LITERATURE REVIEW ON ECO-CONSTRUCTION, DECONSTRUCTION AND ECO-DESIGN INNOVATION IN THE BOATING INDUSTRY

Around Europe Advisors, Lda.

May 2020

I. INTRODUCTION

CAPITEN is an interregional cooperation project, supported by Interreg Atlantic Area programme, that brings together 18 partners from Portugal, Spain, France, Ireland and the United Kingdom. This project seeks to promote stronger growth across regions and create jobs in multiple sectors of the boating industry (tourism, water sports, industry and leisure).

It highlights innovative products (in particular those which will help increase the number of people participating in water sports), as well as the development of eco-design, eco-construction and deconstruction processes aiming to better sustainability processes in the sector (with special regard to the reduction of environmental impact and the reuse / recycling of waste generated).

Specifically, regarding the boating industry, this project focuses on reducing the carbon footprint, helping create a greener industry, being essential as a first step to develop knowledge about the geographical area within the framework of the programme, in order to identify regional stakeholders, the industrial processes at hand and the good practices to be shared / adapted among partners and / or project's territories.

Keeping in mind the added value its actions can (and should represent) for stakeholders of the boating sector of the participating regions, the CAPITEN project takes a regional form promoting territorial cooperation and allowing to share knowledge and experiences that will help identify solutions to specific issues of each region.

Alto Minho, as partner region on the project, is strongly committed to the sustainable development of this sector (in regard to water sports and tourism[1]), strengthening its development, and setting the blue and green economies as cornerstones.

The literature review on eco-construction, deconstruction and eco-design innovation in the boating industry was drawn up to be a report to help reflect on the sustainability of Alto Minho's boating sector, identifying needs and critical points, as well as presenting recommendations for developing actions which will contribute to raise awareness among stakeholders and, thus, mitigate the industry's negative environmental impact.

It is organized into six main chapters:

- Chapter 1 introduces the methodology followed for the preparation of this document;
- Chapter 2 not only presents the concept of environmental sustainability within the boating industry, but also the sector's impact on the environment (focusing on materials used);
- Chapter 3 examines the main concepts: eco-design, eco-construction and deconstruction, outlining the promotion of innovation which will help reduce the environmental impact of the boating industry;

[1] The strategic priorities are supported in different strategic planning and action documents that the region has been developing and implementing to reach a medium/long-term vision.

- Chapters 4 and 5 go through the literature review, presenting the national global context and then focusing in the Alto Minho region;
- A final chapter presents an overview of the main conclusions and recommendations that resulted from the analysis carried out in the previous chapters.

It is worth noting that the lack of data and the difficulty of collecting information from stakeholders of the nautical industry were critical factors for the development of this work, leading to the recommendations presented in the specific chapter.

Finally, it should be noted that this report is ought to be, in structure and content, **an exploratory document that aims to pave the way for debate and reflection on environmental issues in the context of the boating industry** in order for each territory and industry help meet the objectives of the most recent climate summit, held in December 2019 in Madrid.

II. METHODOLOGY

The methodology used for the development of this work was started together with the Intermunicipal Community (CIM) of Alto Minho, in July 2019, and its main purpose is to improve the knowledge about the environmental sustainability and impact of the region's boating industry.

The work was carried out in four sequential phases that are set out below, however it was necessary to adjust its duration (compared to the duration initially envisaged), result of the encountered difficulties in obtaining appropriate data needed to facilitate the achievement of the objectives pointed out above.

Phase1 – Development of a database

Following the database model established by the CAPITEN consortium, in regard to the information intended to be collected, it was possible to identify the stakeholders of Alto Minho's boating industry (including companies and their associative representatives; sports clubs and associations; public entities; universities and research centres), information which was completed and corrected by CIM Alto Minho.

All stakeholders were contacted by telephone or spoken to in person, and they were asked to confirm their identity and contact information and complete a short online survey (see Appendix 1) to identify their awareness level and action plans to reduce impact and promote environmental sustainability.

This survey allowed us to identify 34 regional stakeholders[2], which are active in the municipalities within CIM Alto Minho (Arcos de Valdevez, Caminha, Melgaço, Monção, Paredes de Coura, Ponte da Barca, Ponte de Lima, Valença, Viana do Castelo and Vila Nova de Cerveira).

Of the 34 contacted stakeholders, only 7 completed the online survey (see Appendix 2) corresponding to a response rate of 28%, which was a representative sample of the sector.

Phase 2 – Primary and secondary data collection

While developing the previous phase, secondary data was collected (using the sources provided by Alto Minho CIM and the information collected by the technical team of the study) in order to complete the information obtained in the first phase on eco-design, eco-construction and deconstruction processes under implementation / development by the regional boating industry.

Bearing in mind that literature review on a regional context should start by reviewing the literature at a national level and in order to ensure that this document reflects the specific

[2] This list was developed during second phase since the analysis of strategic documents that the region developed for the nautical sector made possible to identify stakeholders which did not at first appear in first phase. These stakeholders were not asked to complete the online survey.

reality of the regions of the other Portuguese CAPITEN partners, representatives were interviewed via Skype to collect primary data that complemented the information already collected from Alto Minho CIM.

Phase3 - Analysis and discussion of data

Then, the data collected was analysed and discussed, and the main limitations to the present study were identified (such as lack of information, the regional stakeholders' lack of willingness for innovation, and their few environmental sustainability actions).

Whenever necessary to ensure the correct treatment of data, additional primary and secondary data were collected, which lead to the conclusions obtained on the analysis carried out in this stage.

Relevant to mention that the study also focuses on the identification of aspects that contribute (could contribute) to the reduction of the environmental impact of the regional boating industry, and at this stage, the recommendations that were considered relevant to overcome the described limitations and constraints were also added.

The analysis of the stakeholders' performance was based on[3]:

- Waste management;
- Discharge and wastewater management;
- Air emissions and noise;
- Consumption of water, electricity and gas
- Implementation of ISO 14.001;
- Implementation / participation in innovative projects to reduce the environmental impact of the activity.

Phase 4 – Writing up the study

The results and conclusions of the previous phase gave rise to the final document, which was submitted to CIM Alto Minho and the other Portuguese CAPITEN partners for validation and comments.

[3] Analysis limited by the stakeholders' lack of willingness to conduct face-to-face interviews in order to identify their manufacture conditions and processes.

III. ENVIRONMENTAL SUSTAINABILITY IN THE BOATING INDUSTRY

Just like any other activity in close contact with the environment, the boating industry, in its entirety, assumes the duality of producing environmental assets and liabilities and, therefore, it is necessary to manage and reduce its ecological impact.

This industry is organized into a relevant set of processes with negative environmental impacts generated from greenhouse gas emissions and materials used.

More importantly, we are aware that the key raw material of the boating industry is the ocean, which makes it crucial to ensure that development takes place in an integrated manner, without turning its profitability and job creation capacity directly linked to the loss of quality of this raw material.

It's a challenge the boating industry faces, and it's vital for this activity to ensure the protection of ecosystems, thereby allowing the industry to keep developing its activities (regardless of typology), as well as help improving quality of life of coastal populations.

In this context, concepts such as eco-design or eco-construction, reuse, recycling or even circular economy are particularly relevant.

Applying eco-design concepts to the boating industry, for example, allows acting at the very beginning of the value chain of this industry, developing **a true strategy to prevent its environmental impacts.**

It is closely related to one of the methods considered to be most appropriate for assessing the environmental impact[4] of an activity or product: **the life cycle approach**, which takes into account (allows measuring) its environmental impact from conception to destruction, considering not only its use, but all activities related to it. In this context and within the boating industry, we should consider a specific type, yachts, whose useful life is more than 30 years and its construction period can be measured in days (see figure 1).

This approach takes into account the environmental impact of each product, not only from its design (concept and production process), but also considering its usage and what happens at the end of its useful life, thus promoting forward-looking reflection on natural resource management in manufacturing processes, energy consumption, environmental impact from its usage to end, and will also help preventing/controlling each product's contribution to climate change.

The life cycle of the product begins with raw material extraction, followed by the manufacture of semi-finished products and their assembly and completion operations. It is used until it is out of use, and on this last phase where the product becomes waste are also included materials recycling and waste management processes.

[4] Concept related to ISO 14.001 standard, better described in the following chapters.

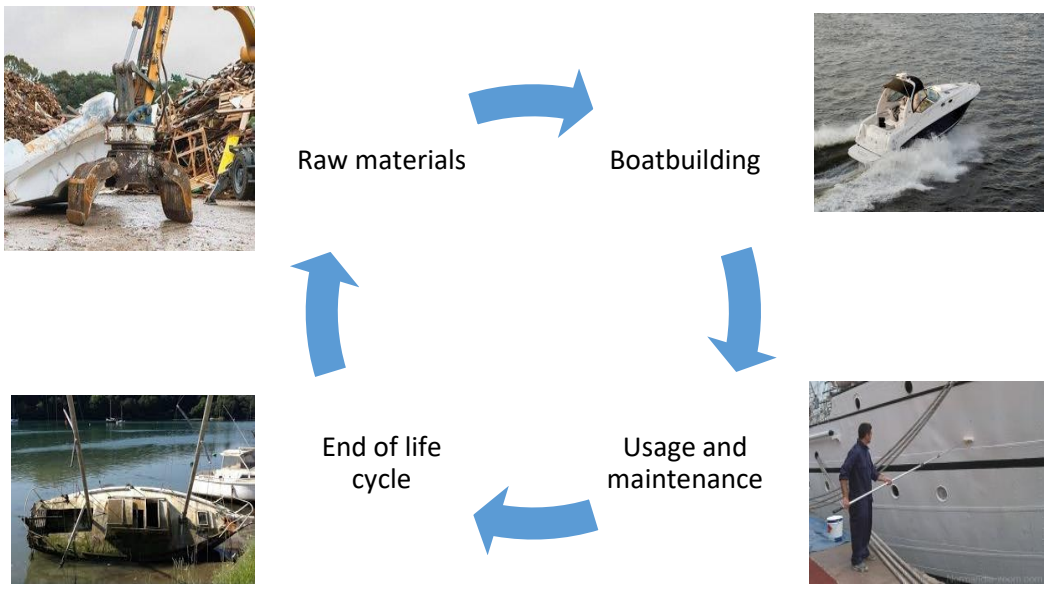

Figure 1 – Vessel's life cycle (Source: own elaboration)

In the specific case of the marine industry, applying the product life cycle approach must consider critical variables: weight and useful life.

- ***Weight optimisation:*** it's important to consider that the ecological balance should be proportional to the amount of construction materials and any weight reduction has an immediate positive effect in terms of environmental impact (extraction, manufacturing, end of life)
  However, this on weight reduction can also lower the power required to propel the vessel, and thus having an impact in both energy and materials savings during the use phase and therefore weight can represent a significant disadvantage in terms of efficiency, budget, and ecological balance. Eco-design and eco-construction establish that it is necessary to best optimize the architecture of the ship and its equipment.

- ***Lifetime:*** the environmental impacts generated throughout a vessel's lifetime are related to its usage period. So, a ship with low environmental impact during the construction phase and a short life cycle is not necessarily better for environment than a second vessel with more impact during construction, but whose life cycle is longer. Check, for example, the case of a sailboat (Figure 2):

	Hull (material)	Duration	Hull (material)
Sailboat	Fibreglass	30 years	High
	Wood	+ 100 years (depending on protection, maintenance and / or restoration)	Low
	Aluminium	+ 50 years	High

Figure 2 - Duration vs. Environmental Impact (Source: own elaboration)

The main phases of building pleasure yachts are the construction of the hull and deck, the interior design, installation of equipment and sails (in case of a sailboat), the installation of the engine and propulsion system, as well as technical and electronic boat equipment, and the construction of the hull, deck, and structure are the most demanding in terms of resources and energy consumption, critical phases to product sustainability in the boating industry.
Furthermore, resources (especially materials) used in the different manufacturing processes of the boating industry become fundamental elements in determining the sustainability of this sector. The main factors to consider are: volume of materials needed and how long it takes to replace it in/by nature; energy consumption of the manufacturing processes; the amount and typology of maintenance and conservation materials; volume of waste generated at the end of life and the capacity of reusing/recycling waste.

There are no figures in Europe showing the proportion of the different materials used in the construction of hulls, structures, and bridges. However, it is reasonable to assert that European recreational crafts are built with composite materials. Wood, aluminium, and steel are also used as building materials, but they represent a minor part of the current production volumes[5]. Metal and wood in small amounts are preferred materials for the vessel's interior design and equipment.

Considering its importance in a European context, the sustainability of the above-mentioned materials is covered in the following points:

a. Aluminium

Aluminium (AI) is the most abundant metal in the Earth's crust, within the non-ferrous metals, and the most used in the boating industry and other everyday applications.

The principal advantages are its alloy (2,70g/cm^3), the behaviour regarding mechanical resistance of mucosal coating, high thermal and electrical conductivity, durability (aluminium is stable in the air) and good corrosion resistance (with a correct surface treatment it is resistant to both seawater and many water solutions and chemical agents), which enable its use in many structural and decorative applications. On the other hand, if an aluminium casing

[5] As an illustration, the French nautical industry produces about 95% of boats in composite, about 3% in aluminium, some 2% in wood (plywood or moulded wood), and less than 1% in steel.

does not oxidize, it may be subject to electrolysis, arising electrical leaks and causing discoloration (a phenomenon that often occurs in ports).

Aluminium is a good choice for boatbuilding because it can be reused after its initial product, since the use of recycled material for re-melting aluminium greatly reduces the energy, compared to the one used for processing aluminium material extracted directly from nature (saving up to 90%).

b. Steel

Manufacturing, processing and recycling steel is already duly regulated (controlled) registering little impact on the environment. However, it has a significant negative impact throughout the phase of use of the product (in this case, vessels), the longest one of the life cycle, since it is very dense and very sensitive to corrosion.

Due to its rigidity and resistance features, steel is used in mechanically resistant and stable vessels, but still, it requires maintenance and more energy to move on water.

c. Wood

Wooden hulls are usually made of plywood. The moulded wood technique, created after World War II, consists of a plank of thin strips of wood, glued to each other and covered with fibres placed transversally on top of each other, using high pressure and heat, which allow a wide variety of shapes.

A plywood or moulded wooden hull can be lighter than metal or composite hulls. On the other hand, the strength-to-weight ratio is higher compared to aluminium and wood is not only good for impact resistance, but also aesthetics. Nevertheless, maintenance is needed.

Wood has been the preferred material for building traditional and resistant boats.

d. Composite materials

Boats built from sandwich or monolithic composites account for the vast majority of recreational crafts produced today in Europe. The principal advantages are its light construction weight, low costs, rigidity, complex shapes, Impact resistance and damage tolerance, among others.

The use of composite materials in shipbuilding dates to the 1940s (first introduced by the United States Navy), which represented a new chapter in shipbuilding.

Advanced composite materials combined with light structural innovations represent the main tools to reduce hull weight.

e. Thermoplastic polymers and composite materials

In recent years, thermoplastic polymers or thermoplastic polymers reinforced with fibreglass or carbon started being used to build a large number of small vessels (kayaks, canoes, small boats, etc.). These polymers have high impact resistance and are recyclable. However, if not reinforced, they are not very resistant in flexion, which limits the size of the parts produced.

In this context, the application of glass fibre laminates (e.g. Twintex), thermoplastic polymers or carbon fibres is widened, due to its lightness (epoxy (EP) is lighter than polyester) and high impact resistance. The difficulty of implementing these materials has, however, limited their use in the manufacture of expensive parts whose impact resistance is essential.

The following figure covers a brief analysis of the materials and their environmental impacts throughout a product's life cycle.

Material	Extraction	Transformation	Usage	Recycling
Aluminium	Origin: bauxite. (-) Non-renewable. (-) Very contaminant red mud generator.	(-) 4 to 5 tonnes of bauxite generates 1 tonne of aluminium. (-) Consumes large amounts of energy. (-) Consumes large amounts of water and cryolite (used as a solvent). (-) Emission of CO2 by electrolysis.	(+) Corrosion resistant (with the right surface treatment, it is resistant to sea water, as well as many aqueous solutions and other chemical agents) (+) Light	(+) Very regulated (controlled) and it's about 95% recyclable. (+) It uses only 5% of the energy required for manufacturing with aluminium and bauxite extraction.
Steel	Origin: iron. (-) Non-renewable. (+) Abundant resource.	(+) Duly regulated (controlled) process.	(-) Very sensitive to corrosion (requires means of protection - painting). (-) Heavy (leading to high fuel consumption on motorboats)	(+) Almost 100% recyclable.
Wood	Origin: forest. (+) Renewable if the forest is used sustainably. (+) Forest is a carbon emitter and oxygen source. (-) Use of imported wood (generating CO2 emissions in transport).	(+) Solid wood (little used) (-) Plywood (wood/potential VOC emission).	(-) Water-sensitive (requires protective media - painting, resin coatings, ...)	(-) Solid wood - possible in traditional construction. (-) Plywood - difficult to achieve.

Material	Extraction	Transformation	Usage	Recycling
Composite materials	(-) Dependent on the availability of petroleum resources for resins. (+) Silice for fibreglass.	(-) A large amount of energy is needed for manufacturing fibres and resins. (-) There is VOC emissions in products and processes.	(+) Corrosion resistant. - (+) Lightweight.	(-) Currently difficult to achieve. There are, however, (+) several initiatives and works in progress towards this direction.
Thermoplastic polymers and composite materials	(-) Depends on the availability of petroleum resources for resins. (+) Silice for glass fibres.	(-) A large amount of energy is needed for manufacturing fibres and resins. (+) No VOC emissions during the process.	(+) High impact resistance. (-) Low rigidity and mechanical resistance.	(+) Duly regulated (controlled).

Figure 3 - Analysis of construction materials used by the marine industry (Source: own elaboration)

All construction materials have advantages and disadvantages according to their environmental impact and it is therefore essential to find a balance in using each one of them.

It should be noted, however, that wood is not always the most environmentally friendly material for the marine industry. In regard to marinas, for example, it is not due to the large quantity of surface coatings and adhesives required for construction and maintenance processes. In this case, Green building solutions lead to greener resins.

On the other hand, steel and aluminium have high manufacture and maintenance costs, and it also requires high energy consumption for the propulsion system, which must be taken into consideration.

Composite materials have many benefits, but their recycling processes need significant improvement. Furthermore, depending on the resin and the implementation process in use, construction can be a source of Volatile Organic Compound (VOC) emissions, which is harmful to human health and the environment.

Notwithstanding, it is worth mentioning the investment in research and experiences all over the world, which aims at improving the sustainability of materials used in the maritime industry. In Brazil, composites are being developed, which aggregate polymers and vegetable fibres (such as coconut). In Spain, tests are being developed on new compounds (Thermal Recycling of Composites) resulting from recycling glass and carbon fibres of end-of-life vessels, which can even be used for 3D printing, for example. In Denmark, boats produced with reused plastic bottles are being tested (converting marine waste into recreational boats).

Essential to the sustainability of the marine industry (as any other industry) is the need to monitor its environmental impacts (follow-up).

It is important to identify which nautical activities have the potential to generate greater environmental impact. One example is the use of fishing and sport ports, especially in regard to:

- Discharge of different types of wastewater in the usual use of boats (black water, wastewater from cleaning boats, ballast water, sewage water ...);
- Pollution (from boat movement in ports, movement of vehicles on docks, working machinery, loading work, noise ...);
- Dumping waste from the usual use of both sport and fishing vessels and merchant ships.

In this sense, the International Convention for the Prevention of Pollution from Ships (MARPOL) was established, which is the main international convention covering prevention of pollution of the marine environment by ships due to operational or accidental causes.

MARPOL Convention was adopted by the International Maritime Organization (IMO) and was adopted in response to the large number of tanker accidents that occurred in 1976 and 1977. With several updates since then, this international agreement includes regulations aimed at preventing and minimising pollution generated by ships (either accidental or resulting from routine operations). Currently, it includes six appendices, most of which with strict controls on operational discharges[6].

As for waste reception and management, it is also important to outline that, in the Portuguese case, each port should develop its own Waste Reception and Management Plan[7]. However, this seems to be an "exceptional" case since as far as traditional boats and some types of recreational craft are concerned, whose main building materials are iron and wood, the waste from end-of-life products is diverted to and treated by facilities for collection, management, and treatment of non-specialized waste (in waste generated by the nautical sector) and no specific process for its dismantling is defined/established[8].

In the same context, most of today's vessels (in Europe) are produced with polymers and composites which (like aluminium) are known to be more polluting than wood and therefore require more complex and more expensive end-of-life waste management and recycling processes, and at national level there are no specific regulations for the scrapping/dismantling these "new" vessels[9].

[6] Appendix I - Regulations for the Prevention of Pollution by Oil; Appendix II - Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk; Appendix III - Prevention of Pollution by Harmful Substances Carried by Sea in Packaged; Appendix IV - Prevention of Pollution by Sewage from Ships; Appendix V - Prevention of Pollution by Garbage from Ships; Appendix VI - Prevention of Air Pollution from Ships.

[7] The Waste Reception and Management Plan of the Port of Viana do Castelo will be further mentioned due to its direct impact on the sustainability of Alto Minho's boating sector.

[8] Topic overviewed on Skype interview with the Associação Comercial e Industrial do Funchal (partner in CAPITEN project), on 4th December 2019, indicating that the situation is no different from the one in the mainland.

[9] Idem.

Furthermore, ISO[10] (International Organization for Standardization) has developed ISO 14.001, which defines an environmental management system enabling organizations to improve their environmental performance. ISO 14.001 aims to support organizations which intend to manage their environmental responsibilities in a systematic way, resulting in a more environmentally sustainable activity. The intended outcomes include:

- Enhancement of environmental performance;
- Fulfilment of compliance obligations;
- Achievement of environmental objectives.

ISO 14.001 is applicable to any organization, regardless of size, type and nature, and applies to the nautical sector. It also applies to the environmental aspects of its activities, products and services that the organization determines it can either control or influence considering a life cycle perspective.

[10] ISO (International Organization for Standardization) is an independent, non-governmental international organization with a membership of 164 national standards bodies. It brings together experts to share knowledge and develop voluntary, consensus-based, market relevant International standards which support innovation and provide solutions to global challenges.

IV. ECO-CONSTRUCTION, DECONSTRUCTION AND ECO-DESIGN INNOVATION IN THE BOATING INDUSTRY

Eco-construction, deconstruction and eco-design are directly related to the need for developing efficient products in terms of energy and resource consumption.

Just like other sectors, having in mind the impact of the development and growth of the leisure marine sector and, consequently, its contribution to climate change, has facilitated support and encourage green innovations, fostering its activities and products.

It is, therefore, all the more important to improve its waste recycling procedures, as well as the incorporation of recycled products into manufacturing processes. It is increasingly important to know and monitor the environmental impact caused by these activities and the use of products, not only to improve regulating and controlling the sector, but also considering the importance of preventing those impacts.

As previously mentioned, the maritime industry is focusing its attention on innovative issues, such as the introduction of biodegradable and contaminant free materials, renewable energies (including electric/hybrid motors), the application of effective processes for dismantling defunct vessels and the improvement of environmental management processes on ports and marinas.

As far as vessels are concerned, the concepts initially presented – eco-design, eco-construction and deconstruction - fundamental to the sustainability of the nautical sector (and from the perspective of the product life cycle) are discussed below.

a. Eco-construction and Eco-design

Eco-construction is a broad concept with different applications, but it always assesses environmental issues associated with the choice of materials and construction processes. It is about improving the conditions of the final products through energy efficiency and the use of green materials.

In the case of the marine industry, it represents first of all a change in industrial culture where business models "accept" and respond to the fact that resources are not unlimited. It is not just a question of producing environmentally friendly vessels, but first and foremost doing it by using methodologies and processes that respect and safeguard them.

Eco-construction is closely linked to eco-design or ecological design, the process by which the design of products considers the environment as well as cost, quality, aesthetics, durability, etc.

Its objective is to reduce the environmental impact of the product throughout its life cycle.

Although eco-design is also related to sustainable design, they correspond to different concepts: if the goal of eco-design is to reduce the environmental impact of the product throughout its life cycle, the goal of sustainable design is the same, but using waste as raw material in manufacture processes.

Sustainable design aims to create designs that use materials in the manufacturing process which can be reused ensuring a new use for products that, in principle, did not have it, while ecological design can resort to any material.

An example of this distinction can be found in surfboard design. Primarily, these surfboards were made of polyurethane foam, wood, polyester resin and fibreglass. In order to function correctly and ensure that the materials perform their functions properly, very toxic chemicals are often used (affecting soil, sea and air). However, in recent decades, different materials and resins have been combined to find a solution that has revolutionized the market: epoxy. These boards, different from the previous ones (now resulting from eco-design), are a combination of polystyrene foams, epoxy resin and fibreglass, resulting in a lighter and more durable surfboard.

Another solution, this time by sustainable design, includes projects that use recycled wood and recycled plastics for manufacturing surfboards.

The current trend applies these concepts, with the objective of respecting the environment and climate change through a sustainable and economically viable maritime sector. An industry oriented to minimize the environmental impact and manufacturing boats designed to respect the marine environment.

The social and global commitment give rise to projects that are increasingly regulated in terms of environmental and social efficiency and not just focused on the economic value (profitability).

Companies on this study are now (or should be as soon as possible) asked to be aware of the impact of the company's projects and businesses on the environment, to consider in their manufacturing processes sustainable applications and join the "green" wave (now also included in the concept of corporate social responsibility - CSR).

In addition to the environmental impact of ship construction and repair (including shipyards), as well as the impact of raw materials used in manufacturing processes (analysed in the previous section), the shipbuilding industry plays a key role in the process of better manage these vessels' operations and environmental performance.

Traditionally, ship construction and repair are understood as an autonomous and totally independent activity, solely responsible for what happens on its premises and unaccountable for what happens to vessels once delivered to the final consumer. In the case of ships, for example, if a shipowner requests the construction of a ship designed to be used with heavy fuel oil, this is the type of vessel that the shipyard will build.

However, in a narrower perspective of the correlation between construction, use, maintenance and eventual dismantling of different types of vessels, the shipyard should be responsible for the environmental impacts that such vessel will generate throughout its lifetime.

A more integrated approach is therefore needed, aware of the challenges, technical improvements, available solutions and technological innovation introduced in the sector, leading to environmentally improved products.

Design a "green" boat is more than select greener raw materials or components easier to assemble (reducing production times, labour costs and energy consumption), but also parts and

components that are easily removed, recovered and recycled at the end of the vessel's life. This is a complex set of areas and concepts that need to be put together in order to reduce/prevent the environmental impacts of this product (see Figure 4).

Figure 4- Working areas within the framework of Eco-design of nautical products (Source: Monsó, 2012)

Ecological design is an integral and indispensable part of any preventive strategy to be implemented in the nautical sector, ensuring that the environmental impact of products is considered from their design phase.

It is also important to point out that eco-design is regulated by a set of European directives that aim to improve the environmental performance of the most diverse products, including nautical products.

b. Deconstruction

Also important is the industry's sustainable action on the last stage of the products' life cycle, especially if these products may constitute hazardous waste and/or waste that is difficult to process/recycle.

It is as important as the little regulation of end-of-life vessels, and in the specific case of the nautical sector, the non-existent management of disused vessels.

The deconstruction of vessels requires to disassemble the structure, with the goal of dismantling or demolishing it (regardless of whether the parts generated in the process can be recycled).

This is normally carried out on a quay, yard, or dismantling dock and includes a wide range of activities, from dismantling gears and equipment to cutting and recycling the vessel’s structure.

The deconstruction of boats is understood as a difficult and complex process to apply and enforce due essentially to the impacts on the environment and human health as well as the safety levels it requires.

Ship dismantling implies the separation and recovery of the different elements, assuming the materials are hazardous, and it is essential to ensure the return to a useful life of some or all of these materials.

Reusing and recycling materials seem fundamental to reduce waste currently generated by the nautical industry (returning to the concepts explained above, i.e. the need to prevent the impacts of disused vessels through the use of alternative raw materials instead of non-renewable materials) and/or for the identification of new uses of equipment and recovered elements.

The problem of boat dismantling and scrapping is one of the most relevant problems of today's nautical industry, although large vessels have well-defined processes for their dismantling end-of-life ships, as far as pleasure boats (especially yachts) are concerned, the lack of specific processes, regulations and infrastructure leads to abandoned boats in marinas. In regard to sport boats (such as boards or kayaks), there is no information on their dismantling process even though it has been (empirically) identified that the usual practice is only to dispose of "leftovers" resulting from major damage (such as ship cracking) and disposed in inorganic (and therefore non-specific) waste containers.

Finally, twenty-five to twenty-nine years constitutes the useful life of a ship and its destination is most likely to be demolition. Obviously, they can be stored and be a tourist attraction or marine habitat (IMO, 2004), but the most common action is demolition.

Taking into account that there is a set of materials common to all ships (asbestos; PCBs - potentially harmful compounds to human health and the environment; ballast water and sewage water - both polluted waters; various oils; paints and coatings; metals among others), reaching the end of their useful life (containing a set of hazardous materials) makes it a hazardous waste. And like any hazardous waste, it must be sent for treatment or disposal and therefore represents an increased cost to its owner.

Dismantling and recycling thus become a key step towards the desired sustainability:

- The **ferrous and non-ferrous metal** component increases the value of the ship at the end of its useful life. The use of recycled scrap now represents 40% to 60% of the inputs to EU metal production
- Recycling scrap requires less **energy** than mineral extraction and is therefore very profitable for the ship scrap industry.

Activities related to metal waste management and the dismantling of ship structures and equipment are expanding worldwide, especially in developing countries, which see it as a profitable and practical business.

This is a "win-win" solution as these low costs are attractive to shipowners at the end of their lifetime as well as to those who are willing to set up dismantling and recycling businesses in developing countries. These are countries with limited capacity for the management of hazardous

waste and other wastes and where concerns for public health and the environment are not among their strategic priorities.

c. Sustainable Boating Industry

Following the points mentioned above, it is worth reflecting on what can be done to make a more sustainable boating industry.

In the context, there are already some generally accepted premises:

- The commitment to use eco-materials, by promoting self-consumption and energy efficiency in boatbuilding processes;
- The promotion of eco-design that considers the environment in boats' development process;
- The use of renewable energy to propel and power ships;
- The promotion of technology transfer related to the safe management of hazardous waste and other locally produced waste types to countries/regions that do not yet have access to it;
- Allow hazardous waste and other waste types to be moved solely when the transport and destination of such waste is environmentally safe;
- Guarantee protection, through strict regulation for construction and repair infrastructures of vessels (including shipyards) carrying out this activity (management and recycling of hazardous waste and other waste types related to scrapping of vessels), within standards that protect human health and the environment from the harmful effects that may result.

This information can be systematised considering the different life cycle stages of vessels:

Phase	Actions to lessen the impact on the environment
Design	1. Integration of Life cycle. 2. Systems and processes with low CO2 emissions. 3. Systems and processes with low water emissions. 4. Use of recycled and recyclable materials. 5. By-product recovery concept. 6. Energy efficiency. 7. Low maintenance.
Production	1. Efficient use of natural resources. 2. Use of recycled/sustainably-sourced products 3. Energy efficient production systems. 4. Automated and fast production systems. 5. Minimization of emissions. 6. Minimization of waste in the production process.

Phase	Actions to lessen the impact on the environment
Distribution	1. Ecological and recyclable packaging. 2. Require suppliers to meet minimum environmental requirements (ISO 14.001). 3. Design of energy-efficient stores. 4. Management of administrative processes to keep paper wastage, transport and low water footprint to a minimum. 5. Efficient distribution of products by train or boat.
Communication and CSR	1. Collaboration with sustainable environmental projects and sea conservation. 2. Quality CSR internally and externally. 3. Direct interaction with end users for a responsible use of nautical products. 4. Awareness and communication of knowledge and conservation of the sea.
Consumerism	1. Editing of good practice manuals for responsible use of marine products. 2. Updated information on the web on issues and themes of responsible and efficient use.
Recycling	1. Information to own and manage waste in case of disuse or accident. 2. System to facilitate removal and decontamination.

Figure 5 - Environmental improvement actions in the nautical sector (Source: Monsó, 2012)

Also included in the current sustainability trends of the nautical sector is high autonomy electric motors such as the Horizon 2020 "E-Ferry" project whose aim is to "promote energy efficiency and not emit greenhouse gases" and thus meeting the IMO's objective of reducing these gases at least 50% by 2050 (compared to 2008) in relation to nautical transport. The same development logic is followed by hybrid monitoring solutions, which are the focus for the development of "green" nautical transport in countries such as Japan or the United States of America.

No less important is the implementation of regulations such as ISO 14.001 (Environmental Management System) by the nautical sector, as indicated above. This standard allows companies to show their commitment to environmental protection by managing the risks related to the activity (in this case, design, construction, and deconstruction processes).

ISO standards recognise the need for standardisation of management tools in the environmental field, being ISO 14.001 the reference standard for the implementation of an Environmental Management System that specifies audit requirements for certification purposes.

As mentioned in chapter III, ISO helps identify and manage environmental risks related to internal processes carried out by an organization and identifies the requirements for effective risk management, with the objective of preventing and protecting the environment, provide legal compliance and satisfy socio-economic needs.

The ISO 14.001 certification is an added value for companies and organizations that want to inspire greater confidence in customers, employees, communities, as well as society. This vote of confidence comes from the **voluntary commitment to improve environmental behaviour**.

In response to the emerging global concern about the environment and the proliferation of regional/national environmental standards, it is now a universal indicator to assess the efforts of an organization to ensure reliable and adequate environmental protection.

The ISO 14.001 does not set specific environmental performance criteria for pollution prevention, nor does it interfere with global environmental performance, but rather is meant to build tools and systems focused on the organisation's manufacturing processes and their effects or externalities on the environment.

This standard, from the ISO 14.000 series, maps out a new approach that governments and the industry can follow to set up efficient measures to tackle environmental issues. In the specific case of ship dismantling, there are additional efforts by the international community to control the activities related to this process and make it a sustainable and safe activity. To this end, a set of international conventions, guidelines and regulations has been established, the most relevant being the following:

- IMO Guidelines on Ship Recycling and reduce hazardous substances in the ship, as well as the assessment and selection of the dismantling location;
- Technical guidelines for the environmentally sound management of the full and partial Dismantling of Ships (Basel Convention), setting out procedures and requirements that must be implemented to attain Environmentally Sound Management of hazardous wastes.
- Guidelines on health and safety in ship scrapping (ILO) on the safety and health of workers involved in ship scrapping;
- Industry Code of Practice on Ship Recycling (ICS) and the minimization of the use of hazardous substances on the ship;
- Green Paper On better ship dismantling (European Union – COM (2007) 0269), which aims to make the nautical sector a more sustainable and environmentally- friendly activity;
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal;
- The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships
- Regulation (EC) No 1013/2006 of the European Parliament and of the Council on shipments of waste;
- Regulation (EU) No 1257/2013 of the European Parliament and of the Council on ship recycling.

V. LITERATURE REVIEW ON PORTUGAL'S BOATING INDUSTRY

a. Key characteristics

The Portuguese coast is extensive, around 2,800 km in length and has an excellent variety of features for developing boating activities.

Portugal is situated in south-western Europe, bordering the Atlantic Ocean in the west, and includes two autonomous regions Azores and Madeira, benefiting from geostrategic conditions that help to reinforce existing tourism flow associated with water-related activities (recreation and sports) mostly transport of persons by sea (including cruises) and transport of goods by boat / ship that sail between the North and South of Europe and between American and Europe.

The Portuguese mainland coast is very diverse, with significant differences from a morphological point of view, which determines the existence of specific favourable conditions for recreational and sporting nautical practices. In addition, the transparency of the waters, especially in the Azores and Madeira, as well as the artificial reefs in the Algarve, are basic conditions for increasing diving activities.

Portugal also presents a diversity of conditions in continental waters - rivers, lagoons and reservoirs - that enables the practice of nautical activities such as rowing, canoeing, rafting, canyoning, sport fishing, among others.

In addition to the excellent natural resources previously identified, the weather conditions are very favourable to the practice of nautical activities throughout the year. It is also added the fact that Portugal has hosted, in recent years, several major international nautical events such as the Volvo Ocean Race (sailing) or the Moche RipCurl Pro Portugal (surfing), which have contributed to position and strengthen the country's image as a destination of excellence for the practice of these sports.

More specifically, they are resources for the practice of different nautical activities in continental waters:

- **Alto Minho**: Minho, Lima, Cávado rivers and its affluents have excellent conditions for several canoeing activities, canyoning (Laboreiro and Âncora rivers), jet-ski (Cávado river), sport fishing, rafting (Minho river), rowing and other sport activities.
- **Douro River** (and its affluents): have excellent conditions for rowing and canoeing (in Melres, Gondomar and Caldas de Aregos, Resende), motorboat and jet-ski (Caldas de Aregos, Resende), rafting (Paiva River), river cruises in the Douro valley. The quality of some of the reservoirs along the river, together with the presence of well-equipped hotels to support nautical activities, are attractive factors for international teams of different sports to carry out concentrations during the part of the year when, for climatic reasons, they cannot practice in their countries.

- **Baía de Aveiro:** has excellent conditions for rowing, canoeing and other water-sport activities.
- **Mondego River** (and its affluents): have excellent conditions for rowing and canoeing (Aguieira reservoir) and rafting (in Alva and Alvoco rivers). Note that the Aguieira reservoir is often used to host training teams from Eastern Europe during the winter season, taking advantage of the excellent natural, climatic and welcoming conditions it offers.
- **Tagus River** (and its affluents - with emphasis on the Tagus estuary): with excellent conditions for navigation, rowing, canoeing and hiking on the sea and the Castelo de Bode (Zêzere) dam, with excellent conditions for the practice of motorboats, jet-ski and wakeboard.
- **Sado Estuary** presents conditions for the practice of sailing and other marine tourism activities, such as bird and dolphin watching.
- **Dams of Alentejo** (namely: Avis, Montargil and Santa Clara) present excellent conditions for sport fishing, rowing and canoeing, motorboat and wakeboard (Montargil).
- **Guadiana River** (and especially the Alqueva dam with a water surface of about 250 km2, length of 83 km and 1200 km of banks): it presents excellent conditions for different nautical activities and for the development of tourism activities, such as renting houseboats and bird watching.

Similarly, there are coastal areas with adequate conditions for different nautical activities, such as surfing, and according to the "Portugal Surf Guide", the best places for this sport are:

- **North**: Moledo do Minho, Arda, Aguçadoura, Internacional de Matosinhos and Espinho beaches.
- **Center**: Barra, Cabedelo, Buarcos/Tamargueira, Lagido, Cantinho da Baía, Super Tubos (Peniche), Areia Branca, Navio (Santa Cruz), Ribeira D'Ilhas and Foz Lizandro.
- **Lisbon area:** Grande, Guincho, Carcavelos, São João Lorosa and Surf Sports Center and Fonte da Telha beaches.
- **Alentejo:** São Torpes and Malhão beaches.
- **Algarve:** Arrifana, Amado, Cordoama, Faro and Sagres beaches.
- **Madeira:** Machico beach (east coast).
- **Azores:** Santa Bárbara-Areais beach.

In turn, sailing is common all over the country, especially in the Lisbon area, Cascais, Sesimbra, Troia, Algarve and autonomous areas (where the largest number of annual events are held, not only in sailing but also cruising).

Diving is possible in different parts of the country due to favourable conditions:

- Mainland: Berlengas, Sesimbra (good learn-to-dive destination), Cabo de Sines, passing by Vila Nova de Milfontes, Porto Covo, until Pessegueiro Island, in Sagres (the most attractive places are the "Vapor das 19"; Shadows Canyon" cave and Carrapateira Beach) and in the Algarve (worth noting the Ocean Revival Project14 situated off the coastal

town of Portimão, an artificial reef unique in the world, which includes ships from the Portuguese Navy).

- In Azores, Santa Maria Island is an ideal place for diving.

Finally, marine tourism activities have a small expression all over the coast and in some inland rivers being especially held in the Algarve and Azores and Madeira (relating to whale and seabirds watching, and fishing for recreation and sport).

Portugal, given its coastal extension and conditions for nautical activities of different kinds as described, is an ideal place to build a structurally strong naval industry and harness its full potential.

However, building sport and recreational boats in Portugal is a small industry focused mainly on motorized recreational boats and inflatable boat although there is also a sailing yard, where several models are manufactured, as well as custom designs, mainly in fibreglass.

In contrast to the limited scenario of manufacturing surfboards and similar boards, the company that stands out in building canoes and kayaks, with medals won in European, World and Olympic championships – is the Nelo company[11].

All Portuguese companies working in the marine leisure sector have called themselves environmentally conscious, but there are still few examples of marine leisure companies using sustainable production processes and ecological building materials.

In contrast to the general trend, in 2015 Algarve Sun Concept was born, a shipbuilding company specialized in developing and manufacturing electro-solar boats, an innovative concept in line with processes already mentioned and under development in the United States and Japan. It focuses on the manufacture of recreational and professional boats with electro-solar propulsion, aimed at specific market segments (the recreational market and the commercial and professional market (tourism and fishing)). Its flagship product is boats for protected coastal areas and lakes and rivers, where noise, contamination and stress have an impact on landscape and well-being.

b. Boating industry in Portugal

In the sea economy, the sectors related to shipbuilding and maintenance/repair, entertainment, sport and tourism are among the most relevant in the national framework.

In the case of the shipbuilding industry, from 2014 onwards, it began to recover despite the decline in 2008 and 2011, largely due to the fact that the Viana do Castelo shipyard stopped building boats, growing at a higher rate than the rest of the sea economy and companies from this industry[12].

From 2014-2017, the revenue of building of ships and floating structures registered an average annual growth of 43.7%. In the same period, the construction of recreational and sports boats

[11] Due to its contribution to the development of the nautical sector in Alto Minho, this company will be described in more detail in the following chapter.
[12] On a global outlook of Portugal, it highlights the vital role of the maritime industry of Alto Minho.

recorded a similar average annual growth of about 30%. Ship repair and maintenance are at the same levels compared to 2014.

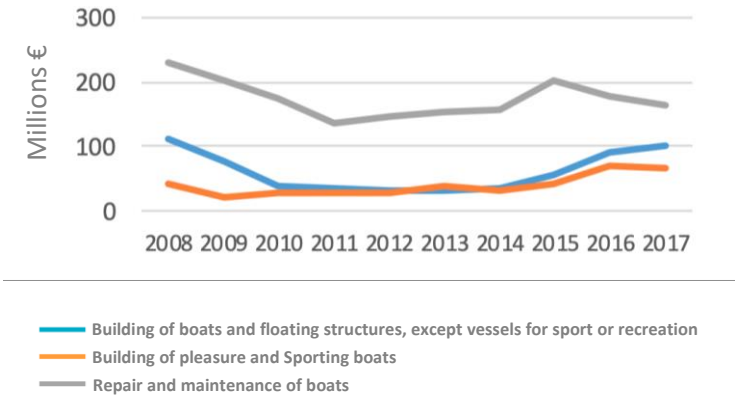

Figure 6 - Revenue of Portuguese maritime industry (Sousa, 2019)

However, in the same period, there was a loss in productivity compared to other European Union countries (in 2016, around 24% lower than the European average) and this is explained by different researchers as a result of a weak national focus on nautical innovation (especially the limitation imposed on the private sector to access programmes to support innovation).

In terms of competitiveness of national shipyards, for example, this is explained by the low implementation of industry 4.0 in this activity.

As the competitive advantages ensured by the privileged geographical location, the mild weather conditions and the specialized workforce, which still continue to guarantee employment and wealth, making the nautical sector one of the most relevant in the Portuguese economy, are not sufficient, it is necessary to make this sector evolve in order to meet the demands of globalization.

As a result, organizations like PwC (2020) present the main challenges faced by shipbuilding and ship maintenance & repair activity in Portugal:

- *To specialize some shipyards in building sophisticated small and medium-sized vessels and incorporate high added value and state of the art technology;*
- *Review the technologies and processes used in shipbuilding and maintenance&repair activity, taking into account the challenges of competitiveness and environmental sustainability that lie ahead;*
- *Invest in sustainable shipbuilding and maintenance&repair activity as a differentiating factor and generating a unique value proposal".*

In this context and even if on a smaller scale, the importance of projects such as CAPITEN and its support to initiatives such as the one developed by AD ELO (Local Development Association of Bairrada and Mondego) should be highlighted as good practices of eco-design and eco-construction. In fact, it is an action that demonstrates the capacity that the national nautical sector already has for eco-innovation (which needs to be developed).

This partner of CIM Alto Minho, through this project, supported the creation of a surfboard using exclusively recyclable materials (in this case, biomass). The surfboard is an example of

sustainability and use of biodegradable materials, being, above all, an element of promotion and dissemination of the potential and opportunities generated by sustainable boating and demonstration of the ability to establish processes and products with reduced environmental impact, in this case, sport[13].

Of a different nature, emphasis should also be given to the eco-reconstruction experiments on traditional Portuguese vessels (which have been taking place along the national Atlantic coast). One example is the recovery of the extinct *barca serrana* of the Mondego river[14] which combines ancestral boat building techniques with the industry's concept of sustainability[15].

In the context of fishing vessels, the challenge is to "*encourage research on technologies and processes that reduce the cost related to energy needed to propel fishing vessels in order to cope with the impacts of rising fuel prices and/or decline in market fish prices* " (PwC, 2020).

c. Legal and regulatory frameworks

Regarding the legal framework which regulates (and controls) the marine leisure sector and activities, the main laws are summarised below, with special emphasis on their contribution to the sustainable development of the national marine leisure sector:

- Council of Ministers Resolution No. 25/93 of 14 April: Approves the "**Clean Sea Plan**". The general objective of this law is to establish a mechanism to respond to both oil spills and hazardous substance releases as well as improve response capabilities and minimize the impact of spills. It defines the responsibilities of an organization by establishing the powers given to authorities. It also includes a reference to the need to regulate waste management associated with spills in accordance with the relevant national legislation regarding waste disposal to specific waste treatment facilities.
- Decree-Law No. 26/95 of 8 February: This legislation amends the General Regulations of the Captaincies referring the need for sustainability in the sector, setting out strict requirements for waste management. In particular, it establishes **rules on the demolition and dismantling of vessels and the role of ports of registry in these processes**.
- Decree No. 733/96 of 12 December (as amended by Decree No.1013/99 of 16 November): which defines "***the safety conditions and certification, dimensional characteristics, tonnage and classification of recreational crafts***"
- Decree-Law No.96/97 of 24 April: transposes into national law the Directive 94/25/CE of the European Parliament and of the Council of 16 June 1994, relating to recreational craft. The decree establishes the measures to ensure that recreational craft, semi-finished products and components may be **placed on the market and put into service** in

[13]Topic overviewed on Skype interview with the Associação de Desenvolvimento Local da Bairrada e Mondego, on 12th December 2019

[14] Barca serrana do Mondego: name probably originated in the coastal region, being the known reference in the area. It was used for transportation along the Mondego river and disappeared around the 1950's.

[15] Other references are the municipal varino "O Boa Viagem", the traditional vessel from the Tagus estuary; the Monte Branco Beach Shipyard, owned by the Municipality of Murtosa, which ensures the continuity of the ancestral art of building moliceiros.

accordance with their intended purpose only if they do not endanger the safety and health of persons or the environment when correctly constructed and maintained. Although this law includes recreational boats, the following shall be excluded from the scope of this Directive: craft intended solely for racing (rowing and training boats); canoes; kayaks; gondolas; pedalos; sailing surfboards; powered crafts; original, and individual replicas of, historical craft designed before 1950, experimental crafts; and crafts specifically intended to be crewed and to carry passengers for commercial purposes, among others.

- Decree-Law No.266/2001 of 2 October: which "allows the Instituto Portuário do Sul to grant a concession for construction and operation, on a public and exclusive service basis, of the Olhão Shipyard, intended for naval construction and repair". In Base XVIII "Environmental Protection", it includes a **compliance notice for current regulations on environmental pollution**, besides notifying the competent authorities of any risk of contamination that may occur.
- Decree No.1491/2002 of 5 December: It **adjusts the safety conditions and certification, dimensional characteristics, tonnage and classification of recreational craft** due to "technological developments which have occurred in the meantime, as well as the need to bring these regulations into line with Community rules". This law does not mention any processes associated with the concepts of eco-construction, deconstruction and eco-design, being only mentioned safety rules of the boats since their construction.
- Decree-Law No.165/2003 of 24 July: transposes into national law the Directive No. 2000/59/CE of the European Parliament and of the Council of 27 November, establishes the measures on port reception facilities for ship-generated waste and cargo residues. Its main objective is the protection of the marine environment[16]. According to this directive, each port facility must prepare for an effective planning of waste management and delivery.
- Decree-Law No.209/2004 of 3 March: approves the European list of waste and waste types for disposal and recovery operations. Among others, it makes specific reference to bilge oils.
- Decree-Law No. 111/2008 of June 30th: law that "approves the technical regulation of national fishing vessels between 12m and 24m in length". There are no references, in this decree, on pollution or sustainability.
- Decree-Law No.51/2012 of 6 March: "Transposes into national law the Directive No.2009/21/CE of the European Parliament and of the Council of 23 April 2009 "on compliance with flag State obligations[17], *aimed at improving maritime safety and the prevention of pollution from ships through a set of rules to be followed by those States in various ship operations activities, increasing transparency and the quality of their maritime administration performance and control over ships of their flags. It emphasizes*

[16] Amended by Decree-Law No. 197/2004 of 17 August, Decree-Law No. 57/2009 of 3 March and Decree-Law No. 83/2017 of 18 July.

[17] Flag State: "State, which through relevant legislation and national maritime administration, authorises ships flying its flag".

the obligation of the national maritime administration to implement a quality management system of its operational activities related to flag State obligations.

- Decree-Law No.43/2018 18 June: Created a National System for Vessels and Seafarers, which establishes the conditions for its operations and access. It's a unique national data system to keep up-to-date information on vessels, seafarers and other maritime-related events, through the "Balcão Eletrónico do Mar" (Virtual Desk), in order to make the interactions with Public Administration faster and more efficient, reducing bureaucracy and travel costs. It foresees the dematerialisation of all proceedings, benefiting the environment and economy. This law does not overlook the need to provide support at a local level, which is ensured by organizations close to citizens, oriented to Personalized Services.
- Decree-Law No.93/2018 of 13 November: which supports "the new Juridical Regime of Recreational Boating". It regulates customs controls and border and duties of management entities or concessionaires of mooring spaces; however, it does not mention the sustainability of the sector. It is a simple and modern proceeding of registering and certifying vessels and recreational boats without needing to go to the competent authorities.

From the different examples of regulations described above, it is possible to identify the growing concern for environment and sustainability issues, especially motivated by the need to transpose the directives of the European Parliament and Commission into national law.

Organizations, regardless of their activity, size and location, must comply to an increasing number of environmental requirements imposed not only by the State, but also customers and society together.

VI. LITERATURE REVIEW ON THE ALTO MINHO REGION

Alto Minho is a sub-region (NUT III) in Northern Portugal (NUT II), District of Viana do Castelo. It borders to the north the Autonomous region of Galicia (Spain), to the south with the Cávado sub-region and to the west with the Atlantic Ocean. The region is composed of municipalities: Arcos de Valdevez, Caminha, Melgaço, Monção, Paredes de Coura, Ponte da Barca, Ponte de Lima, Valença, Viana do Castelo and Vila Nova de Cerveira.

It has relevant port infrastructures - the Port of Viana do Castelo - which includes[18]:

- The Commercial Port – with capacity to move more than 900,000 tons of cargo per year, and to receive ships with a draught of 8 meters and 180 meters in length;
- Marina (Sport and leisure port) – capacity for 500 vessels up to 3m of draft and 20 meters long, on 2 docks (one of them presenting around 100% occupancy rates);
- The Fishing Port - the base of the traditional fishing fleet (mostly composed of coastal fishing boats). Doca Pesca owns it since 2014. Here an average of 1,500 tons of fish are unloaded per year (with an average value of 3.5 million euros);
- The Industrial Port - where the shipyards of this city are located (which have built 15 ships and repaired 180, for the last 5 years).

There are also 3 marinas located in Caminha, Vila Nova de Cerveira and Valença and 5 centers for nautical activities (the rowing, sailing, canoeing, high-performance surf centres - all located in Viana do Castelo - and the nautical centre of Ponte de Lima).

The Port of Viana do Castelo is managed by the Administração dos Portos do Douro, Leixões and Viana do Castelo, S. A. (APDL) which developed the Waste Management and Recycling Plan, on compliance with Directive No. 2000/59/EC previously described. This plan regulates the installation and use of port reception facilities for ship-generated waste and cargo residues from ships, as well as fishing and recreational vessels, adopting measures to ensure the delivery of waste by shipowners or legal representatives.

The plan defines areas[19], types of waste and means of delivery/reception. It specifies waste categories into packaging waste, textile wastes, fishing waste (fish preparation, nets, among others), municipal waste (household waste), chemical compounds (hydrocarbons), chemical and organic waste, electronic waste and wood processing.

Containers, oil containers and recycling bins are provided by the Port.

[18] Information available at “Plano de Ação para a Sustentabilidade Energética Viana Do Castelo”.

[19] Area I – Commercial Quay (lies at the left shore of Lima river, 2000 metres upstream its origin), only delivery area for end-of-life material, known as scrapping (tyres and discarded vehicles) ; Area II – The Fishing Port (right shore of the Lima river), is mentioned on the plan, which is “in partial decline”; Area III – Marina (lies at the right shore of the Lima river, 2.700 metres upstream its origin, nearby the “Eiffel Bridge”).

In regard to waste collection, each type of waste is associated with a specific means of collection and is then delivered to companies that will make its disposal and/or use.

It should be noted that one of the region's main clusters is the "cluster of the economy of the sea" and that the construction of a terminal for small/medium-sized passenger ships is already envisaged, as a complement to the port infrastructure previously presented.

This economic dimension is first and foremost a social dimension of the region[20] set in decades building vessels designed accordingly to the characteristics of the routes (maritime and/or fluvial):

- Barquinho do Rio Minho - The Minho River Boat: a vessel used to transport passengers between shores (carrying 20 to 30 passengers) or various cargo that can also be used for fishing);
- Maceira: boat from Vila Praia de Âncora, prepared for a crew of 2 men for sea and river fishing.

The current fishing fleet, as already mentioned, has a traditional feature of being composed of small vessels associated with a local/regional economic activity. It is an old fleet of boats that need maintenance and, in many cases of renovation, a context that "forces" them to think strategically about the eco-construction and/or deconstruction processes.

Nevertheless, it is a relevant fishing fleet at a national level since the Port of Viana do Castelo is the fourth in terms of the total number of registered fishermen (according to the North region, after the Port of Póvoa do Varzim).

In the regional context (Alto Minho), the most relevant municipalities in the context of fishing activity are Caminha and Viana do Castelo, the latter representing 3% of the total (official) Portuguese fishermen (8% of the total for the Northern region) with the particularity of dedicating themselves to fishing in inland waters[21].

The most important industry in the region is the nautical sector, in terms of ship construction and maintenance, is worth noting the Estaleiros de Viana do Castelo, currently managed by the company West Sea - Estaleiros Navais, Lda, which took over in 2014.

This shipyard is one of the most important infrastructures in Western Europe, harbouring medium and large boats. It is equipped with modules and lifting facilities for manufacturing large modules and metallic equipment. The area covers about 250,000m2, the yard has facilities for shipbuilding,

[20] In this context, the traditional boats of the Alto Minho could also be revitalized (particularly for tourism purposes) following the example of other areas of the country already mentioned above. This is not only about generating new tourist experiences, but also fostering the use of environmentally friendly boats and, at the same time, boosting new business opportunities in the field of nautical eco-construction.
The regional example of Ponte de Lima should be outlined, where a copy of the water-river boat was recovered for tourist purposes, in 2019.

[21] Data from 2012 and the sharp downward trend in the number of registered fishermen in this region should be considered (a reduction of almost 50% since 2003).

ship repair and conversions of any type of vessel up to 37,000 tons, 190m in length and 29m across, as well as small and medium-sized vessels.

Figure 7 - Image: Estaleiros de Viana do Castelo (Source: official website)

Among its corporate commitments are several references to environmental protection, reflecting a growing concern and a clear intention to ensure that these yards conform to sustainable patterns and infrastructures.

However, most shipyards in the region are small-sized, dedicated to ship repair of fishing boats and, in a lower scale, to the construction of this kind of vessels. Moreover, due to the traditional nature of this activity, important knowledge and skills have not been transmitted to new human resources. Even so, CIM Alto Minho considers it a business opportunity that can be undertaken as an advantage regarding "exporting" these services to other regions nearby.

Given the importance of this activity at both national and regional economic contexts, building recreational crafts and naval sport crafts has been considered as a sub-sector of great potential and is currently considered as one of the sectors of the future (in terms of regional development related to growth and employment) due to the capacity already locally demonstrated to create high-quality technological innovations.

To a large extent, this perspective reflects the path (and international recognition) of another benchmark company in the nautical sector (already mentioned in the previous chapter): Nelo [22], which is the leading company in building high-performance kayaks and canoes and the key innovation factor in canoeing, boat design, services and technology.

Innovation is an important mission in Nelo's ideology, undertaking improvement processes and developing new concepts and ideas. They build and design all models.

[22] Despite being a company from Vila do Conde, its influence and importance to the development of the nautical sector of Alto Minho makes it relevant for this study.

To these regional "giants", which place the Alto Minho region as one of the most relevant in terms of shipbuilding and ship repair activities, as well as the manufacture of pleasure boats (in terms of turnover and number of workers), it's worth mentioning some companies, small-sized but rather important to the regional sector. In terms of inflatable boat construction, the Vanguard Marine international group, from Viana do Castelo, stands out, designing and manufacturing working boats and rescue boats for a wide range of clients (companies, Armed Forces, clubs, marinas, diving centres, federations, shipbuilding, rescue and emergency organisations and defence bodies), as well as vessels for sport or recreation.

It also reflects a concern with sustainability, using materials that minimize environmental impacts and incorporating as many recyclable elements as possible.

In terms of recreational boating, the company Starfisher, located in Vila Nova de Cerveira, should also be highlighted. It designs and builds, in an integrated manner, all boat components made of fibreglass reinforced polyester (FRP), fine wood and stainless steel. Nowadays, it has more than 60 distributors along the European coast, in countries like Spain, France, United Kingdom, Ireland, Italy, Croatia, Cyprus, Portugal, Norway, Russia, or Austria.

These companies, together with the 34 entities previously indicated (companies, associations, academia, and public entities) constitute the nautical sector - all of them contacted in the scope of this work to provide information on the state of the industry in the Alto Minho region, regarding the inclusion of sustainability strategies in production processes.

One-third of the companies contacted work in construction, maintenance or deconstruction (dismantling) of vessels. The remaining entities, almost all of them, are companies dedicated to water sports and construction and maintenance of motorsport, sailing or rowing boats.

All the entities identified to be related to the nautical sector in the Alto Minho region were surveyed, which allowed evaluating the current situation of the nautical sector in the region in regard to the sustainability of their products, services and processes and also their level of commitment to innovation in eco-design, eco-construction or deconstruction.

The companies which replied to the survey (Appendix I), answered that any innovative process is currently being developed. No company is involved in any project to reduce the environmental impact of their activity. However, more than half of the companies participating in the survey say they use a waste management system.

All companies, except one, are familiar with ISO 14.001, although only one has already implemented it and two others intend to do it soon.

Taking into account the results of this direct consultation and primary data collection, it can be concluded that:

- The shipbuilding industry in the region is concentrated in the shipyards of Viana do Castelo;
- Currently, no innovative projects on eco-construction, eco-deconstruction and eco-design are being developed;

- Stakeholders are aware of the need of a correct waste management system and the implementation of measures (especially preventive) for environmental protection;
- Companies in the nautical sector show intention to optimize their processes to achieve responsible energy consumption;
- Despite the information and dissemination of ISO 14.001, its implementation has not reached its full potential.

In this specific context and as a warning, assuming that the official number of boats in Alto Minho is an indicator of the importance of sustainable boat construction and deconstruction in the region, the downward trends in the number of local fishing boats, the coastal fishing boats slightly increasing and the increase in number of recreational boats make it even more relevant to reflect on the process of scrapping the former and the process of building the latter.

A final remark to outline the importance of the regional commitment to the sustainability of the local marine industry for the preservation of different protected areas, whether they are biosphere reserves, national/natural parks, Natura 2000 network, or classified (Atlantic and fluvial) beaches.

VII. CONCLUSIONS AND RECOMMENDATIONS

Although the present work should be understood as an exploratory study on the nautical sector of the Alto Minho region, especially due to the limitations in accessing information, it is important to reflect on the key data collected as well as on possible improvements that the MCP of this region may propose to promote and/or implement to promote and raise public awareness on the sustainability, processes, and products of the nautical sector as well as on the regional relevance of investing in the development of innovation that may be integrated into preventive strategies regarding environmental impact and climate change in this sector.

a. Conclusions

The regional socio-economic context (mainly in regard to the tradition of shipbuilding and ship repair) assumes particular importance when analysing the concepts of eco-design, eco-construction and deconstruction applied in the sector, since it highlights that traditional activities implemented in the territory should not only assume an innovative feature but, above all, environmentally sustainable processes should be included in the nautical industry.

There is a field of opportunities and sectorial evolution that must be formally supported by the competent authorities, in order to place the Alto Minho region as pioneer in promoting sustainable boating activities. Research, innovation, training and dissemination of knowledge are essential to the sector's capacity building.

Thus, to the Recommendation already presented in the "Action Plan for the Development of the Boating sector in Alto Minho" to invest in the creation of a technological centre for the study and development of new materials, supporting modernisation of small-sized companies, having IPVC as a partner, the extension of the scope of this centre, the study and development of environmentally friendly materials and processes (i.e. associated with eco-design and eco-construction and with the capacity for dismantling without the generation of waste).

However, despite being a spotted opportunity, the following critical factors should be considered:

- There is practically no secondary data related to the sustainability and environmental impact of the Alto Minho nautical sector, nor encouragement and development of innovation related to eco-design, eco-construction and deconstruction.
- Although boat recycling is not yet an economically profitable activity, its development helps ascertain the environmental and ecological consequences of the nautical sector at regional level.
- The improvement of the legal framework at European level, combined with a logical and fair tax policy, will be useful in solving the environmental problems associated with the processes of storage, deconstruction and recycling of vessels. This process, which does not exist in Alto Minho, is still incipient at the European level.

- The creation of specialized boat recycling centres and the adaptation of existing infrastructures to recycling processes (in terms of materials and intensity of use) are indispensable conditions for the sustainability of the boating industry.
- Assess the use of synthetic composites (on which wastewater is about 80% in the process of scrap material) in order to find circular economy solutions for a high cost-benefit process is a key sustainability challenge that Alto Minho should address as soon as possible.
- No record was found of small and medium-sized companies in the regional nautical sector undertaking innovative projects on eco-construction, deconstruction and eco-design. The growing concern of companies for the environment makes their processes and projects more environmentally friendly and more effective in reducing emissions and noise, but this is achieved by transferring existing processes or legal impositions and not from innovation processes developed by local agents.
- Companies are aware of waste management systems. They mentioned having an environmentally friendly waste management system. However, most of these systems are applied only to sort out waste and its delivery to collection/sorting centres.
- Although a lot of good work has been carried out in disseminating ISO 14.001 standard (since almost all of the companies contacted were aware of this standard), no actions to implement it have been undertaken at the moment (only one of the companies indicated to be in process of implementing the standard).

b. Recommendations

As previously described, the development of this work and especially the results achieved from the literature review on eco-design, deconstruction and eco-construction innovation in the regional nautical industry has made possible to set out a list of needs that must be met and CIM Alto Minho may take a more active and leading role in this process.

Main recommendations arising from this research, which CIM may promote and suggestions for improvement include:

Recommendation1

Integrate the "sustainability" dimension in the "Action Plan for the Development of Marine Leisure in Alto Minho" giving meaning and putting into action the concepts of eco-design, eco-construction and deconstruction (applicability), preferably related to storage infrastructures and nautical industry waste recycling through innovative processes.

Recommendation2

Promotion of processes and infrastructures of collection, treatment and recycling of boats and nautical equipment.

Recommendation3

Promote studies to characterise the stakeholders of the regional nautical sector in order to detail activities and contributions to the regional economy (in terms of growth, employment and sustainability), deepening the characterisation carried out within the scope of the abovementioned plan.

Recommendation4

Promote actions to raise awareness of local stakeholders to the need of ensuring environmental sustainability in their business/activities. It is about contributing to the awareness of the impact of their actions for the development of a more environmentally friendly activity.

Recommendation5

In the field of engineering and, specifically, in naval engineering, promote training professionals (especially the engineer and the nautical entrepreneur) for decision making based on the sustainability and environmental impact of those decisions in their work (also contributing to new innovation processes in terms of eco-design, eco-construction and deconstruction). As an example, the following topics are relevant to this training:

- Design and construction of ships for long-lasting use, reuse and recycling;
- Choose recyclable and non-toxic materials;
- Reduce the maximum level of waste material;
- Choose local suppliers with environmentally friendly practices;
- Raise awareness on life cycle of products.

Recommendation6

Raising awareness among policymakers (especially local ones) on the need to establish active policies/strategies to promote and encourage innovation and apply environmentally sustainable standards on the nautical industry.

Recommendation7

Promote smart specialization in the process of promoting/introducing innovation in eco-design, eco-construction and deconstruction processes, selecting the regional nautical areas with greater environmental impact, prioritising them for intervention by local public authorities (following the good practice developed by the partner CAPITEN AD ELO, which focused on developing and supporting products that met the specific needs of their region, in this case surfing and the eco-design and eco-construction issues of boards).

Recommendation8

Claiming and/or promoting investment (within their scope) that promote innovation consequently leading to the increase of the number of nautical industry's stakeholders contributing to the industry's environmental sustainability and to the reduction of its environmental impact.

A final remark to the importance of the Alto Minho region as a nautical reference and the leverage that this classification can have on the sustainability of the regional boating industry since its development can lead to the first econautical station in the country.

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APPENDICES

APPENDIX 1 – Survey conducted among stakeholders of Alto Minho's boating industry

CAPITEN project is aimed at the main stakeholders of Alto Minho's boating industry, in order to identify those involved in eco-construction, eco-design and deconstruction processes, and promoting shared products, actions and projects through a European database which this project is developing.

The main goal of the project is to disseminate innovation and the best practices of the boating industry along the Atlantic coast, consequently generating a sustainable economic growth respectful of the environment.

All candidate projects/processes/products referenced in the CAPITEN database will be subject to a detailed analysis. Thus, your organisation may be contacted again by the CAPITEN project, in order to deepen this preliminary assessment and get a full understanding of the relevance of their inclusion in the project database.

The CAPITEN Program is committed to respecting and safeguarding the privacy of the people contacted for this purpose.

Thank you very much for your collaboration.

General Information:

1. Company | Business Cluster | Organization
2. Contact person
3. Phone/Mobile phone

Description:

4. Short description of the company's nature of business.
5. Do you develop innovative products based in eco-construction, eco-development and/or eco-design processes? (Please provide a short product description)
6. Are you involved in any innovative project to reduce the environmental impact of your activity? (Please provide a short description)
7. Do you use environmentally friendly waste management methods? YES/NO
8. Do you use any environmentally friendly waste management system? YES/NO
9. Are you familiar with ISO 14.001 standard on "Environmental Management System"? YES/NO
10. Have you implemented this standard? YES/NO

11. Do you intend to implement this standard soon? YES/NO
12. Observations | Comments

APPENDIX 2 – Findings from the survey

General data:

The general data protection framework applies to this survey and all information has been processed in accordance with general data protection regulation.

Company's nature of business:

1. Please provide a short description of the company/business cluster/organization's nature of business.

Carry out promotion actions and support the practice of Canoeing in all its aspects
Skipper for recreational boats and transport training
Registration, changes in registration, maintenance, event licensing, vessel licensing, (sport fishing, lashing and stranding…), licence for fisheries…
Sport Activities
Repair of all kinds of boats, mechanics (official brand agents of the sector), water and shore assistance, aesthetic repairs; collection of boats during the winter; sale of new and used boats and engines.
Rowing Club (training, competition and leisure).
Nautical station (network of quality nautical tourism, organized from the integrated valorisation of nautical resources of a territory, including accommodation, restaurants, nautical activities and other relevant experiences and services to attract tourists and other users, adding value and creating diversified and integrated experiences).

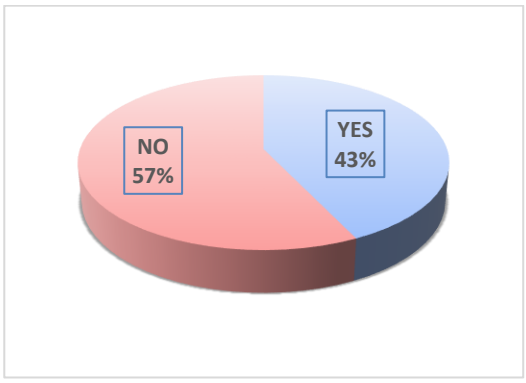
2. Do you develop innovative products based in eco-construction, eco-development and/or eco-design processes? (Please provide a short product description)

No entity is developing these kinds of products.

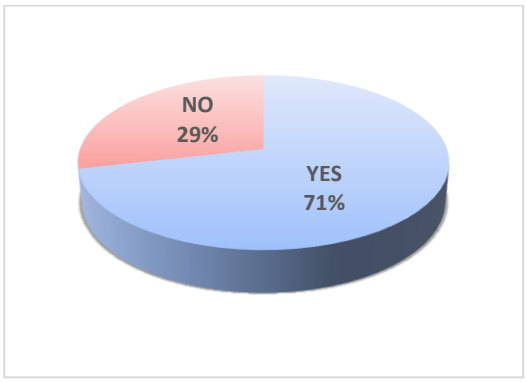
3. Are you involved in any innovative project to reduce the environmental impact of your activity? (Please provide a short description)

Composting (project from the Municipal Services of Viana do Castelo).
Use of IT solutions for dematerialization and reduction of paper consumption.
Selection of materials used in repair in order to avoid corrosion and debris, more natural components to avoid water pollution, protection/battery boxes, oil and gasoline filters that reduce gas emissions.

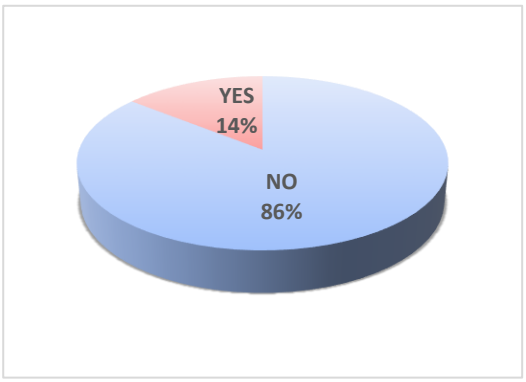
4. Do you use environmentally friendly waste management methods?



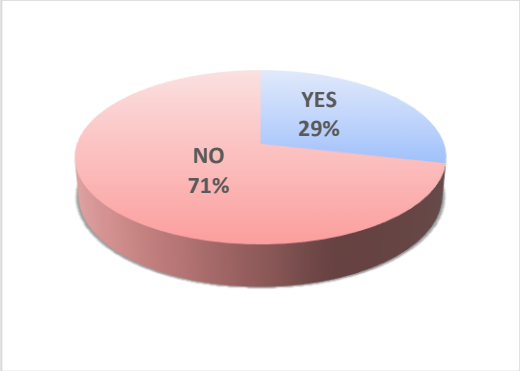
5. Are you familiar with ISO 14.001 standard on "Environmental Management System"?



6. Have you implemented this standard?



7. Do you intend to implement this standard soon?



8. Observations | Comments

Concerns with environmental sustainability and processes are still incipient.