launched in 2016 in the desert of the Wilayat of Tataouine, approx. 130 km from Djerba. The idea started when the project originator stumbled across an advertisement on a “tilapia” fish breeding program. This type of fish can live in fresh or brackish water in extremely hot areas, like Tataouine. Cement basins were built and filled with fresh water from a well, and five thousand fish larvae were cultured in the ponds. Two years after the start of the project, the productivity of the fish farm increased to 100 kilograms per week. With the technical help of students from the University of Tunis, the fish farming wastewater rich in salt and minerals was no longer released in the environment but used to produce lettuce and other crops such as tomatoes, peppers and strawberries. This strengthened the initiative by creating an additional source of income.
Promoter:	Individual initiative supported by the NGO “Skills for Success” based in Tataouine.
Sources:	https://www.hdhod.com/ https://www.aa.com.tr/ar/

3.1.3 Re-use of waste from fisheries and aquaculture production and activities

Since ancient times, the Mediterranean has supported important fishing activities as well as various ways of seafood farming. Today, industrial, semi-industrial and small-scale capture fisheries coexist using a large variety of techniques and equipment to exploit a variety of benthic and pelagic fish stocks, as well as molluscs and crustaceans. The growing concerns for the long-term sustainability of the two sectors have given impetus to initiatives based on the principles of circular economy to minimise waste for higher efficiency.

Bio-products from seafood waste/by-products

In the case of seafood, not all of the species harvested are used as food, since consumers prefer only a few selected seafood items. A significant portion of the total harvest, therefore, remains unused or poorly used for different reasons related to unattractive colour, small size or high fat content. Some studies observed that food loss and waste for the whole fisheries sector amounted to 35% of global catches, out of which up to 15% is from by-catch.

This means a large volume of waste includes processing discards consisting of shell, head, bones intestine, fin, skin, voluminous amounts of wastewater discharged as effluents (e.g. discards from finfish constitute 25-50% of the raw material), and low-value, under-utilised fish caught as by-catch of commercial fishing operations. This waste can be collected and re-used to produce new materials, products or pollution-free biodiesel.

Indeed, the use of animal guts to produce biodiesel is not a new technology. Fish oil, derived from the leftover gut/waste after fish fillets are produced, is mixed with methanol (roughly 10%) and other products. This simple technology, easily adaptable and transferable, could provide low-cost energy without GHG emissions and generate additional income for fishers' and fish farmers' communities.

For example, the Spanish food company Jealsa, producing canned sea food, adopts a circular economy approach in fish manufacturing by recovering fish waste for other production processes such as pharmaceutical, cosmetic, aquaculture, pet food and functional ingredients. Thanks to a recovery ecosystem and the application of marine biorefinery techniques, they use 100% of the fish that arrive at their facilities.

Fishmeal for aquaculture

According to a study from the Marine Ingredients Organisation (IFFO) and the University of Stirling Institute of Aquaculture (United Kingdom), there is underutilisation of by-products from both wild fisheries and aquaculture. If all fish were processed and all the by-products collected, it is estimated that globally there would be around 36 million tons of raw material available, producing about 9.5 million tons of fishmeal and 1.5 million tons of fish oil (The Marine Ingredients Organization 2016). At EU level, the landing obligation, in force since January 2019 and established through the Common Fisheries Policy, is a valuable tool to promote the use of fishery waste for fish meal, among other uses.

Apart from human consumption and use, the aquaculture industry can use fish waste to develop nutritious food products for animal feed. For example, fish skin is a great source of proteins (also protein hydrolysates), while fish bones contain high amounts of calcium phosphate, minerals and approximately 30% protein, including protein hydrolysates thanks to the use of different enzymes. In particular, fish silage - a liquid made from a mixture of fish

or fish waste with enzymes, acids and microorganisms - can be used as a high-quality and cheaper fishmeal (Afreen and Ucak 2019). Globally, an estimated 12 million tons of by-products derived from the seafood processing industry are not used for marine ingredients (Newton 2016).

Re-use of seafood shells

Globally, aquaculture (farmed fish, shellfish and aquatic plants) has surpassed wild capture fisheries as the main source of all consumed seafood. In the European Union, the sector accounts for approx. 25% of consumed seafood. The production is concentrated in four countries: Spain (27%), France (18%), Italy (12%), and Greece (11%), together accounting for 69% of sales and 62% of turnover (The EU Aquaculture Sector – Economic report 2020).

The Autonomous Community of Galicia (Spain) is the European leader in the production of mussels and ranks third in the world. Mussels' shells can be transformed into calcium carbonate, the main component of the valves (between 95 and 99%) and used for multiple purposes, such as production of cement, plastics, paints/varnishes, pharmaceutical and cosmetic products, fertiliser in agriculture and even bleach in the paper industry. This explains the reason why Galicia is very much active in the creation of products with high added value from mussel waste[6].

Oyster shells are the easiest to recycle, as smaller oysters use the shells of larger ones. So they can be used to rebuild oyster beds or start farming them. They could also be used to restore degraded ecosystems and create habitats for fish and crustaceans for commercial fishing. Furthermore, thanks to their composition, they can be used for the control of soil acidity in agriculture, as supplements for chicken feed and as an ingredient for the production of cement.

Biogas production from fish waste/sludge

The seafood sector is multiplying efforts to improve its environmental sustainabilityand reduce the impact of the large amount of unused waste it produces. Research and entrepreneurial initiatives join forces to develop an economical and efficient system that transforms waste into fuel for the production of green energy.

In this sense, the waste and/or sludge produced by the seafood industry as a whole - sometimes mixed with other organic waste - can provide biogas to be used as a fuel for the production of heat and energy, in aquaculture or in other sectors.

6 The Technological Center for Multisectoral Research in Galicia collaborates in the research project MEXICAL, which aims to study the integral recovery of mussel shells to obtain two products with high added value: mineral fertilisers for soils and fodder for birds

FISH4FISH

Objetive(s):	To produce innovative active and sustainable packaging material using marine biomass wastes
Field of action:	Re-use: Re-use of waste from fishery and aquaculture production and activities
Geographic scope:	Mediterranean region
Description:	The project aims to: 1) give value to bio-waste from the seafood sector through the production of a new active and sustainable material for fish packaging; 2) increase the fish shelf life thanks to the improved antimicrobial and antioxidant activities and barrier properties of the material packaging; 3) help reduce sea and terrestrial plastic litter providing a fully biodegradable and compostable solution. FISH4FISH will produce innovative, active and sustainable packaging material based on chitinolytic derivatives, using marine biomass waste. Such packaging enhances fish shelf-life and, once it is wasted, it can be used as fertiliser and microbial preservatives for plants. This may contribute to reducing plastic litter, giving new value to the fish industry waste, enhancing competitiveness of the fish-processing industry, and reducing food waste. Additionally, the project will concretely contribute to pursuing SGD 9 (industry, innovation and infrastructure), SDG 12 (sustainable consumption and production patterns), SDG 13 (combat climate change and its impacts) and SDG 14 (conserve and sustainably use the oceans, seas and marine resources).
Promoter:	Consortium coordinated by the Department of Biotechnology, Chemistry and Pharmacy, University of Siena (Italy)
Sources:	http://fish4fish.dbcf.unisi.it/

RELICTA



Objetive(s):	To produce bioplastic from fish waste/by-products
Field of action:	Re-use: Re-use of waste from fishery and aquaculture production and activities
Geographic scope:	Sardinia (Italy)
Description:	From fish to green polyurethane: this idea rests on solid laws of chemistry but is also the result of a growing attention to the need to give new life to fish waste. Bones, scales, etc. are transformed into a non-harmful and non-toxic biomaterial. The method starts with fish oil derived from these scraps to which oxygen is added to form epoxides. After making the products react with carbon dioxide and amines, the researchers obtained a material very similar to common plastic: elastic, with good mechanical properties (just like polyurethane), but above all non-polluting and biodegradable under specific conditions. This idea taken by five students gave birth to RELICTA, a start-up producing transparent bioplastic made out of fish waste that can be used for food packaging, as well as for cosmetics and electronic devices. Water-soluble, biodegradable, compostable, durable and flexible: Relicta is a heat-sealable film for vacuuming the most delicate products such as surgical masks or food to be stored. Also excellent for wrapping small pharmaceutical packaging in shrink-wrapped conditions, this plastic keeps its insulating properties intact for twelve months and degrades into the sea without leaving a trace or doing damage.
Promoter:	RELICTA (start-up)
Sources:	https://it.linkedin.com/company/relicta-innovation-of-packaging

SALMO

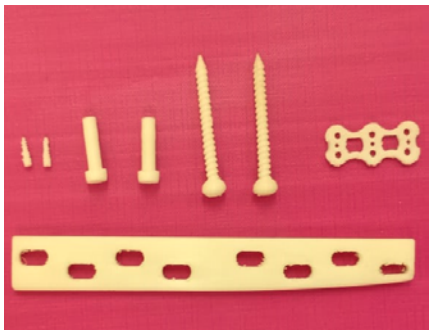
Objetive(s):	To convert waste biomass from salmon farming into drop-in fuels suitable for marine diesel engines.
Field of action:	Re-use: Re-use of waste from fishery and aquaculture production and activities
Geographic scope:	United Kingdom
Description:	The United Kingdom has some of the world's leading salmon farms within a thriving aquaculture sector concentrated in Scotland and Northern Ireland. In Scotland, more than 200 fish farms operate producing more than 150 000 tonnes of salmon a year. Processing waste such as heads, skin, viscera, etc produces approximately 20 000 tonnes of waste oil, and fuel from it would save more than 34 000 tonnes of CO2 per annum. This initiative aims to make the national shipping sector more sustainable with advanced renewable fuel derived from aquaculture waste. SALMO will convert waste biomass from salmon farming into drop-in fuels suitable for use in marine diesel engines.
Promoter:	Green Fuels Research Ltd
Sources:	https://greenfuels.co.uk/salmo-project-to-focus-on-marine-fuels/

SEA SKIN



Objetive(s):	To convert fish skin into leather products
Field of action:	Re-use: Re-use of waste from fishery and aquaculture production and activities
Geographic scope:	Morocco
Description:	Sea skin is a social enterprise that produces and markets leather goods (e.g. handbags, shoes or smartphone cases) made from fish skin, integrating fishermen's wives in a precarious situation. Raw fish skin - sole, whiting, salmon, etc. - is collected from restaurants and a fillet plant. It is entrusted to local women who peel the skin by removing the remaining flesh residue and then rinse it clean. The skin is tanned with vegetable products, flattened and dried until customised and shaped into a luxury leather product.
Promoter:	Sea Skin (private company)
Sources:	https://www.facebook.com/SeaSkin.Morocco/

TECHNO SHELL





Objetive(s):	To produce medicines and nutritional supplements from recycled fish waste
Field of action:	Re-use: Re-use of waste from fishery and aquaculture production and activities
Geographic scope:	Helwan Governorate, south of Cairo, Egypt
Description:	Two students of the Faculty of Medical Engineering at the Helwan University set up the start-up company “Techno Shell” to recycle fish waste and manufacture drugs and medical and nutritional supplements. The idea stems from the need to tackle the lack of a mechanisms to dispose of and safely recycle organic waste, especially fish waste. Two components compose the project: i) collecting waste from fish restaurants, especially crustaceans and bones and extracting those chemicals used to product calcium-rich nutritional supplements and/or to treat vitamin D deficiency and osteomalacia; ii) manufacturing artificial bones from oyster shell waste for people with severe fractures or, in some case, suffering from bone cancers in the light of similar characteristics and composition. The manufacturing of final products occurs through a 3D technology.
Promoter:	Private initiative supported by the Ministry of Youth and Sports, the Ministry of Higher Education, the Academy of Scientific Research, the United Nations Development Office, Helwan University, and the Scientific Creativity Center at Damietta University.
Sources:	https://m.akhbarelyom.com/news/newdetails/3056680/1/ https://pressn.net/article/8378229?news https://www.zero10.org/2020/05/blog-post_446.html https://www.facebook.com/884895828326042/photos/a.1085041708311452/1600187983463486/?type=3

3.1.4 Use of biodegradable or recyclable gear

To date, six raw polymer types are utilised to manufacture the majority of nets within Europe: Polyamide (PA), Polyester (PES), Polyethylene (PET), Polypropylene (PP), Aramid, and High-density polyethylene (HDPE) (EC 2020c). However, within the current design of fishing nets within Europe, there are up to 700 different combinations of these polymers and other materials. Such mixing of different raw materials, although potentially important for the use of the fishing gear, makes it nearly impossible to recycle as a single unit.Furthermore, there is a range of other factors that reduce the likelihood of fishing gear being recycled. These factors are, for example: presence of toxic or unrecyclable materials in nets (i.e., lead shot in sink lines); likelihood that collected gear may have been contaminated (i.e. sand, salt) or other man-made material mixed; the small number of recyclers within Europe (two predominate; Plastix and Aquafil); need to provide these recyclers with cleaned and sorted gear; lack of agreed upon standards for circular design of fishing gear (EC 2020c).

There is a need to develop solutions for eco-design of fishing gear and innovations are being tested including options for reusable materials, recyclable ones and biodegradable ones. These solutions would be relevant for both the fishing and the aquaculture sector.

Recommendations for circular fishing gear design

Using a less diverse range of material types and materials comprising a mix of materials. Mixed materials within fishing gear (whether associated with different components, or where two materials are interweaved together) inherently reduce the likelihood of the material being re-used and/or recycled. However, any reductionor elimination of such materials (and therefore use of alternative non-mixed materials) must not reduce the utility of the material (e.g., durability, performance) and the component they are used in.

The re-design of fishing gear must be associated with a high (or complete) use of recycled/reused materials, with the gradual elimination of virgin plastics within new gear. Guidance standards for circular design of fishing gear should be developed.

Source: EC 2020

Solutions at the design stage are being tested in the Mediterranean for shellfish aquaculture devices made of biodegradable materials (see the practices below experimenting biodegradable and reusable nets for mussel farming).

Biodegradable Or Reusable Nets For Mussel Farming



Objetive(s):	To address the issue of ghost nets
Field of action:	Eco-design
Geographic scope:	Italy
Description:	According to FAO data, the production of mussels in Italy is estimated at around 80 thousand tons, which corresponds to the use of about 700/1000 tons of nets that must be replaced at least once during the life cycle of the mussel. According to the results from the DeFishGear project, which focused on the Adriatic and Ionian Seas, these nets constitute the third most present waste in the seabed of Italy, with an annual dispersion of about 8-9 tons. Life Muscles project (2021-2025) implements two innovative alternatives: (i) a washing and recycling process starting with shredding the tubular nets, oxidizing the residual organic material, washing and finally reusing the recovered polypropylene; (ii) the use of an innovative biopolymer - "mater-bi" - produced by the Italian company Novamont. The goal of Cozza Plastic- Free (2021) is to replace the plastic nets used for the growth of mussels with Novamont's MATER-BI bioplastic nets in all mussel farms in the Campania Region. The project Miami (2021) worked to identify a biodegradable material or technopolymer alternative to nylon and to experiment with the technical reliability (deformability, strength and plasticity) of the use of the innovative materials, for the production of socks for the sowing and breeding of mussels. These solutions have been tested in the Tyrrhenian and in the Adriatic Seas.
Promoter:	Life Muscles - Legambiente, University of Siena, Bologna, Rome-La Sapienza; Cozza Plastic Free - Coldiretti Impresa Pesca Campania, Università Federico II – Dipartimento di Medicina Veterinaria e Produzioni Animali, Novamont e Legambiente Campania; MIAMI - Regione Puglia
Sources:	http://www.hydracoop.it/progetti/progettomiami/

3.1.5 Recycle/Up-cycle end-of-life gear and containers

Abandoned, lost or discarded fishing gear (ALDFG) and ghost nets are a significant and very persistent type of marine litter with numerous harmful effects for marine and coastal environments and human livelihoods and wellbeing. They pose threats to marine habitats and wildlife (e.g. entanglement and 'ghost' fishing, digestion, etc.), human safety (e.g. divers, boat crews, etc.) and property damage (e.g. damaging propellers). In most cases, the loss of gear is unwanted by the fishermen, but in some cases fishing gear is intentionally discarded, mostly to avoid the waste management cycle and related cost or efforts. ALDFG also results in both economic and social impacts that can be significant. ALDFG effects upon marine users include navigational hazards; loss of amenity and disruption of the enjoyment of beaches and coastal areas; safety concerns; additional costs resulting from fouling vessels and other gear.

As pointed out at regional scale in 2015 already (UNEP/MAP 2015), ALDFG pose an issue in the Mediterranean. The most common types of fishing gear used in terms of amounts expressed in length (m) are longlines and hooks, gillnets, surrounding nets and lift nets, seine nets and trawl nets (Figure 10).

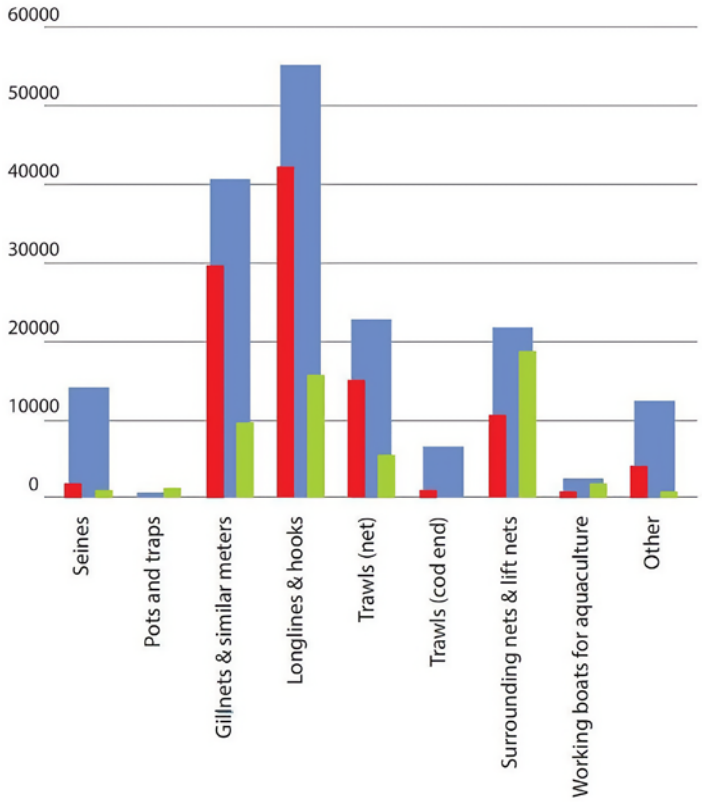


Figure 10. Estimates of types and amounts of fishing gear used (blue), disposed (red) and lost(green) throughout the year (length, m). Source: UNEP/MAP 2015.

The recently-amended (2021) Regional Plan on Marine Litter Management in the Mediterranean proposes specific measures to tackle this issue. Fishing for Litter is recommended to facilitate clean-up of the floating litter and the seabed from marine litter caught incidentally and/or generated by fishing vessels in their regular activities including derelict fishing gear. Moreover, gear marking to indicate ownership and the use of degradable gear is also recommended.

In order to tackle this issue, several actions have been implemented in the Mediterranean in recent years, and various business activities have been launched, building on re-cycling and up-cycling practices. Such experiences are actually at the boundary between circular economy, waste management and pollution remediation. All of them aim to obtain new products from waste and deal with plastic materials.

Regenerated nylon yard from fishing nets.

Fishing nets are made of synthetic materials such as nylon, which is very resilient and durable. These characteristics make them so dangerous for the marine environment in the long term. At the same time, nylon fishing nets are very precious as a source of secondary raw material because it can be depolymerised and polymerised again, and new, regenerated nylon wire can be produced with the same high-level characteristics or the original one. Industrial plants exist in the Mediterranean area where fishing nets are recycled and new yard is produced. These plants are generally part of a product chain linked both to the fishing sector and to manufactures of textile products, ranging from furnishing fabrics to clothing and footwear.

Recycled plastic from fishing materials. Fishing gear is constituted by a variety of plastic materials, other than nylon. In order to recycle heterogeneous waste coming from fishing but also from other maritime sectors (aquaculture, shipping), plastic pellets can be obtained to be used to create different products (e.g. in the examples below, smartphone cases, furniture).

Re-use and recycling of Expanded PolyStyrene (EPS) boxes.

Regarding packaging, a comprehensive essay on the commercialisation chain for refrigerated fishery products packed in EPS/XPS, as well as their management cycle, processing and recovery of their waste within the European countries in the Atlantic Area has been prepared in the context of OceanWise project (Wise reduction of EPS marine litter in the North-East Atlantic Ocean) (2021). The essay also assesses the usage of bioplastics as an alternative to EPS materials. The essay indicates, for example, the reverse logistics process as one of the possible ways to increase circularity in EPS products: producers would collect EPS waste generated by their customers (first commercialisation level). In this scheme, producers would create an effective disposal-collection system from the market, would assume all costs from waste management and would favour the selective concentration of EPS waste directly to recovery companies.

The same essay also highlights that using biodegradable bioplastics as raw material for manufacturing similar to EPS fish-boxes does not seem to be a solution for the problem of EPS litter in the ocean. In many cases, alternatives to EPS boxes launched in the market are made of compostable BIOEPS that will remain as a problem of marine litter once they reach the ocean. There are some marine-safe materials (biodegradable in marine environments) that could represent a baseline, but they are not well established yet. Compostable bioplastics (the most used bioplastics) are in line with sustainability and circularity, but only when valorising them as compost. Dependency on composting plants is huge, and biowaste management systems are not established yet. At this moment, compost companies are not ready to manage large amounts of BIOEPS boxes, and they cannot differentiate biodegradable plastics vs non-biodegradable. The project is still under development. Final results will be available by end of October 2022.

Practices to practically tackle this issue are available in Europe. For example, in Denmark, the first recycling plant to process expanded polystyrene into plastic pellets has been developed by the FLAG Thy-Mors. Other FLAGS could be interested in applying similar solutions to their areas. Some experiences are available also in Southern Europe. However, the related costs are high and private investment and technical expertise need to be leveraged to launch such activities.

Concrete initiatives on reusable fish boxes are being experimented with in the Mediterranean region. In Catalonia, the organisation of fishing producers of the Blue Fish (the Catalan Bluefish Fisheries Producers Organisation groups 14 vessels from the encircling fleet in the ports of Girona and Vilanova and la Geltrú) is experimenting with the replacement of single-use wooden boxes with reusable boxes. This change will reduce costs, improve logistics, give the product a quality image and, above all, reduce waste generation. This is an experiment carried out with the participation of the European Maritime and Fisheries Fund (EMFF).

Regenerated Nylon From Derelict Fishing Gear

ECONYL® by Aquafil: the Healthy Seas initiative / Nylo® by Fil&Fab



Objetive(s):	To address the issue of derelict fishing gear
Field of action:	Up-cycle: Regenerated materials from fisheries and aquaculture fishing gear
Geographic scope:	Italy, France, Slovenia, Croatia, USA, UK, China and Thailand
Description:	Aquafil regenerates fishing nets and other nylon waste (e.g. textile production scraps) into a new yarn, called ECONYL®, having the same characteristics as nylon made of virgin raw material. Aquafil works with two different types of fishing nets: those coming from aquaculture and fish industries and the ocean nets recovered by volunteer divers though the Healthy Sea initiative (global scale). Healthy Seas tackles the ghost fishing phenomenon through clean-ups with volunteer divers and by working with stakeholders of the fishing sector toward marine litter prevention, volunteers collect end-of-life and abandoned/lost fishing nets. The Healthy Seas initiative runs around the world (North Sea, Mediterranean Sea, Red Sea, Baltic Sea, Pacific Ocean). The fishing nets are first cleaned, sorted and then sent to regeneration plants (for the Mediterranean, in Slovenia). Collected nylon fishing nets are regenerated into ECONYL® carpet and textile yarns that are used for a variety of products from apparel to fabrics for interiors. For example, the Healthy Seas initiative has created a brand and produces socks and swimwear made from ECONYL® yard. Healthy Seas links together several NGOs and social enterprises in the Mediterranean, like for example Enaleia from Greece whose founder - Lefteris Arapakis - is the current Coast Ambassador (UN young champion of the earth Europe). Fil&Fab brings together maritime, public, financial and technical players from the French provinces of Bretagne, Normandie, Occitanie and Provence-Alpes-Côte d'Azur. Nylo® are 100% recycled fishing net polyamide pellets that are used to produce a variety of products such as 3D printing filaments, watches and glasses.
Promoter:	Aquafil Spa; Fil & Fab
Sources:	www.aquafil.com/ www.econyl.com/ www.healthyseas.org/; www.fil-et-fab.fr/

Expanded Polystyrene Fish Box Recycling

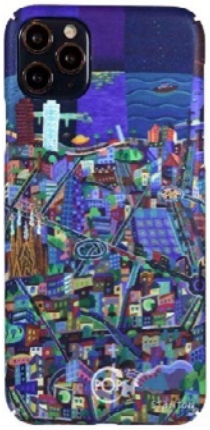
EPS boxes by EUMEPS



Objetive(s):	To promote sustainable fish boxes for transport
Field of action:	Recycle: Recycle/Up-cycle end-of-life products
Geographic scope:	Europe
Description:	The Association for European Manufacturers of Expanded Polystyrene (EUMEPS) represents the Expanded Polystyrene (EPS) industry. EPS boxes are designed to ease collection and sorting in big sites (fish processors, markets, harbours), They can be mechanically recycled. Experiences of re-use of EPS boxes are available. In Portugal, Bewi, the multinational company specialised in packaging, components and insulation solutions, started up a recycling activity for EPS fish box waste, collecting it from harbours, fish markets and processors around the country. Recycling activity is expected to exceed 85% at the end of 2021. In 2021, AIPE – the Italian Association of EPS Manufacturers – signed a cooperation agreement with Federpesca – the Italian Association of Fishboat Owners – and developed an EPS Fish Box Recycling Project with the Apulia Region (in Molfetta) with the participation of all stakeholders of the fishery, agriculture and waste value chain. As a result, 55,000 EPS fish boxes are being recycled and 1,000,000 EPS seed trays too, thanks to the additional participation of Coldiretti, Italian Farmers Association.
Promoter:	EUMEPS, AIPE Italian Association of EPS Manufacturers
Sources:	https://m.akhbarelyom.com/news/newdetails/3056680/1/

Regenerated Plastics From Derelict Fishing Gear

iPhone cases made from fishing nets by POPSICASE



Objetive(s):	To address the issue of derelict fishing gear
Field of action:	Recycle: Regenerated materials from fisheries and aquaculture fishing gear
Geographic scope:	Mediterranean coast of Spain
Description:	Derelict fishing gear is lost and discarded gear that is no longer under the control of a commercial or recreational fisher. It includes lines, nets, pots, traps, floats, and other equipment. Once lost or discarded in the sea, gear can continue to trap and kill fish, crustaceans, marine mammals, sea turtles, and seabirds, also called ghost fishing. Derelict fishing gear can cause other problems as well, including damaging sensitive seafloor habitats such as coral reefs and seagrass beds. This is a great issue for the Mediterranean. Recycling of fishing gear into new products represents an alternative to disposal for litter collected at sea, but also an opportunity for prevention of fishing gear abandonment. Popsicase iPhone cases are made from end-of-life, collected and abandoned fishing nets and scrap aluminium, thanks to a programme called Net Viva Mediterrànea, of which Popsicase is a part. Net VIVA Mediterranea is a collaborative project with participation from local institutions, companies, fishermen associations and NGOs. Spanish fishermen can deposit used nets in large collection bins made available in 17 ports along the Mediterranean coast. These old nets are then cut, cleaned, sorted and processed, and finally transformed into a 100% recycled plastic material (pellets) named NETVIVA. Cases are made from the pellets. The protective cases are also certified “Cradle to Cradle”: returned POPSICASES are refunded with a 25% discount on the price of a new case, and they are recycled into new cases.
Promoter:	POPSICASE, Barcelona, Spain.
Sources:	www.popsicase.com

Recycled Plastic From Shipping And Fishing Activities

BlueCycle furniture series



Objetive(s):	To reuse marine plastic waste generated from shipping and fishing activities
Field of action:	Re-cycle: Regenerated materials from fisheries and aquaculture fishing gear
Geographic scope:	Greek Ionian and Aegean coastal and island communities
Description:	BlueCycle is a circular economy initiative that aims to reuse marine plastic waste generated from shipping and fishing activities. BlueCycle was created and operates under the auspices of the Aikaterini Laskaridis Foundation. Marine plastic waste (Nylon 6, Nylon 66, Polyester (PES), Polypropylene (PP), Polyethylene (PE), High density polyethylene (HDPE), Ultra-high molecular weight polyethylene (UHMPE) is derived from fishing and shipping gear. It is transformed into pellets that are used to produce recycled 3D printing filament. Recycling is followed by design and development of new products, digitally crafted by 3D printers, with support from robotics, from up-cycled marine plastic. Second Nature is a furniture series (tables, chairs, tools for playgrounds) that highlights how digital design and fabrication technologies can be deployed to tackle marine plastic pollution.
Promoter:	Sea Skin (private company)
Sources:	https://www.facebook.com/SeaSkin.Morocco/

3.1.6 Recycle litter caught during fishing/aquaculture operations

The waste that lies on the seafloor or floats in the water column is commonly captured by fishing nets, especially bottom trawl nets, and constitutes a variable part of the daily catch of fishermen. If fishermen dispose of these items safely on land, the result is a direct removal of waste from the sea without the need for a specific cleaning action. Fishing For Litter (FFL) activities are spreading in the Mediterranean. These initiatives provide fishers with bags or bins in which to store litter and ensure that disposal facilities are established and easy to access (Ronchi et al 2019). The activity is built on the assumption that it must be as simple as possible for fishermen and that it must not have direct or indirect costs for them. The majority of the vessels involved are bottom trawlers since most of the marine litter is located on the seabed. FFL has two main aims: to directly remove litter from the marine environment and to raise awareness about the problem of marine litter amongst the fishing industry and the general public, which is intended to result in a change in attitudes and behaviour. Moreover, FFL can provide data on seafloor litter (Ronchi et al. 2019).

The Regional Plan on Marine Litter Management in the Mediterranean (2021) recommends Fishing For Litter to facilitate clean-up of the floating litter and the seabed from marine litter caught incidentally and/or generated by fishing vessels in their regular activities including derelict fishing gear. Decision IG.22/10 that implements the Regional Plan further defined a Guide on best practices for Fishing for Litter in the Mediterranean (UNEP/MAP 2016).

Once collected and delivered on land, marine litter is generally disposed of. Heterogeneity of its composition, long-time permanence in a saline environment and presence of organic substances on the surface, make marine litter difficult to recycle. Despite this, some practices are being developed in order to recycle plastic marine litter. Some of these practices are closely linked to fishing for litter activities and develop as sustainability initiatives, supporting fishermen and local communities in general. Some other practices focus on developing industrial processes (e.g. production of fuel) from litter collected from the sea. Such experiences are situated at the boundary between circular economy, waste management and pollution remediation. All of them aim to obtain new products from waste and deal with plastic materials.

Fuel production

Mixed and heterogeneous plastic wastes can be turned into energy in the form of solid, liquid and gaseous fuels by pyrolysis, a thermal degradation process normally taking place between 300-900°C. Pyrolysis of marine plastic litter can potentially achieve the required degree of marine litter decomposition, and the use of additives and catalysts can drive this process towards desired outcomes (Faussone et al. 2021). Moreover, since huge amounts of fuel are used globally every year for marine transportation (207 Mt in 2017 alone, and over 36 Mt in 2019 in EU countries), this makes for a sustainable entry point for marine litter recycling products within a circular economy concept. However, often neglected is the environmental impact of the pyrolysis process itself, especially gaseous emissions into the atmosphere are the primary concern (Faussone et al. 2021). Pyrolysis or combustion of fluorinated polymers or fluoropolymer dispersion can result in the unintentional formation and release of fluorinated POPs (e.g. PFOA), other PFAS, other toxic substances, ozone depleting substances and greenhouse gases (SCP/RAC 2022). Air pollution control technology to reduce POPs emissions to the air has led to their transfer to residues such as fly ash and to a lesser extent bottom ash. This requires that there be strict regulation and control the ash, to avoid further dispersion of POPs and to avoid food chain contamination (SCP/RAC 2022).

Recycled plastic from fishing for litter activities

Plastic litter is heterogenous and affected by long permanence in the sea, but when properly sorted and cleaned, it can be chemically reduced into monomers and then regenerated into plastic pellets. These can be used to produce any kind of new product. Environmental and societal sustainability of this type of practice can be valorised on the market to promote the product as a brand. Circular economy, environmental and societal sustainability certificates are important added values for marketing. On the other side, it has to be stressed how a Life-Cycle-Assessment of these practices is needed in order to evaluate whether they can really be considered sustainable. In fact, chemical recycling generally requires huge quantity of energy and this can become a very relevant counter factor to be considered.

Marine Fuel Production From Litter Collected During Fishing Operations

MarGnet project: fuel production from marine litter by low temperature pyrolysis



Objetive(s):	To recycle mixed and heterogeneous marine litter into a new product
Field of action:	Recycle: Recycling marine litter collected during fishing operations
Geographic scope:	Northern Adriatic Sea
Description:	Marine litter (ML) is recognized as a major concern for the future of the sea. It includes all anthropogenic material that has entered the marine environment by intentional or unintentional actions and varies in their chemical composition and physical characteristics. ML strongly interferes with fishing activities. Waste collected during fishing may damage fishing gear and result in lost time, effort and revenue for operators. MarGnet produced a prototype to transform marine litter into certified (ISO8217 compliant) marine fuels. The prototype is a portable pyrolysis plant that can be installed in harbour areas and fed with marine litter collected by local fishers. The pilot plant can produce three types of fuel: high quality light fuel, marine gas oil and intermediate fuel oil. Mixed plastic litter, including polyolefins packaging and polyamides fishing nets, were converted into products at approximately 45 wt% yield of which approximately 50/60%wt Low Sulphur Marine Gas Oil (MGO) DMA ISO8217 compliant and about 5/8 wt% ISO Petroleum Marine Fuels IFO180 RMF, ISO8217 compliant. To our knowledge, this is the first report of chemical recycling of real marine litter targeting the production of standardised marine fuels.
Promoter:	MarGnet project funded by the European Maritime and Fisheries Fund (EMFF)
Sources:	www.margnet.eu Faussone, G.C.; Kržan, A.; Grilc, M. Conversion of Marine Litter from Venice Lagoon into Marine Fuels via Thermochemical Route: The Overview of Products, Their Yield, Quality and Environmental Impact. Sustainability 2021, 13, 9481. https://doi.org/10.3390/su13169481

Recycled Plastics From Litter Collected During Fishing Operations

Sea2See: watches and glasses from marine litter collected by fishers



Objetive(s):	To design and produce optical frames and sunglasses from recycled marine plastic collected by fishermen
Field of action:	Recycle: Recycling marine litter collected during fishing operations
Geographic scope:	Western Mediterranean, West Africa
Description:	Sea2see designs and produces optical frames and sunglasses in Italy, as well as watches in Switzerland, entirely made with recycled marine plastic collected by fishermen in Spain, France and West Africa. Containers have been disposed of in 24 ports of Spain (Catalonia) and 8 of Mediterranean France. Separation and classification of different types of plastic is done manually. The regenerative technologyused reduces waste to monomers by chemical reactions to reproduce virgin-like polymers to create our UPSEA™ PLAST. The obtained raw material is Cradle to Cradle(tm) Gold Certified. In fact, every component in the product is circular
Promoter:	Sea2See, Barcelona, Spain
Sources:	www.sea2see.org/

3.2 Port systems, shipbuilding and repair

A port is a natural or artificial structure designed and equipped to allow the landing and mooring of boats as well as their protection from adverse weather conditions. The concept of "port" goes beyond the simple movement of goods and people, since it includes road and rail connections, executive offices, service companies, and other components. In this sense, ports should be considered complex and productive entities strongly linked to the socio-economic context in which they operate and to the territory in which they are physically located. This is the reason why the definition of "port systems" is often preferred.

Around 90% of the traded goods in the world are carried across the sea, and since the demand for global freight steadily increases, maritime trade volumes are set to triple by 2050 (UNCTAD 2018). The ports with the highest volume of goods in the Mediterranean are: the Port of Piraeus (Greece), the Port of Valencia, the Port of Barcelona, the Port of Algeciras (Spain), the Port of Genoa (Italy) and the Tangier Med port (Morocco) (SYM Naval 2021). Tangier Med is one of the most technologically advanced ports in the Mediterranean and the biggest in Africa.

Most of the world's major ports are looking at the Circular Economy as a way to address their own sustainability challenges. Furthermore, the global health crisis caused by the Covid-19 pandemic made crystal clear how our economies and societies are interdependent, complex and vulnerable, and how, in a globalised economy, ports are key to ensuring the flow of goods and energy. In this regard, Circular Economy is a unique opportunity for ports to improve their sustainability and pursue greater resilience.

Although Circular Economy may take different forms, the common underpinning concept is the promotion of synergies between economic operators,and the creation of closed circuits for generating value through the recycling and the re-using of materials and energy. Since industrial clusters are already present in ports, the promotion of these synergies would be facilitated.

There are already inspiring examples of extending the life of port-related products, materials and resources as long as possible, and minimising waste generation, especially when it comes to metals, plastics, cements and biomaterials (LOOP-Ports project)[7]. Such examples represent lessons to learn from and replicate, as they put in practice the principles of circularity: rethink, reduce, reuse, repair, recycle and recover.

Trends/Outlook in the Mediterranean

The Mediterranean Sea is located at the crossroads of three major maritime passages, namely the Strait of

Gibraltar, the Suez Canal and the Bosporus Strait. It has more than 450 ports and terminals that together account for approximately 30% of global sea-borne trade in volume (European Commission). Since there are different types of trade, there are also different types of ports depending on if they are more suitable for bulk goods (e.g. oil products, chemicals, agricultural products and minerals), miscellaneous products (often unfished goods), or roll-on/roll-off (ro-ro) for wheeled cargos (IEmed, 2021).

7 LOOP-Ports involved 13 partners from
6 EU Member States (Spain, Italy, France, Germany, Denmark and Netherlands) and run for over 2 years. It ended in November 2020.

Around 1.5 million workers are directly employed in European ports, and the same amount is employed indirectly across the EU maritime Member States (European Commission). There are countries (e.g. in the Netherlands) where the full contribution of port activities to the national GDP can reach 3%, other countries (e.g. Egypt) where most of the volume of its trade is concentrated in one single port (the Port of Alexandria) and countries where port systems have historically played a fundamental role in their economic growth (e.g. the Port of Beirut in Lebanon or the port of Aqaba in Jordan).

Being the crossroads of all kinds of waste and industrial streams, ports act as logistical hubs for the flow of waste materials, exerting serious pressure on the environment (e.g. oil spills, air/noise/light pollution, etc.). Even if there is wide agreement upon the fact that ports need to be equipped with waste facilities[8], the reduction of their environmental impact is mainly linked to the adoption of a circular economy approach.

Opportunities for ports to become more circular can be found on different paths. In this regard, the Loop-Ports project identifies three main themes:

i. Circularity in port assets and equipment: optimisation and life-time extension of ports' assets, infrastructures and equipment (e.g. buildings, cranes, quays, buoys, etc.) through maintenance and smart use (e.g. sharing, renting, etc.) including green procurement;

ii. Circular flow of materials within ports: new use for would-be waste generated by port activities (e.g. ship waste and by-products of industries operating within ports) and design of innovative activities (e.g. recycling, upcycling and cascading) to be implemented within ports;

iii. Ports as part of circular markets: ports enabling other industries - both onshore and offshore - to move towards circular practices by developing new activities that connect supply and demand of a given material moving through the port in a circular way.

One or more of these themes can be deployed in different ways by port authorities, the companies within the port and in collaboration with other companies and even cities near to the port, depending on the context.

The trend of the sector is determined by the growing centrality of the Mediterranean and its potential to better connect global and regional markets as witnessed by Morocco, which put its port system at the core of its economic growth (e.g., TangerMed trans-shipment port) or by infrastructure projects (e.g. New Suez Canal). However, the competitiveness of a port is not only determined by geography, but also by the overall quality of the services offered, especially in terms of connections with other transport networks (integration between port facilities, inland terminals and multimodal corridors, among others). The trend to use mega ships and the oligopoly of a few shipping industrial complexes active in the Mediterranean can induce an overall improvement in infrastructure, technology and logistics in the region, but also creates a dynamic of competition between ports serving the same market (Laura Basagni, 2020).

Shipbuilding and repair

Ships operate for 25-35 years before both repair and refitting become uneconomical and they are taken out of service and sent for scrapping. Along their life, ships face extreme weather conditions and transport massive cargo, something that requires strength, flexibility and durability. Steel is able to provide these mechanical properties and meet the demand

8 Directive of the European Parliament and of the Council on port reception facilities for the delivery of waste from ships, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0883&rid=1

for a cost-efficient raw material. This is the reason why steel is often used in the naval industry for the circularity concept. Often making up between 75-85% of a vessel, steel is not only the primary material but also the primary driver of price for a vessel sold for recycling. Guided by developments in the steel market as well as ship recycling capacity/capability and regulations[9], shipowners decide whether to keep or sell a vessel, either for further trading or for recycling (primarily as scrap steel) (Sustainable Shipping Initiative, 2021). In the context of Circular Economy, ship recycling becomes a lifecycle concern and not merely an end-of-life decision about providing material input to the ship recycling industry.

Ship recycling is a distinct phase made of value-adding activities of dismantling, sorting, preparing and reusing of parts (e.g., materials and items and even some hazardous wastes). The demand for recovered parts depends on price and quality as well as local consumption (or options for exporting), particularly of steel. In certain cases, the ship recycling yard may also resell a ship without dismantling it (H. Sornn-Friese, E. Roth, P. Sofev et.al., 2021)

The Mediterranean hosts some important shipyards and provides relevant expertise and skills for building and repairing. Many yards in the Mediterranean are now looking to meet the demand for smaller expedition and luxury vessels (SeaTrade Cruise News). The shipbuilding and repair sectors are currently undergoing a remarkable period of expansion across the Mediterranean, especially when it comes to cruise ships since this segment of tourism continues to rise. The Italian shipbuilding group “Fincantieri” is the global leader in cruise ship construction accounting for over 50% of the market share.

The Mediterranean’s repair scene has also expanded. The Chantier Naval in Marseille (France) and the Navantia Shipyard in Cadiz (Spain) are important players in the ship repair sector (SeaTrade Cruise News), which is crucial when promoting circular economy in maritime transports by extending the life of products and materials.

The Mediterranean countries are, after Northern Europe, the largest region in terms of repair yards (ca. 70 in total) (Figure 11). This is due to its strategic geographical positioning and climate conditions, that allow work throughout the full year. If we focus on the Mediterranean, we find that almost 90% of the existing shipyards are concentrated on the north side, due among other things to their historical tradition and higher qualification workforce.

9 For instance. the current international regulation of ship recycling such as the Hong Kong Convention (HKC) and the European ship recycling regulation (EU-SRR).

Port Of Marseille (Chantier Naval)



Objetive(s):	To position the Port of Marseille as an expert venue for ship repair, maintenance and conversion
Field of action:	Ship repair
Geographic scope:	Marseille (France)
Description:	The Chantier Naval de Marseille (CNM), located in the eastern area of the Port of Marseille, was created in 2010 as a subsidiary of the Italian shipyard San Giorgio del Porto to take over heavy ship repair operations in the Grand Port Maritime de Marseille. The CNM, which invested 10 million EUR in 2017 to become a Mediterranean hub in ship repair, was granted a 15-year concession to refit two dry docks and two berths. It was also selected to refit the largest dry dock in the Mediterranean. To date, cruise ships represent the bulk of its activity so much that the Italian cruise company "Costa Crociere" entered the capital of CNM. Today, the CNM is a one-stop shop for repair, conversion and refitting operations in the shipping industry.
Promoter:	San Giorgio del Porto/Chantier Naval de Marseille
Sources:	https://cndm.fr/facilities.php

FORNÆS Ship Recycling



Objetive(s):	To sell used products in the condition they were when dismounted from the vessels.
Field of action:	Ship recycling
Geographic scope:	Denmark
Description:	Fornaes Ship Recycling, located at the Port of Grenaa in the middle of Denmark, is a well-known company for scrapping ships and all kinds of marine equipment. Since 1993, the company has scrapped over 1,500 ships and vessels, including fishing vessels of various sizes, freighters, supply vessels, ferries and military vessels, mostly from Scandinavia and the United Kingdom. To date, they have Northern Europe's largest stock of used ship equipment and marine machinery.
Promoter:	Fornaes Ship Recycling
Sources:	https://www.fornaes.com/



Figure 11. Shipyards, shipbuilders and docks in the Mediterranean. Source: Trusteddoks.com

Repair and maintenance activities in shipyards include: transformation interventions, general revisions, maintenance programs, repairs of large damages and minor equipment. This is conducted by reduced staff and space and needs great synchronisation, timeliness, flexibility and reliability. It is a sector with a regional scope and requires a high level of negotiation capacity to obtain contracts on a recurring basis (Ruiz del Real 2020).

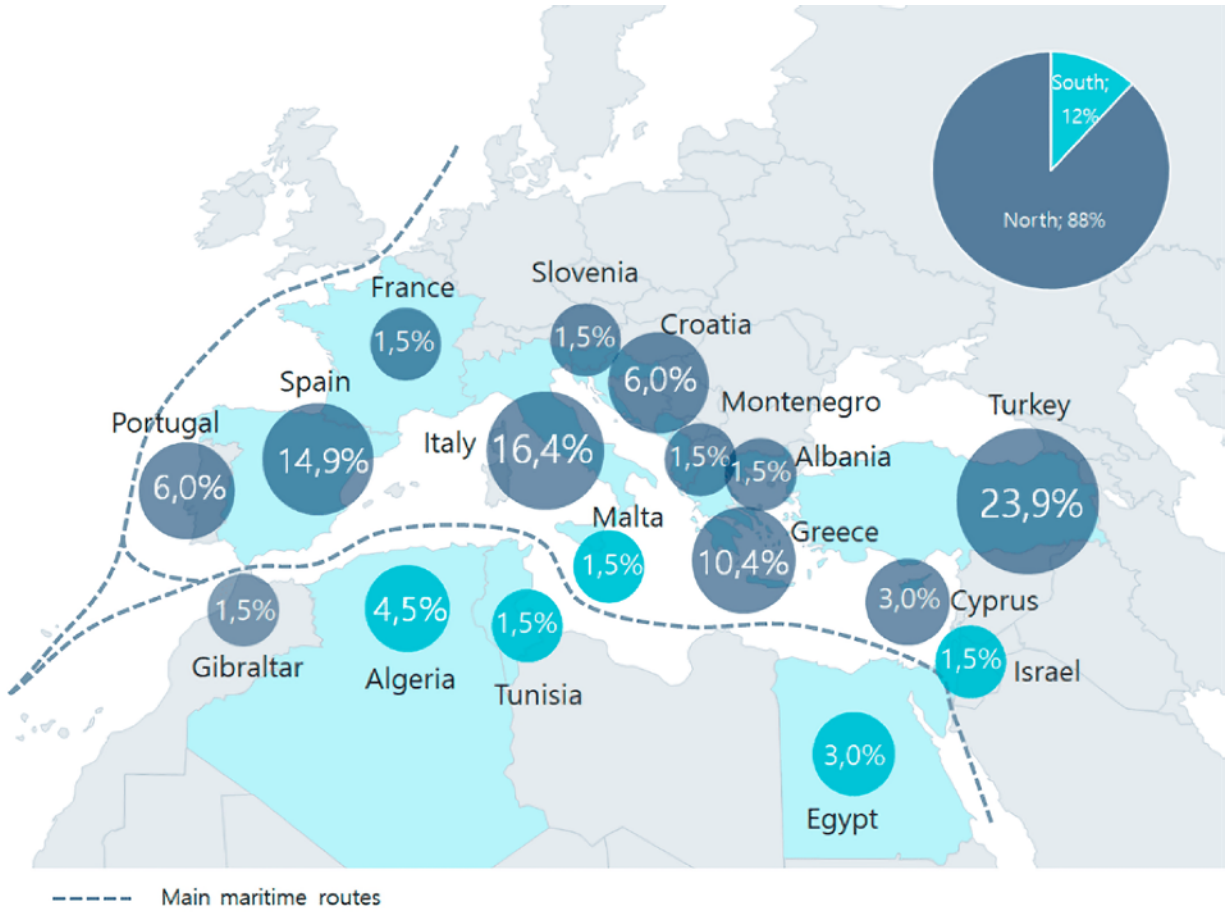


Figure 12. Distribution of repair shipyards in Iberian Peninsula & Mediterranean Sea (Percentage of shipyards out of total; 2019). Source: Ruiz del Real (2020).

3.2.1 Recycling and reuse of waste

Marine pollution is one of the most serious environmental threats for the Mediterranean Sea (BLUEMED, 2018). Even if it originates mainly from land-based sources, the contribution from sea-based activities is significant. Ports, which are heavily affected by marine litter, could play a strategic role when it comes to remediation and prevention. Indeed, resource efficiency and the concept of a circular economy are gaining importance as guiding principles through which ports' waste should not end up in the sea but rather be reduced, disposed of properly and preferably used again. Although concrete measures are being implemented in this direction, the coordination between measures put in place by ports and further downstream management operations is often an unresolved issue.

Plastics from aquacultural farms

The ports of Goro/Garibaldi in the North-eastern part of Italy host a high number of fishing companies (over 50% of the capacity in the entire region) and a thriving aquaculture sector devoted to onshore and offshore breeding of different species of clams, oysters and mussels. Through the establishment of a stakeholder partnership, the two ports have addressed the problem of plastic waste used in aquaculture in two ways. First, through the promotion of circular supply chains, allowing the collection and recycling of existing equipment. Second, by new and innovative ways of rethinking the nets, creating bio-degradable or sustainably-produced nets with the aim of limiting the impact of the industry on the environment.

Waste reuse

Dredging is a fundamental activity for most ports and harbours. It consists of the excavation of material from the sea, river or lakebed, and the relocation of the excavated material elsewhere for disposal (IADC/CEDA 1997). Dredging, which has multiple important functions (e.g. ensure navigation by maintaining or improving depths, control floods or remove contaminated sediments) can be designed and conducted within a circular economy approach. For instance, the Port of Gävle (the third largest in Sweden) not only used dredged material to build a new cargo terminal, but once treated, used large volumes of contaminated sediments extracted during that dredging process to create new land (A. Carpenter, 2018).

Other cases demonstrate that waste management designed around circular economy principles brings in additional energy for ports along with reduction of waste directed to the landfill, lower emission of greenhouse gases, reduction of carbon dioxide generated by transport and an increase in the recycling fraction (Canary Island's ports).

3.2.2 Emissions reduction: decreased greenhouse gas emissions

Ports can play a significant role in maritime greenhouse gas emission reduction. Scientific literature stresses how carbon dioxide capture is critical to resolving the climate change crisis. A significant share of carbon dioxide emissions from shipping are derived from the time the ships stay in ports. There is extensive literature about the topic, including technical and operational mitigation measures, best practices, monitoring and cooperation mechanisms, etc.

From carbon dioxide to biofuel

The waste generated in industrial areas is usually thought of as tangible goods that can be moved from one side to the other. However, the primary waste in ports is composed of greenhouse gases emitted into the atmosphere that can be used as a raw material. Indeed, microalgae have shown potential to capture carbon dioxide from the atmosphere and enable circular carbon economy via bio refinery. This is the target of the Port of Marseille Fos and its partners within the Vasco project, namely the cultivation of algae as a way to treat industrial fumes and its transformation into biofuel. A new phase of the project is under discussion to deploy an industrial-scale demonstrator, the last step in developing a solution to reduce atmospheric emissions of CO2, NOx and particles from the Fos-sur-Mer industrial port area.

Recycling fuel

Since 1992, Tradebe has been one of the companies in charge of managing and transforming hydrocarbon waste from ships that dock at the Port of Barcelona. Its activity began with the collection of 3,000 m3 per year of waste generated by cruise ships, a volume that has increased to the current 85,000 m3 from all types of vessels. These figures have achieved the reduction of CO2 emissions by more than 60,000 metric tons per year. This collection is led by two vessels and tanker trucks that transport this waste to the Tradebe treatment plant located at the port facilities. There, the waste is separated into phases that are treated separately and refined to obtain a recycled fuel that contains the parameters of the original so that it can be consumed again (PierNext 2021).

Port Of Rotterdam



Objetive(s):	To promote the establishment of a circular hub
Field of action:	Plastic, biomass, metals, minerals, chemicals, biofuels and industrial waste
Geographic scope:	The Netherlands
Description:	As the largest port in Europe and the raw materials cluster of the Netherlands, Rotterdam can make a significant contribution to raw materials and climate challenge. The Port of Rotterdam Authority is engaged in supporting start-ups and grow-ups in developing their circular ideas and technologies while working together with many regional and chain partners to develop new, circular value chains, for example around the chemical recycling of plastics and the reuse and recycling of batteries. The Port has adopted four approaches to advance circularity: i) encouraging innovation by attracting new circular initiatives and scaling start-ups. Looking towards the future, the Port will focus on promising technologies that can cope with the large volumes of the Rotterdam region; ii) sorting and recycling are priorities. This is a perfect match because all the links of a variety of value chains are present in Rotterdam: from primary production, transport, sorting and recycling to a market for a range of secondary products; iii) support industrial symbiosis. The concentration of industrial and logistical activities makes it relatively easy for companies to exchange products and residual flows, and make use of shared facilities; iv) working on Carbon Capture and Utilisation), a technology in which CO2 is captured and reused as a resource for the industry. The report "Rotterdam towards a circular port - a deep dive into Waste-to-Value opportunities" maps out the current waste flows in the port, as well as developments within a number of innovative industrial companies that are already committed to circular activities. The report also provides insights into promising new circular activities that could be developed.
Promoter:	Port of Rotterdam
Sources:	https://www.portofrotterdam.com/en

Port Of Amsterdam



Objetive(s):	To become the most important circular economy hotspot in Europe.
Field of action:	Waste, raw materials and port logistics
Geographic scope:	The Netherlands
Description:	The Port of Amsterdam offers start-ups and scaleups the opportunity to connect with other circular and biobased initiatives and other industries through crossovers. The Port organises its work on circular economy around four pillars: i) revaluing municipal waste by offering circular companies the opportunity to connect with initiatives that extract energy from waste and innovations in the field of water cycles; ii) setting itself as a biorefinery cluster engaged in extracting biofuel, electricity and heating from fertilizers and complex organic matter; iii) hosting a large number of innovative and specialized chemical plants that offer start-ups and scaleups in the circular economy the option of co-siting and collaboration; iv) promoting R&D and innovation infrastructure so as to offer specialized plug-and-play facilities for biobased and circular innovation. In this way, start-ups and scaleups can accelerate their vision.
Promoter:	Port of Amsterdam
Sources:	https://www.portofamsterdam.com/en

Port Of Dover



Objetive(s):	To improve the overall environmental performance
Field of action:	Recycling and reuse of waste
Geographic scope:	United Kingdom
Description:	The port of Dover is the busiest international roll-on roll-off ferry port in Europe, handling up to £122 billion of trade and 17% of the UK's trade in goods. It is the country's second busiest cruise port, together with a growing and diversifying cargo business, a popular marina and a significant property portfolio. The port achieved a 12.79% reduction in carbon footprint in 2019, which means a reduction of 48.99% of its footprint since 2007. Furthermore, it achieved 100% landfill avoidance with a 94.7% recycling rate of the general waste stream while the percentage of recycling of cruise ship waste increased from 23% to 40%.
Promoter:	Port of Dover
Sources:	http://www.sea2see.org/Dover port; https://www.britishports.org.uk/dovers-award-winning-practice/

Port Of Tallinn



Objetive(s):	To implement circular economy principles in port activities
Field of action:	Re-cycle: Recycling and reuse of waste
Geographic scope:	Baltic sea
Description:	The Port of Tallinn contributes to improving the purity of the Baltic Sea by helping prevent the discharge of waste from ships into the sea. The harbours of the Port of Tallinn have adequate capacities for receiving any kind of waste from all ship calls. The Port supports ships that have invested in scrubber systems in order to reduce sulphur compound (SOx) emissions to the air and accepts scrubber waste without any additional charge. All waste from ships is recycled, reused and handled in an environmentally sound manner. In 2019, 93% of waste in the port was reused following circular economy principles.
Promoter:	Port of Tallinn
Sources:	http://www.sea2see.org/https://www.ts.ee/en/

Port Of Marseille



Objetive(s):	To promote biological recovery of industrial fumes
Field of action:	Reduce: Greenhouse gases emissions
Geographic scope:	Marseille, France
Description:	Launched in autumn 2015, Vasco2 is a research program led by the Port of Marseille Fos focusing on recovering the CO2 emitted by industry. The aim is to contribute to the energy transition through innovation by testing a novel solution for biomass production based on the biological recycling of industrial CO2. The project was built on: tests in seawater and then in fresh water, no selection of algae and no pre-treatment of the water or fumes. Microalgae were cultivated, harvested and concentrated on site, they were transformed into biocrude and refined until a biofuel was obtained. The project then decided to move to the industrial stage. The results obtained demonstrated very encouraging prospects for CO2 production and storage in biomass in relation to offering an emerging solution for treating fumes. The prospects for structuring a genuine industrial ecology sector are very real.
Promoter:	Port of Marseille Fos
Sources:	https://dweb.marseille-port.fr/en/projets/vasco-2-0 http://www.sea2see.org/

3.3 Marinas

The term “marinas” refers to quite different situations: from small ports belonging to the oldest part of a town to large and modern infrastructure able to host thousands of boats and provide all types of services to tens of thousands of boaters. Marinas, recreational boating and yachting are tightly interconnected.

There is a total of around 940 marinas in the Mediterranean, more than half in three countries: Italy (253), Spain (191) and France (124) (Cappato et al. 2011). Greece, Croatia and Turkey also have a network of ports and marinas. In 2015, other new marina projects were identified: 17 in Greece, 10 in Spain, 1 in Malta and several in Italy and in the Adriatic (exact number unknown) (Carreño et al. 2019). Many marinas in the basin are at full capacity during the high season and cannot accommodate more yachts. Berth demand is still growing and is used to justify new marina projects. However, in countries with a high density of marinas like France (one every 14 km), the potential for spatial expansion is now limited by environmental protection legislation. On other coasts, the leisure boating sector continues to cause significant infrastructure development pressure.

Marinas have common characteristics and peculiarities that can make the application of circular economy particularly effective. Actually, they are both promoters and beneficiaries when adopting circular economy approaches as showcased by many existing projects. Such pilot projects include certification initiatives to promote appropriate management of marinas’ areas by means of methods and tools that meet environmental challenges, especially when it comes to chronic and accidental pollution, and toxic waste from operations (www.ports-propres.org), the reuse of boats’ cooking oils (Save the sea Recycle cooking oil; Roule ma Frite 17), digitalization for smart lighting through led technology (Capo d’Orlando) or smart mobility through electric cars (Marina di Teulada and Villasimius). Likewise, data loggers, sensors and integrated systems for measuring/recording meteorological parameters, air pollution, noise and the quality/pollution of waters within the marina or in the wider area are also used.

Networking among the investors and actors dealing with marinas’ design, operation and maintenance is crucial. Initiatives in this direction are welcome (Yacht Club de Monaco).

Trends/Outlook in the Mediterranean. Marinas, especially in Western EU-Mediterranean countries, are generally close to full occupation of their capacity. Greece and Turkey are about to follow the same trend. Boat owners may further explore marinas in Southern Mediterranean countries (Morocco, Algeria, Tunisia) as “home marinas,” which they can reach easily via air traffic. This can be an option especially for international yacht owners from Russia, the Arabian Peninsula and Asia (Mancini & Tode 2020).

To cope with the many cases of overcrowding, marinas will play a key role in offering boaters disposal solutions for end-of-life boats. This can bring concrete advantages to marinas both in terms of berths finally free from crumbling boats and also of second-hand material to be recovered and eventually sold back to boaters.

Over the next year, marinas will likely be called to introduce management practices to deal with the on-going shift from “ownership” to “servitization”. The whole maritime sector will soon align to the trend already in place for cars (e.g. Uber, and BlaBlaCar), accommodation (e.g. Airbnb) and buses (e.g. GoGoBus). In fact, there are already platforms for boat sharing (e.g. Boatbound, GetMyBoat, Barqo, Sharemysea), which have led to a fast-growing economic segment. In this way, the same boat will meet the demand of many more people.

As shown in the motor car market, the future is electric. The electric boating revolution is still small, but it's set to grow. Marinas will have to adapt quickly in order to meet the demand of the owners of electric outboard motors (MLD Marinas).

3.3.1 State of play of Circular Economy practices and best available technologies

Renting and sharing are becoming common practices in marinas, this may allow reducing the total number of boats in circulation, and consequently pollution. However, this should be assessed on a case-by-case basis and with the support of quantitative evaluations. In fact, there are studies showing the relevance of the Environmental Rebound Effect (ERE). In the case of peer-to-peer shared access to boats, Warmington-Lundström and Laurenti (2020) showed that, despite decreases in primary production, substituted consumption behaviour, such as increased flights to reach the location of marinas or increased boat rides per person, can result in significant rebound and, in almost a third of cases, backfire.

In any case, marinas have a crucial role to play when it comes to end-of-life boats by promoting, whenever possible, the recirculation of the material for other purposes, including the construction of new boats. Complementary to this, practices of collection and reuse of lubricants and cooking oils are becoming popular in Mediterranean marinas as a way to address an important source of pollution of marine ecosystems.

3.3.2 Innovation and digitalisation as enablers of Circular Economy

Circular Economy is a regenerative economic system where waste is minimized/eliminated through the paradigm reuse, repair, recycling and remanufacturing. This allows "closing the loop," and minimizes the need for new input and the creation of new waste. Such a radical change of the economicmodel requires innovative approaches, and technologies, to be applied to the current production and consumption system.

On the other hand, artificial intelligence, the Internet of Things, Big Data and Blockchain are already in many production processes, improving the use of natural resources, optimizing design, production, use and the repair and recycling phases of the objects. Digital is a rapidly growing market scenario which transforms the concept of "product," also thanks to its r esilience to unexpected crises such as the Covid-19 pandemic.

Digitize products and services

Digitalisation becomes essential to rethinking business models and moving towards so-called "servitization", namely considering products as a service rather than a property (e.g. leasing, pay-per-use and sharing). This would allow companies to double revenues since the same number of products can satisfy the demand of many more people. On the other hand, this may lead to an increasing consumption in the long run with related environmental impacts (rebound effect).

Minimize pollution and maximize energy efficiency

Marinas have increasingly realized that they need to rethink their practices to mitigate the impact of hundreds of small boats and yachts that stay and travel every day. This includes the use of renewable energy sources, a way to lower electricity costs while meeting the need for power for lighting and operations.

Med Boat Sharing

Objetive(s):	To provide an innovative boat service
Field of action:	Digitalisation: Innovation and digitalisation as enablers of Circular Economy
Geographic scope:	Mediterranean
Description:	It is the alternative to buying or renting a boat. It allows using the same boat from the same port for a whole year for a fixed annual fee. The service guarantees up to 8 people the exclusive use of the boat. Planning and alternating outings with the others, each of them has the right to at least six weeks of navigation throughout the year (one-day trip or several days together) to be booked online.
Promoter:	Med Boat Sharing (private company), Italy
Sources:	https://medboatsharing.com/

Ports Propres

Objetive(s):	To preserve the aquatic environments and the sustainable development of coastal and marine activities.
Field of action:	Digitalisation: Renovation and digitalisation as enablers of Circular Economy
Geographic scope:	France
Description:	The “Clean Harbours” approach was launched in the Provence Alpes Côte d’Azur region in 2001. To date, over one hundred and fifty marinas are certified either as “clean ports” or “active in biodiversity”. In both cases, this voluntary certification is a sign of environmental excellence in terms of environmental management of marinas. As part of the process to get the certification, a marina is required to undertake specific steps to tackle liquid/solid waste and put in place concrete measures for energy efficiency.
Promoter:	Ports Propres
Sources:	https://www.ports-propres.org/

3.3.3 Re-use of waste

It is essential to recycle materials in order to 'close the loop' by reusing waste streams as inputs for new products or sources of energy. Waste disposal should be phased out, and where it is unavoidable, it must be adequately controlled to safeguard the human health and the environment.

Reuse of plastics

Plastics have very long degradation time and can persist in the environment for decades, polluting soils, rivers and seas. Being the third highest volume man-made material on the planet after steel and concrete, the ability to reuse it becomes crucial. A lot of research work and pilot actions have been carried out on how to substitute the use of fiberglass employed for composite fabrication in boat building, as well as how to use recycled plastic from solid wastes for structural elements of marinas or fuel production.

Reuse of mechanical oils and cooking oils

Oils serve to prevent friction between moving mechanical parts. Over time, they lose their characteristics and must be replaced, thus becoming a highly dangerous waste. Poured into water, a few kilos can pollute a surface as large as six Olympic swimming pools through a thin film that prevents the oxygenation of the underlying flora and fauna. Used oil can be reconditioned (removal of impurities) and used again, sent to refinery to produce gasoline and coke, or processed and burned for energy recovery (heat or power), etc. Likewise, used vegetable oil and animal fat should never be poured into water but collected and treated by licensed companies so as to be processed/reused (e.g. conversion into biodiesel).

Lankhorst Recycling Products

Objetive(s):	To produce a wide range of products from recycled raw material
Field of action:	Re-use of waste
Geographic scope:	Global
Description:	They produce a wide range of products from recycled plastic, many of which are sold to marinas, harbour authorities and river management entities. They build ropes, poles and planks, jetties, sheet piling, decking, façade panels, and bridges.
Promoter:	Lankhorst (private company)
Sources:	https://www.lankhorst-recycling.com/en

Save The Sea / Recycle Cooking Oil

Objetive(s):	To avoid spilling cooking oil into the sea
Field of action:	Re-use of waste
Geographic scope:	Italy
Description:	It is a national initiative targeting marinas/ports and boaters throughout the country that aims to raise awareness of the correct start of the recovery of used cooking oils. Thirty-seven ports joined the initiative. The oil collected and properly managed will become a reusable product. For each ton of waste oil recovered, there is a reduction of 2.3 tons of CO2 equivalent, and from every 100 Kg of recycled exhausted vegetable and animal oils and fats, it is possible to obtain 65 Kg of lubricant, 20 Kg of biodiesel, as well as cosmetics and soaps. Once the containers are full, a company authorized by RenOils will collect the used cooking oil which will be sent for proper recovery and recycling.
Promoter:	MareVivo and RenOils
Sources:	https://marevivo.it/attivita/save-the-sea/

Roule Ma Frite 17

Objetive(s):	To use frying oil for boat cleaning products
Field of action:	Re-use of waste
Geographic scope:	Saint-Denis-d'Oléron, Nouvelle-Aquitaine (France)
Description:	A boat cleaner based on frying oil. It proved to be an ultra-degreaser and stain remover for boats' hulls and a fully biodegradable boat fuel. The oil is collected by the Association not only from the restaurants of the port. There is a network of 400 restaurateurs, canteens, nursing homes and communities, which allow the collection of approx. 80,000 litres of used cooking oil intended to be transformed into biofuel. Since the legislation prevents them from producing more, the association sought new outlets for its cooking oil thanks to the support of Corsican company Bio Corse that develops professional cleaners and technical oils based on frying oil. This is an important step forward considering the quantity of soaps used in marinas for boat cleaning. These soaps often contain chlorine and nutrients, such as ammonia and phosphates, that can cause excessive plant and algae growth and decrease the amount of oxygen available to other organisms.
Promoter:	Association Roule ma Frite 17
Sources:	https://www.facebook.com/roulemafrite17Oleron/

3.4 Recreational boating and yachting

Recreational boating and yachting are sectors that have been gaining relevance over the last decade. This is demonstrated by the growing attention paid to them by regional organizations working on blue economy (e.g. the Guidelines for the sustainability of cruising and recreational boating in the Mediterranean region, prepared by Plan Bleu (2022)).

Recreational boats of between 2.5-24 m in length represent more than 90% of the total Mediterranean fleet of vessels. The construction of recreational boats in the European Mediterranean countries shows an average annual growth rate of 10% from the 2008 crisis, from which the sector has recovered. Most of the leisure boat fleet (87%) is composed of motorboats, while 11% are sailboats and 2% are other types (e.g., inflatable boats, canoes, etc.). This general segmentation occurs in all Mediterranean countries, although in some countries, sailing boats are more popular than the overall average (Carreño et al 2019).

The impact of COVID-19 and the recovery phase is still unclear, and recent studies show a mixed impact on the industry (European Boating Industry, 2021).

Evidence shows that 50% of the global fleet of large yachts – also called superyachts – spends eight months out of twelve in Mediterranean waters. In terms of charter destination, 70% of large yacht charter contracts worldwide are for the Mediterranean (56% for the Western Mediterranean). The Superyacht Migration Report gives a 3.5% average annual growth in large yacht presence within the Mediterranean Sea, with 37% of them below 40m, 47.5% from 40-60m, 13% from 60-90m, and 2.5% of vessels more than 90m (Carreño et al 2019).

At the EU level, several analyses have been conducted on the challenges and opportunities linked to a circular economy approach of the nautical industry. The Study on Nautical Tourism (European Commission 2016) highlighted that end-of-life boats are one of the main threats to the environment and pose a serious recycling challenge. The Boat DIGEST project has produced four sets of "Guidelines" targeted at marinas, associations, schools, repair and refit companies. They offer information on the actions that can be taken by these four groups and the role they play in raising boat owners' awareness about the issue. The BOATCYCLE project developed a guide for the sustainable eco-design and production of yachts, sailing and inflatable boats, and helped turn four waste streams from boat scrapyards (fibreglass, neoprene, wood and PVC) into resources. The project assessed that the recycling of these materials can reduce sector's environmental impacts up to 50%. The guide also promotes innovative eco design approaches for boatyards.

Recently, (April 2021) the European Boating Industry (EBI) and the European Composites Industry Association (EuCIA), representing respectively the Recreational Boating and Composites industries at European level, have agreed to jointly tackle the key challenges around circularity of composites used in the recreational boating industry and promote sustainable recycling solutions in the supply chain for end-of-life boats. Composites are the main material for manufacturing of recreational boats.

Trends/Outlook in the Mediterranean

Recreational boating is a stagnating market (with the exception of some niche segments), and the renting of boats seems to be more appealing than owning or co-owning. On the other hand, yachting is experiencing a growth both in the number and the size of yachts. Despite increasing environmental regulation and technological possibilities, pollution/ environmental degradation caused by yachting is still relevant (Mancini & Tode, 2020).

For both recreational boating and yachting, the ongoing trend for identifying and implementing sustainability solutions will continue (e.g. hydrodynamic hulls for less fuel consumption, hybrid propulsion, recyclable materials and ecological paints for interiors, solar panels in place of generators, tanks for black and grey water, less impact of anchoring and mooring, etc). As already mentioned, a high proportion of the recreational fleet is approaching its end of life, and the lack of easy-to-use and cheap options for boat owners to properly dispose of their boats could bring many of them to sink their boats or abandon them on land (Mancini & Tode 2020). This element, however, is also a great opportunity for the recycling business.

Moreover, the design and development of sustainable accessories for recreational boating is gaining attention, in particular as for innovative, affordable and sustainable anchoring systems (PME Mare; Stop Ancre).

Recreational boating and yachting are key segments of the tourism sector in the Mediterranean. Although there are many challenges that incentivize abandonment (e.g. high number of boats close to their end of life, lack of registersof destruction, unclear boat collection and disposal schemes, high costs of specialized companies, etc.), there are encouraging “circular” experiences already available.

A circular economy approach is facilitated by the existence of innovative materials (e.g. recyclable composites or renewable materials) designed and experimented with not only in the lab but on real scale. These practices, which need to be scaled up with production of larger boats and completion of certification processes, seem suitable for being replicated around the Mediterranean.

An organized collection network at the country level, with standardized protocols, direct links between owners, transporters, dismantlers and recycling companies has been set up in France, at no cost for owners. This practice proved to be successful and seems easily transferrable across the Mediterranean, contributing to combatting abandonment of end-of-life boats while opening up business opportunities in this new value chain.

These practices are complemented with other initiatives, again easily duplicable and transferrable across the basin, like networks for commerce of spear pieces (easing reparation and prolonging lifetime of boats), creation of accessories from sails or pieces of end-of-life boats and grinding of glass fibre material to produce panels for new uses and products (as an alternative to disposal).

3.4.1 State of play of circular economy practices and best available technologies

The Mediterranean is a major destination for recreational boating and yachting. Average age of pleasure boats in the Mediterranean is growing and many of them will reach end of life in the next years, converting into an enormous amount of waste to be disposed of. Boat dismissal is an issue for owners since collection schemes are not clear and costs are high. Also due to difficulties in disposing of them, abandoning end-of-life boats is unfortunately a common practice. Given their composition, composite boats represent a source of pollution for the marine and coastal environment. For many years, yachts and pleasure craft were designed and built without considering disposal requirements at their end of life. So, for decades, landfill and incineration have been the two popular disposal methods used by composite industries. Increasing environmental awareness drives us to identify a sustainable disposal method and provide a solution to prevent accumulation of waste.

3.4.2 Innovative product design

Recyclable composites:

Glass fibre composites represent an issue for recycling due to the difficulty of separating the fibres from the plastic and recycling the two components. The material is constructed in such a way that it is strong, durable and non-homogeneous, thus it is intrinsically difficult to recycle. This creates a number of problems, like the monetary and energy costs of recycling, compared to creating virgin materials. For glass fibre, for example, the price of virgin glass fibre is so low that no process currently available can provide recycled glass fibre with the same characteristics as virgin fibre at a competitive price. Secondly, the materials are always at a lower value level as they are decreased in quality due to the recycling process and lifetime wear or reduced to their feedstock elements.

Innovative products are becoming available to substitute traditional fiberglass composite in recreational boats, yachts and race boats. These products are fully recyclable, it being possible to separate the different components and create new products without downgrading the technical characteristics.

3.4.3 Innovative product design

Second-hand, end-of-series and destocking parts:

Prolongation of products' life is one of the means to limit the production of waste generated over time. In the case of pleasure boats, repair is often linked to the need to find specific spare pieces. This is generally a challenging, time consuming and expensive activity for boat owners. A solution to this issue is given by service providers linking boat owners, boatyards and spare sellers in a network where demand and offer can meet each other.

Use of end-of-life boats for hospitality on land:

Re-use of end-of-life boats for non-nautical uses has been introduced. Although representing a niche possibility, this practice is interesting beinglinked to local territories, linking owners of boats to be dismantled with new product customers and providing opportunities for the growth of small enterprises and handicraft activities in the area.

3.4.4 Up-cycle of old sails

Creation of bags, accessories, shoes:

Sails, like other boat components and accessories, also represent waste at end-of-life time. The opportunity to utilize old sail cloth and leavings from sail cloth production can help exploit materials otherwise destined for disposal. This practice has been implemented so far at the handicraft level.

3.4.5 Composite recovery processes

Grinding and production of panels for new uses/products:

Fibre-reinforced plastic recycling is widely practiced from various industrial sectors (nautical, automotive, cold chain, healthcare, street furniture, food). Generally, companies are not specialized in using one source sector only (pleasure boats, in our case), but they can get specialized in generating new products that are sector specific. For example, production of interiors – coatings and furnishing - for new boats.

Recyclable Composites For A Circular Yacht Economy

Composite for recyclable racing boats



Objetive(s):	To create a fully recyclable boat
Field of action:	Innovative design: Recyclable composite technology
Geographic scope:	Worldwide
Description:	Abandoned fiberglass boats represent one of the biggest environmental issues in the nautical sector. The practice has been developed with the aim of creating a fully replicable boat, thus avoiding dispersion of composites and their polluting components in the environment and allowing reuse of raw materials and minimization of waste. rComposite is a new composite made with original vegetable fibres (mainly flax) and an innovative thermoplastic resin Elium® that can be separated from the fibres and regenerated through a simple pulverization and dissolution process. In the case of realization of a sandwich laminate, the soul of the composite in Atlas HPE is recyclable too. Thanks to the innovative resin that can be “dissolved”, it is possible to separate and recover the individual constituent elements (fibre, core, resin). The recovered fibres retain their initial properties and they can be reused in a new cycle. Racing boats such as dinghies, foiling dinghies, and racing yachts have already been prototyped and produced with this new material. Besides being completely recyclable and sustainable, these boats maintain the mechanical characteristics of the boats built with traditional laminate (glass and polyester or vinylester resin). In place of glass fibres that aren’t reusable or recyclable once in the resin, the new technology is based on the use of bio-based fibres to reduce carbon footprint. Moreover, the production process is the vacuum infusion that guarantees a better working environment, free of harmful emissions of any kind.
Promoter:	Northern Light Composites is a brand by Northern Light Srl viale San Marco 13/B, Monfalcone, (Gorizia), Italy.
Sources:	Mancini A. 2021. rComposite di Northern Light Composites. Nautica 714 (October 2021): 1-9. In Italian. northernlightcomposites.com

Reuse On Land Of Disused Boats

Bathô – chantier naval insolite



Objetive(s):

To prolong the lifetime of boats and prevents the abandonment of end-of-life boats

Field of action:

Re-use of end-of-life boats

Geographic scope:

Rezé, Nantes (France)

Description:

Bathô is a Solidarity Company of Social Utility (ESUS) for the reuse of old pleasure boats by converting them for various purposes on land. The main use is for tourism accommodation but solutions are developed also for bar and restaurant, domestic use (additional room in the garden), playgrounds, exhibitions, as extra spaces for companies (e.g. meeting rooms).

The company buys the old boats for a symbolic euro discharging the old owner of the concern around getting rid of it. The boats are emptied of their fitting interiors. Their equipment (engines, navigation accessories) is dismantled and then resold or recycled. The interior of the boats is re-arranged in a personalized way, the hull and the deck are preserved and repainted. The boats are connected to water and electricity networks. A wooden deck is attached to the boat to allow its use on ground. All renovation work as well as the shipyard team makes the delivery and installation of converted boats. The company also offers training courses, in nautical and boat interior fittings trades. About 450 hours of work are needed to renovate a boat. The cost of the new product ranges between EUR 12,000 to EUR 30,000. Bathô is committed to the creation of a regional sector reuse of pleasure boats with the ambition to treat 30% of abandoned ships in Pays de la Loire and to extend their lifespans by at least 10 years.

Promoter:

Bathô, 24 rue de l'Abbé Grégoire 44400 – Rezé, France Contact@batho.fr

Sources:

www.batho.fr/ ; Boldrini J. C., 2020. Du bateau de plaisance en fin de vie à l'habitat insolite pour tourisme éco-responsable. La co-création de valeurs soutenables par le réemploi en économie circulaire. XXIX Conférence Internationale de Management Stratégique. 3-5 juin 2020

Recyclable Fibers Into Sustainable Composites

FILAVA for recyclable composite



Objetive(s):	To produce direct roving made of enhanced volcanic rock filaments to be used for yachts
Field of action:	Innovative design: Recyclable fibres for composites
Geographic scope:	Worldwide
Description:	FILAVA™ is a direct roving made of enhanced volcanic rock filaments and manufactured in the melt spinning process, where the fibres are formed via a batch melt, followed by the lava which flows through bushing plates with nozzles and is then vitrified by cooling. The raw material is enriched with various mineral additives with the aim of increasing and guaranteeing its original mechanical and chemical properties (© ISOMATEX). At the end of life, the fibre can be recovered and re-transformed into new spools of virgin fibre. The fibre is less dangerous to manage than glass fibre, because it is much thicker and longer and it is less volatile. The recycling process of Filava can take place in different ways, depending on the resin used to transform the fabric into a composite. Production of hulls and other components for yachts and racing boats are one of the tested uses of FILAVA. For example, the Italian company Amer Yachts (Permare Group, Italy) is preparing to build a superyacht with a hull in completely recyclable material. This action will pave the way for the construction of eco-friendly boats.
Promoter:	GS4C srl. Corso Vercelli 57. 20144 Milano, Italy
Sources:	www.gs4c.com

CAMOZ and SALTY BAGS

Recycled Sail Design





Objetive(s):	To produce handcrafted accessories made with recycled material from the nautical sector
Field of action:	Up-cycle old sails and fabric scamps by turning sail cloth into new products
Geographic scope:	Worldwide
Description:	It has been estimated that at least 80,000 boats reach the end of their life each year, leaving their hull and deck, rigging, and sails to be dismantled. Unfortunately, only 2.5% of the boats are recycled or upcycled. That means a lot of old sails become waste, and if abandoned in the environment, they become a source of pollution. Sails and fabric remnants are used to make bags and wallets. The cloths used are old sails, kitesurf parachutes and fabric scraps from the sailmakers. Materials used (by CAMOZ): Dacron. It is the most widespread and durable fibre in today's sails. It ranges from white colour to dacron in pastel shades used for vintage boats; Dacron Cream & Tanbark. The coloured dacron is used for specific needs and it is derived from vintage sails, it exists in beige and brick colour; Kevlar. It is the very tenacious yellow yarn found in membranes; Taffeta: Soft to the touch and sober colours, usually grey with black or yellow threads; Mylar. used in membranes coupled with other materials, it gives a glossy effect and plays of transparency; Carbon. The real fibre of the racing sail, grey or black: it is the most resistant and light material.
Promoter:	Camoz. Santa Croce 2091, Venice (VE), Italy Erotokritou Moraiti 14, Corfu, Greece
Sources:	www.camoz.it www.theswitchers.eu/en/switchers/italian-accessories-give-new-wind-old-sails/ saltybag.com/

Service To Find Second-Hand, End-Of-Series And Destocking Parts For Pleasure Boats

Cap’tain Chercheur: spare parts for pleasure boats



Objetive(s):	To provide spare parts for motorboats, sailboats or semi-rigid boats
Field of action:	Repair: find second-hand, end-of-series and destocking parts for pleasure boats for interested customers and connect them to sellers.
Geographic scope:	France
Description:	The search for spare parts for a boat can be challenging. This practice aims to help recreational boat practitioners to find spare parts for motorboats, sailboats or semi-rigid boats. At the same time, this practice aims to Offer an eco-responsible alternative to the purchase of new products. The provider is relying on a network of partners looking for and offering various and varied parts, running and standing rigging, various fittings, marine hardware and specific equipment. Interested customers can submit their request and benefit from the advice of experts on the best solution to apply to fix the problem. The needed part is then requested. Once the requested part is found, the potential customer is provided with a quotation and the information on where to buy the part from a reseller. The service includes offering alternative solutions if the exact part cannot be found. The search commission applied is 10% of the price.
Promoter:	Captainchercheur
Sources:	captainchercheur.com

Recycling Fiber Glass Wastes By A Mechanical Process

RFM® panels from recycled fibre glass



Objetive(s):	To avoid incineration and landfilling of fiberglass and produce new kinds of fibreglass
Field of action:	Recycling of fibreglass products.
Geographic scope:	Italy
Description:	Waste materials from the sanitary and manufacturing sector, as well as from companies producing boats, campers, agricultural vehicles, etc. are collected. Waste is grounded (mechanical, cold process) and transformed into new products, which are in turn recyclable with a cold pressure moulding technique. Certified panels are one of the main products. They are used in the manufacture of furniture components and other interior and exterior furnishing accessories, The RFM® panels are perfectly workable, non-deformable and waterproof. Panes can be produced according to specific needs and characteristics: thickness (from a minimum of 4mm), density and weight of the product can be customized, RFM® panels can be processed in all ways: drilling, milling, water cutting, screwing, lamination. RFM® panels can be sanded, painted and lacquered. Being totally water repellent and waterproof, they are extremely stable and therefore ideal in all humid environments. Insertion of metal and structural elements inside the recycled fiberglass panel is possible.
Promoter:	Gees Recycling Srl, Via Monte Colombera n. 22 Aviano (Pordenone) Italy
Sources:	https://www.geesrecycling.com/

The Recreational Boat Deconstruction Sector

APER La plaisance éco-responsable



Objetive(s):	To treat waste from pleasure boats or sports boats.
Field of action:	Recycle: Dismantling, recycling and correctly disposing leisure boats
Geographic scope:	France
Description:	The Association pour la Plaisance Eco-Responsable (APER) is a non-profit association acting as the official French eco-organization for the treatment of waste from pleasure boats or sports boats. Initially created by the Federation of Nautical Industries (FIN) in 2009, the APER was transformed in 2018 in order to respond to the implementation of the Extended Producer Responsibility (EPR) of pleasure or sport boats. The members are manufacturers and importers of pleasure or sports boats in France. The APER eco-organization has been officially approved by the public authorities (Decree of February 21, 2019, published in the Official Journal of March 2, 2019) to set up and manage this sector throughout the national territory. The scope of activity of the APER concerns the treatment of pleasure boats at the end of their life from their reception in the deconstruction centre, dismantlement and transfer to the processing and recycling companies. APER works to bring together the owners of end-of-life pleasure boats and the thirty processing and recycling companies approved within the framework of this voluntary sector. APER is funded through: a compulsory eco-contribution, collected from its members (marketers) on each sale of new boats in France; a share of the DAFN (Annual Right of Francization and Navigation) donated by the State to the eco-organization. Thanks to these two financings, deconstruction is free. Only transport to an approved deconstruction centre is at the expense of the boater.
Promoter:	APER La plaissance eco-responsible, France
Sources:	www.recyclermonbateau.fr/

4 Barriers to enhancement of circularity in Blue sectors in the Mediterranean



From the literature review conducted to prepare this report and from several interactions with stakeholders, in the Mediterranean and beyond, the following obstacles have been identified to accelerate efforts for the integration of Circular Economy within Blue Economy sectors.

Policy & governance

→ Lack of or inadequate policy and legal framework: the definition of "waste" in national legislation and the limitations related to its utilization prevent their valorisation as "by-products" or "co-products". This happens for example in ports. In some countries, ship waste delivered as separated fractions, based on the MARPOL rules, are mixed by port operators and have to be separated again, due to misalignment with national rules.

→ Lack of empowerment: this is an issue for ports. For compliance reasons, some ports cannot collaborate with individual stakeholders as it is required that all companies operating in the port must have equal access to the services of the port authority.

Industrial development

→ Lack of capacity to scale up: for SMEs, it is difficult to scale up their circular economy pilot projects and initiatives due to the lack of equipment, infrastructure, proper management and financial capacity.

→ Lack of industrial infrastructure: for some type of circular economy activities in the blue economy sectors, industrial facilities are needed (e.g. for depolymerisation and re-polymerisation of plastics).

→ Missing supply-chains: circular economy development relies on the capacity to link producers of by-products with entities able to add value to the waste. Supply chains are missing, hindering the creation of a market based on circular products.

Economy & finance

→ Lack of financial resources: availability of financial resources is needed to scale up circular pilot activities/initiatives.

Awareness & skills

→ Lack of skills: specific skills are necessary to develop a circular economy activity or turn a linear production process into a circular one. Waste management regulation, product quality standards, supply chain functioning, innovative technology, sustainable finance are some of the missing competences.

→ Lack of perception that circular economy is a business opportunity: all too often, circular economy in the blue economy sectors is perceived as an obligation dictated by environmental regulations, and this concerns both SMEs and large companies. The business opportunity "component" is not properly communicated

5 Conclusions to mainstream Circular Economy into the current Blue economic model



The Covid-19 pandemic that hit the world economy highlighted the vulnerabilities and unsustainability of our current linear model of productionand consumption (take-make-dispose), which relies on unlimited natural resources as well as on low transportation and labour costs. The latest report of the IPCC on climate change constitutes an urgent call to shift to sustainable consumption and production patterns and in particular to implement Circular Economy approaches in all sectors. Moreover, since manufacturing firms spend on average about 40% on materials (A new Circular Economy Action Plan, 2020), a circular approach would increase profitability while sheltering them from resource price fluctuations.

Circular Economy is about reducing the consumption of natural resources and regenerating nature while increasing the reuse of materials. In the current literature, this is often summarized with the so-called seven Rs: Redesign, Reduce, Reuse, Renew, Repair, Recycle and Retrieve. In other words, it is an economic model that minimizes waste, which becomes a resource, by reusing the materials in successive production cycles.

From the literature review conducted for the preparation of the present report and from interactions with stakeholders, including the discussions during the conference "Fostering Circular Blue Economy in the Mediterranean" held in Barcelona on 11th May, 2022, in order to make Circular Economy operational within the Blue Economy sectors in the Mediterranean region. Countries and stakeholders should consider addressing the following aspects.

Policy & governance

→ Fully implement existing strategic, policy and regulatory frameworks:
The new Circular Action Plan issued by the European Commission is the guiding document for the Member States, most of which (e.g., Italy, Spain, France, and Greece) have elaborated their own national circular economy strategies. The level of implementation of the Circular Action Plan, as a building block of the European Green Deal, will determine the degree to which the blue economy sectors will move towards "circularity". The same goes for other strategic documents aiming at redirecting national policiessuch as the "EU Strategy for Plastics in the Circular Economy", the "Single-Use Plastics Directive", and the "Farm to Fork" Strategy. As for the current EU and national regulatory frameworks related to the promotion of circular economy, they must be simplified to make them easily understandable and implementable by the local authorities.

→ Frame "circularity" into coherent international and national policies and regulations:
This is particularly important when defining "waste" as a secondary raw material under controlled conditions. Regardless of the governance level, in policies having an impact on the entire value chain (collection, reception, storage, and value capture), discrepancies must be removed, especially from a legal and fiscal perspective. Additionally, local authorities have to be increasingly involved since they are important enablers of circularity by incentivizing experimentation and ensuring flexibility for local adaptation.

Industrial development

→ Promote sustainable industrial development:
Circular blue economy requires that industry as a whole manage to decouple economic growth and resource use. Decoupling entails radical changes in production (and consumption) patterns so as to do more with less in respect to earth's sustainability boundaries. The new industrialization paradigm, to be built on circular economy metrics and indicators, will increase value addition and lower production costs by reducing/

substituting intermediate inputs, including raw materials, energy consumption and other goods and services usually needed for production. In areas where infrastructure for circular activities are not available, specific studies should be run so as to recommend, or not, their creation on the basis of the potential of the circular market in the area.

→ Create circular supply chains:
The business sector (industry and SMEs) is increasingly aware that circular supply chains would eliminate waste and increase efficiency by facilitating the multiple use of the initial resource. A supply chain is "circular" when waste is eliminated and products and materials recirculate into the system, unlocking enough value among the agents so that they are incentivized to participate. This is easier for those blue economy sectors in which materials can be disassembled and re-produced locally since this reduces the cost linked to the re-use and increases the value of products. It is recommended to ensure circular practices at the very outset of the supply chain in the framework of tender documents and contracts granting special fees or rebates for good environmental practices. Digitalisation is an important tool to strengthen circular economy opportunities as it can support supply chain and ensure traceability and transparency to the entire product value chain.

Economy & finance

→ Design and implement circular business models: circular business models rotate around three basic strategies: i) retain product ownership: producers rent or lease their products to the customer rather than selling it, and are responsible for products when consumers have 'finished' with them; ii) product life extension: products are designed to last longer, opening up possibilities for markets in used products; durability becomes the competitive differentiator and provides a strong rationale for premium pricing; iii) design for recycling: producers redesign their products and manufacturing processes to maximize recoverability of the materials involved to be used in new products.Ports deserve a special mention. In ports, circular elements can be added to their existing business models to enable circular operations, at the same time, they can become facilitators of circularity by triggering industrial symbiosis schemes within or near their premisses. Ports can also support circularity in cities' infrastructures by enabling heat, water and waste exchanges. Finally, they can contribute to the creation of circular markets by leveraging their function as transport hubs.

→ Address sectorial and territorial specificities: in order to identify and strengthen opportunities for circular economy, actions must be tailored to the specificities of each sector and its segments. Likewise, circular actions must consider the specificities of each country as well as the difference at the local level within the same country that often occur due to segment characteristics, supply chain, and market opportunities

Economy & finance

→ Ensure financial resources including through innovative financial tools:
In the short run, "blue" enterprises shifting to circular businesses will face significant costs. It is a fact that the circular economy ensures economic savings in the long term because the cost of recovering some material is still higher than their value. This drawback is exacerbated by the lack of incentives for SMEs to support the transition towards a circular economy. Structural investments, special taxation schemes, financial incentives are very much needed to enable the transition to circular economy assets (including

acquisition of equipment, skills, changes in logistics, etc.). The system of grants and loans embedded in the EU funding system will definitely help, even if access is not so easy (e.g., the BLUEfasma project highlighted the need to create a simplified system to access EU funds allocated to promote circularity in fisheries and aquaculture).

Know-how, awareness & skills

→ **Share practical knowledge and know-how: :**
Digitalisation is a powerful enabler of circularity in the blue economy sectors. It helps design and manufacture (e.g., 3D printing, artificial intelligence) products with low levels of waste and emissions, extend the life of products by making their maintenance more effective, sell services rather than products (e.g. sharing, leasing, etc.) so that firms can monitor each product along its entire lifecycle and improve the following generation. Since digitalisation of economy requires specific knowledge and abilities, the promotion of circular manufacturing cannot happen without digital literacy.

Technological innovation and strengthening of know-how are essential for the transition towards a circular economy. For this reason, it is crucial to link academic research with blue economy industries, share best practices and create communities of practice dedicated to circular economy in each country and at the regional level (e.g. lessons learnt from the BLUEfasma and Loop-Ports projects). Developing standards for circularity, or expanding existing standards with circularity dimensions, is also recommended for new products and services.

→ **Communicate Circular Economy as an opportunity:**
Few "blue" entrepreneurs grasp the meaning of circular economy, and fewer put in practice circular principles vis-à-vis the consolidated linear model. The main reason is that they do not perceive the full range of benefits that a circular system can bring to their business, especially entrepreneurs from the southern countries of the Mediterranean. For this reason, mechanisms for the participation of entrepreneurs should be designed while working to operationalize the so-called "social acceptance", namely the social license to operate in those blue economy sectors that have a significant impact on local communities.

→ **Raise consumer awareness:**
In order to boost circular economy in the blue sectors, increasing the demand for circular products is essential and the role of consumers is key. Ocean literacy, communication and educational activities targeting consumer groups should be undertaken for the different markets of the blue economy sectors.

→ **Ensure clarity of circular concepts and build needed skills:**
There is a need to clarify founding concepts of circularity such as eco-design and to end waste among many others. This requires supporting initiatives ranging from technical assistance to capacity-building programmes. On the other hand, working in the blue economy sectors requires specific skills that are not always readily available. In this regard, it is desirable to go beyond the academic approach and design flexible and informal mechanisms of exchange of ideas and practices, especially with the highest possible involvement of innovative start-ups and SMEs.

→ Emphasize the social dimension:
Circular economy provides opportunities for local communities. Circular economy models help keep traditional professions alive and counter urbanisation and abandonment of coastal villages. Circular business models can also be instrumental to create job opportunities for youth and women and other vulnerable social groups.

Concluding reflections

There are many initiatives, at different scales, on circular economy principles applied to the blue economy sectors in the Mediterranean. Cross-fertilization is thus highly recommended. Some interesting initiatives take place outside the Mediterranean region, they should be capitalized on and, whenever possible, adapted.

Most of the blue circular economy practices described in this report are from the northern shore of the Mediterranean. The countries from the MENA region are presenting very promising examples, but they still lack a systematic view and structured approach when it comes to implementing circular principles. Although almost all of the blue economic sectors are experimenting with circular initiatives, it must be noted that aquaculture and fisheries seem to offer the most accessible circular opportunities in terms of needed capacity and investment costs.

Many practices in the Mediterranean region are related to waste recycling and/or repair and re-use, but only a minor part implements up-cycling or eco-design approaches for a zero-waste economy. This confirms that the change of paradigm in the model of production (and consumption) is still far from being a common practice. Eco-design and zero-waste concepts, along with the whole circular economy approach, must continue to be promoted and communicated as well as facilitated from the regulatory point of view and financially or fiscally incentivized (e.g. grants and loans, tax exemptions, etc.).

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