Preliminary analysis of the economic feasibility of maintenance services for superyachts in Portugal

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DECLARATION:

I declare that this document is an original work of my own authorship and that it fulfils all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Signature

Nicola San Martino

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I hereby express my gratitude first to my parents, which are my example of life, to my two sisters Sara and Giulia and my whole family, who always supported me and forced me to my best, without them I would not be finalizing this master's degree in Lisbon; to my wonderful girlfriend, who has never stopped loving me and giving me the motivation to go forward. To my Portuguese-Brazilian-Italian family: Giudina, Fra D, Fra M, Fede, Agne, Pi, Jacopo, Julio, Berni, Vivi and to my Portuguese brother Lulu. To hour house in Monte Clerigo and, obviously, to Rua dos Açores.

ABSTRACT:

This thesis considers an innovative theme in comparison with typical naval architecture thesis, namely the world of yachts, in particular that of superyachts and the specialized infrastructures used in this sector. The objectives of this thesis were to define the technical requirements for providing high quality services to yachts in the Portuguese coast and to perform an economic analysis of the competitiveness of an integrated service proposal for a typical superyacht yearly cycle. The reason why it was decided to choose this theme is because Portugal is located into a strategical position for the transit of superyachts between Europe and the Caribbean, both for its proximity to the Strait of Gibraltar and for the islands in the middle of the Atlantic Oceans, and from a preliminary study it was seen that there are not enough and well-developed infrastructures to deal with this business.

The thesis first presents a review of the scientific and technical literature on yacht maintenance services, repositioning between European regions and across the Atlantic and marina technical developments. The typical whether conditions of the Portuguese costs and of the major routs used for the Atlantic Crossing are analysed. The typical patterns of yacht repositioning between the Mediterranean, the Caribbean and the North Sea are identified. A large database made of the major superyacht marinas and shipyards in the Mediterranean and North Sea it is created. The technical requirements applicable to marinas for providing an integrated and high quality service are defined. The technical infrastructures and equipment required from a superyacht shipyard are defined, including the definition of the profile of a state-of-the-art shipyard.

A case study has been developed to assess the economic feasibility of providing maintenance, wintering and repositioning services (yearly cycle) for superyachts, based on a hub in the Portuguese coast. All the costs related to shipping transport by a semi-submersible ship between Caribbean-Portimão and Caribbean-Genoa are analysed, as well as voyage costs of sailing between Portimão-Cannes and Genoa-Cannes, just like the costs related to different marinas of the two situations and the costs related to the yearly repair and maintenance work to be undertaken on a Italian shipyard and a Portuguese shipyard. An economic comparison with the existing situation has been carried and conclusions drawn regarding the feasibility of the proposal. Final results obtained are consistent to the previous study and to the information collected on each part of this thesis.

Keywords:

Superyachts, Marinas, Shipyards, Maintenance and repair services, Atlantic crossings, Shipping

RESUMO:

A presente tese foca-se num tema novo em comparação com a típica tese de arquitetura naval: em particular esta trata do mundo de iates, sobretudo de super-iates e das específicas infraestruturas usadas neste sector. Os objectivos da presente tese foram detectar os requisitos técnicos para oferecer um serviço de alta qualidade para super-iates na costa portuguesa e, depois, fazer uma análise económica sobre a competitividade de um serviço integrado num típico ciclo anual de super-iates. Foi decido este tema porque Portugal se encontra numa posição estratégica no trânsito de super-iates entre a Europa e as Caraíbas, pela proximidade ao estreito da Gibraltar e também às ilhas no Atlântico. Um estudo preliminar tinha já indicado que não existem infra-estruturas suficientes e bem desenvolvidas para lidar com este negócio.

Apresenta-se primeiramente uma revisão da literatura científica e técnica sobre serviços de manutenção de iates, reposicionamento entre regiões europeias e através do Atlântico e os desenvolvimentos técnicos da marina. São analisadas, igualmente, as condições meteorológica típicas das costas portuguesas e das principais rotas utilizadas para a travessia do Atlântico. São identificados os padrões típicos de reposicionamento de iates entre o Mediterrâneo, o Caribe e o Mar do Norte. Pode-se encontrar, no desenvolvimento da tese, um grande base de dados com as principais marinas e estaleiros de super-iate que ficam no Mediterrâneo e no Mar do Norte. Depois, são definidos os requisitos técnicos aplicáveis às marinas para oferecer um serviço integrado e de alta qualidade. São definidas as infra-estruturas técnicas e os equipamentos necessários a um estaleiro de super-iates, permitindo definir o perfil de um estaleiro naval de última geração.

Desenvolve-se um caso de estudo que avalia a viabilidade económica da prestação de serviços de manutenção, hibernação e reposicionamento (ciclo anual) de super-iates, baseada num hub na costa portuguesa. São analisados todos os custos relacionados com o transporte marítimo por um navio semissubmersível entre as Caraíbas-Portimão e as Caraíbas-Génova, bem como os custos da viagem entre Portimão-Cannes e Génova-Cannes, assim como os custos das diferentes marinas nas duas viagens; por ultimo, há um análise dos custos dos trabalhos anuais de reparação e manutenção realizados num estaleiro italiano e num estaleiro português. Nas conclusões procede-se a uma comparação económica com a situação existente e conclui-se sobre a viabilidade da proposta. Os resultados finais obtidos são coerentes com os estudos anteriores e com as informações recolhidas através da bibliografia desta tese.

Palavras-chave:

Super-iates; Marinas; Estaleiro; Serviços de Manutenção e Reparação; Travessia Atlântica; Transporte Marítimo

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ACRONYMS:

AIS: Automatic Identification System

CE: Conformité Européenne

EC: European Community

ECORYS: Yearly Average Labour Cost Per Employee in Each Country of European Union

EUR: Euro

FRP: Fiber Reinforced Polymers

GIN: Genova Industrie Navali

GNP: Gross National Product

GT: Gross Tonnage

ICOMIA: Internatioal Council of Marine Industry Associations

IFO: Intermediate Fuel Oil

LSFO: Low Sulphur Fuel Oil

LY3: MCA Large Commercial Yacht Code

MARPOL: The International Convention for the Prevention of Pollution from Ships

MGO: Marine Gas Oil

NM: Nautical Miles

SECA: Sulphur Emission Control Area

UK: United Kingdom

US: United States

USD: United States Dollars

USVI: United States Virgin Islands

VI: Virgin Islands

SYMBOLOGY:

B – Breadth

° C – Celsius degrees

ft – Feet

g – Grams

hp – Horse power

Kn – Knots

Kw – kilowatt

Kwh – Kilowatt-hour

l – Liters

L_{OA} – Length over all

L_O/L_O – Lift-on / Lift-off

m – Meters

m^2 – Squared meters

mm – Millimeters

NO_X – Nitrogen Oxides

SO_X – Sulfur Oxides

t – Tons

W – Watt

1 INTRODUCTION

1.1 Background and Motivation

Yachting world, since its beginning, has been a sector limited to a very small niche of people, but that involves a considerable quantity of money and works around it. Initially, the number and the size of yachts around the world were much smaller than now, and consequently the infrastructures related to them. At the beginning, yachts were made just on wood, all handmade by artisans; they were very heavy and raw, and mostly were sailing yachts with just a small percentage of motor yachts.

Marinas and shipyards were very rare and concentrated just around the biggest cities and some touristic locations, just thinking that the first ever marinas built specifically for nautical tourism were realized around 1950. Without the right environment and social context, it was impossible for this industry to grow. There was not a real touristic business behind yachting and the “nautical world” in general.

Year by year, by improving infrastructures with the construction of new marinas (nowadays there are more than 300 marinas just in Italy) and shipyards spread on all the coasts, and especially with the new technologies and materials available for yacht building, this sector has grown, becoming a business of international interest that involves many different sectors with variable degrees of correlation with it. A considerable increment and development was recorded on the 70’s, when the potential of this business was starting to be realized. During those years, many marinas and shipyards where built, a lot of new newbuilding shipyards were born producing different types of yachts, arousing the interest and the curiosity of an increasing number of people.

Nowadays, yachting is a business of almost 90 billion USD, increasing every year, despite social and economic contexts not being, at times, favorable. It represents indeed a special form of high value-added tourism, representing a significant income for many countries, mainly in the Mediterranean and Caribbean Islands. In particular, the most relevant subsector is also the most luxurious one: superyachts. However, these large yachts bring with them significant technical requirements for both marinas and shipyards and many owners still struggle with difficulties when paying for the substantial expenses involved in the operation of such yachts.

The idea for this thesis originally came from some Portuguese studies (Vitorino, 2017) dedicated to the Economy of the Sea that stated that this country could become a hub for maintenance services for superyachts. The importance of this market for Portuguese tourism, industries and economy, in general, and the recognition that the yachting world is a valid option to bet on for relaunching the country’s economy, certainly makes this theme an interesting area of study and research. Although this possibility has been around for many years, no studies where found detailing what this hub could specifically be and how feasible from the economic point of view it could be. This thesis is a first attempt to provide some light in the path for setting up such a hub in Portugal.

In particular, what was really missing was a complete study about superyachts, that would include their movements and migration during the year, how they move (if by sailing themselves or shipped by a specialized ship) and which routes they use, a description of the ideal superyacht marina and the related facilities needed, as well as a description of state-of-the-art shipyards and which infrastructures and equipment they include, and all the other aspects related to superyachts.

Superyachts are, for the purpose of this thesis, defined as those vessels with a L_{OA} greater than 30 meters, even if the matter about this definition is quite complicated as it does not exist an unique and scientific definition for superyachts or megayachts. This definition was chosen, for this study, because it was deemed that it is the most relevant, not only for the peculiarities of the superyachts themselves, but also for all the specific infrastructures, facilities and services related to them and needed for their operation and maintenance.

Since Portugal is not a major location for superyachts, which mainly are based either in the Mediterranean Sea or in the Caribbean Islands, and regarding the new buildings in the North Sea, it seemed clear that for Portugal to be active in the maintenance, repair and wintering of these superyachts it needed to take advantage of its geographical position in the Atlantic. Portugal, in fact, is located in a strategic location, on the western part of Europe, very close to the Strait of Gibraltar, and with many islands in the middle of the Atlantic Ocean, and could be the focal point of superyacht traffic, not only for a short step before the Atlantic crossing, but also for the yearly maintenance that all yachts need, for the refitting business, for marinas and luxury nautical tourism.

The initial idea was to characterize the yacht traffic along these routes and identify the potential market size for providing repair, maintenance and wintering services for such yachts in Portuguese ports. It has however been found very little data on the actual volumes of yachts transiting along these routes, which are nevertheless known to be very significant. As a consequence, numerical results in this thesis have been obtained for a typical yearly cycle of a superyacht in different scenarios.

The objective is to present an evaluation of the costs involved in a typical yearly cycle for a superyacht in two scenarios: a cycle corresponding to the current situation (yacht based in the Mediterranean) and a cycle corresponding to a situation in which the yacht uses Portuguese shipyards and marinas for repair and maintenance. In any case, the yacht also carries out a transit across the Atlantic in order to allow cruising both in the Mediterranean Sea and the Caribbean Islands.

In the sense that numerical results are presented only for this specific scenarios and for a specific superyacht, this thesis provides only a first estimate on whether these activities in Portugal present some economic feasibility or not. It is recognized that only the volume of yachts actually transiting along the Portuguese coast, their size characterization and the technical capabilities of Portuguese marinas and shipyards will determine whether it is possible to develop a hub for such activities in Portugal. That complete and holistic assessment remains a task for further research and study.

The initial part of the thesis provides, however, important background information on the necessary infrastructure and equipment for these maintenance and repair activities, while already providing some insight into the potential problems faced by Portuguese marinas and shipyards if they want to engage in this very specific market segment. This part of the thesis also identifies the main information still missing for a complete evaluation of the real economic potential for creating a hub for these activities in the Portuguese coast.

1.2 Objectives

Considering the background above, this thesis has the following objectives:

- Review of the scientific and technical literature on repositioning and migration of yachts between European regions and across the Atlantic; the main routes followed for sailing and the main routes used for shipping yachts in heavy-lift ships; marinas and shipyards technical developments; yacht maintenance and services; wintering practices.
- Define the technical requirements, both for marinas and shipyards, for providing a high quality service to superyachts, by creating and analysing a consistent database of the major superyacht marinas and shipyards in the Mediterranean, Portugal and North Sea.
- Performing a comparison of the economic costs of a superyacht yearly cycle for the existing situation and for a service proposal based on a superyacht hub in Portugal, by exploring all the information collected and the acquired knowledge.

1.3 Structure of the Thesis

The thesis is organized in seven chapters and respective appendices. The detailed structure of the thesis is as follows.

Chapter 1 is the introduction of this thesis and provides the background for the theme, the objectives and actual structure of the thesis.

Chapter 2 provides important information on the typical characteristics of the superyacht fleet in the beginning of the XXI century.

Chapter 3 provides a characterization of the yacht traffic along the Portuguese coast, starting from typical weather conditions, patterns of traffic along the two main transit routes and yacht transportation practices.

Chapter 4 provides a characterization and comparison of the most relevant marinas in three regions: West Mediterranean, Atlantic Northern Europe and Portugal. Main parameters for characterizing these marinas are identified and compared across the three regions.

Chapter 5 provides a characterization and comparison of major shipyards involved in superyacht repair and maintenance in the same West Mediterranean, Atlantic Northern Europe and Portugal. It is important to mention that in the Portuguese case the shipyards included are those which could potentially be used in such activities.

Chapter 6 shows the results of a case study carried out for assessing the economic feasibility of using Portuguese shipyards for carrying out repair and maintenance of a specific superyacht and as a base for transiting across the Atlantic Ocean. Comparison is made with the current cycle which resorts to West Mediterranean marinas and shipyards.

Chapter 7 includes the final conclusions of this thesis and recommendations for further work.

2 CHARACTERIZATION OF THE SUPERYACHT FLEET

Yachting is an ever-changing and developing world, in particular the superyacht segment. Despite the importance and the impact of this business on the economy in general and on the many sectors directly involved in particular, it is little-explored and it is not easy to draw a general framework of it. In this chapter, starting from the yacht classification definitions themselves and going to the possible routines and locations, required facilities of superyacht marinas and shipyards, an overview is given about superyacht technology. This insight is valuable in order to identify basic requirements for equipment and technological capabilities that need to be considered when setting up a hub for superyacht services.

First of all, there is not a unique and official definition for the various yachts categories, including superyachts. They might be defined by several criteria like minimum price, size, weight, or if it has or not an heliport or a swimming pool (Springer, 2019), but the most scientific and quoted criterion is the length, most of the times length over all (L_{OA}). Broadly speaking, a yacht is a luxury watercraft made for recreational activities (Worth Avenue Yachts , 2019). According to (Springer, 2019), "*a superyacht or megayacht is a large, luxurious, professionally crewed motor or sailing yacht, ranging from 24 meters (79 ft.) to more than 180 meters (590 ft.) in length*" so it does not make difference between superyacht and megayacht. The same definition, that a superyacht or a megayacht is a yacht from 24 metres and above, is given by Yachting Pages, and the only difference between these two terms is that megayacht it is used more in the U.S. (Bees, 2020).

Considering what reports the SuperYacht Times, "*a superyacht is defined as a motor or sailing yacht with a length of 30 metres or more. The yacht should be used privately or made available for charter on the basis that the customer charters the whole yacht*". (Dazert, 2021). According to Worth Avenue Yachts, a superyacht is a yacht from 24 meters (78 feet) and above, while a megayacht is a yacht larger than 60 metres (200 feet) (Worth Avenue Yachts , 2019). From the classification societies point of view, on the other hand, there is another type of definition and distinction, in terms of length, followed to apply the rules, which is: "*large yacht is a pleasure vessel with a load line length equal or above 24 metres*" (Moretti, 2015). For yachts larger than 300-foot sometimes it is used the world "Gigayachts" but, as for the other categories, it is more a trend then anything. (Springer, 2019).

(Santos, Lectures Notes of TMPII course, 2020) also concludes that there is not a universal definition for superyachts and megayachts, but generally they are considered to have more than 24 metres or, in some few cases, 30 metres, in length overall. This thesis will consider superyachts to comprise large yacht used for pleasure or commercial activity with a length overall equal or greater than 30 metres. Indeed, later in this chapter it will be shown that the largest part of the yacht fleet comprises vessels between 30 metres and 40 metres. This option is also related to the need of defining marina and shipyard requirements at a high level, suitable for receiving large yachts while performing a high-quality service.

Every yacht, independently on the size and type, must be registered under a flag, and the government of the flag sets the safety regulations, crew requirements and fiscal aspects, which are very important for the yacht registration. Flag administrations can perform the safety aspects with their own inspectors of delegate this activity to other companies like classification societies. The most common flags for superyachts, especially for economic and fiscal reasons, are Cayman Islands, Isle of Man, Malta, The Marshall Islands, Luxemburg, Georgetown and Kingstown (Moretti, 2015).

The classification societies, which establish and apply the rules and the technical standards of the vessels, ensure that the structural strength, integrity of the hull and many other technical aspects respect the minimum standard and safety criteria. The major class societies involved with superyachts are: Rina, American Bureau of Shipping, Bureau Veritas and Lloyd's Register.

For private yachts, the mandatory requirements are limited to registration survey and tonnage measurement. In addition to them, MARPOL (The International Convention for the Prevention of Pollution from Ships) and The Anti-Fouling System Convention are also to be respected (Moretti, 2015).

For commercial yachts (used for charters), moreover, all flag administrations require these to be certificated in accordance to specific large yacht safety codes. The most common safety code is the "MCA Large Commercial Yacht Code (LY3)", which is applied by many flags and is recognised as a model for all the yachting industries. Other yacht codes are, for example, the Malta Commercial Yacht Code, United Arab Emirates yacht regulations for yachts above 24m, Decreto 4 aprile 2005, n.95 Regolamento di sicurezza recante norme tecniche per le navi destinate esclusivamente al noleggio per finalità turistiche, as mentioned in (Santos, Lectures Notes of TMPII course, 2020).

These codes require yachts to be provided with some certificates, depending on tonnage and size of the yacht. The most relevant ones are (Moretti, 2015):

- International Tonnage Certificate: A measurement of the internal volumes of the yacht expressed in gross tons (GT). This measurement should not be confused with displacement tonnage, which quantifies the weight of a vessel.
- Large Yacht Code Certificate: Covers life-saving appliances, fire protection and means of escape, navigational and signalling equipment, intact and damaged stability, manning and crew accommodation.
- International Load Line Certificate: This certifies the weather-tightness of the yacht.
- Safety Radio Certificate: This is applicable if gross tonnage exceeds 300 [GT] This concerns the radio communication and distress installations.
- MARPOL Annex VI: This is applicable if gross tonnage exceeds 400 [GT] as well as to all main and auxiliary engines with a power exceeding 130 [kW]. It concerns the emissions from main and auxiliary engines (NOx and SOx).
- Safety Construction and Safety Equipment: These are additional prescriptions on machinery, electrical parts, life-saving and navigational equipment for yachts with a gross tonnage above 500GT.

Regarding yachts below 24 meters, all those available on the European Community market need to be certificated under "*EC Directive 2013/53/EU*" (Santos, Lectures Notes of TMPII course, 2020), except for charter yachts which require additional certifications and restrictions using the above codes (Worth Avenue Yachts , 2019). As a result of the directive just mentioned, recreational crafts below 24 metres must be built in accordance with the "*Harmonized standards developed at international level by the ISO*

Technical Committee 188 on Small Craft" (ICOMIA (Internatioal Council of Marine Industry Associations), 2021). However, once a certain model of yacht gets all the certifications, a series of those yachts is built and sold on the market.

Considering the superyacht characterization indicated above, it is possible to provide a brief analysis of the existing fleet (data could only be found for yachts above 30 m in length overall). In August 2021, there were 5325 superyachts over 30 metres of L_{OA} around all over the world, divided into 4492 motor yachts and 833 sailing yachts. Furthermore, 486 new superyachts over 30 metres of L_{OA} were under building, 450 motor yachts and 36 sailing yachts (Dazert, 2021). This data is more impressive if compared to the ones of the previous years: on 2000 the fleet was made of 1835 units, on 2010 of 3716 units and on 2018 of 4950 units, as shown on Figure 1 (Santos, Lectures Notes of TMPII course, 2020).

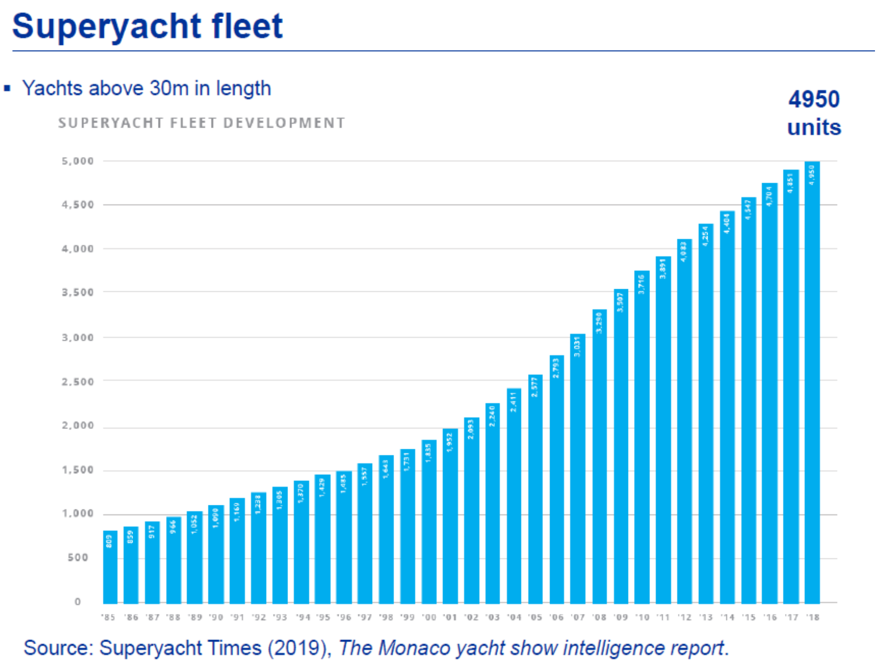

Figure 1 - Superyacht Fleet Development (Santos, Lectures Notes of TMPII course, 2020)

Looking at the numbers above it is clear how this sector is continuously developing despite any economic crises and social context, as it is deduced from the growth during the pandemic time of Covid-19, during which this sector has grown more than during the previous biennium. The pandemic has also caused a significant increase of the material costs and a difficulty on supply of resources. This had a dual consequence: firstly, an increase of the price and waiting time for newbuilding superyachts, and secondly a considerable growth of the second-hand market.

In fact, the second-hand superyacht market in reaching the peak of the last five years with 178 superyacht units over 30 metres of L_{OA} during the second quart of 2021 and more than 500 units on the last nine months (Dazert, 2021), as reported on the graph on Figure 2. This might be because owners do not want to wait years until getting a new delivery yacht, or maybe because a newbuilding yacht requires a constant support and interest by the owner, that need to go the shipyard and following the design and the construction, which was much more difficult to do during the Pandemic. Another possible reason is that some owners have decided to sell their yachts as a result of economic difficulties related to the pandemic.

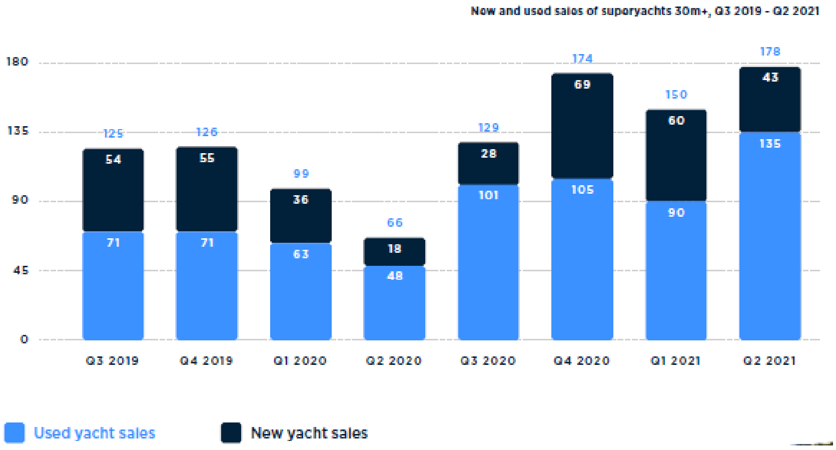

Figure 2 - New and Used Sales Superyacht Fleet (Dazert, 2021)

Another interesting aspect of the superyacht fleet is that, referring to the data of 2021, the majority of the existing fleet, around 63%, belongs to the category between 30 metres of L_{OA} and 40 metres of L_{OA}, as shown on Figure 3, meanwhile for the new superyachts under constructions just the 44% falls into the 30-40 category (Dazert, 2021). It means that despite nowadays the largest part of the fleet is made of “small” superyachts between 30 and 40 metres of L_{OA}, the future is going to another direction, with a significant increase in the share of larger superyacht units. This information is particularly important for planning new investments, in order to improve infrastructures dedicated to this size of superyachts.

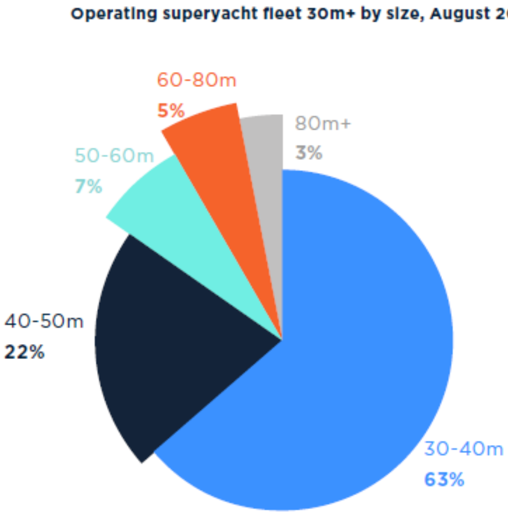

Figure 3 - Operating Superyacht Fleet (Dazert, 2021)

Apart from size categories, there are also different typologies of yachts: in the first place it is possible to distinguish motor yachts and sailing yachts. Then, motor yachts can be of different types:

- Open: yachts up to 15 metres totally opened, without cabin, large open space equipped with sunbathing cushions and living area. There are many manufactures, the main ones are: Centre Console, Rivamare, Frausher, Ranieri.
- Day-cruiser: category designed for daily use but with a small cabin in case of necessity for short cruises. Main manufactures: Riva, Itama, Cranchi, Pershing, Princess, Sessa, Cantieri di Sarnico.
- Ribs: increasingly common, especially maxi-ribs, can be both open or day-cruiser, and can be up to 24 metres. The main manufacturers are: Sacs, Joker Boats, Tempest-Capelli, Coaster, Heaven, Indomito Battelli.
- Off-shore: a niche sector of extremely fast yachts, characterized by a small beam and spaces but, a small cabin, but a high technologic stern drive, surface drives and engines. The most important brands are: Cigarette Racing, MTI, Scarab Wellcraft, Chaoudron Powerboats, Outerlimits.
- “Classic” motor yacht: the classic motor yacht, of different shapes, layout and size, up to 180 metre (Azzam (Burchia, 2013)). There are many manufacturers, the most important ones are: Lürssen, Feadship, Ferretti, Benetti, Pershing, Mangusta, Codecasa, Azimut, Gulf Craft.
- Sportfish or Fisherman: usually up to 40 metres maximum, can be with one or two bridges and with an upper flybridge particularly high which is the peculiarity of these types of yachts. They are also characterized by large and open stern, oversized engines to allow this boat to be fast despite rough sea conditions and obviously full of fishing equipment (fighting chair, rod holders, divergent …). Main brands are: Hatteras, Tiara, Pursuit, Edge water.
- Expedition or Explorer: yachts designed and built in order to be able to cover long range routs without stopping, so with a large fuel capacity. They are not fast, mostly displacing and with a cruise speed of 12-14 [Kn] and maximum of 16-18 [Kn]. This type of yachts is also characterized by a high bow and the superstructures are positioned more on the bow then the other yachts. Main manufacturers are: Lürssen, Feadship, Ferretti, Benetti, Baglietto.

Regarding sailing boats, firstly they can be separated in two categories: monohull and multiple-hull (double hulls are called catamarans, triple hulls are called trimarans). Then, the major sub-segments are:

- Racing-sailing yacht: designed and built for competitions and regattas, are made with precious and light materials (carbon fibre, kevlar, …) in order to be lighter and faster, they might have small cabins for long-range competitions. Main manufacturers are: Comet, Hanse, Wally.
- Gulet: old-style sailing yachts, mostly made of wood, ideal for weekly and short-range cruises. They are slow and use the sail, sometimes squared sails, just to help thee engine during sailing.
- Motorsailer: sailing boats that have large cabins and covered space in relation to the size of the yacht. They are not really performing and use the engine for most of the time.
- Cruise sailing yacht: designed and built for long-range cruises, they have great dimensions and are able to cover crossing and long routs. They are luxurious and more comfortable than performing, but able to sail without engine without any problem. (Colombo, 2020). The main manufacturers are: Bavaria, Perini Navi, Wally, Oceanis, Beneteau, Lagoon.

Yachts can be built using different materials: wood, composites, steel and aluminium. Wood was the first material used in boat construction, and it is still used for some small-medium yachts, in particular marine-ply which is much lighter and more adapt for marine environment and boat construction than classic wood. Wooden yachts require a lot of maintenance and it is not possible to build them in series.

Even if wood it is not the most used material in yacht construction anymore, it is largely used on finishing. In almost every yacht, of any type and size, it is possible to have wood-finishing, from the interiors to the exteriors. The most common types are teak and okoumé, for their quality and salt water resistance (Redazione Abimis, 2018).

Regarding composites materials, they are surely the most common and used materials on yacht construction up to 35-40 metres, thanks to the relative low cost and for their good strength. The most used fibre is fibre-glass, because it is a good compromise of technical characteristics and price. For particular constructions, mostly for high-performance yachts (offshore, racing-sailing yachts), where it is needed to be as light and as strong as possible, particular fibres could be used, such as Kevlar-fibre and carbon-fibre, that have greater technical characteristics compared to fibre-glass, but much more expensive.

Composites yachts are cheaper and requires less maintenance compared to wooden yachts, but, on the other hand, are less durable and can be affected of osmosis, a phenomenon in which the composite material soaks of water, becoming much heavier and less resistant (Chauvin, 2020). However, for several reasons, composite materials are not used for building very large superyachts: the largest superyacht built in composite materials is the “Majesty 175 by Gulf Craft”, with its 54 [m] (175-foot) of length and 9,6 metres of beam. (Barchemgazine, 2020).

For what concerns metals on yacht building, it is used steel for the hull, which is heavier but strong and more resistant, and aluminium for the superstructures. This helps to obtain a lower centre of gravity and increase the stability, in the first place, and save weight in the second place. There are exceptions of yacht made entirely of aluminium, especially small to medium size yachts, that are very light (almost half of the weight compared to the fibre-glass) and seven times more impact-resistant, but are more expensive and subject to galvanic corrosion (Mondinelli, 2014).

Engines and drives can vary a lot depending on the yacht in question. For small yachts, mostly open, ribs and sometimes off-shore, the most used propulsion system is by outboard engines, which combine engine and drive in a unique block. This type of engines has several advantages and disadvantages like lightness and space-efficiencies but also power limitation and high fuel consumption. In fact, the most powerful outboard engine available on the market is limited to 627 [hp] per engine, by Seven Marine, which is the most powerful outboard engine ever made, and the fuel consumption is very high because, in order to provide such a power while limiting weight and dimensions, are turbo-compressed and high-performance engines. This propulsion system can be made of just one engine up to 6 outboard engines, like the brand-new Cigarette Tirranna, a 59-foot open off-shore built by Cigarette Racing, powered by six 450R outboard engines by Mercury Racing, shown on Figure 4. (Moser, 2019). The most important brands for outboard engines are: Mercury, Suzuki, Honda, Evinrude and Yamaha.

Figure 4 - Cigarette Powered by 6 Outboards

An alternative to outboards are sterndrives. This type of propulsion has the engine inside the hull, on the engine room, that has to be on the extreme stern of the yacht, and the drive outboard, underwater, fixed on the transom of the yacht. Such setup gives the opportunity to combine the best engine and the best drive, and the power installable it is up to 1200/1500 [hp]. The major brands are: Mercruiser, Volvo Penta, FPT and Yanmar.

A particular type of drive, called surface drive, can be installed on performing yachts, not necessary off-shore. This special drive, once the yacht reaches its cruise speed, allows the propeller to be for 1/3 out of the water and 2/3 underwater, and improve maximum speed of 15% compared to sterndrive setup and of 20% compared to normal shaft. In addition, fuel economy it is increased of 15%. (Fiorentino, 2014). The two major brands are Arnenson Surface Drives and Jolly Drives. On Figure 5 these is an example of a superyacht equipped with surface drives.

Figure 5 – A 108-foot Pershing Yacht With a Triple Surface Drives Setup

Another particular drive is the water-jet, also installed on performing yachts and also big superyachts with particular characteristics. The most important brands are KaMeWa, Rolls-Royce and Kongsberg. On some extreme yachts it might be possible to install one or more gas turbines engines, that can provide enormous power despite small dimension, but they need particular fuel, difficult to find, and they are extremely expensive. The most important brand is Rolls-Royce.

Finally, inboard diesel engines with shaft lines is the most common setup used in medium and large superyachts. It is the same system used on ships, more resistant and simpler compared to all the others, and it has no power limitation as proved engines used for other marine applications are available. The major brands are: MAN, FPT Powertrain Technologies (FPT Powertrain Technologies , 2021), MTU and Caterpillar. There are cases of complex propulsion systems that combine marine diesel engines and gas turbines: the fastest superyacht in the world is "*World is not Enough*" built by Millennium Yachts, it is a 42 metres (140-foot) equipped with two main MAN diesel engines offering a combined power of 10870 *hp* plus a Lycombing turbine of 9200 [hp] able to reach 70 [kn] and having a cruise speed of 45 knots. (Superyachts, 2020). Another example is *Azzam*, the largest superyacht ever built with its 180 metres in length, which is equipped with two diesel engines plus two gas turbines for a total power of 94000 [hp], making it able to reach 32 knots and making it the fastest superyacht larger than 300-foot in the world (Cione, 2021).

3 CHARACTERIZATION OF YACHT TRAFFIC ALONG THE PORTUGUESE COAST

3.1 Weather Conditions

In Portugal, the climate is pleasantly mild, being influenced by the Atlantic Ocean. The climate is cool and rainy in the north, and gradually gets warmer and sunnier as you go south; in the far south, the Algarve has a dry and sunny microclimate. Summer is sunny everywhere, because in this season Portugal is protected by the Azores Anti-cyclone; however, from time to time it can pass the tail of an Atlantic perturbation to the north. During the rest of the year there is no shortage of rains, which are gradually more frequent and abundant as we proceed northwards. For this reason, the landscape in the north is very green, and gradually becomes more arid going south, until you reach the Algarve which has a fairly dry climate. In fact, the annual records, which amount to 1,450 [mm] in Braga and 1,100 [mm] in Porto, go to around 900 [mm] in Coimbra, to 700 [mm] in Lisbon, to drop to around 500 [mm] in the Algarve (Clima e Viaggi, s.d.). The wettest season is winter.

Winter, from December to February, is mild on the coasts, even the northern ones, since the average temperature in January goes from 9.5 [° C] in Porto, to 11.5 [° C] in Lisbon, to 12 [° C] in Faro. In winter there are periods of good weather, because the Azores anticyclone is able to reach the country even in this season, but there are also waves of bad weather, with rain and wind. Sometimes, the wind can blow with gale force, especially in the north. The location on the ocean guarantees good shelter from cold currents and night frosts, which are actually very rare and in any case not intense, especially on the coast, where records are a few degrees below zero in the north and about 0 [° C] in the south (Clima e Viaggi, s.d.).

Summer, from June to mid-September, is sunny everywhere, and it is mild or even cool on the northern coasts, and hot in the center-south. In Porto, the July average is 21 Celsius degrees, and daytime highs are around 25 degrees. In Lisbon, the average of the two hottest months (July and August) is higher, reaching 23.5 [° C] in August, with highs of 28 degrees. However, in the coastal areas most exposed to ocean winds (like Peniche, Sines, Sagres), it is cool even in summer. The Algarve coast is more sheltered, and therefore the temperatures are similar to those of Lisbon. However, from mid-June to early September, all of Portugal can be hit by heat waves from Africa. In these situations, the temperature can exceed 36/37 [° C] on the coasts, while it can exceed 40 [° C] in inland areas.

Moving deeper into the opened ocean conditions, there are a lot of considerations to take into account when planning the Atlantic crossing.

The most important consideration must be about the hurricane season, which is from June to the beginning of December. Leaving the Mediterranean or one of the westernmost islands of Europe (Canarias, Azores...) during this season it’s too risky, but since the first days of December yachts can start their voyage, but it’s advised to go as south as possible in the early season, maybe even southern than Cape Verde, to avoid any late hurricane that may be still develop.

Another important consideration to do is the position and the intensity of the Azores high, that drives the trade winds. Usually, the Azores high sinks south a little and ridges further west in January giving an increase in wind. This is confirmed by winds measured from satellite which also tend to show an increase in wind speeds as we move through December into January. How far north or south it is situated tends to determine just where the band of the maximum wind is and hence the route while the intensity of the high and the pressure gradient determine the strength of the trades. The pressure gradient is shown by how tight the isobars are on a synoptic chart but as we are relatively close to the equator, isobars tend not to be as helpful as further north. On Figure 6 is shown a map of an example of temperature and pressure curves (isobars) of the Atlantic Ocean

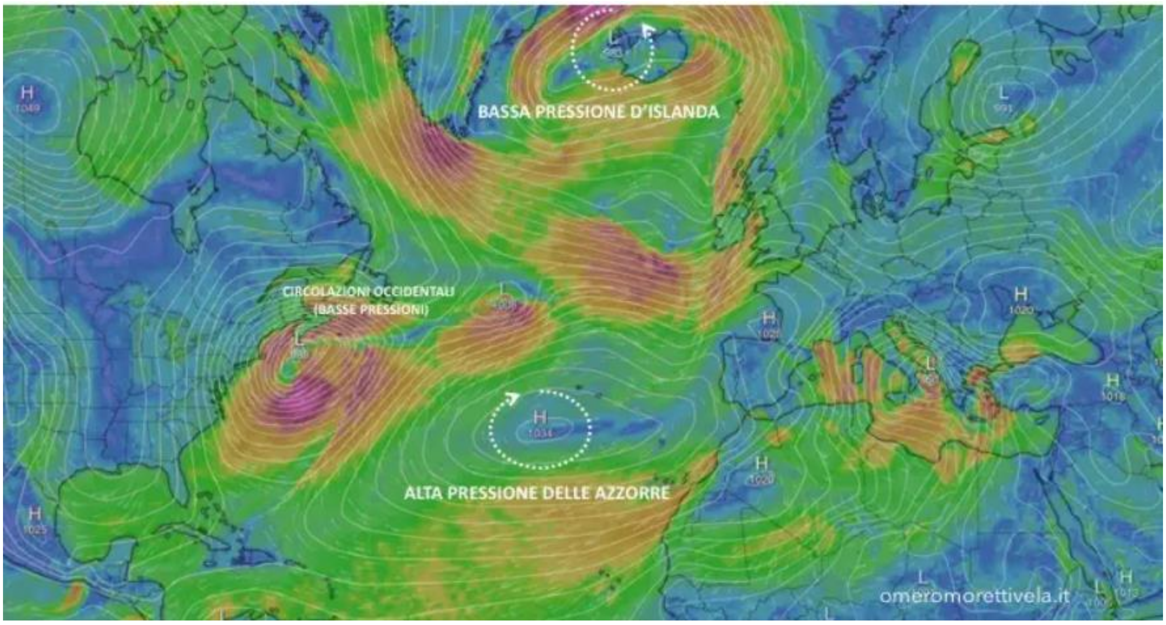

Figure 6 - Map of Temperature and Pressure of the Atlantic Ocean

The trades change every year and is generally around in a range between 15 [Kn] and 25 [Kn], however there are years in which wind will see periods of time under 15 knots and years with days above 25 knots (Today, s.d.). During the crossing is important to monitor what is happening to the north as large and deep depressions in the North Atlantic might unleash long trailing cold fronts that penetrate into the high pressure, reversing trade winds.

Without any weather information, the traditional route is to head south towards the Cape Verde Islands where statistically the steadiest trade winds will be found, passing close to the northwest of the islands a more direct course to our destination can be followed.

An alternative option could be to choose anyway the northerly routes that, thanks to stronger winds generated by the depressions, make this crossing quicker and allows yachts to approach Caribbean from a more north position. The risks of following these routes are not limited to the difficulties itself, but are also related to the risks of damage of the yachts, for rough weather conditions, that may reset the advantages of this choice.

It’s actually possible to say that there are three main routes for an East to West Atlantic Crossing (Heppell, 2018):

- Northern route: Las Palmas to Antigua 2580 [NM]
- Middle route: Las Palmas to St. Lucia 2800 [NM]
- Southern route: Las Palmas to Cape Verde 850 [NM] + Cape Verde to Barbados 2000 [NM]

On Figure 7 are shown the positions of the islands mentioned above and of the British Virgin Islands

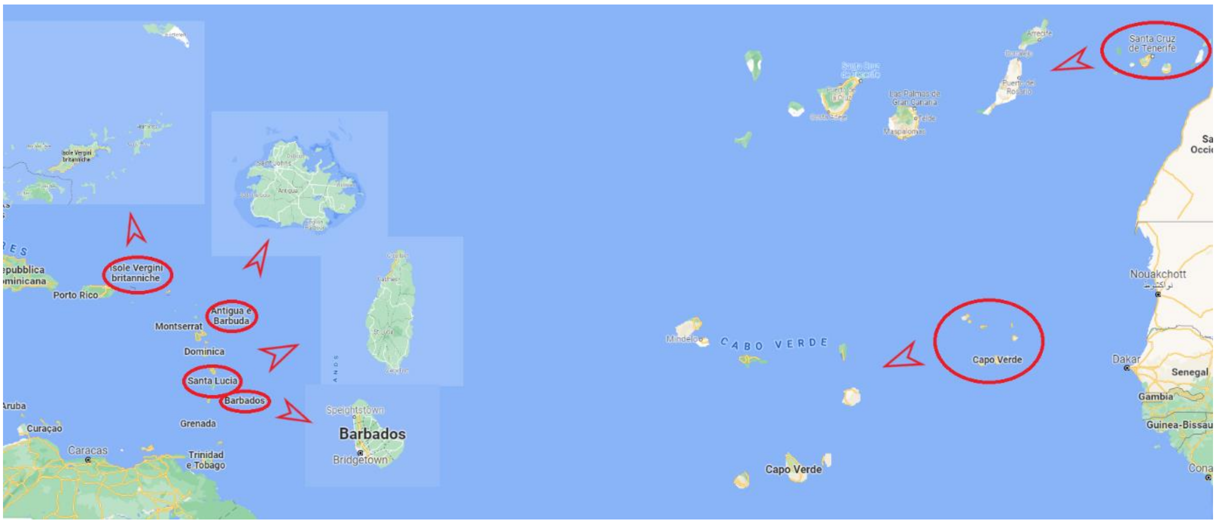

Figure 7 - Position of The Islands of the Three Main Routes and of the British Virgin Islands

Usually, the first route is mostly chosen by sailing yachts bigger than 20 [m] and by big motor yachts capable of withstanding rough weather conditions, and by those yachts that want to arrive as soon as possible to their destination.

The middle route is the most chosen one and well-travelled by any type of yacht able to do the crossing. T represents a compromise of good weather, position and length. The Southern route is preferred by those motor yachts that need to brake the route to fill the fuel tanks, so by smaller motor yachts that don’t have the autonomy to complete the Atlantic crossing without stopping (Heppell, 2018).

There are other valid options as an alternative to the three main one. For example, for a yacht coming from the Northern Europe, a possible route would be sailing along the coast until reaching Lisbon, then from Lisbon sailing to the Azores and from there crossing all the way to Bermuda Island

- Lisbon to Angra do Heroismo (Azores) 845 [NM] + Angra do Heroismo to Bermuda 1870 [NM]

This route also allows to make the crossing dividing the route into shorter legs compared to the other possibilities, making it attractive to those motor yachts that might have autonomy limitations. In addition, due to the strategic position of the Bermuda, it is the best route for who wants to go to East Coast of the United States, in fact the distance that separates the Bermuda to Savannah (Georgia) is 830 [NM].

Another relevant route is crossing the Atlantic starting from Lagos and going Azores and from there, depending form the final destination, going to the Bermuda (for USA Coast) or to The Settlement (British Virgin Islands (for Caribbean)

- Lagos to Angra do Heroismo (Azores) 885 [NM] + Angra do Heroismo to Bermuda 1870 [NM]
- Lagos to Angra do Heroismo (Azores) 885 [NM] + Angra do Heroismo to The Settlement (VG) 2300 [NM]

In Figure 8 are reported the positions of the Bermuda and of the archipelago of the Azores

Figure 8 - Position of the Azores and of the Bermuda

These other two options, leaving the coast from Lagos instead then Lisbon, might be chosen from those yachts coming from the Mediterranean and after sailed through the Strait of Gibraltar decide to start their Atlantic crossing from the closest port rather than sailing back to Lisbon.

More in general, it is possible to say that using the Azores as a stepping stone it is a valid option to almost all of the most common destinations, especially for the East Coast of the United States; about the Bermuda, dividing the routs into three legs passing by the Azores and this islands are convenient for those yachts who wants to sail along the USA Coast, or alternatively for those ones who needs to make shorter routes, but it is not the best option to reach the Caribbean.

3.2 Yacht traffic across the Atlantic

3.2.1 Yacht distribution in the Mediterranean and Caribbean

The study related to the traffic and migration of yachts across the Atlantic is a complex and intertwined subject. To better understand it, it is more appropriate to take into account a wider look and have an idea to the situation and the distribution of the yachts around the world.

According to the last information publicized by ICOMIA (International Council of Marine Associations), the world association that gathers nautical manufacturers, there are 33 million boats in the world and almost half are located in the United States. Furthermore, the fleet of superyacht at the beginning of 2020 is “just” made of 5520 units. (ICOMIA, 2020)

As might be predicted, the distribution of the yachts is not uniform and constant during the year, but it has cyclical peaks and troughs in the Mediterranean and the Caribbean depending on the time of year. This is also applicable to the pattern of superyacht numbers in the rest of the world year-round.

The Mediterranean attracts the majority of the fleet in July and August – the peak summer months – and, simultaneously, this is when numbers in the rest of the world decrease and almost drop off completely in the Caribbean. This supports the fact that, during peak times, the Mediterranean is the most popular region for superyacht visitations worldwide. While the number of yachts in the rest of the world decrees between June and August to concentrate in the Mediterranean, at the other time of the year most of the superyachts emigrate to the rest of the world, sometimes rising over 60 per cent of the fleet between January and April.

This shows that a large percentage of the fleet is not just cruising in a predictable way representing the typical distribution of yachts between the Mediterranean and Caribbean and is perhaps more spread around.

The Caribbean attracts a much smaller percentage of the fleet, even during the peak months of January and February, which sees between 10 and 18 per cent of the total (Matheison, 2019). One interesting observation is that while superyacht numbers around the year in the Mediterranean and rest of the world have remained stable over the years, the percentage of yachts visiting the Caribbean during the peak season has dropped significantly.

Between January 2015 and January 2018, for example, the percentage of the fleet in the region has dropped by about eight per cent. This supports that the Caribbean is decreasing in popularity. In addition, meteorological phenomena could influence this rate, for example the devastating hurricane in 2017 could also have had an impact on numbers, even though the data shows that the drop-off in numbers started in 2016. However, the trend might be reversing as December 2018 shows an almost three per cent increase of yachts in the Caribbean compared to December 2017 (Matheison, 2019).

Looking more closely at the areas within the rest of the world, there is no particular destination that seems to have increased or decreased in popularity since 2015. In fact, the data (Matheison, 2019) shows that all the destinations seem to experience similar cyclical peaks and through in superyacht visitations according to the time of year.

On the last position of the scale there is the west coast of the United States, followed by Australasia and Melanesia, which show a certain level of stability by attracting five per cent of the fleet. South-east Asia has increased a bit in popularity reaching 12 per cent since of the superyacht fleet. The region covering the east coast of the United States and the Bahamas follows a quite stable trend, having peaks during the winter months and dropping off in summer. This region, however, does not fall to the same extent as the Caribbean, which indicates that a substantial number of US-based yachts may winter in US yards and marinas thanks to the nearness to one of the most important landmarks of the yacht and superyacht business (Matheison, 2019).

From what has been analyzed, considering the average number of yachts in each region over the past four years, it is possible to say that the majority of the superyacht fleet year-round spends most of its time in the Mediterranean, as said before, with the busiest months predictably being July and August, following in popularity by the east coast of the United States and the Bahamas. This is likely representative of a large percentage of the fleet that will be active in the summer months and then choose to winter in the superyacht hubs of either the Mediterranean or the United States.

January is the most crowded month in the Caribbean, and this mirrors a large number of events in the region at that time as well as some yachts arriving after the Christmas and New Year period.

Lastly, there is no particular time of year when superyacht visits peak in south-east Asia, Australasia and Melanesia and the Middle East, and numbers remain fairly low all year round.

The global sample size for this superyacht migration is 4,433 vessels, which is around 80 % of the existing fleet. This is consistent with the number of yachts still in existence. In fact, according to the study made by Marine Traffic, the parameters for classifying a vessel as 'active' is at least 10 AIS (Automatic Identification System) transmissions over a four-year period of analysis. Of course, this represents an absolute minimum of activity, but differentiates the 'active fleet' from the estimated 1,000 superyachts that have been decommissioned or lost over time.

Applying the same parameters to the Mediterranean, there are 2,074 vessels that have been active within this time period, which is 47 per cent of the global fleet. The actual active fleet is around half that of the existing fleet, and this is supported by empirical data. In fact, when analyzing superyacht activity within the Mediterranean, the average number of superyachts active at any one time, including low season, is 1,025.

Unsurprisingly, the quietest month from the 48 analyzed was the first, January 2015, in which only 503 active yachts were recorded, while the busiest month of all was August 2018, with 1,515 active yachts documented (Marchetti & Palmas, 2020). Equally unsurprising is that the quietest quarter for activity is December 2017 to February 2018, with an average for any given wintering month of 678 vessels underway, probably because most of the fleet was on a shipyard for maintainace.

While Italy remains the Mediterranean's most popular high-season destination, namely between July and September, only one month saw another territory record more active vessels than Italy, France in July 2016.

There are some particular areas of focus when it comes to activity within key territorial waters. Much has been made of the emergence of the Eastern Mediterranean as a growth area, because of the lack of berth spaces during the high season in French and Italian Riviera hubs. Taking three key Eastern Mediterranean territories like Croatia, Greece and Turkey, it is clear how this affirmation is correct. During the peak months of July and August, there was an increase of 30 per cent in the cumulative number of yachts operating in these waters between 2015 and 2018. It is well known that the well-established yachting hub of Greece and its Ionian islands made up a significant portion of this activity, but all three territories have demonstrated significant growth in activity.

The Spanish cruising figures exploded and saw vast gains, peaking in summer 2017, which saw increases of 34, 24 and 25 per cent for July, August and September respectively. However, they dropped off in 2018 amid warnings that the market is slowing. Notably, however, Spanish numbers remain strong well into the winter (Marchetti & Palmas, 2020).

Finally, Portugal represents a springboard to all the yachts and superyachts that moves from Europe, Mediterranean and Northern Europe, to the American Continent because of its logistical position. Portugal is the westernmost County of Europe, not only about the mainland but also considering the Azores archipelagos which is a nerve point for all the rotes.

3.2 2. Yacht traffic between Northern Europe and Caribbean Islands

To better analyze the yacht traffic between Northern Europe and Caribbean Islands, it is important to underline that this region is characterized by the presence of some of the most important newbuilding shipyards of superyachts, especially on the Netherlands. It's clear how this impacts and influences yacht traffic, suffice it to say, for example, that all the yachts commissioned must be delivered to their final destination.

In addition, considering the superyacht world, is not rare that owners prefer, when possible, to do the ordinary and extraordinary maintenance by the original shipyard; this means that superyachts spread around the world, including Caribbean, go back to Northern Europe regularly.

This characteristic compensates the fact that, even if nowadays is increasing, this region is not as touristic as might be for example the wormer Italy or Baleares Islands.

For sure another aspect to take into account is the "normal" traffic due to all the owners based into this region that wants to enjoy the Caribbean during winter time, when it is almost impossible to sail around these countries.

Considering the routes in question, almost all of them, independently from which port they begin (Amsterdam, Hamburg, Southampton…) will go through the English Channel, skirt the Northern Coast of French and Portuguese Coast reaching Lisbon.

Therefore, they could split: most of them, those who can, will sail through the Northern Route, using the Azores (Horta) as a springboard to their crossing, with the advantages, disadvantages and limitation already analyzed.

The remainder of yachts moving from Northern Europe to Caribbean, either for their choice, final destination or for other various needs, can choose to continue sailing to the south and then split again into the Middle Route and the Southern Route.

3.2.3 Yacht traffic between Mediterranean and Caribbean Islands

Going into details for what concerns yacht traffic between Mediterranean and Caribbean Islands, as already said, there are periodic peaks of concentration of yachts and superyachts in the Mediterranean during the high season, throughout July and August.

The data reported on 3.2.1. give an idea on how intense and crowded this migration flow is: to give an example, according to the “Yachting World” (Bunting, 2019), each year around 1200 yachts cross the Atlantic just from the Cape Verdes, Canarias and Madeira along the Northern Route, and this is just the tip of the iceberg.

Due to the popularity of the hubs, luxury marinas and the amazing spots that Mediterranean can offer, yacht and superyacht owners are attracted on this part of the world to enjoy the summer. On the other hand, touristic season on the Mediterranean is quite short and to exploit their yachts during the rest of the year, owners must move to other destination, and most of them go to the Caribbean.

Another important aspect is that the most important refitting and maintenance shipyard for yacht and superyacht are located on strategic ports spread around the Mediterranean. This means that even the owners that might prefer to enjoy all the year on the Caribbean Islands, when it is necessary, they have to transport their yachts to this shipyards, increasing this migration flux.

About routes that might be chosen to cross the Atlantic from Europe to Caribbean and back, the criteria are more or less the same already reported. Independently form which port they start, yacht need to cross first the Mediterranean until they cross the Pillars of Hercules, well known as Strait of Gibraltar.

From this position they can split into the three routes depending on the final destination, weather conditions and so on.

3.3 Yacht traffic between Northern Europe and the Mediterranean

One region that holds much potential for owners wanting to explore is Northern Europe, that is particularly interesting not only because of its cruising potential but also because of its thriving superyacht business, being home to a selection of the world’s most prominent shipyards.

The Mediterranean area and the Caribbean area used to have the supremacy in terms of facilities and interest, but nowadays the traffic between Northern Europe and the Mediterranean is growing and even if it still represents a small slice of this business, it could take its place in the global scene.

An important aspect is that some of the biggest and most important newbuilding shipyards of superyacht are located in the North of Europe. According to the 2019 superyacht migration report of “The Superyacht News” (Matheison, 2019), over the past five years, there have been 89 superyachts delivered in the Netherlands – 15 per cent of all deliveries during this period. Furthermore, there are currently 53 superyachts under construction in the Netherlands, proving just how important the region is for the industry as a whole. This is one of the reasons why heading to Amsterdam and the rest of the Northern Route makes so much sense for owners.

Also the Dutch yachts can have a refit proposition at their yard of origin in Holland instead of going somewhere else Amsterdam is in the perfect position to be a starting or end hub as they continue up north for a leisure trip. So while there may not be the guaranteed fair-weather conditions of the Mediterranean, these higher latitudes are certainly an interesting option for owners looking to explore and consequently the traffic between Mediterranean and Northern Europe.

Apart from this aspect, the pleasure tourism plays an important role on this traffic. In fact, for those owners that are used to spend their time in the Mediterranean, the North of Europe represents something new to discover, a new experience, virgin landscapes to visit and a chance to live yachting life in a different way.

In addition, thanks to the always improving technology, comfort and safety can be guaranteed also in the North Sea, encouraging owners to bring their yacht from the worm and calm Mediterranean to this region. It's clear how much the improvement of tourism and the developing of the yacht industries influence the traffic of yacht and superyacht between Northern Europe and the Mediterranean and the rest of the world.

About the routs, there are two options to go from the Mediterranean to the Northern Europe and back:

- Cross the Strait of Gibraltar, sailing along the Portuguese coast, French coast a though the English Channel,
- For those yachts that have the right dimensions, they can choose to sail through one of the inland channels that connect the South and the North of France, such as the Canal du Midi or the Canal de Briare.

3.4 Yacht transportation

Transport by large merchant ships now has a global reach and is constantly expanding, both in terms of the number of ports served and on the size and types of yachts transported, which are increasingly high. Due to the yacht's migration flows already analyzed, it is evident why this market sector is growing so fast and consequently how the services and the options available for yacht owners are better and in continuous development.

There are several reasons why an owner would choose to transport his yacht by entrusting it to a company specialized on this kind of business. For example, not all the yachts are able to reach the destination by sailing autonomously. A motor yacht of about 20 meters that has to go from the Mediterranean to the Caribbean doesn't have the fuel autonomy necessary for such a long voyage (Storgaard, 2019).

More in general, there is not just a minimum length above which yachts can cross autonomously the Atlantic but it depends on several characteristics. It is convenient to distinguish sailing yachts from motor yachts:

- Sailing yachts: can easily make the cross above 10 [m] L_{OA} if properly equipped, but there are cases of yacht crossing the Atlantic even smaller than that: the world record was set by Hugo Vihlen on a boat of just 5 feet and 4 inches in length (Storgaard, 2019) .

  This type of yacht does not have range limitation because of the double propulsion (sail and engine)
- Motor yachts: it really depends on the type of motor yacht, but anyway usually above 24 [m] L_{OA}. The most indicated are those of the Expedition segment, designed and built with ideal technical characteristics for long range voyages, but if they are big enough and have the

necessary autonomy, even other types of motor yachts (normal one, fly-bridge…) can make the crossing. In fact, the major limitation for motor yachts is the fuel autonomy because, having just one type of propulsion (engine), they need to cover all the distance by the endothermic engines. Even for this case there are some exceptions: on 2019 Sergio Davì completed the Atlantic Crossing on a 11,30 [m] L_{OA} rib, from Palermo to New York (Ingiosi, 2019)

In addition to the above criteria, an important aspect to consider is the class given by the classification society and the CE (CE stands for "Conformité Européenne" in French) Yacht Compliance Classification. In fact, every yacht up to 24 [m] L_{OA}, has to be registered on a classification society that, when it is built, evaluates the technical characteristics and gives an approval category. In order to be able to make the Atlantic crossing, a yacht needs to be classified with the highest of the four classes, which is CE Class A: "A recreational craft given design category A is considered to be designed for winds that may exceed wind force 8 (Beaufort scale) and significant wave heights of 4 [m] and above but excluding abnormal conditions such as storm, violent storm, hurricane, tornado and extreme sea conditions or rogue waves" (Cocheril, 2012). This certification has to be reconfirmed by the classification society after a certain amount of time that depends on the class assigned; for the Class A every 8 years (Bottero, 2002)

Superyachts above 24 [m] L_{OA}, for the law, are a full-fledged a ship and it has to respect all the rules and the characteristics required by the classification society of which it is registered, but they will not have any limitation regarding the Atlantic crossing.

Another reason could be that the owner wants to move his yacht in a time of the year that is not conducive to the navigation for a certain route and so it is safer to transport his yacht onboard a ship.

3.4.1. Main routes

Thanks to ever-increasing market, this kind of service is available almost from and for all the most important ports in the world. During last year, the four major companies of yacht transportation delivered more than 2000 yachts from and to all over the world, but more concentrated on the busiest routes and between Mediterranean and Caribbean, especially on May and June (from Caribbean) and on November and December (from Mediterranean).

The main routes in the area of the Northern Atlantic Ocean are the following according with (DYT; Super Yacht Transport, s.d.). From the US East Coast to the Mediterranean and the other way around the main routes are the following:

- Ft. Lauderdale, FL / Miami -- Genoa, Italy
- Ft. Lauderdale, FL/ Miami -- Palma de Mallorca, Spain
- Ft. Lauderdale, FL/ Miami -- Toulon, France
- Ft. Lauderdale, FL/ Miami -- Yalova, Turkey

On Figure 9 is shown an example of the route mentioned above

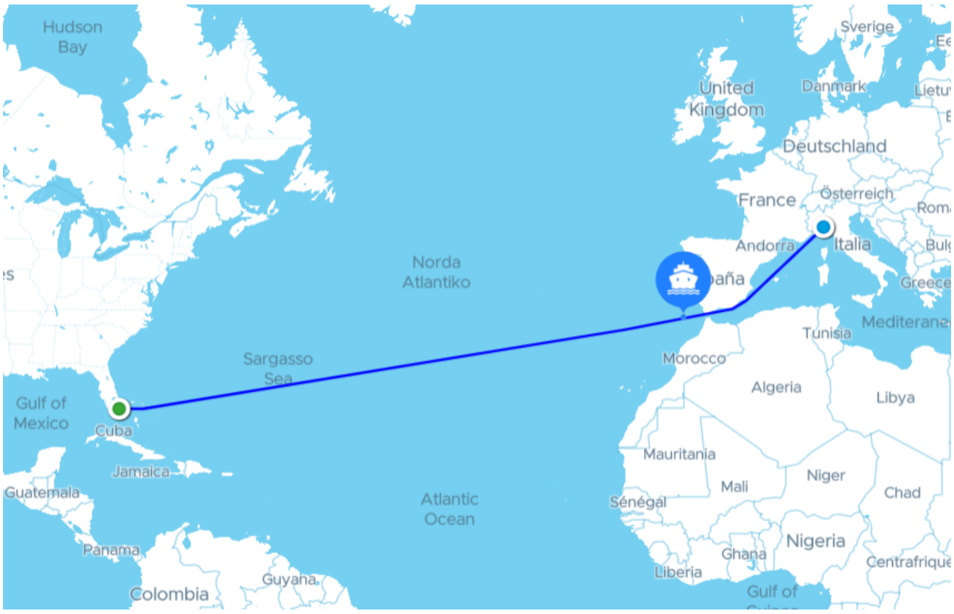

Figure 9 - Example of Route Between Ft. Lauderdale, FL / Miami -- Genoa, Italy (Sea Rates, 2021)

From the Caribbean to the Mediterranean and the other way around, the main routes are the following:

- Le Marin, Martinique – Genoa, Italy
- St. Thomas, USVI – Genoa, Italy
- St. Thomas, USVI – Palma de Mallorca, Spain
- Le Marin, Martinique – Palma de Mallorca, Spain

Figure 10 shows the route between Le Marin, Martinique and Palma de Mallorca, Spain

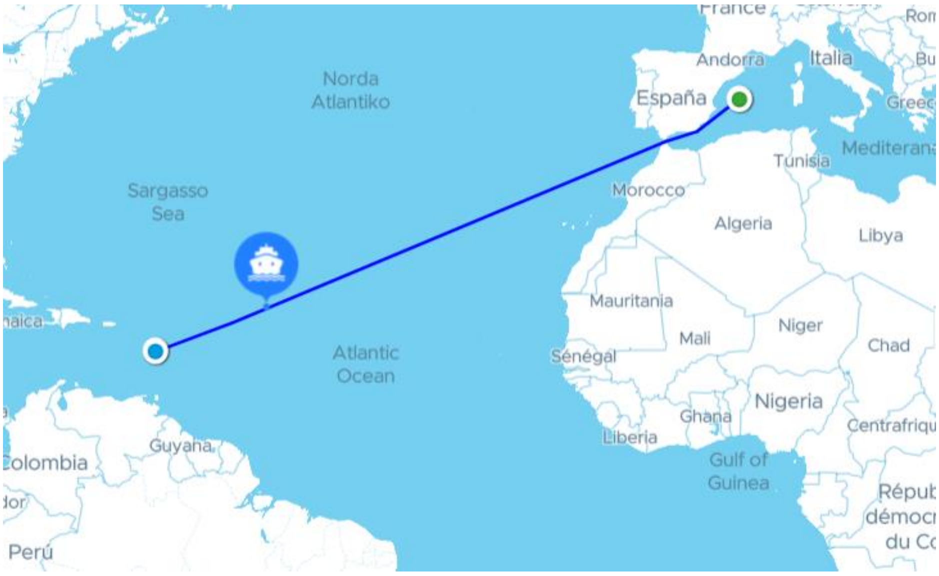

Figure 10 - Example of Route Between Le Marin, Martinique – Palma de Mallorca, Spain (Sea Rates, 2021)

From Northern Europe to the US East Coast and the other way around, the main route is the following, as shown on Figure 11:

- Rotterdam, the Netherlands – Ft. Lauderdale, FL

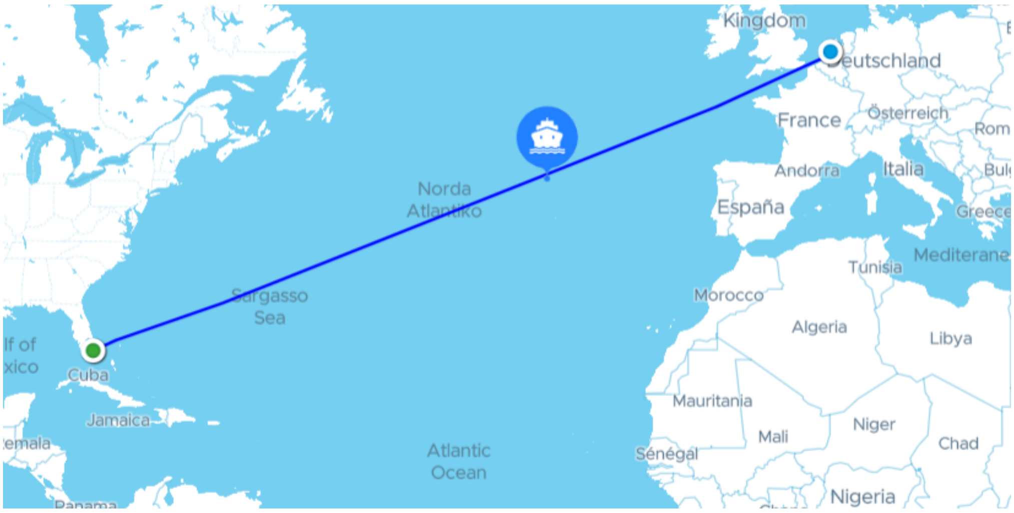

Figure 11 - Example of Route Between Rotterdam, the Netherlands – Ft. Lauderdale, FL (Sea Rates, 2021)

From Northern Europe to the Caribbean and the other way around, the main route is between Rotterdam, the Netherlands and St. Thomas, USVI.

Obviously, there are connections as well between the Mediterranean and the South Pacific (Genoa, Italy – Papeete, Tahiti – Auckland, New Zeeland – Brisbane, Australia), South Pacific and the US, Central America and the Mediterranean, etc, but these fall out of the scope of this thesis.

3.4.2. Shipping companies and ship types

The main companies of yacht transportation, very highly specialized, are: DYT Yacht Transport, based in Florida; Peters & May Group, based in Southampton; Complete Marine Freight, based in the Netherlands; Seven Seas Yacht Transport, based in the United Sates; United Yacht Transport, based in Florida. The type of ship used to transport yachts really depends on the size of the yachts and on the quality of the service that the company can offer.

For small boats that feet into a container, which have standard dimensions, the easiest and cheapest choice would be to transport it into a container by a containership, much more common than other types of vessel made for this purpose. For all the other boats, yacht and superyacht bigger than a container, the containership is not a viable way. It might be possible to use a general cargo, which is a ship made to transport almost any kind of cargo, but due to the value, the fragile nature and the delicacy of goods like this, it’s not the best option to transport yachts with other goods.

Another option, much more appropriate, would be to choose a company that operates a dedicated ship available for the transportation of yachts. Generally, this kind of ships can be of two types: Lo/Lo or a semi-submersible vessel. Lo/Lo ships (Lift-on / Lift-off) are equipped with special cranes able to lift the yachts from the water to the positions on the bridge where they will be secured and tied for the navigation and back into the water when reached the destination, like shown on Figure 12. The disadvantage of this kind of ship is that lifting a yacht, even by dedicated and specialized cranes equipped with straps to distribute the pressure acting on the hull, is always a risk, not only for the operation itself but also because it can cause cracks and scratches on the finishes and on the gelcoat, and other kind of damage.

Figure 12 - Typical Lo/Lo Ship

Semi-submersible vessel (Float-on / Float-off) is for sure the best vessel to transport yachts. They are characterized by the presence of numerous ballast tanks that allow the vessel to be lowered until the main deck is below the surface of the water in order to accommodate large floating loads, in this case yachts, that are able to get into the right place across the deck. The crew prepares the supports (berths), but the yachts reach the correct location by themselves and without the mast (in case of sailing yacht). The load is lifted from the water and stability is ensured by adding water on the ballast tanks. To avoid damage to the ballast water tanks due to over or under pressure, the internal pressure of the tanks and the level are also monitored. This type of ship eliminates the disadvantages of all the other kind of ships about transportation of yachts and due to its innovative system minimizes the chances of damage of this expensive and particular goods. Ships may be fully open on the sides or of the dock type, as shown in Figure 13 and Figure 14

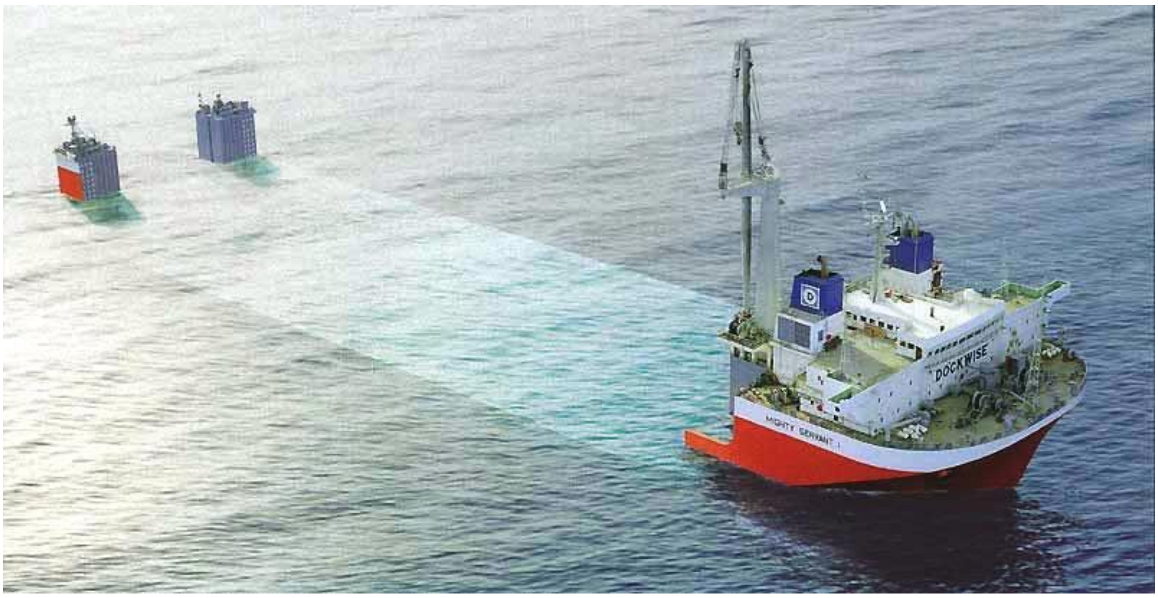

Figure 13 - Typical Float-on / Float-off Ship Ready to be Loaded

Figure 14 - Typical Float-on / Float-off Ship Fully Loaded

3.4.2. Cost levels for yacht transportation

When talking about costs, it is necessary to analyze separately the transportation by navigation and the transportation by ship. Concerning moving a yacht by sailing from port one to port two, costs can vary a lot depending on the type of yacht, if motor yacht or sailing yacht. In the first case the cost of the fuel would have a huge impact on the total costs, on the other hand for sailing yachts it's reasonable to say that most of the propulsion used would be by the wind, and even if not, the power installed on sailing yacht is way less than a motor yacht, and so the consumption of fuel.

Another relevant cost is the crew, that might be not the same of normal activity of the yacht but more specialized on this kind of voyage. In many cases, a professional crew is hired for these type of voyages across the Atlantic Ocean, and that represents a significant cost. This cost is strongly influenced by the number of crew members needed, depending on the size of the yacht and on the journey time, and on the experience of the captain and his crew. An order of magnitude, for a crew of three members, necessary to sail through the Atlantic by a 35-foot sailing yacht, would cost 300 [USD/Day] for the captain, 150 [USD/Day] for the second and 100 [USD/Day] for the third crew member. (Carrier, 2013). Another example: for a delivery skipper from Greece to Tortola, British Virgin Islands, is 13250 [USD], Including airfare and food. (Carrier, 2013)

If the owner would choose to hire a specialized crew to move his yacht, this cost could be floating from 4000 [USD] to 14000 [USD] just for the captain, plus the other crew members that depends from the size of the yacht and the route (Carrier, 2013). On the other hand, if the owner decides to sail by himself, taking into account a medium-size sailing yacht, it's possible to estimate the cost of crossing the Atlantic around 7000 [USD] plus the marinas. Considering that, depending on the routes and on the yacht, it' necessary to make one or more stops before reaching the final destination, ports costs might be relevant on the total cost of the transportation. It's also important to take into account the insurance for the voyage, because for sure it would be a high risk voyage and owners want to be protected from any unforeseen that might be happen.

Regarding the costs related to the transportation by ships, it's necessary to distinguish the transportation by containerships and by all the other ships. In case of containerized cargo, independently on the type of goods inside the containers, the cost would be smaller compared to all the other options, due to the numerous advantages of standardized cargo, that allows to optimize the voyage of the ship pulling down the costs. In addition, there is much more competitiveness on containerized shipping, that plays an important role on reducing costs. For transportation by Lo/Lo and Float-on / Float-off, costs really depend on the route, on the dimensions and on the value of the yacht itself.

To have an idea, to transport a motor yacht of $L_{OA} = 30\ [m]$ and $B = 7\ [m]$, that is worth around 8 million dollars, from Genoa to Fort Lauderdale it would cost around 150000 [USD] plus the insurance and the crew (Complete Marine Freight, 2021). Another example: to ship a 47 [ft] long yacht from Turkey to Florida it would cost around 25000 [USD] by Dockwise company (Carrier, 2013). For a 120-foot yacht would be about 175000 [USD] according to Dockwise. (Frank, 2013)

More in general, for the routes between Miami (which is the crucial point for the Caribbean) and Europe, shipping a yacht by a Lo/Lo or a semi-submersible ship would cost not less than 1000 [USD] per foot. (Frank, 2013). On Table 1 are presented the examples above-mentioned and the respective linear costs in Euros:

Examples of Shipping Costs				
Loa [m]	**Cost of Shipping [USD]**	**Linear Cost of Shipping [USD/m]**	**Conversion [USD] to [EUR]**	**Linear Cost of Shipping [EUR/m]**
30	150000	5000	0,752	3760
14,3 (47 ft)	25000	1745	0,752	1312
36,6 (120 ft)	175000	4785	0,752	3597
////	////	3280	0,752	2467

Table 1 - Examples of Shipping Costs

4. CHARACTERIZATION OF MAJOR SUPERYACHT MARINAS

The word “Marina” usually indicates structures, places, environments very different from each other: it is called “Marina” the touristic port of Belem, which counts around 80 berths, and the touristic port of Marseille, that has a capacity of more than 3000 berths. These marinas are also very different from the point of view of visual impact, organization, available maintenance and services.

Actually, it should be necessary to distinguish two major categories of Marinas:

- Transit Marinas, which are those ports, located in a strategic position, useful for a stopover or supply point for yachts and that are significantly influenced by the season of the year,
- Permanents Marinas, that are ports where the primary activity is to host yachts for most of the year, usually clients are more or less the same every year.

Transit Marinas are usually located in a touristic spot or in a crossing point of the major transit routes, the majority of these ports are small-medium size; there is a continuous renewed of people, even daily. On this kind of marinas is not rare to have entire months of total inactivity and this means fluctuation of prices: super low prices on the low seasons and high prices on the high seasons. Due to the type of traffic, usually there is a small shipyard for fast and small repairs, mostly operated from local supplies. Another important characteristic of these Marinas is the availability, because usually the total capacity of the port is available for transits.

The organization for these marinas is quite complicated: for example, in order to optimize the revenue, strike the perfect balance of size and occupancy every day with all the draw brakes it is hard. Another example could be that due to the not constant intensity of work, guarantee the services and the quality of the facilities it’s a balance of savings and risks for the manager of the marina.

Regarding Stable Marinas, usually they are located close to large cities and owners benefit from such a service as a base for their yachts and most of the times are way larger than transit marinas. The intensity of work is more or less the same during the whole year, with an increase during summer time. Normally there is a large percentage of berths already taken and reserved for long term rents and just a small number of berths for transits and short rents. For this category of marinas, the organization is a bit easier compared to the other, because there is a small number of possible scenarios. Due to the almost constant intensity of work, the staff, services, and local supplies are well settled and abundant. In addition, because yachts are more or less the same, the combination to optimize the space is way easier than in a marina where every day yachts are different. These type of marinas are usually combined with one or more shipyards, well equipped and organized to offer any service, from the routine maintenance to deep refitting of yachts.

In terms of structures, there are two different types of harbours:

- Canal harbours: they are often placed to the mouths of rivers or in a particular spot to better use the morphology of that territory. These marinas are particularly safe and calm because don’t allow the waves to enter and damage the yachts; on the other hand, they have limitation on the size of yachts able to receive.

- Classic harbours: are the most common type of marina, can be located almost everywhere and can be designed specifically for the needs required.

A marina, independently from the size and type, is protected from the dominant wind and swell of that region, with the entrance facing the protect side. There always are a sea wall and inner quay, and, depending on the size of the marina, there might be one or more floating docks, even equipped with fingers to make embarkation and disembarkation more comfortable.

About mooring systems, there are several options. The most common is a combination of dead weights, chains and ropes: along the center of the water surface inside the port there are one or more lines of dead weights, not necessary all of the same dimension, designed for the yacht's size usually located on that part of the dock, connected by a main chain line. From the main chain line, connected by marine karabiners, start the secondary chain line, perpendicular to the main one, one for each berth and long around 20m. At the end of each secondary chain line start a rope, that will be fixed at the bow of the yacht. Alternatively, another system could be with wooden poles, fixed on the sea bottom, from where the mooring ropes start. This system is more indicated for those marinas that have no problems in terms of space, because each poles will take some space off from the berth.

Technically speaking, there are several characterization criteria that can be considered for all the Marinas: number of berths, maximum size of yachts that can be hosted (in meters), depth limitation (in meters). The next sections will present the technical characteristics of the major marinas in the West Mediterranean, Northwestern Atlantic and Portugal.

4.1 Major marinas in the Mediterranean: Spain, France, Italy, Malta and Monte Carlo

This section will report the most important characteristics of the major marinas of Spain, France, Italy, Malta and Monte Carlo bordering the Mediterranean. Unfortunately, such information, despite its importance, it is not always available on the websites of the marinas. The Spanish ports that have been taken into account are listed in Figures 15 to 17. These figures show, respectively, the number of berths, maximum length of the yachts and depth limit (if any) of each Spanish marina mentioned above. The red lines indicate the average of each parameter for the marinas considered.

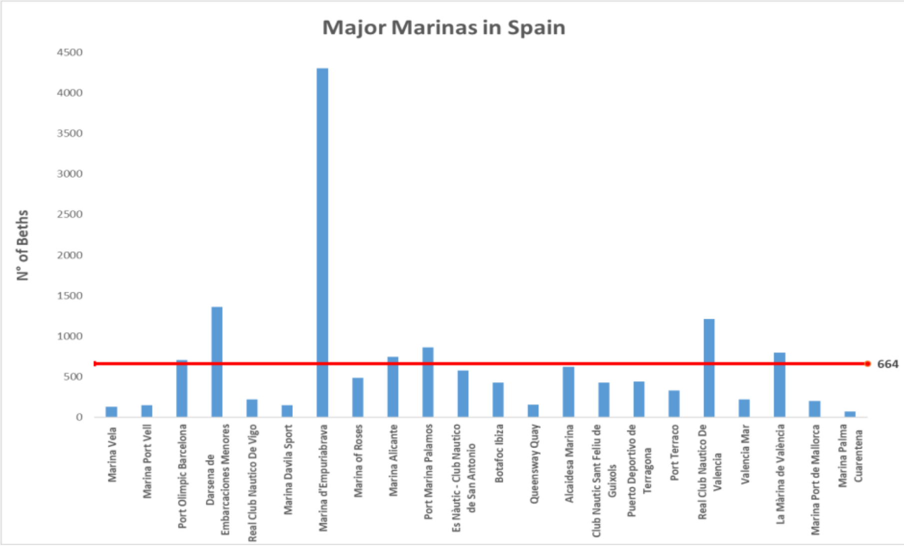

Figure 15 - Number of Berths of the Major Marinas in Spain

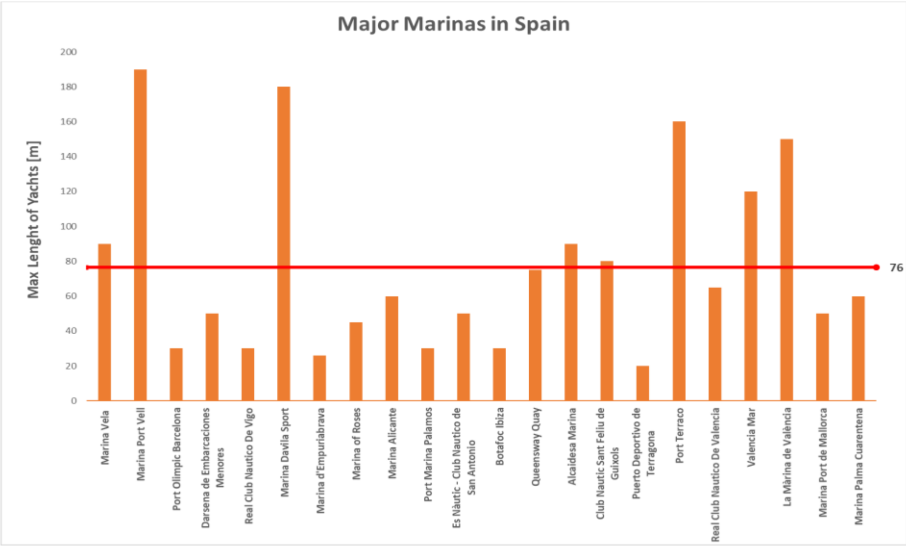

Figure 16 - Maximum Length of Yachts of the Major Marinas in Spain

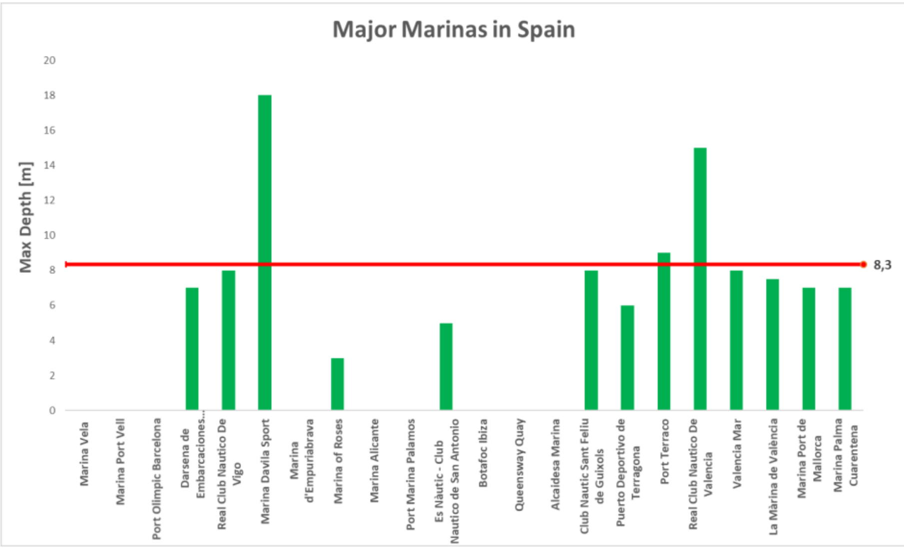

Figure 17 - Maximum Depth of the Major Marinas in Spain

The following figures, from Figure 18 to Figure 20 represent respectively: number of berths, maximum length of the hostable yachts, depth limit (if any) of the French taken into account. The red lines indicate the average of each parameter for the marinas considered.

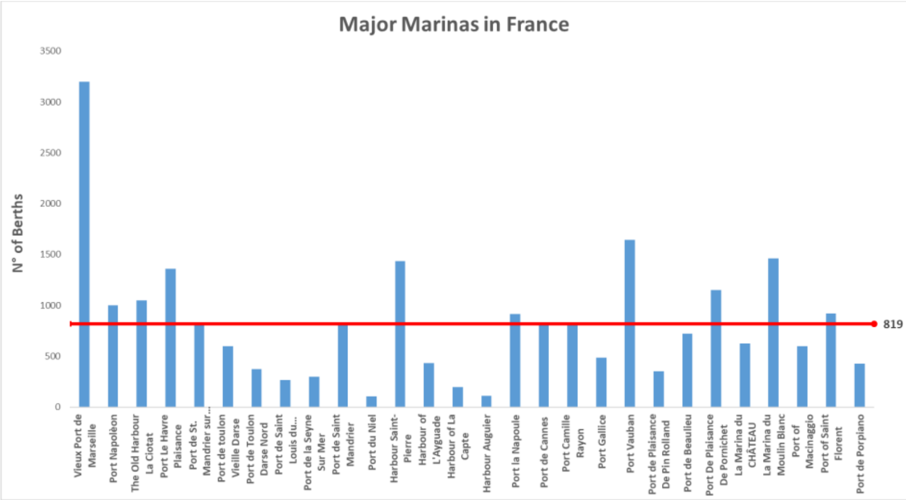

Figure 18 - Number of Berths of the Major Marinas in France

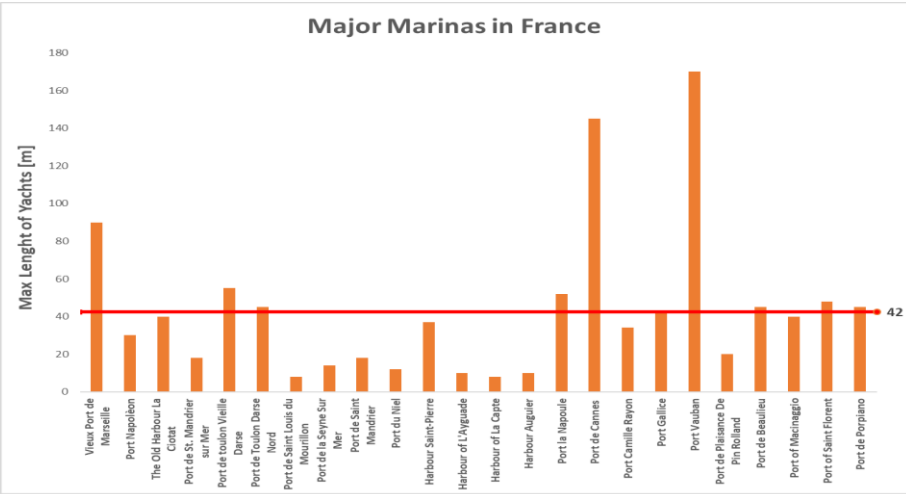

Figure 19 - Maximum Length of Yachts of the Major Marinas in France

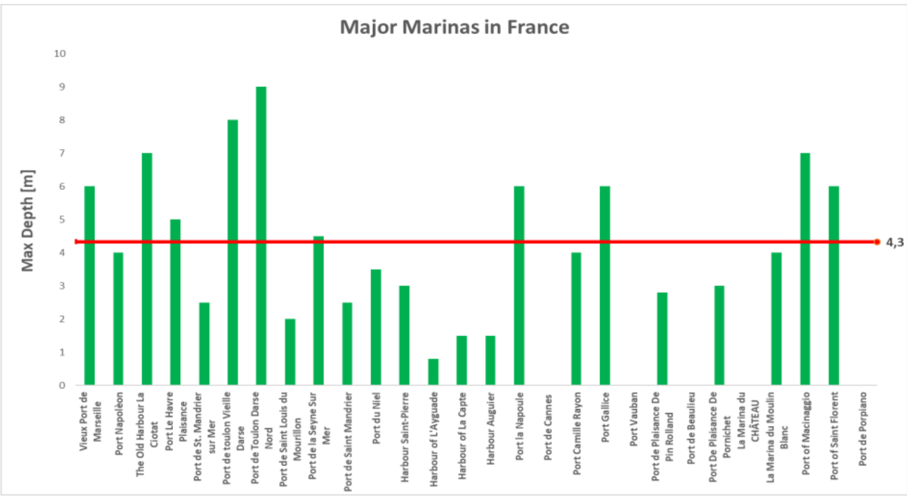

Figure 20 - Maximum Depth of the Major Marinas in France

Here below the graphs, from Figure 21 to Figure 23, show respectively: number of berths, maximum length of the hostable yachts, depth limit (if any) of the major marinas of Italy, Monte Carlo and Malta. The red lines indicate the average of each parameter for the marinas considered.

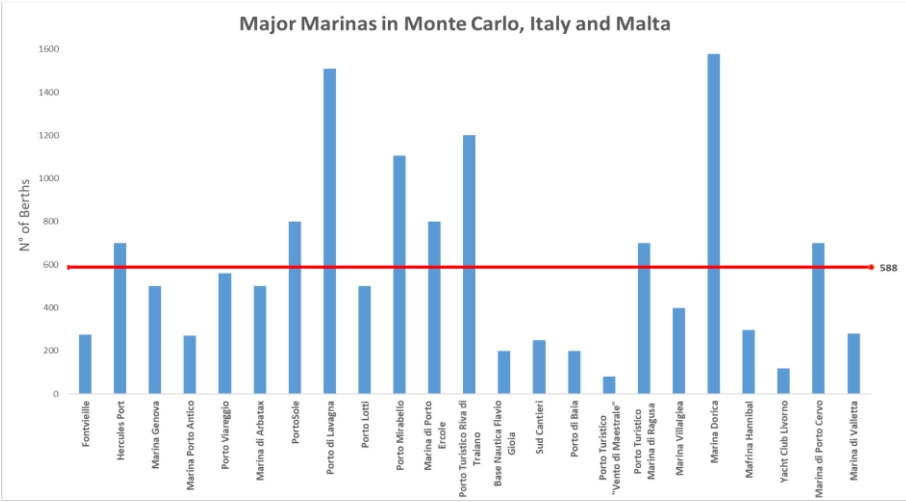

Figure 21 - Number of Berths of the Major Marinas in Monte Carlo, Italy and Malta

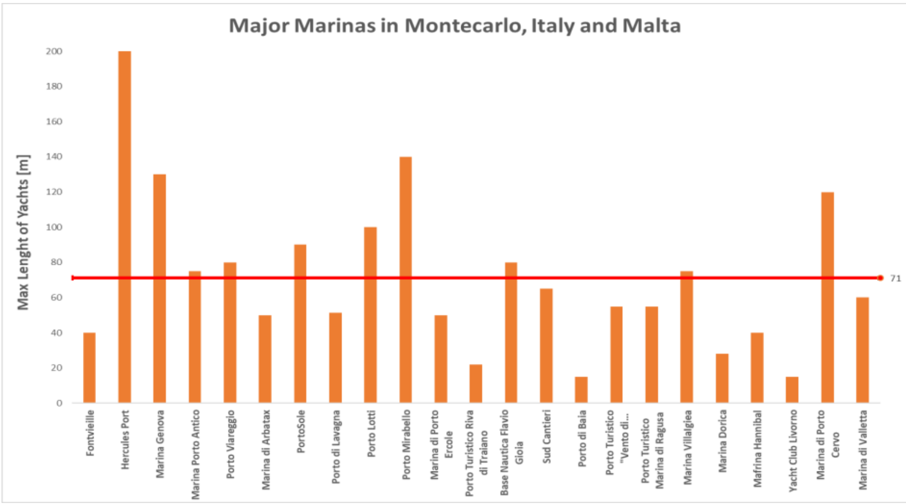

Figure 22 - Maximum Length of Yachts of the Major Marinas in Monte Carlo, Italy and Malta

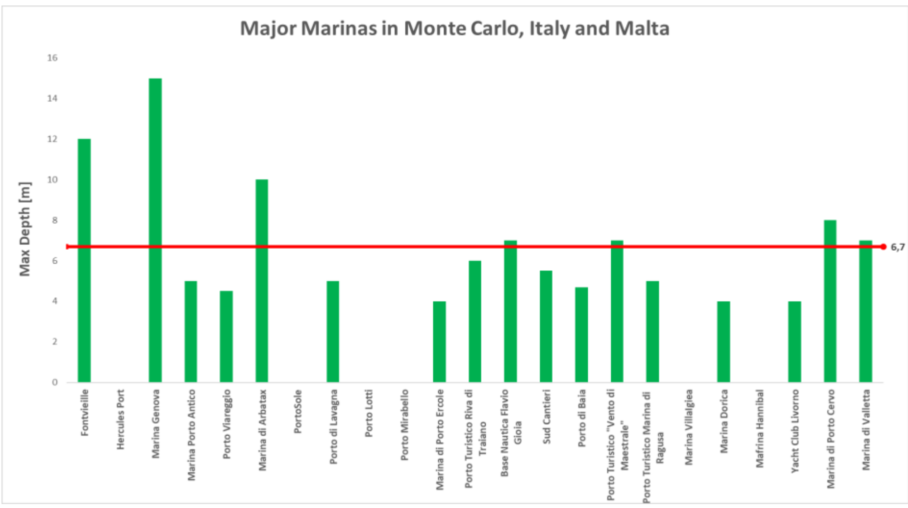

Figure 23 - Maximum Depth of the Major Marinas in Monte Carlo, Italy and Malta

Taking a close look to the graphs, it’s possible to say that Spain has an average number of berths close to 700 per marina, with an average maximum length of yachts that can be hosted of 75 [m]. About France, the average number of berths is 820 but the average maximum length of yachts that can be hosted is 42 [m]. Regarding Italy, Monte Carlo and Malta, the average number of berths is almost 600 and the average maximum length of yachts that can be hosted is 72 [m].

Comparing these data, it is possible to say that the country with the grater predisposition for superyachts is Spain, almost on a par with Italy, Monte Carlo and Malta, and followed by France. On the other hand, France has the largest marinas in terms of capacity. This could be due to the fact that France has more channel ports compared to the other countries, and, as already said on the introduction of this Chapter, this type of harbors has strong limitation in terms of size of yachts receivable but are on average larger in capacity.

It is important to say that in each country under study there are more than three marinas that can host yachts over 100 [m] except Malta, this means that France, Italy, Spain and Monte Carlo have attractive infrastructures for this type of tourism.

Finally, observing the locations of the major marinas under study, it is possible to say that there is a strong concentration of marinas on the center of the Mediterranean, between Valencia and Fiumicino, including the Baleares Sea, French Riviera, and Ligurian Sea. This is consistent to study made on section 3.2.1 about superyachts migration and concentration.

4.2 Major marinas in Northern Europe: Spain, France and United Kingdom

This section will report the most important characteristics of the major marinas in the north of Spain, France and United Kingdom bordering the Atlantic Ocean. Following, from Figure 24 to Figure 26, are shown the graphs reporting respectively: number of berths, maximum length of the hostable yachts, depth limit (if any) of the ports in question. The red lines indicate the average of each parameter for the marinas considered.

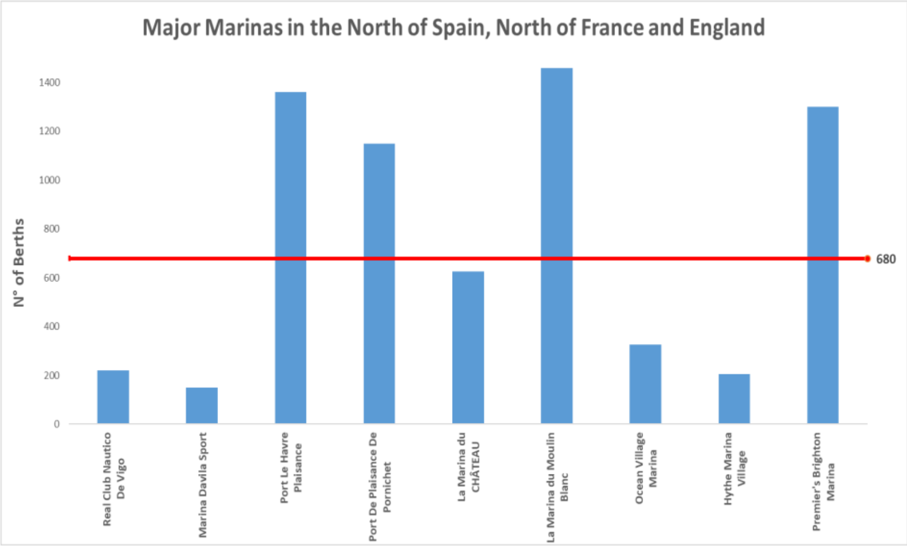

Figure 24 - Number of Berths of the Major Marinas in the North of Spain, North of France and England

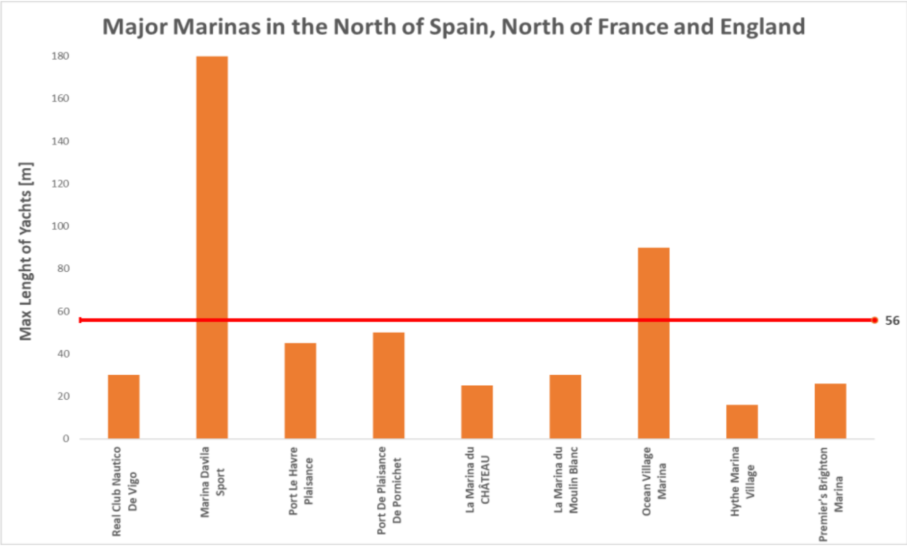

Figure 25 - Maximum Length of Yachts of the Major Marinas in England and in the North of Spain, France

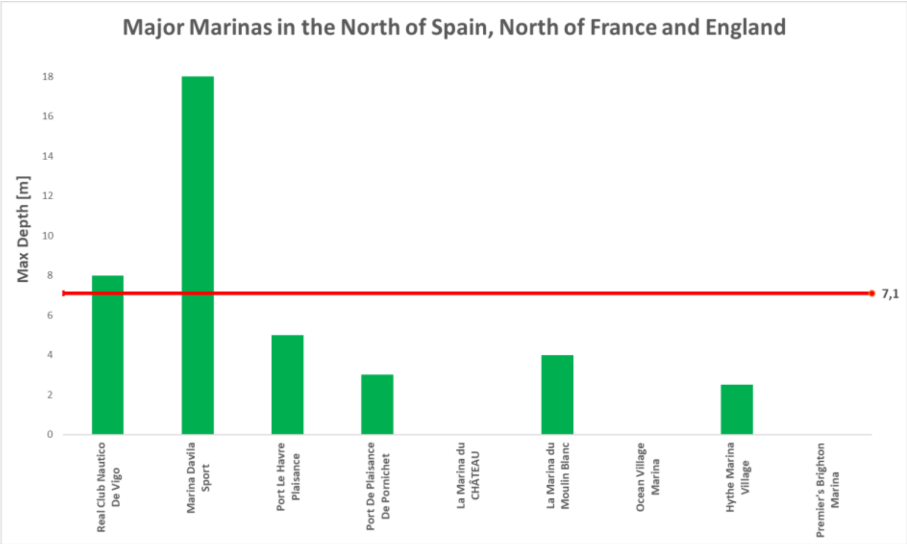

Figure 26 - Maximum Depth of the Major Marinas in the North of Spain, North of France and England

Making some considerations about the data collected, first of all there is a smaller number of relevant marinas compared to the Mediterranean ones. In addition, the average number of berths in the marinas analyzed is around 700 but the average maximum length of yachts that can be hosted is just 55 [m], including Marina Davila Sport in Vigo (180 [m]) which is the only one exceeding 100 [m]. This means that in the United Kingdom and in the northern coasts of France and Spain there is a less predispositions on receiving superyachts over 50 [m] and consequently the luxury tourism related to them.

4.3 Major marinas in Portugal

In this section are reported the most significant characteristics of the major Marinas in Portugal, both of the mainland, the archipelagos of the Azores and of Madeira.

Figure 27, Figure 28 and Figure 29 shown the graphs reporting respectively: number of berths, maximum length of the hostable yachts, depth limit (if any) of the major marinas in Portugal. The red lines indicate the average of each parameter for the marinas considered.

Analyzing the information and the graphs obtained, it looks clear how different the situation in Portugal is in comparison to the rest of the countries under study. First of all, the average number of berths and of the maximum length of yachts that can be received are the lowest recorded, respectively of ≈ 450 and ≈ 35 [m]. Moreover, the picks of berths and lengths are respectively 825 and 60 [m], both in Marina di Vilamoura in Vilamoura and are way greater compared to the average; in addition, there is just one other marina that can host yachts of 50 [m], which is Marina de Portimão (50 [m]).

Another relevant aspect is the distribution of the major marinas: the bigger ones are in the southern region, Algarve. This region, which is characterized by better weather conditions and it is more protected from waves, tides and currents, is also located close to the connection between the Atlantic Ocean and the Mediterranean, the Strait of Gibraltar, one of the busiest stretches of water in the planet. All these characteristics makes the Algarve really attractive both for nautical tourism and as a logistic springboard for the traffic between Mediterranean and Atlantic Ocean with an incredible potential that can be exploited with an improvement of dedicated and highly specialized infrastructures.

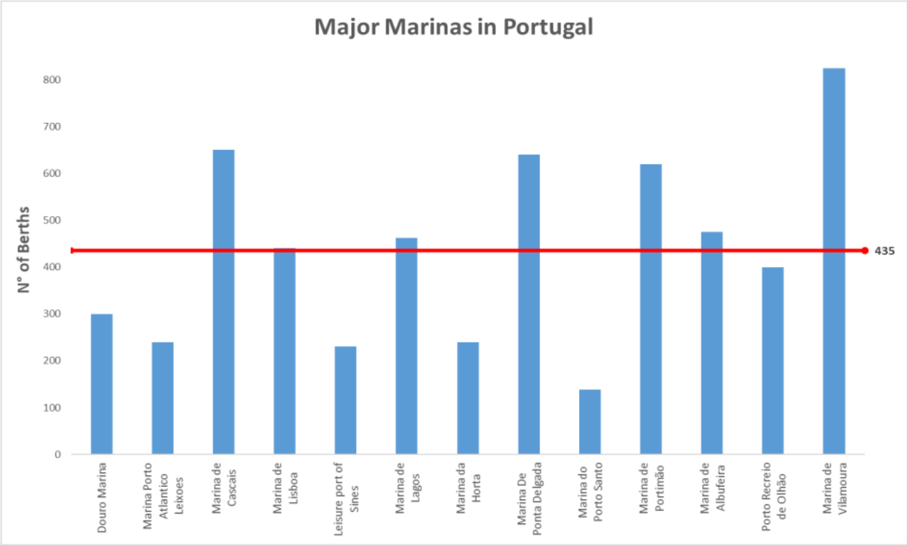

Figure 27 - Number of Berths of the Major Marinas in Portugal

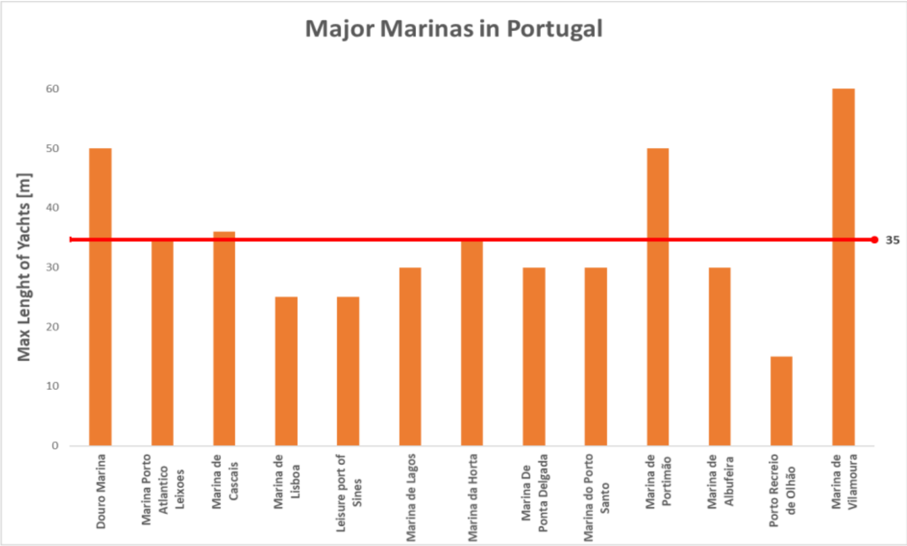

Figure 28 - Maximum Length of Yachts of the Major Marinas in Portugal

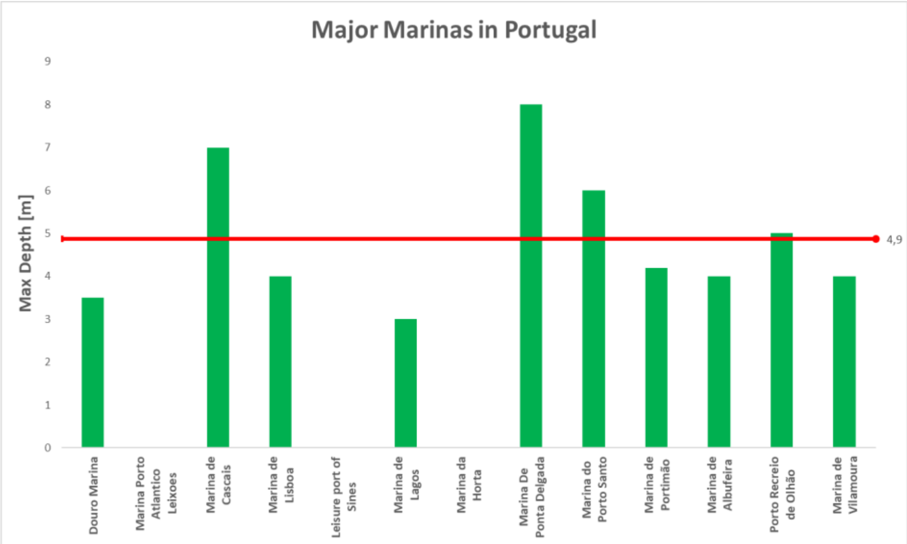

Figure 29 - Maximum Depth of the Major Marinas in Portugal

The same potential is also present in the Azores and in the island of Madeira. In keeping with the section 3.1, some of the most important and busy routes between the Mediterranean and the Caribbean and the American continent in general, stop to these islands. The study made shows that the biggest marina in Madeira has just 140 berths and is able to receive yachts up to 30 [m]; for the Azores the highest capacity is of Marina De Ponta Delgada with 640 berths but just for yachts up to 30 [m], and the maximum yacht's size is in Marina da Horta with 35 [m]. It is clear how the marinas present on this territory are not enough developed to cope the intensity of this traffic, such as the dimensions of superyachts that increase year by year.

The following graphs, on Figure 30, Figure 31 and Figure 32, show respectively the number of marinas per each country with a capacity $\leq 500\, Berths$, the number of marinas per each country able to host yachts larger than 50 [m] L_{OA} and the number of marinas with a depth limitation greater than 5 [m].

Analyzing the graphs below, it is possible to see how Spain, France and Italy are the countries with the larger number of marinas respecting these parameters, which is in line with the previous data collected. In particular on Figure 30 is possible to see that the first one is France with 16 marinas, followed by Italy with 12 and Spain with 11, after which it jumps down to 4 with Portugal. Regarding Figure 31, the country with the larger number of marinas that can receive superyachts larger than 50 meters is Spain with 16 marina, immediately before Italy with 15 and followed by France with just 6. Finally, on Figure 32, it is possible to see that the countries with a larger number of marinas deeper than 5 meters are respectively Spain with 14, Italy with 13 and France with 12 marinas.

Another relevant data is the percentage of these marinas, in relation to the total number of ports analyzed per each country, exceeding respectively a capacity of 500 berths, moorings for yachts larger than 50 [m] and a depth greater than [m]:

- Spain: 50%, 73% and 64% of 22 marinas
- France: 64%, 24% and 48% of 25 marinas
- Principality of Monaco-Monte Carlo: 50%, 100% and 100% of 2 marinas
- Italy: 60%, 75% and 65% of 20 marinas
- Malta: 0%, 100% and 100% of 1 marina
- United Kingdom: 33%, 33% and 33% of 3 marinas
- Portugal: 31%, 15% and 31% of 13 marinas

Excluding the only marina considered in Malta, Portugal has the lowest percentages in all the three parameters. These graphs make a comparison between the countries taken into account of how many of the major marinas satisfy certain parameters, which indicate how developed the infrastructures are. This is important to know concretely how many marinas are ready to host big superyachts.

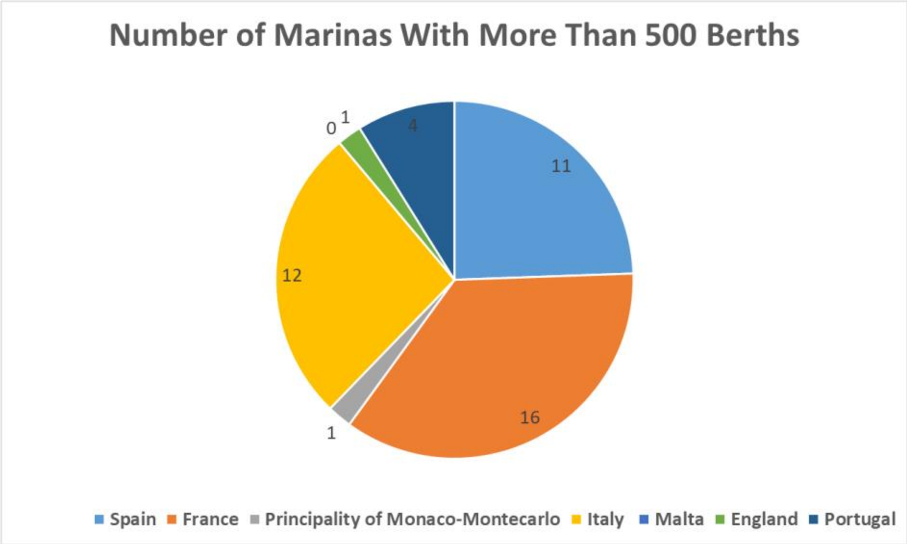

Figure 30 - Number of Marinas With More Than 500 Berths

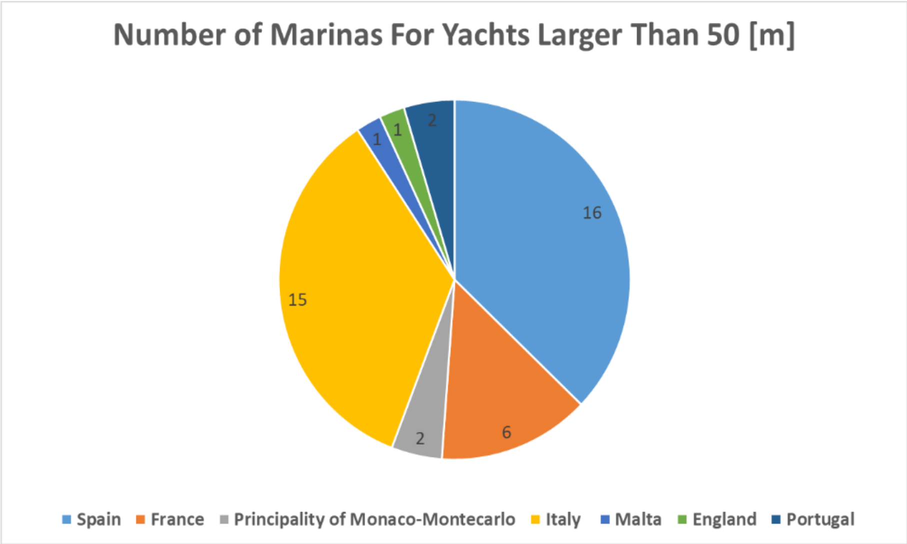

Figure 31 - Number of Marinas For Yachts Larger Than 50 [m]

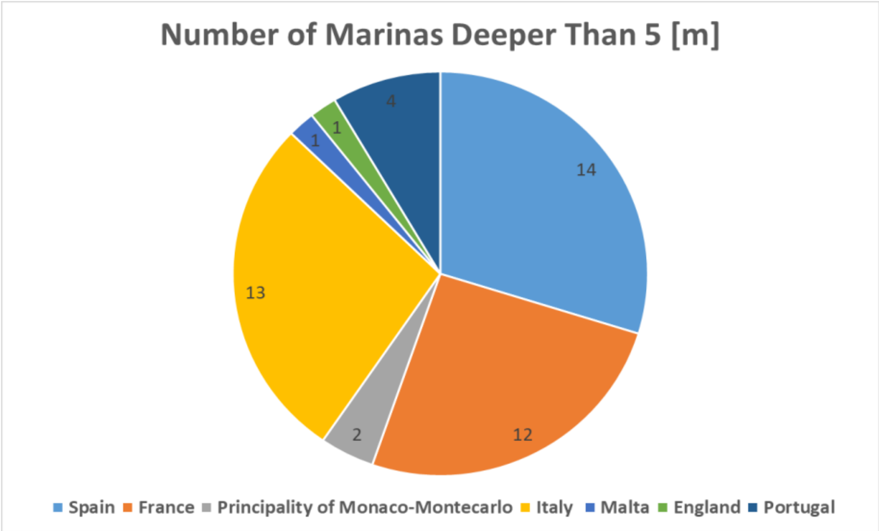

Figure 32 - Number of Marina Deeper Than 5 [m]

4.4 Required superyacht marina facilities

Considering the marinas above, there are some essential facilities that almost all marinas offer to their clients: first of all, water and electricity supply. Nowadays, the amount and intensity of electricity required from all yachts has increased exponentially due to the increase and improvement of technology onboard, and the necessary adaptation of the existing systems onshore does not always keep pace. This service could be included on the fees of the berths or might be an extra service, regulated by service points [1], equipped with a delivery control system, because, especially for yachts up to 25 [m], the consumption of electricity could be of the same order of magnitude of the price of the berth. Another essential facility is the 24/h surveillance, integrated with a video surveillance system, which is vital to protect precious goods such as port full of multi-millionaire yachts. An important aspect is the equipment need to respect the always new and more restrictive laws about preventing pollution. For example, since 2012 every marina must be equipped with a bilge pumping system, to collect the dirty water mixed with oil and fuel of yachts.

For those ports that can receive superyachts, in order to encourage this type of tourism and to fulfil the needs of these boats and clients, there are several essential facilities that almost all of them offer, for example:

- High speed fuel station: superyachts, especially motor yacht, can storage thousands and ... *bar*, one of the largest superyacht in the world with a length of 156 [m] and a beam of 24 [m], has a fuel capacity of more than 500.000 liters). There are special fuel stations in order to pump 6000 liters per minute, reducing significantly the time needed for this operation.
- Assistance for the bow's rope: this might look obvious but the rope connected to the chain and the deadweight that it's used to moor the bows of the yachts and let it they stay on the right position it is usually given by a mooring man on the jetties to a crew member at the stern and then brought it at the bow by the side of the yacht. It looks clear how this operation would be complicated and would take time for superyachts, with numerous obstacles like fenders, so it requires a mooring man with a tender boat to give the rope directly at the bow.
- Heliport: superyacht's owners look for any kind of luxury facilities, as well as their guests; in addition, most of the superyachts can be chartered, so every week the guests change. Not all the ports are close to an airport and in order to reach the yachts in the fastest and most comfortable way it's really important to have a heliport inside the Marina.

[1] Source: https://www.systemgroupmarine.com/marine/service-bollards/

4.5 Cost levels in superyacht marinas

Yachting is one of the most luxurious and exclusive sectors in the world, not only for the costs of the yachts themselves: this is also reflected to the operating costs of the yachts, and one of the most relevant one is the marina. Usually, the cost of the berth is proportional to the size of the yacht and it is not only depending on the length but also on the beam. In fact, normally boats are moored perpendicularly to the pier, so it is clear how important is to consider the space occupied by the yacht as a rectangular (L_{OA} *

B) and not only as linear. If a yacht falls into a category for the length but in the upper one for the beam it will pay the upper price, and vice-versa.

Another criterion that have an impact to the price of the berth is the time spent in the same marina. Almost all the marinas distinguish at least two types of offers: daily and monthly, but some of them have other options like weekly, yearly and multi-yearly prices. Of course, the highest price is the daily one and way smaller for longer periods of contract.

The price is also strongly influenced, on most of the cases, by the period of the year concerned: during summer time and in particularly August, which is the most crowded time of the year for marine traffic, everything is going to be more expensive, including berth fees.

The figures below report, as examples, the rates of the berths of Marina Di Porto Cervo in Italy Table 2, of La Màrina de València in Spain on Table 3, of Port la Napoule in France on Table 4 and of Marina de Vilamoura in Portugal on Table 5.

Analyzing the examples in these figures, it can be noticed that berth rates of Marina di Porto Cervo are divided into 8 periods of the year and how strongly the prices change from the high season periods to the low season periods. The opposite regarding berth rates of La Màrina de València, where there is not any change on price during the year. On Port La Napoule instead there are just two different price for high and low season and there are not long terms rent options for large yachts. On the other hand, on Marina de Vilamoura, there are several options regarding long term rents, up to 20 years.

During the stay on the marina, there are other costs to consider that can be entailing significantly the total costs: water and electricity. Sometimes they might be included on the fees of the berth but most commonly they are counted separately: electricity in [EUR/Kwh] and water in [EUR/liter] or [EUR/m^3]. In some cases, this cost could be evaluated as a forfeit. It is highly likely that a superyacht of 35 [m] in length can absorb so many [Kw] in one night to spend more in electricity then in berth fees. Another cost to consider is the garbage service, that is often considered an extra-service not considered in berth price. Table 6 shows a table with electricity, water and garbage costs of Marina Di Porto Cervo.

Tariffe Giornaliere | Daily Rates	Categoria / Category	I	II	III	IV	V	VI	VII	VII bis	VIII	VIII bis	IX	IX bis	X	X +
	Max. Lunghezza f.t. / *Overall Length*	6.5m	8m	10m	12m	15m	18m	25m	25m	30m	30m	40m	40m	55m	> 55m
	Max. Larghezza f.t. / *Overall width*	2.3m	2,75	3.3m	3.7m	4.2m	4.7m	5.5m	7m	6m	8m	7m	10m	10m	> 10m
	1-gen 31-mar 1-Jan 31-Mar	€ 4,00	€ 5,00	€ 8,00	€ 11,00	€ 15,00	€ 20,00	€ 32,00	€ 33,00	€ 42,00	€ 56,00	€ 64,00	€ 91,00	€ 138,00	0,30 p/m2
	1-apr 31-mag 1-apr 31-mag	€ 6,00	€ 8,00	€ 12,00	€ 17,00	€ 23,00	€ 30,00	€ 48,00	€ 50,00	€ 63,00	€ 84,00	€ 96,00	€ 137,00	€ 207,00	0,75 p/m2
	1-giu 30-giu 1-Jun 30-Jun	€ 32,00	€ 46,00	€ 69,00	€ 92,00	€ 131,00	€ 175,00	€ 285,00	€ 290,00	€ 373,00	€ 496,00	€ 579,00	€ 829,00	€ 1.216,00	2,30 p/m2
	1-lug 24-lug 1-Jul 24-Jul	€ 45,00	€ 67,00	€ 100,00	€ 134,00	€ 285,00	€ 383,00	€ 623,00	€ 634,00	€ 815,00	€ 1.087,00	€ 1.269,00	€ 1.813,00	€ 2.667,00	4,90 p/m2
	25-lug 31-ago 25-lug 31-ago	€ 45,00	€ 67,00	€ 100,00	€ 134,00	€ 299,00	€ 402,00	€ 654,00	€ 666,00	€ 856,00	€ 1.141,00	€ 1.332,00	€ 1.904,00	€ 2.800,00	5,10 p/m2
	1-set 15-set 1-Sep 15-Sep	€ 32,00	€ 46,00	€ 69,00	€ 92,00	€ 131,00	€ 175,00	€ 285,00	€ 290,00	€ 373,00	€ 496,00	€ 579,00	€ 1.813,00	€ 2.667,00	4,90 p/m2
	16-set 30-set 16-Sep 30-Sep	€ 32,00	€ 46,00	€ 69,00	€ 92,00	€ 131,00	€ 175,00	€ 285,00	€ 290,00	€ 373,00	€ 496,00	€ 579,00	€ 1.813,00	€ 2.667,00	4,90 p/m2
	1-ott 31-dic 1-Oct 31-Dec	€ 4,00	€ 5,00	€ 8,00	€ 11,00	€ 15,00	€ 20,00	€ 32,00	€ 33,00	€ 42,00	€ 56,00	€ 64,00	€ 91,00	€ 138,00	0,30 p/m2
Lungo termine	Annual contract	€ 4.560	€ 6.720	€ 9.960	€ 13.440	€ 25.800	€ 34.200	€ 57.786	€ 59.076	€ 75.600	€ 100.800	€ 117.600	€ 168.120	€ 244.800	
	Il contratto può iniziare in qualsiasi periodo dell'anno / Contract can commence at any time of the year														
	Summer contract	€ 3.800	€ 5.600	€ 8.300	€ 11.200	€ 21.500	€ 28.500	€ 48.155	€ 49.230	€ 63.000	€ 84.000	€ 98.000	€ 140.100	€ 204.000	
	Il contratto è valido dal 1 giugno al 30 Settembre / Contract commences 1st june to 30th September														
	Winter contract oct/apr	€ 650	€ 1.000	€ 1.400	€ 1.900	€ 2.400	€ 3.500	€ 5.800	€ 6.000	€ 8.400	€ 9.800	€ 11.900	€ 12.500	€ 21.000	
	Il contratto è valido dal 1 ottobre al 30 aprile / Contract commences 1st of october to 30th april														

*Sconti applicabili per periodi superiori ad due mesi. Per maggiori informazioni contattare la Direzione Marina / Discounts are applicable for visits in excess of two months. Please contact the marina office for details.

Table 2 - Berth Rates of Marina Di Porto Cervo

SOUTH MARINA				
LOA up to	Day	3 months*	6 months*	Annual*
7.00 m	6'75 €	425'25 €	789'75 €	1.478'25 €
8.00 m	7'90 €	497'70 €	924'30 €	1.730'10 €
9.00 m	9'50 €	598'50 €	1.111'50 €	2.080'50 €
10.00 m	11'50 €	724'50 €	1.345'50 €	2.518'50 €
11.00 m	13'75 €	866'25 €	1.608'75 €	3.011'25 €
12.00 m	17'00 €	1.071'00 €	1.989'00 €	3.723'00 €
13.00 m	18'90 €	1.190'70 €	2.211'30 €	4.139'10 €
14.00 m	21'00 €	1.323'00 €	2.457'00 €	4.599'00 €
15.00 m	23'25 €	1.464'75 €	2.720'25 €	5.091'75 €
16.00 m	25'25 €	1.590'75 €	2.954'25 €	5.529'75 €
17.00 m	27'50 €	1.732'50 €	3.217'50 €	6.022'50 €
18.00 m	32'00 €	2.016'00 €	3.744'00 €	7.008'00 €
19.00 m	34'25 €	2.157'75 €	4.007'25€	7.500'75 €
20.00 m	38'75 €	2.441'25 €	4.533'75 €	8.486'25 €
25.00 m	54'90 €	3.458'70 €	6.423'30 €	12.023'10 €
30.00 m	66'75 €	4.205'25 €	7.809'75 €	14.618'25 €
35.00 m	77'50 €	4.882'50 €	9.067'50 €	16.972'50 €

NORTH MARINA				
LOA up to	Day	3 months*	6 months*	Annual*
7.00 m	7'50 €	472'50 €	877'50 €	1.642'50€
8.00 m	8'75 €	551'25 €	1.023'75 €	1.916'25 €
9.00 m	10'50 €	661'50 €	1.228'50 €	2.299'50 €
10.00 m	12'75 €	803'25 €	1.491'75 €	2.792'25 €
11.00 m	15'00 €	945'00 €	1.755'00 €	3.285'00 €
12.00 m	18'90 €	1.190'70 €	2.211'30 €	4.139'10 €
13.00 m	21'00 €	1.323'00 €	2.457'00 €	4.599'00 €
14.00 m	23'50 €	1.480'50 €	2.749'50 €	5.146'50 €
15.00 m	25'75 €	1.622'25 €	3.012'75€	5.639'25 €
16.00 m	28'00 €	1.764'00 €	3.276'00 €	6.132'00 €
17.00 m	30'50 €	1.921'50 €	3.568'50 €	6.679'50 €
18.00 m	35'50 €	2.236'50 €	4.153'50 €	7.774'50 €
19.00 m	38'00 €	2.394'00 €	4.446'00 €	8.322'00 €
20.00 m	43'00 €	2.709'00 €	5.031'00 €	9.417'00 €
25.00 m	61'00 €	3.843'00 €	7.137'00 €	13.359'00 €
30.00 m	74'00 €	4.662'00 €	8.658'00 €	16.206'00 €
35.00 m	86'00 €	5.418'00 €	10.062'00 €	18.834'00 €

> 35.00 m	
North Marina	0.36€ x m^2/día
South Marina	0.36€ x m^2/día

Table 3 – Berth Rates of La Màrina de València

Catégories	Dimensions des navires autorisés		SAISON du 1er Avril au 30 Septembre			HORS SAISON du 1er Octobre au 31 Mars			ANNUEL
	Long. Maxi "Hors tout"	Larg. Maxi	JOUR	SEMAINE	MOIS	JOUR	SEMAINE	MOIS	
A	-5,00	2,00	10,80 €	65,00 €	259,95 €	5,50 €	32,40 €	130,00 €	1 482,50 €
B	5,00 à 5,49	2,15	12,00 €	71,50 €	285,90 €	5,95 €	35,80 €	142,95 €	1 737,75 €
C	5,50 à 5,99	2,30	13,00 €	77,80 €	311,40 €	6,45 €	38,95 €	155,70 €	2 131,10 €
D	6,00 à 6,49	2,45	15,15 €	90,75 €	362,90 €	7,50 €	45,40 €	181,40 €	2 483,20 €
E	6,50 à 6,99	2,60	17,35 €	104,00 €	415,90 €	8,60 €	52,00 €	207,90 €	3 162,30 €
F	7,00 à 7,49	2,70	19,50 €	116,90 €	467,90 €	9,80 €	58,50 €	234,00 €	3 557,55 €
G	7,50 à 7,99	2,80	21,60 €	130,00 €	519,80 €	10,90 €	64,95 €	259,90 €	3 952,90 €
H	8,00 à 8,49	2,95	24,30 €	145,60 €	582,10 €	12,20 €	72,75 €	291,10 €	4 426,45 €
I	8,50 à 8,99	3,10	26,80 €	161,10 €	644,40 €	13,50 €	80,55 €	322,30 €	4 900,05 €
J	9,00 à 9,49	3,25	28,80 €	172,80 €	691,20 €	14,50 €	86,40 €	345,60 €	5 256,10 €
K	9,50 à 9,99	3,40	31,00 €	185,85 €	743,25 €	15,50 €	92,95 €	371,60 €	5 651,40 €
L	10,00 à 10,49	3,55	36,20 €	217,10 €	868,20 €	18,10 €	108,70 €	434,10 €	6 602,40 €
M	10,50 à 10,99	3,70	41,25 €	247,00 €	987,70 €	20,55 €	123,50 €	493,90 €	7 510,35 €
N	11,00 à 11,49	3,85	43,40 €	259,90 €	1 039,75 €	21,60 €	130,00 €	519,80 €	7 905,75 €
O	11,50 à 11,99	4,00	45,55 €	273,00 €	1 091,80 €	22,70 €	136,50 €	545,70 €	8 301,00 €
P	12,00 à 12,99	4,30	49,60 €	297,10 €	1 189,00 €	24,80 €	148,70 €	594,40 €	9 040,65 €
Q	13,00 à 13,99	4,60	58,50 €	351,30 €	1 405,05 €	29,30 €	175,70 €	702,60 €	10 684,40 €
R	14,00 à 15,99	4,90	70,75 €	424,60 €	1 698,50 €	35,40 €	212,25 €	849,30 €	12 915,15 €
S	16,00 à 17,99	5,20	89,80 €	537,90 €	2 151,40 €	44,95 €	269,00 €	1 075,65 €	16 359,30 €
T	18,00 à 23,99	6,00	108,50 €	651,20 €	2 604,25 €	54,30 €	325,60 €	1 302,15 €	19 803,40 €
U	24,00 à 28,99	7,00	146,25 €	877,45 €	3 510,00 €	73,15 €	438,80 €	1 755,10 €	26 691,50 €
V	29,00 à 33,99	8,00	188,70 €			94,35 €			
W	34,00 à 38,99	9,00	235,90 €			117,90 €			
X	39,00 à 43,99	10,00	283,15 €			141,60 €			
Y	44,00 à 48,99	11,00	330,20 €			165,10 €			
Z	49,00 à 53,99	12,00	377,55 €			188,70 €			

Table 4 - Berth Rates of Port la Napoule

Embarcações de Recreio Pleasure Craft Freizeiboote				Estação Alta High Season Hauptsaison 01/07/2021 - 31/08/2021			Estação Média Medium Season Vor/Nach Saison 01/06/2021 - 30/06/2021 01/09/2021 - 30/09/2021			Estação Baixa Low Season Nebensaison 01/01/2021 - 31/05/2021 01/10/2021 - 31/12/2021					
Classe Class Klasse	Comp. fora a fora Overall Length Gesamtlänge De From Von	Até To Bis zu	Boca Beam Breite	Dia Day Tag	Semana Week Woche	Mês Month Monat	Dia Day Tag	Semana Week Woche	Mês Month Monat	Dia Day Tag	Semana Week Woche	Mês Month Monat	3 Meses 3 Months 3 Monate	6 Meses 6 Months 6 Monate	9 Meses 9 Months 9 Monate 16/09/2021 a/to/bis 15/06/2022
I	3m	6m	2,30m	23,60	162,10	663,00	20,30	137,60	578,00	6,20	32,30	131,00	376,00	712,00	1.006,00
II	6m	8m	2,70m	28,10	191,50	795,00	24,40	165,20	686,00	8,40	54,60	223,00	561,00	930,00	1.172,00
IIa	6m	8m	3,10m	31,20	204,50	841,00	27,10	178,20	734,00	9,90	64,50	264,00	692,00	1.154,00	1.385,00
III	8m	10m	3,60m	36,20	243,10	980,00	31,40	212,30	853,00	11,80	78,90	318,00	866,00	1.436,00	1.849,00
IV	10m	12m	3,30m	41,40	282,40	1.171,00	36,50	247,60	1.027,00	13,60	88,20	361,00	1.034,00	1.693,00	2.474,00
IVa	10m	12m	4,00m	52,10	340,10	1.397,00	46,30	296,90	1.218,00	15,80	104,60	425,00	1.241,00	2.052,00	3.051,00
V	12m	15m	4,50m	61,90	411,00	1.735,00	53,20	362,80	1.514,00	19,70	131,40	535,00	1.536,00	2.691,00	3.693,00
Va	12m	15m	5,30m	72,90	474,50	1.978,00	63,60	413,70	1.723,00	22,00	149,20	613,00	1.754,00	3.033,00	4.068,00
VI	15m	20m	5,00m	99,90	656,50	2.736,00	87,70	572,40	2.382,00	31,40	214,30	868,00	2.484,00	4.085,00	5.093,00
VIa	15m	20m	6,00m	112,90	756,40	3.102,00	98,50	659,60	2.703,00	34,60	235,80	952,00	2.751,00	4.522,00	5.836,00
VII	20m	26m	5,70m	149,20	1.004,80	4.131,00	131,70	876,00	3.598,00	43,10	291,40	1.177,00	3.379,00	5.573,00	7.557,00
VIII	26m	35m	6,90m	192,80	1.278,60	5.222,00	168,40	1.114,40	4.549,00	55,60	368,30	1.498,00	4.272,00	7.067,00	9.717,00
IX	35m	40m	8,30m	213,10	1.419,50	5.798,00	186,90	1.238,50	5.057,00	65,30	431,50	1.756,00	5.046,00	8.296,00	10.249,00
Cais de Honra Honor Jetty Ehrenliegeplatz				386,30			337,10			123,30					

Classe Class Klasse	Especiais Specials Spezial						
	1 Ano 1 Year 1 Jahr	2 Anos 2 Years 2 Jahre	3 Anos 3 Years 3 Jahre	4 Anos 4 Years 4 Jahre	5 Anos 5 Years 5 Jahre	10 Anos 10 Years 10 Jahre	20 Anos 20 Years 20 Jahre
I	2.062,00	3.335,00	4.884,00	6.355,00	6.865,00	12.109,00	23.107,00
II	2.409,00	3.764,00	5.513,00	7.172,00	8.921,00	15.393,00	26.076,00
IIa	2.851,00	4.446,00	6.511,00	8.472,00	10.173,00	17.448,00	30.803,00
III	3.811,00	5.932,00	8.688,00	11.303,00	12.995,00	22.617,00	41.096,00
IV	4.951,00	7.777,00	11.390,00	14.819,00	18.469,00	32.626,00	53.878,00
IVa	5.824,00	9.192,00	13.461,00	17.514,00	22.489,00	39.338,00	63.678,00
V	7.424,00	11.386,00	16.675,00	21.696,00	27.635,00	48.650,00	78.879,00
Va	8.438,00	12.928,00	18.933,00	24.633,00	30.968,00	53.694,00	89.561,00
VI	10.696,00	16.462,00	24.110,00	31.368,00	39.449,00	68.484,00	114.046,00
VIa	12.265,00	18.865,00	27.629,00	35.947,00	44.192,00	77.072,00	130.695,00
VII	15.876,00	24.534,00	35.933,00	46.751,00	57.095,00	99.938,00	169.971,00
VIII	20.410,00	31.546,00	46.201,00	60.111,00	70.331,00	123.177,00	218.552,00
IX	21.541,00	32.644,00	47.809,00	62.203,00	76.696,00	134.806,00	226.153,00
Cais de Honra Honor Jetty Ehrenliegeplatz							

Table 5 - Berth Rates of Marina de Vilamoura

	Categoria / Category Max. Lunghezza f.t. / *Overall Length* Max. Larghezza f.t. / *Overall width*	I 6.5m 2.3m	II 8m 2,75	III 10m 3.3m	IV 12m 3.7m	V 15m 4.2m	VI 18m 4.7m	VII 25m 5.5m	VII bis 25m 7m	VIII 30m 6m	VIII bis 30m 8m	IX 40m 7m	IX bis 40m 10m	X 55m 10m	X+ > 55m > 10m
Altri	Acqua / Water - Daily Rate forfait	€ 2,00	€ 3,00	€ 3,50	€ 5,00	€ 7,50	€ 12,00	€ 35,00	€ 35,00	€ 50,00	€ 50,00	€ 62,00	€ 90,00	€ 120,00	€ 0,240 p/m2
	Elettricità / Electricity - Daily Rate forf:	€ 3,50	€ 5,00	€ 7,50	€ 14,00	€ 30,00	€ 40,00	€ 50,00	€ 60,00	€ 75,00	€ 100,00	€ 175,00	€ 250,00	€ 300,00	€ 0,650 p/m2
	Acqua / Water - (Euro/liter)							0,0055							
	Elettricità / Electricity - (Euro/kWh)							0,45							
	Serv.racc e smalt. rifiuti / Garbage	€ 3,00	€ 5,00	€ 7,00	€ 9,00	€ 11,00	€ 18,00	€ 25,00	€ 27,00	€ 46,00	€ 46,00	€ 80,00	€ 80,00	€ 100,00	€ 0,220 p/m2
	Services annual v lug/aug+8gg/mese	€ 80,00	€ 120,00	€ 140,00	€ 200,00	€ 300,00	€ 480,00	€ 1.400,00	€ 1.400,00	€ 2.000,00	€ 2.000,00	€ 2.480,00	€ 3.600,00	€ 4.800,00	
	Services annual e lug/aug+8gg/mese	€ 140,00	€ 200,00	€ 300,00	€ 560,00	€ 1.200,00	€ 1.600,00	€ 2.000,00	€ 2.400,00	€ 3.000,00	€ 4.000,00	€ 7.000,00	€ 10.000,00	€ 12.000,00	
	Allaccio energia elettrica / Electric co	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	€ 20,00	20,00
	ISPS (guard)														35,00 p/ora

Table 6 - Electricity, Water and Garbage Costs of Marina Di Porto Cervo

In addition to the costs analyzed above, there is the cost of all the extra and optional features that a marina can offer, that vary from port to port in terms of availability and price (Marina di Porto Cervo, 2021).

In order to give a more practical idea on how much could vary the costs of staying in a marina depending on the country, it was calculated, for a typical superyacht of about 40 meters, the cost of a yearly permanence on a marina in Spain, France, Italy and Portugal, reported on Table 7.

Price Comparison Between Typical Marinas in Spain, France, Italy and Portugal for a 40 [m] Superyacht			
Spain (Marina Port de Mallorca)	**France (Port la Napoule)**	**Italy (Marina di Porto Cervo)**	**Portugal (Marina de Vilamoura)**
27500 [EUR]	43000 [EUR]	117000 [EUR]	21540 [EUR]

Table 7 - Price Comparison Between Typical Marinas in Spain, France, Italy and Portugal for a 40 [m] Superyacht

It looks evident, looking at the results obtained on the table above, how much difference there is between the price calculated for Italy and the one calculated for Spain and Portugal in particular, which is of an order of magnitude greater than the other two. Regarding France, it is almost correspondent of the double of the price for Spain and Portugal, but still way less than Italy. It is important to mention that the price obtained can change completely choosing other marinas, and the ones above are just an example to make a quick comparison of a possible scenario. In addition, on the marinas considered for this example, the prices include water and electricity supply, and for three of them (Marina Port de Mallorca, Marina di Porto Cervo and Marina de Vilamoura) there was already the yearly price available, on the contrary for the other one (Port la Napoule), for which it was available just the daily prices for low season (from October to March) and high season (from April to Septemper).

5 CHARACTERIZATION OF INFRASTRUCTURE FOR SUPERYACHT REPAIR AND MAINTENANCE

The shipyards sector, as well as marinas, plays an essential role in the superyacht world.

Superyachts are floating luxury mansions and to keep every part fully working and always looking as new, it is necessary a constant and deep maintenance and, when necessary, repair.

Due to the complexity of these floating objects, the types of works that must be done during their life vary from mechanical to painting and structural operations. In order to be able to offer all these services, specialized infrastructures are needed.

The typical layout of a superyacht repair and maintenance shipyard is composed by:

- Breakwater: which is a structure built on the seaward side of the shipyard for protecting from waves. If the shipyard is located inside a port, it might be not have a dedicated breakwater because it would be protected from the one of the port.
- Waiting dock (mooring berths): inside the breakwater, is where yachts are moored waiting to be lifted and taken over or to be delivered. It might be possible that some works, mostly interior works, can be done while the yacht is on water.
- Open yard: where most of yachts are stored. Some works can be done here like careenage and others that do not need a protected environment.
- Covered space and sheds: it is usually slightly set back in respect to the water and it can be composed by one or more sheds. If it is one it is usually internally divided into different workshops, otherwise there is one shed for the major workshops like painting and resining, carpentry and mechanical works, joinery and systems.
- Internal dry-dock: it is a covered dry-dock where any type of work on superyachts too big to be lifted and moved by any kind of equipment can be made.

On Figure 33 there is an example of a perfect superyacht repair and maintenance shipyard's layout.

Figure 33 - Example of a Perfect Superyacht Repair and Maintenance Shipyard's Layout.

Hauling and lifting space: can be made of different elements, depending on the shipyard. The equipment for haulage and docking such as dry-dock, syncrolift, travel-lift or also a simply gantry crane, are located on the external part of the yard, as close as possible to the water. Other lifting equipment are distributed around the shipyard, to move yachts and parts where needed.

Hauling and lifting infrastructures are not only essential for any shipyard but they also determine the size of yachts with they can work on and so the other infrastructures of the shipyard. Of course, the weight of superyachts can change a lot depending on the size, Figure 34: a 30 [m] motor yacht can weight around 110 [t] while a 119 [m] superyacht may have a lightweight of about 5000 [t]

Figure 34 - Different Sizes of Superyachts

It is relevant to distinguish two different types of shipyards: those inside marinas and those who are not. Sometimes, if the shipyard is a facility of a marina, it is quite small and with the infrastructures and equipment are consequently dimensioned; in addition, in this case the services offered are limited to the basic ones, for examples: cleaning, anti-fouling, small and easy mechanical and electrical works, storage. Other works, if available, are carried out by external resources.

On the other hand, if the shipyard is an independent company, it is probably way larger, the infrastructures and the equipment are more developed and it is capable of carry out almost any type of work by its in-house resources. Of course, this is not a rule and it may occur exceptions.

5.1 Typical facilities in the Mediterranean: Spain, France, Italy

On this section are reported the typical facilities of the major superyacht repair and maintenance shipyard in the Mediterranean of Spain, France and Italy are reported. To have a schematic and scientific approach, for all the shipyards taken into account on section 5.1, 5.2 and 5.3, the characteristics considered are:

- Yard: surface in $m^2$of the external yard
- Covered space: surface in m^2 of covered space
- Services: Refitting, painting and composite works, mechanics, metal works, carpentry and joinery, electricity and electronic works, naval engineering and architecture
- Waiting docks: number of docks, number of berths, dimension of docks *m*, max length of vessels that can be moored *m*
- Drydocks and Slipways: number of drydocks, number of slipways, dimensions in *m*
- Travel-Lifts and Syncrolifts: number of travel-lifts, number of syncrolifts, lifting capacity in *t*
- Other lifting equipment: type of equipment, number of elements per type, lifting capacity in *t*

About Spain, 7 shipyards were analyzed and here below there are the tables with the typical facilities of the major superyacht repair and maintenance shipyards in Spain.

Table 8 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in Spain. Table 9 presents the services of the major superyacht repair and maintenance shipyards in Spain. Table 10 presents the lifting capacity of the major superyacht repair and maintenance shipyards in Spain

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in Spain						
Country	City	Name	Inside/Outside a Marina	Yard [m2]	Covered Sheds and Workshops [m2]	Waiting Docks
Spain	Barcelona	Marina Vela - Marina Nautic Center	Inside	12000	4000	1 Afloat Waiting Dock of 250 for yachts up tp 70 [m]
		Pendennis	Outside	30000	12000	48 berths up to 130 [m]
		Marina Barcelona 92	Outside	124000	45000	5 quays for yachts up to 180 [m]
	Las Palmas	Rolnautic Varadero	Inside	34445	////	////
	Girona	Port Nautic Castello	Inside	2880	////	////
	Denia	Port Denia's Super Yacht Shipyard	Inside	21000	2000	Marina for yachts up to 140 [m]
	Palma de Mallorca	Astilleros de Mallorca	Inside	55000	23000	Quay of 120 [m]

Table 8 – Infrastructures, location and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in Spain

Services of the Major Superyacht Repair and Maintenance Shipyard in Spain									
Country	City	Name	Refitting	Painting and Composits Works	Mechanics	Metal Works	Carpentry and Joinery	Electricity and Electronic Works	Naval Engineering and Architecture
Spain	Barcelona	Marina Vela - Marina Nautic Center	x	●	●	●	●	●	●
		Pendennis	●	●	●	●	●	●	●
		Marina Barcelona 92	●	●	●	●	●	●	●
	Las Palmas	Rolnautic Varadero	●	●	●	●	●	●	●
	Girona	Port Nautic Castello	x	x	●	x	x	●	x
	Denia	Port Denia's Super Yacht Shipyard	x	●	●	●	●	●	x
	Palma de Mallorca	Astilleros de Mallorca	●	●	●	●	●	●	●

Table 9 - Services of the Major Superyacht Repair and Maintenance Shipyards in Spain

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in Spain					
Country	City	Name	Drydocks; Slipways [m]	Travel-Lift; Syncrolifts [t]	Cranes; Other Lifting Equipment [t]
Spain	Barcelona	Marina Vela - Marina Nautic Center	////	Travel-Lift: 160	///
		Pendennis	Slipway: 130	2 Travel-Lifts: 620 and 120	2 Mobile cranes: 25 and 15
		Marina Barcelona 92	Drydok: 180	Travel-Lift: 350; 2 Syncrolfits: 2000 and 4800	Mobile cranes up to 100
	Las Palmas	Rolnautic Varadero	Drydock: 220	Travel-Lift: 65; Syncrolift: 7	////
	Girona	Port Nautic Castello	////	Travel-Lift: 50	Mobile cranes: 25; truck with cranes
	Denia	Port Denia's Super Yacht Shipyard	Slipway: 80	Travel-Lift: 150	////
	Palma de Mallorca	Astilleros de Mallorca	Drydock: 120; 4 Slipways up to 80	6 Travel-Lifts from 30 to 1000	3 Cranes: 25, 10 and 3; gantry crane of 130

Table 10 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in Spain

Regarding France, 8 shipyards were analyzed and here below there are the tables with the typical facilities of the major superyacht repair and maintenance shipyards in France.

Table 11 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in France. Table 12 presents the services of the major superyacht repair and maintenance shipyards in France. Table 13 presents the lifting capacity of the major superyacht repair and maintenance shipyards in France

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in France						
Country	City	Name	Inside/Outside a Marina	Yard [m2]	Covered Sheds [m2]	Waiting Docks
France	Marsille	Palumbo Superyachts Refit	Outside	35000	9700	Floating Docks and Piers for yachts up to 200 [m]
		Genova Industrie Navali (GIN)	Otuside	90000	20000	900 linear metres of quays
		Sud Marine Shipyard	Otuside	20000	5000	Docks of 500 linear metres
	La Ciotat	Compositeworks	Otuside	22600	6500	580 linear metres pier
		Nautech Group	Outside	58000	18000	200 [m] alongside mooring
		La Ciotat Shipyards	Outside	40000	12000	Industial quay of 1600 linear meter with no limits in size of yachts + Marina with more than 1000 moorings
	Les Sablettes	IMS Shipyard	Outside	130000	20000	2 Docks and 25 floating berths for yachts up to 100 [m]
	Le Havre	Le Havre Naval Projects	Inside	35000	9000	180 linear metres of quay

Table 11 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in France

Services of the Major Superyacht Repair and Maintenance Shipyard in France									
Country	City	Name	Refitting	Painting and Composits Works	Mechanics	Metal Works	Carpentry and Joinery	Electricity and Electronic Works	Naval Engineering and Architecture
France	Marsille	Palumbo Superyachts Refit	●	●	●	●	●	●	●
		Genova Industrie Navali (GIN)	●	●	●	●	●	●	●
		Sud Marine Shipyard	●	●	●	●	●	●	●
	La Ciotat	Compositeworks	x	●	●	●	●	●	x
		Nautech Group	●	●	●	●	●	●	●
		La Ciotat Shipyards	●	●	●	●	●	●	●
	Les Sablettes	IMS Shipyard	●	●	●	●	●	●	●
	Le Havre	Le Havre Naval Projects	●	●	●	●	●	●	x

Table 12 - Services of the Major Superyacht Repair and Maintenance Shipyards in France

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in France					
Country	City	Name	Drydocks; Slipways [m]	Travel-Lift; Syncrolifts [t]	Cranes; Other Lifting Equipment [t]
France	Marsille	Palumbo Superyachts Refit	4 Drydocks: 100x16, 85x16.5, 125x16.5, 125x16	Syncrolift: 5000; travelifts	Cranes
		Genova Industrie Navali (GIN)	3 Drydocks up to 465x85	Yes	//////
		Sud Marine Shipyard	2 Drydocks: 180 and 137	////	Mobile cranes: 20 and 40
	La Ciotat	Compositeworks	2 Drydocks	Travel-Lift: 480	Cranes, tralers, gantry crane
		Nautech Group	Drydock: 60	3 Travel-Lift: 250, 300 and 750	Cranes from 10 to 600
		La Ciotat Shipyards	////	3 Syncrolifts: 300, 2000 and No Limits	Gantry crane up to 600
	Les Sablettes	IMS Shipyard	Yes	Travel-Lifts: 320 and 670	2 Cranes: 35 and 50; self propelled trailer up to 350, 5t forklift, elevation platform, boat slip vessel up tp 100 [t] and 20 [m] in beam
	Le Havre	Le Havre Naval Projects	3 Drydocks: 140x14, 160x19, 180x24	Travel-Lift: 300, widht 10.40 [m], max lenght 45 [m], heigh 12 [m]; Synchrolift: 300, width 32 [m], lenght 100 [m], draft 4.5 [m]	Cranes facilities and gantry crane available

Table 13 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in France

About Italy, the major shipyards that have been taken into account are 10. Here below the tables with the typical facilities of the major superyacht repair and maintenance shipyards in Italy.

Table 14 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in Italy. Table 15 presents the services of the major superyacht repair and maintenance shipyards in Italy. Table 16 presents the lifting capacity of the major superyacht repair and maintenance shipyards in Italy.

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in Italy						
Country	**City**	**Name**	**Inside/Outside a Marina**	**Yard [m2]**	**Covered Sheds [m2]**	**Waiting Docks**
Italy	Genoa	Amico & Co.	Outside	65000	25000	Technical Marina for yachts up to 95m + alongside berthing for yachts up tp 140 [m]
		Genova Industrie Navali (GIN)	Outside	67000	19000	1460 linear metres of quays
	Viareggio	Cantiere Viareggio - Genesis Yacht	Outside	18000	2000	////
	Porto Ercole	Cantieri Navali Dell' Argentario	Inside	9000	2500	Moorings for yachts up to 40m and 5m draft
	Gaeta	Cantiere Navale Flavio Gioia	Inside	7000	1800	No
	Piombino	Genova Industrie Navali (GIN)	Outside	103000	12000	468 linear metres of quays
	La Spezia	Cantiere di Porto Lotti	Inside	7000	2000	Marina fro yacths up to 100 [m]
	Livorno	Cantieri Navali Lorenzoni	Inside	7000	2900	////
	Pozzuoli	Sud Cantieri	Inside	30000	14000	Marina of 250 berths up to 65 [m]
	Portocervo	Cantiere Porto Cervo	Inside	16500	7360	Marina for yachts up to 120 [m]

Table 14 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in Italy

Services of the Major Superyacht Repair and Maintenance Shipyard in Italy									
Country	**City**	**Name**	**Refitting**	**Painting and Composits Works**	**Mechanics**	**Metal Works**	**Carpentry and Joinery**	**Electricity and Electronic Works**	**Naval Engineering and Architecture**
Italy	Genoa	Amico & Co.	●	●	●	●	●	●	●
		Genova Industrie Navali (GIN)	●	●	●	●	●	●	●
	Viareggio	Cantiere Viareggio - Genesis Yacht	x	●	●	●	●	●	x
	Porto Ercole	Cantieri Navali Dell' Argentario	x	●	●	●	●	●	x
	Gaeta	Cantiere Navale Flavio Gioia	x	●	●	●	●	●	x
	Piombino	Genova Industrie Navali (GIN)	●	●	●	●	●	●	●
	La Spezia	Cantiere di Porto Lotti	x	●	●	●	●	●	x
	Livorno	Cantieri Navali Lorenzoni	x	●	●	●	●	●	x
	Pozzuoli	Sud Cantieri	●	●	●	●	●	●	x
	Portocervo	Cantiere Porto Cervo	x	●	●	●	●	●	x

Table 15 - Services of the Major Superyacht Repair and Maintenance Shipyards in Italy

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in Italy					
Country	**City**	**Name**	**Drydocks; Slipways [m]**	**Travel-Lift; Syncrolifts [t]**	**Cranes; Other Lifting Equipment [t]**
Italy	Genoa	Amico & Co.	4 Drydocks up to 170	2 Travel-Lifts: 835 and 320; Syncrolift: 4000	Mobile cranes: 200; bridge cranes: 5; three bridge cranes: 3
		Genova Industrie Navali (GIN)	5 Drydocks up to 267x40	Travel-Lift	Cranes, tralers
	Viareggio	Cantiere Viareggio - Genesis Yacht	////	///	2 Overhead cranes: 15 each
	Porto Ercole	Cantieri Navali Dell' Argentario	Slipway: 60	////	2 Mobile Cranes: 25 and 15
	Gaeta	Cantiere Navale Flavio Gioia	No	Travel-Lift: 100	Mobile Crane: 30
	Piombino	Genova Industrie Navali (GIN)	////	Yes	////
	La Spezia	Cantiere di Porto Lotti	No	Travel-Lift: 160	Crane: 40; 3 trailers of 40, 60, 120
	Livorno	Cantieri Navali Lorenzoni	No	Travel-Lift: 150	Crane: 15; 2 terex cranes: 200 and 70
	Pozzuoli	Sud Cantieri	No	2 Travel-Lift: 80 and 160	3 trailers up to 100
	Portocervo	Cantiere Porto Cervo	Slipway: 50	Travel-Lift: 40	Hydraulic cranes : 8

Table 16 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in Italy

Analyzing the data recorded, it is possible to say that there is a good distribution of superyacht repair and maintenance shipyards along the coasts of these three countries, with a greater intensity around the biggest cities and critical locations.

On Figure 35 - Map of Europe Showing the Location of the Major ShipyardsFigure 35 is shown the map of Europe where are highlighted the position of the major shipyards in Europe

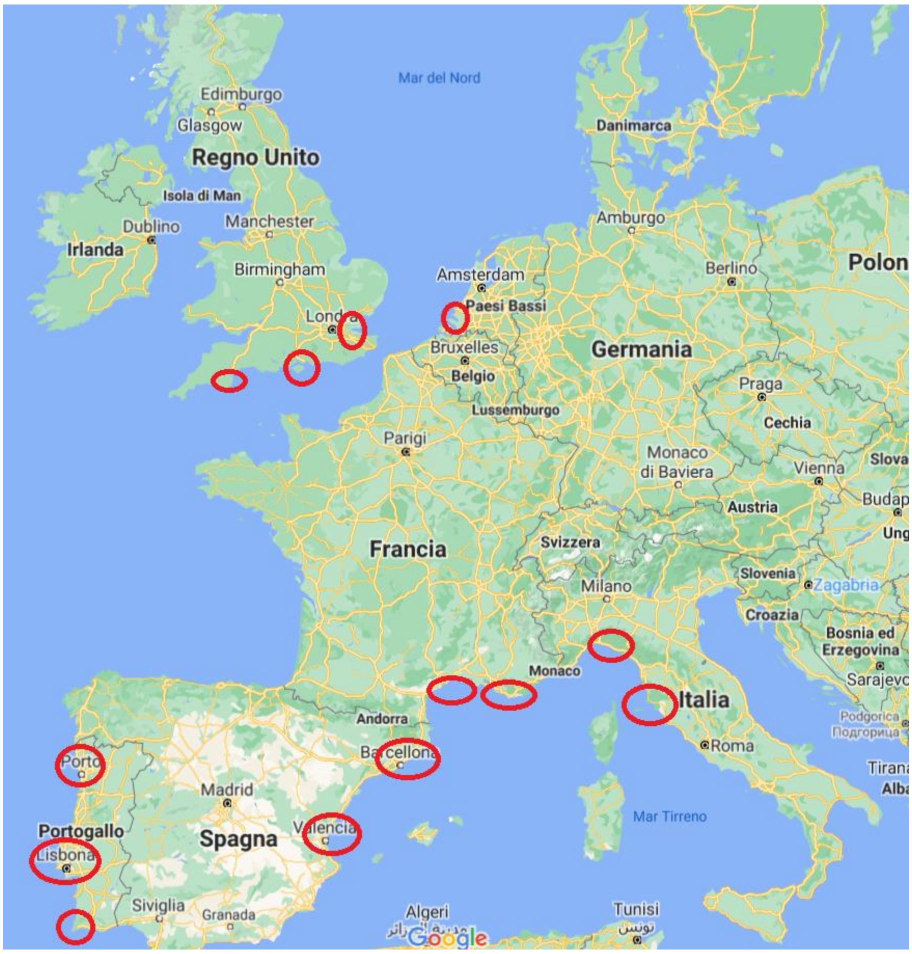

Figure 35 - Map of Europe Showing the Location of the Major Shipyards

Stand out from the other shipyards Marina Barcelona 92 in Spain, La Ciotat Shipyards and IMS Shipyards in France and Amico & Co and Genova Industrie Navali (GIN) in Italy.

These major shipyards, in addition to large outdoor and indoor spaces, are equipped with several lifting systems of different lifting capacity, dedicated infrastructures that make them able to work with several superyachts at the same time and, in case of failures, keep the shipyard working. Furthermore, specialized workshops and engineering studios shall ensure that they are prepared to face any type of refitting work.

5.2 Typical facilities in Atlantic Coast: Spain, France, United Kingdom, Netherlands and Germany

On this section are reported the typical facilities of the major superyacht repair and maintenance shipyard in the Atlantic Ocean of Spain, France, United Kingdom, Netherlands and Germany.

Regarding Spain and France, the shipyards considered are 2. Here below the tables with the typical facilities of the major superyacht repair and maintenance shipyards in the north of Spain and France. Table 17 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in the north of Spain and France. Table 18 presents the services of the major superyacht repair and maintenance shipyards in the north of Spain and France. Table 19 presents the lifting capacity of the major superyacht repair and maintenance shipyards in the north of Spain and France.

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in the North of Spain and France						
Country	**City**	**Name**	**Inside/Outside a Marina**	**Yard [m2]**	**Covered Sheds [m2]**	**Waiting Docks**
Spain	Ría de Avilés (Atlantic)	Astilleros de Ría de Avilés	Outside	31000	13565	Quay of 105 [m]
France	Brest (Atlantic)	Shipyard of Port De Plaisance De Brest	Inside	8000	/////	Marina of 1460 berths

Table 17 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in the North of Spain and France

Services of the Major Superyacht Repair and Maintenance Shipyard in the North of Spain and France									
Country	**City**	**Name**	**Refitting**	**Painting and Composits Works**	**Mechanics**	**Metal Works**	**Carpentry and Joinery**	**Electricity and Electronic Works**	**Naval Engineering and Architecture**
Spain	Ría de Avilés (Atlantic)	Astilleros de Ría de Avilés	●	●	●	●	●	●	x
France	Brest (Atlantic)	Shipyard of Port De Plaisance De Brest	x	●	●	●	●	●	x

Table 18 - Services of the Major Superyacht Repair and Maintenance Shipyards in the North of Spain and France

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in the North of Spain and France					
Country	**City**	**Name**	**Drydocks; Slipways [m]**	**Travel-Lift; Syncrolifts [t]**	**Cranes; Other Lifting Equipment [t]**
Spain	Ría de Avilés (Atlantic)	Astilleros de Ría de Avilés	2 Slipways: 120x20 and 90x14	No	Gantry Crane of 50; 2 DEMAG mobile crane of 45; 2 Imensa mobile cranes of 5
France	Brest (Atlantic)	Shipyard of Port De Plaisance De Brest	////	Travel-Lift: 40	5 Hydraulic gantry cranes: 2.5, 7, 8, 12 and 20; jib crane 3.2; equiport 14; hydro parklev cradle: 15; two fork-lift trucks: 3 each

Table 19 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in the North of Spain and France

About United Kingdom, the shipyards analyzed are 4 and following there are the tables with the typical facilities of the major superyacht repair and maintenance shipyards in the United Kingdom.

Table 20 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in the United Kingdom. Table 21 presents the services of the major superyacht repair and maintenance shipyards in the United Kingdom. Table 22 presents the lifting capacity of the major superyacht repair and maintenance shipyards in the United Kingdom.

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in the United Kingdom						
Country	City	Name	Inside/Outside a Marina	Yard [m2]	Covered Sheds [m2]	Waiting Docks
United Kingdom	Southampton	Hythe Shipyard	Outside	10000	1300	Pier
	Flamouth	Pendennis	Outside	18000	11000	Docks for yachts up to 100 [m]
	Lymington	Berthon Shipyard	Inside	9100	3500	Marina for yachts up to 25 [m]
	Brighton	Boatyard of Brighton Marina	Inside	8400	2200	Marina for yachts up to 30 [m]

Table 20 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in the United Kingdom

Services of the Major Superyacht Repair and Maintenance Shipyard in the United Kingdom									
Country	City	Name	Refitting	Painting and Composits Works	Mechanics	Metal Works	Carpentry and Joinery	Electricity and Electronic Works	Naval Engineering and Architecture
United Kingdom	Southampton	Hythe Shipyard	x	●	●	●	●	●	x
	Flamouth	Pendennis	●	●	●	●	●	●	●
	Lymington	Berthon Shipyard	x	●	●	●	●	●	x
	Brighton	Boatyard of Brighton Marina	x	●	●	●	●	●	x

Table 21 - Services of the Major Superyacht Repair and Maintenance Shipyards in the United Kingdom

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in the United Kingdom					
Country	City	Name	Drydocks; Slipways [m]	Travel-Lift; Syncrolifts [t]	Cranes; Other Lifting Equipment [t]
United Kingdom	Southampton	Hythe Shipyard	Slipway: 85 and 11.5 of maximum beam	Travel-Lift: 100	3 Cranes: 25, 10 and 3; 1 gantry crane of 130
	Flamouth	Pendennis	2 Drydocks both of 75	Travel-Lift: 800	Mobile cranes; fork lift; trailers
	Lymington	Berthon Shipyard	No	Travel-Lift: 75	Pillar crane: 20
	Brighton	Boatyard of Brighton Marina	No	2 Travel-Lifts: 150 and 60	Static cranes; mast track; boat parker of 25; forklift

Table 22 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in the United Kingdom

Below are reported the tables with the typical facilities of the major superyacht repair and maintenance shipyards in Germany and The Netherlands.

Table 23 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in Germany and The Netherlands. Table 24 presents the services of the major superyacht repair and maintenance shipyards in Germany and The Netherlands. Table 25 presents the lifting capacity of the major superyacht repair and maintenance shipyards in Germany and The Netherlands.

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in Germany and The Netherlands						
Country	City	Name	Inside/Outside a Marina	Yard [m2]	Covered Sheds [m2]	Waiting Docks
Netherlands, Germany	Harlingen	ICON Shipyards	Ouside	31000	24000	Docks of 500 linear metres
	Nobiskrüger Allee	Nobiskrüger shipyard	Ouside	180000	44000	400 linear metres pier
	Hamburg	Lürssen	Outside	451000	92000	880

Table 23 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in Germany and The Netherlands

Services of the Major Superyacht Repair and Maintenance Shipyard in Germany and The Netherlands										
Country	City	Name	Refitting	Painting and Composits Works	Mechanics	Metal Works	Carpentry and Joinery	Electricity and Electronic Works	Naval Engineering and Architecture
Netherlands, Germany	Harlingen	ICON Shipyards	●	●	●	●	●	●	X
	Nobiskrüger Allee	Nobiskrüger shipyard	●	●	●	●	●	●	●
	Hamburg	Lürssen	●	●	●	●	●	●	●

Table 24 - Services of the Major Superyacht Repair and Maintenance Shipyards in Germany and The Netherlands

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in Germany and The Netherlands					
Country	City	Name	Drydocks; Slipways [m]	Travel-Lift; Syncrolifts [t]	Cranes; Other Lifting Equipment [t]
Netherlands, Germany	Harlingen	ICON Shipyards	No	Travel-lift: 580	Boat lift; cranes; trailers
	Nobiskrüger Allee	Nobiskrüger shipyard	Drydock: 200x32 covered; 2 Slipways: 165 and 155	////	2 Cranes: 100 and 60
	Hamburg	Lürssen	3 Drydocks up to 164	Syncrolift	10 cranes up to 60; trailers

Table 25 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in Germany and The Netherlands

Regarding the information obtained about these regions, on the Atlantic coasts of Spain and France the number of relevant shipyards are way less than on the Mediterranean ones.

In the United Kingdom, the major shipyard without any doubt is Pendennis in Flamouth, thanks to the two drydocks and 800 [t] travel-lift has an incredible lifting capacity and it is highly specialized on superyacht refitting.

About Germany and Netherlands, these countries count a large number of superyacht newbuilding shipyards that could also have a maintenance and refitting section for their superyachts. Noteworthy, Lürssen is probably the biggest and the most important newbuilding superyacht shipyard in the world. From this shipyard came out the largest superyachts ever made: Azzam (180 [m]), Dilbar (156 [m]), Al Saïd (155 [m]) and so on (Barche a Motore).

5.3 Repair facilities in Portugal

In what concerns Portugal, the shipyards taken into account are 12. Not all of these shipyards have experience with yachts and, therefore, this section has been entitled simply as concerning Repair Facilities. Indeed, NavalRocha, NavalTagus and Nautiber are involved with other types of ships and boats with only a very limited experience with yachts. The tables below show the most relevant repair facilities which could be superyacht repair and maintenance capable in Portugal.

Table 26 presents the infrastructures, location and dimensions of the major superyacht repair and maintenance shipyards in Portugal. Table 27 presents the services of the major superyacht repair and maintenance shipyards in Portugal. Table 28 presents the lifting capacity of the major superyacht repair and maintenance shipyards in Portugal.

Sources: all the data are obtained from the website of each shipyard.

Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyard in Portugal						
Country	City	Name	Inside/Outside a Marina	Yard [m2]	Covered Sheds [m2]	Waiting Docks
Portugal	Porto	Shipyard of Douro Marina	Inside	3500	/////	Marina of 300 berths for yachts up to 50 [m]
	Cascais	Service area of Marina de Cascais	Inside	////	////	Marina for yachts up to 45 [m]
	Lisbon	Centro Nautico de Algés	Outside	12000	/////	Waiting Dock
		Navalrocha	Outside	Unspecified	Unspecified	Pier of 120x5,5 [m]
		Navaltagus	Outside	30000	12000	Pier of 100 [m] for vessels up to 120 [m]
		Estaleiro Naval de Lisboa	Outside	4000	1500	No
	Vila Real de Santo António	Nautiber	Outside	16500	3000	No
	Lagos	Sopramar	Outside	18000	6200	No
	Portimão	Sopramar	Outside	18000	6200	No
	Peniche	Estaleiros Navais de Peniche	Outside	80000	12000	350 linear metres of quay
	Albufeira	Marina de Albufeira Shipyard	Inside	7700	1930	Marina for yachts up to 30 [m]
	Vilamoura	Boatyard Service of Marina Vilamoura	Inside	8400	////	Marina for yachts up to 60 [m]

Table 26 - Infrastructures and Dimensions of the Major Superyacht Repair and Maintenance Shipyards in Portugal

Services of the Major Superyacht Repair and Maintenance Shipyard in Portugal									
Country	City	Name	Refitting	Painting and Composits Works	Mechanics	Metal Works	Carpentry and Joinery	Electricity and Electronic Works	Naval Engineering and Architecture
Portugal	Porto	Shipyard of Douro Marina	x	●	●	x	x	●	x
	Cascais	Service area of Marina de Cascais	x	x	●	x	x	●	x
	Lisbon	Centro Nautico de Algés	x	●	●	●	●	●	●
		Navalrocha	x	●	●	●	●	●	x
		Navaltagus	x	x	●	●	●	●	x
		Estaleiro Naval de Lisboa	x	●	●	●	●	●	x
	Vila Real de Santo António	Nautiber	x	●	●	●	●	●	x
	Lagos	Sopramar	x	●	●	●	●	●	●
	Portimão	Sopramar	x	●	●	●	●	●	●
	Peniche	Estaleiros Navais de Peniche	●	●	●	●	●	●	x
	Albufeira	Marina de Albufeira Shipyard	x	●	●	●	●	●	x
	Vilamoura	Boatyard Service of Marina Vilamoura	x	●	●	x	x	●	x

Table 27 - Services of the Major Superyacht Repair and Maintenance Shipyards in Portugal

Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyard in Portugal					
Country	City	Name	Drydocks; Slipways [m]	Travel-Lift; Syncrolifts [t]	Cranes; Other Lifting Equipment [t]
Portugal	Porto	Shipyard of Douro Marina	No	Travel-Lift: 50	Static cranes; hoist 3.2
	Cascais	Service area of Marina de Cascais	No	Travel-Lift: 70	Crane: 2; ramp; fork lift
	Lisbon	Centro Nautico de Algés	No	Trave-Lift: 50, max beam 7 [m]	no crane
		Navalrocha	3 Drydocks: 173x22x9, 104x12.4x7.3, 65x11.5	No info	No info
		Navaltagus	Drydock: 64x11x4.25; Slipways: 100x4	///	Max lifting capacity on the covered workshop: 25
		Estaleiro Naval de Lisboa	No	Travel-Lift: 30	2 Cranes up to 30
	Vila Real de Santo António	Nautiber	No	Travel-Lift: 250	///
	Lagos	Sopramar	Slipway	3Ttravel-Lifts: 35, 50 and 300	Crane: 25; Lifting platform up to 30m high ; CrocLift (for lifting catamarans) up to 50
	Portimão	Sopramar	Slipway	3Ttravel-Lifts: 35, 50 and 300	Crane: 25; Lifting platform up to 30m high ; CrocLift (for lifting catamarans) up to 50
	Peniche	Estaleiros Navais de Peniche	Slipway of 140x20	Yes	Gantry crane; hydrolift
	Albufeira	Marina de Albufeira Shipyard	No	Travel-Lift: 70	Hoist-crane: 6.3
	Vilamoura	Boatyard Service of Marina Vilamoura	Slipway	Travel-Lift: 60	2 Cranes: 6 and 2; fork lift

Table 28 - Lifting Capacity of the Major Superyacht Repair and Maintenance Shipyards in Portugal

Regarding Portugal, the distribution of shipyards along the coast is not uniform. In fact, most of the Portuguese shipyards are located from Lisbon to the South.

In Lisbon there are several shipyards, most of them are small and they are a facility of a marina, like Cascais. Navalrocha and Navaltagus, are large and well-equipped shipyards, but specialized for ship repair and maintenance, this means that they are able to make just a part of works needed on a superyacht, like mechanical, engine and electrical works. They miss that kind of equipments and workshops for the interior works, a painting shed (painting on superyachts is very important compared to ships because the exterior has to be perfect) and some other specialized facilities for superyachts maintenance and repair. Same goes for Estaleiros Navais de Peniche in Peniche.

The two shipyards of Sopramar, in Lagos and in Portimão, on the other hand, are made for yachts and superyachts.

Comparing the major superyacht shipyards analyzed to the Portuguese ones, there are some differences to highly. First of all, the dimensions: the major shipyards in Italy, Spain and France, already mentioned on section 5.1, are way larger, both in open and covered space, than Sopramar and Navaltgus; the only one with the same order of magnitude is Estaleiros Navais de Peniche.

The other major difference is that the other shipyards are thought, designed and built for superyachts, as opposed to the largest Portuguese ones. This causes a substantial difference on the quantity and quality of services offered from the shipyard to superyachts that require, as already said, particular and dedicated infrastructures, equipment and labor.

5.4 Cost levels in superyacht repair and maintenance

For the costs, it is hard to create a precise list for repair and maintenance operations. First of all, any type of work it is strongly influenced by the yacht's type, size and year of built. Then another important criterion is if the yacht has been well maintained through the years and if all the previous repairs have been done in the right way. Regarding the maintenance of the engines, which for sure would take a big slice of the costs, it depends on the brand and how much they are used, which means how many hours of work they have done. In addition, shipyards do not share price lists of their operations, due to privacy and to the reasons above, but they usually work with personalized price estimation for each yacht. On the other hand, there are a few exceptions of public price lists for Spanish and Italian shipyards, at least for some basic services and their price criteria, such as: launching and towing by different type of lifting equipment, antifouling, cleaning, cost of staying on the yard and worker labor cost.

Regarding Portugal, it was not possible to find any example of prices of yacht shipyards. However, in order to provide anyway an estimate of the costs of a yacht repair and maintenance shipyard in Portugal it was decided to extrapolate the costs from the ones available. According to ECORYS Research and Consulting (ECORYS SCS Group, 2009), which reports a Eurostat graph of the yearly average labour cost per employee in each country of European Union, the average labour cost per employee in Spain and in Italy is the same and amounts to ≈ 35000 [EUR/Year] gross, in place of the average in Portugal which amounts just to ≈ 19000 [EUR/Year] gross, as shown on Figure 36.

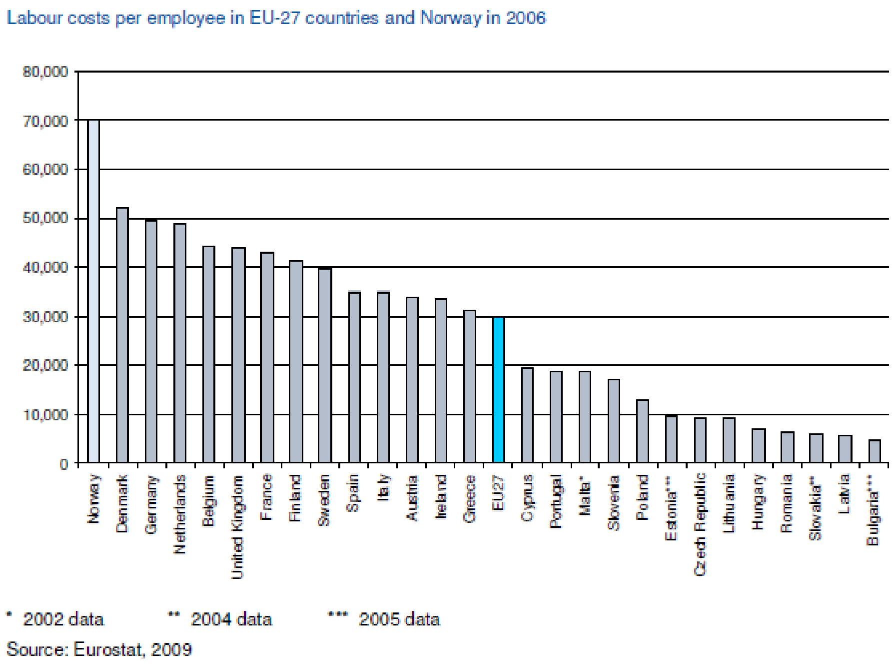

Figure 36 - Yearly Average Labour Cost Per Employee in Each Country of European Union (ECORYS SCS Group, 2009)

Knowing these values, it is possible to make a proportion in order to estimate the man hour cost used by a shipyard in Portugal. In fact, considering Italy where the cost of man hour (CMH) is 50 [EUR/Hour] and where the yearly average labour cost per employee (YLC) is 35000 [EUR/Year] and being the average labour cost per employee in Portugal around 19000 [EUR/Year] it can be deduced that the cost of man hour in Portugal amounts to ≈ 27 [EUR/Hour]

$$YLC_{Italy\ and\ Spain} : CMH_{Italy\ and\ Spain} = YLC_{Portugal} : x \rightarrow x = \frac{19000}{35000} * 50 \qquad (1)$$

Here below, on Table 29, are reported the price lists for a typical yearly maintenance of Port Nautic Castello's shipyard, in Spain, of Cantiere Nautico Jesus in Italy and a shipyard in Portugal.

Cost of Shipyard for a Typical Yearly Maintenance						
Service	Spain (Port Nautic Castello)		Italy (Cantiere Nautico Jesus)		Portugal	
	Price [EUR]	Units	Price [EUR]	Units	Price [EUR]	Units
Haulage	20	Meter of Lenght	2500	Per Operation	1350	Per Operation
Cleaning and Polishing of the Hull	24	Man Hour	80	m2	50	m2
Revision of Main and Auxiliary Engines	50	Man Hour	50	Man Hour	27	Man Hour
Megger Test and Revision of Electroinical Installation	50	Man Hour	50	Man Hour	27	Man Hour
Revision of Air Conditionig/Ventiliation System	45	Man Hour	50	Man Hour	27	Man Hour
Revision of Watermaker and Sewage Treatment Plant	45	Man Hour	50	Man Hour	27	Man Hour
Repairs in Teak Decks	45	Man Hour	600	m2	350	m2
Revision of Radio and Navigation Equipment	50	Man Hour	50	Man Hour	27	Man Hour
Check of Fire-Extinguishing Equipment	38	Man Hour	50	Man Hour	27	Man Hour
Revision of Life-Saving Aplliance	50	Man Hour	1000	Per Operation	700	Per Operation
Revision of Fire Detection Equipment	50	Man Hour	50	Man Hour	27	Man Hour
Launching	20	Meter of Lenght	2500	Per Operation	1350	Per Operation

Table 29 - Price Lists of a Typical Yearly Maintenance of Port Nautic Castello's Shipyard, in Spain, of Cantiere Nautico Jesus in Italy and Portugal

More generally, according to The Superyacht World (Matheison, 2019) and SailBiz (Redazione, 2021) maintenance and repair costs, excluding extraordinary repairs, crews and fuel, amount around at 10% of the newbuilding cost of the yacht. Other important source, CNN (Tamara Hardingham-Gill, 2021), reports that Azzam, the largest superyacht ever built and costed 650 million dollars, might cost over 60 million dollars per year in maintenance and operating cost. In addition, on an interview to Rupert Connor from Luxury Yacht Group for CNN Travel, he says that for a 150-foot superyacht will cost around 2 million dollars a year. This is in line with the other sources and information collected about superyacht maintenance and repair costs (Matheison, 2019).

5.5 Requirements for a state-of-the-art superyacht repair and maintenance shipyard

Considering the technical characteristics of the shipyards presented above, a list of all possible infrastructure, superstructure, equipment and services for repairing and maintaining superyachts is given in Table 30.

State of the art shipyard		
Categories	**Characteristics**	**Original Shipyard**
Haulage Facilites	Syncrolift: No Limit	La Ciotat Shipyard
	Travel-Lift: 1000 [t]	Astilleros de Mallorca
	Drydock: 465x85 [m]	Genova Industrie Navali (GIN) Marsille
	Slipways: 130 [m]	Pendennis Barcelona
Lifting equipment	Gantry Crane: 600 [t]	La Ciotat Shipyard
	Cranes: 200 [t]	Amico & Co.
Berths	Size: up tp 140 [m]	Amico & Co.
	Shore Power: 630 A/ 6Kv, 1800KW	Marina Barcelona 92
	Frash Water Supply: Yes	All Shipyards
Hardstands	Yard diension: 124000 m2	Marina Barcelona 92
Facilites for Maintenance	Covere sheds: 45000 m2	Marina Barcelona 92
	Covere drydocks: 102 [m]	Amico & Co.
	Covered Slipways: No	NONE
	Climate-Controlled cover: Yes	Marina Barcelona 92
Specialities	Composites: Yes	All Shipyards
	Steel/Aluminium works: Yes	All Shipyards
	Stainless steal: Yes	All Shipyards
	Wood works: Yes	Pendennis, Amico & Co.
	Carpentery and Joinery: Yes	All Shipyards
	Upholstery: Yes	All Shipyards
	Mechanics workshop: Yes	All Shipyards
	Electricity workshop: Yes	All Shipyards
	Surface treatment: Yes	All Shipyards
	Painting and finishing: Yes	All Shipyards
	Piping: Yes	All Shipyards
	Hydraulics: Yes	All Shipyards
	Electronics: Yes	All Shipyards
	Air conditioning: Yes	All Shipyards
	Tank cleaning: Yes	All Shipyards
	Residues handling: Yes	All Shipyards
Services	Project management: Yes	All Shipyards
	Engineering (naval architecture): Yes	All Shipyards
	Marine engineering: Yes	All Shipyards
	Interior and exterior design: Yes	All Shipyards
	Yacht support with classification societies: Yes	Genova Industrie Navali (GIN), Palumbo Superyacht Refit and Amico & Co.
	Purchase and logistic: Yes	All Shipyards
Facilities for owners	Helipad: Yes	Marina Barcelona 92
	Yacht chandler: Yes	Marina Barcelona 92, Palumbo Superyacht Refit, Pendennis
Facilities and services for Crew	Consierge	All Shipyards
	Office space	All Shipyards
	Meeting space	All Shipyards
	Soccer Field	Palumbo Superyacht Refit, Amico & Co.
	Basketball Field	Palumbo Superyacht Refit, Amico & Co.
	Tennis Field	Amico & Co.
	Accommodation: B&B, Hotels	Palumbo Superyacht Refit, Amico & Co.
	Crew area, lounge	All Shipyards
	Games room	Palumbo Superyacht Refit, Amico & Co.
	Kitchen	Palumbo Superyacht Refit, Amico & Co.
	Gym	Palumbo Superyacht Refit, Amico & Co.
	Canteen	Palumbo Superyacht Refit
	Shuttle to city centre	Amico & Co.
	Transport: Car, scooters, bike	Amico & Co.
	Assistance with Mooring: Yes	All Shipyards
	Local information and advice on entertainment: Yes	All Shipyards
	Container storage and freight services	Marina Barcelona 92, Palumbo Superyacht Refit, Amico & Co.
	Laundry, tailoring, linens and uniforms	All Shipyards
	Medical assistance: specialist medical and dental treatment	Amico & Co.
	Covid testing: Yes	Amico & Co.
Shipyard Certifications	ISO 14001	Marina Barcelona 92
	ISO 9001	Marina Barcelona 92

Table 30 - Requirements For a State-Of-The-Art Superyacht Repair and Maintenance Shipyard

In order to create this table, the major shipyards, labelled as state-of-the-art shipyards, analyzed on the sections above, were taken into account. More precisely: Marina Barcelona 92, Astilleros de Mallorca, Palumbo Superyachts Refit, Genova Industrie Navali (GIN) in Marsille, La Ciotat Shipyards, Amico & Co. and Genova Industrie Navali (GIN) in Genoa. The aim of the table above is to collect the best possible characteristics from each shipyard to create the "perfect" superyacht maintenance and repair shipyard. A shipyard in Portugal that would serve as a hub for superyacht maintenance and repair would need to provide a similar variety of services, but surely with no need to be fitted with the largest facilities in terms of drydocks, syncrolifts, workshops, cranes and similar.

6 CASE STUDY FOR SUPERYACHT YEARLY CYCLE

6.1 Characterization of integrated service proposal

The information gathered and presented in the previous chapters will now be used to define a typical superyacht cycle and evaluate the total costs implied in the operation of the vessel in a full yearly cycle. On this study it is considered an owner of a motor superyacht of about 40 meters L_{OA}, which spends winter time in the Caribbean, that is the high season of that region, in particular from December to April, and summer time in Cote D'Azur, from May to November, which is the high season for the Mediterranean. Basically, two scenarios are taken into account:

- Scenario 1: the yacht is in the Caribbean Islands from middle of December to middle of April. Then it is shipped from Port St. Vincent in US Virgin Islands to Genoa, by a specialized semi-submersible ship, arriving in early May in order to have time to undertake yearly maintenance. After that, the yacht sails to Cannes and spends the summer in Cote D'Azur until the end of November, when it is shipped back to the Caribbean (same port of departure).
- Scenario 2: the yacht is in the Caribbean Islands from middle of December to middle of April. Then it is shipped by a specialized semi-submersible ship from Port St. Vincent in US Virgin Islands to Portimão in Portugal, where it arrives at the end of April, for its yearly maintenance. On the second half of May it sails by itself to the port of Cannes in Cote D'Azur, where it spends summer until the second half of October when it sails back to Portimão. The yacht spends there around 1,5 months until middle of December when it is shipped back to Port St. Vincent in US Virgin Islands.

The relative schedule of each scenario is presented on Figure 37

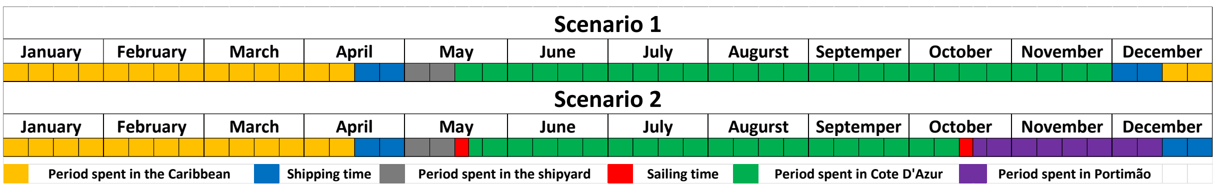

Figure 37 – Schedule of the Two Scenarios

The costs of permanence in the Caribbean will not be taken into account on this study because they are constant on the two scenarios, as well as for the costs related to the common permanence in Cote D'Azur. The only costs evaluated are the ones different in the two scenarios. For the first scenario, the shipyard considered is a typical Italian shipyard in Genoa, while regarding the second scenario, the shipyard is a typical Portuguese one, in Portimão. During the time spent in France, the base-marina is the Port de Cannes, while for Portugal is the Marina de Portimão.

In order to make the comparison of the two scenarios, after choosing the superyacht and the ship to take into account, it will be necessary firstly to define the operation to be undertaken for the yearly maintenance. Secondly, in order to evaluate the differences regarding the voyage of the yacht from the destination of transportation to Cannes and back, all the costs related to that will be considered, such as port costs and sailing costs. After that, all the costs related to the transportation of the yacht by the ship from the Caribbean to Europe will be analyzed, dividing them in operating costs, voyage costs and capital costs. The goal will be to obtain the cost per meter of cargo and for the superyacht understudy for each leg of each scenario. Finally, all the costs related to the marinas and shipyards will be calculated, considering the two itineraries and neglecting the costs in common. Once all these data will be obtained, a comparison of the results will be undertaken, in order to identify the best scenario.

6.2 Technical characteristics of the yacht

The motor yacht taken into account for this study is a Majesty 125, 38,40 meters (125-foot) of L_{OA}, built by Gulf Craft's shipyard on 2010, named "Grenadines III". This composite-made superyacht was built using the FRP (Fiber Reinforced Polymers) vacuum infusion technique, that makes the structures lighter and stronger than normal lamination. It is a triple-deck superyacht plus the flybridge, the typical layout for this size and category of superyacht, with a large room to entertain up to 100 guests when moored and 5 double guestrooms for up to 10 guests. The owner's cabin is equipped with a Spa Pool. The number of crew members is 7, captain included, when in operation. In Figure 38 a picture of the superyacht understudy sailing on open sea.

Figure 38 - Grenadines III Sailing In Open Sea

This superyacht is propelled by twin MTU diesel engine of 2400 [hp] each, able to sail at 15 knots at economic-cruise and 23 knots at fast-cruise. This superyacht is also equipped by two diesel generators of 80 [Kw] each, in order to provide to any electrical necessity of the yacht. Regarding tanks, fuel tanks have a total capacity of 31310 liters, fresh water tanks of 3940 liters, black water tanks of 2800 liters and gray water tanks of 2730 liters. This superyacht, sailing at economic-cruise speed, has a total fuel consumption of around 300 l/h, thus ensuring an autonomy of around 100 hours of sailing equal to 1500 nautical miles at 15 knots (economic-cruise speed). (Charter World, 2021), (212° Yachts, 2021), (Aurora Yachts, 2021). Table 31 shows the technical characteristics of the superyacht understudy.

Technical Characteristics Of Grenadines III			
Builder	Gulf Craft	**Engines**	2 x 2400 hp MTU
Type	Majesty 125	**Generators**	2 x 80 [Kw], 50 [Hz]
Year	2010	**Economic-cruise speed**	15 [Kn]
Loa	38,40 [m]	**Fast-cruise speed**	23 [Kn]
Beam	7,55 [m]	**Fuel Consumption (at economic-cruise speed)**	300 [l/h]
Draft	2,11 [m]	**Range (at economi-cruise speed)**	1500 nautical miles
Displacement	210 [t]	**Fuel Capacity**	31310 [l]
Crew	7	**Frash Water Capacity**	3940 [l]
Guests	10	**Black Water Capacity**	2800 [l]
Cabins	5	**Grey Water Capacity**	2730 [l]

Table 31 - Technical Characteristics of superyacht Grenadines III (Charter World, 2021), (212° Yachts, 2021), (Aurora Yachts, 2021)

6.3 Technical characteristics of the semi-submersible ship

The ship chosen is a semi-submersible ship named “Yacht Express” built by Yantai Raffles Shipyard in China and flying the Netherlands flag. It is owned by the DYT Yacht Transport company. Figure 39 shows a picture of this semi-submersible ship sailing fully loaded.

Figure 39 - The Ship "Yacht Express” Sailing Fully Loaded

Table 32 shows the technical characteristics of Yacht Express.

Technical Characteristics Of Yacht Express			
Name	Yacht Express	**GT**	17951 [t]
Type	Semi-submersible/Heavy Lift Vessel	**DWT**	12500 [t]
IMO-Number	9346029	**NT**	5386 [t]
Flag	The Netherlands	**Loa**	208,89 [m]
Port of Registry	Amsterdam	**Lbp**	191,90 [m]
Year of Built	2007	**Breadth**	32,23 [m]
Hull Material	Steel	**Draught**	5,80 [m]
Crew	28	**Depth**	8,50 [m]
Main Engines	Diesel / Electric: 2x Wärtsilä 12V38DE - 4 stroke single acting 12 cylinder combustion engines 8.700 [kW] / 13.860 hp at 600 rpm connected with electric motors each 5.100 [kW]	**Generators**	2x Wärtsilä 6L20 - 4 stroke 6 cylinder 200 x 280 [mm]diesel generatorsets each 1.080 [kW]
Propellers	2 x Azimodal	**Lifting Equipment**	1x Crane - SWL 10 [t]
Bow Thruster	1x 1.640 [kW]	**Max Speed**	18 [Kn]
Deck Space	5115 [m2]	**Deck Lenght**	165 [m]
Carrying Capacity	5000 [t]	**Deck Width**	31 [m]

Table 32 – Technical Characteristics of “Yacht Express” (Yacht Express, Dockwise Yacht Transport, 2021), (Vesselfinder, 2021)

6.4 Specification of the works during yearly maintenance

The general specification of the works to be undertaken is the following:

- Haulage of the yacht: operated by a 300 [t] travel-lift.
- Cleaning and polishing of hull: cleaning is made by a high-pressure waterjet able to take all the fouling off from the hull; polishing is made by a grinder, equipped with sandpaper’s disks. In order to obtain a great result, it is necessary to iterate few times with different disks of enhancing grinding disks, using also an abrasive paste.
- Revision of main and auxiliary engines: both the main engines and the diesel generators need to be fully revised and maintained. The work to be done really depends on the type of engines themselves and on the total and partial (since last maintenance) hours of operation, but oil changing and filter substitution, for example, have always to be done.
- Megger test and revision of electrical installation: the electrical installation and electronics, in such an aggressive environment like saltwater, are always subjected to a faster corrosion, even if specialized equipment. Therefore, also for the importance of electronic on board, it is necessary to control and revise the equipment, the connections and all the most delicate parts of the electronic system.
- Revision of air conditioning/ventilation system: air conditioning system is an important facility on superyachts, and it is important to ensure that it will not fail while the yacht is in operation. In addition to the revision of the machinery and the system itself, it is also necessary to change or clean air filters. Regarding ventilation system, it is extremely important on the engine room, so it is needed to check the proper functioning.
- Revision of watermaker and sewage treatment plant: in order to guarantee the autonomy of the yacht, both for long-range sails and for staying at the anchor outside a marina, the proper

functioning of watermaker and sewage treatment plant are essential. Thus, the revision of the machinery, filters change and an inspection of the systems are needed while the yacht is in the shipyard.

- Repairs in teak decks: teak decks require constantly maintenance because, being outside, it is subjected to sun and saltwater actions. It is necessary sanding and painting the teak, with proper paints for marine environment. If it is present any damage, it is important to fix it as soon as possible in order to avoid that also the nearby teak will be affected by the water.
- Revision of radio and navigation equipment (radio survey): it is mandatory to have on board radio and navigation equipment fully functional, so a yearly revision needs to be done.
- Check of fire-extinguishing equipment: it is mandatory to check that the level of fire-extinguishers is o the safe range, if it is not it has to be changed, not revised.
- Revision of life-saving appliances: life-saving equipment must be revised cyclically. Regarding escape gear's kit, when it expires it has to be changed with a new one. About life raft, it has to be send to specialized companies that revise it every four years and send it back certificated.
- Revision of fire detection equipment: along the yacht, especially on endangered parts like engine room and kitchen, are installed sensors and fire detectors that needs to be checked and revised.
- Costs of annual survey by class and flag: in addition to what explained above, it is mandatory an annual survey by class and flag, to ensure that the yacht respects all the conditions imposed and mandatory.

6.5 Numerical method for calculation of yacht costs sailing in Cannes from Genoa and from Portimão

According to the case study proposal, the superyacht has to sail in both of scenarios: on the first case it will sail from Genoa to Port of Cannes and back, on the second case it will sail from Portimão to Port of Cannes and back. Obviously, the yacht is the same, so all the technical characteristics, presented on Table 31, will be equal in both cases. The speed taken into account is the economic-cruise speed of the technical datasheet Table 31, as well as the fuel consumption. A sea margin of 20% has been considered in order to obtain more realistic results. The cost of the fuel considered, which is a normal diesel, is the average of 2020 in Genoa, equivalent of ≈ 1,6 [EUR/l], for scenario 1, and the average of 2020 in Portimão, equivalent of ≈ 1,5 [EUR/l], for scenario 2 (Global Petrol Price, 2021). The first route, Genoa – Cannes, is just 102 [Miles] long, the second route Portimão – Cannes is 923 [Miles] log and they were calculated by the website "Complete Marine Freight" (Complete Marine Freight, 2021). The voyage costs are made of fuel costs and port costs.

Fuel costs are firstly calculated, in terms of the total fuel consumed in liters $Fuel_{Tot}$, by multiplying sailing time [h] $Time_{Sailing}$ and fuel consumption at cruise speed [l/h] $Fuel\ Cons._{cruise\ speed}$ adding the sea margin $Sea\ Margin$:

$$Fuel_{Tot} = Time_{Sailing} * Fuel\ Cons._{cruise\ speed} + (0{,}2 * Time_{Sailing} * Fuel\ Cons._{cruise\ speed}) \quad (2)$$

Then, the total fuel costs $C_{Total\ Fuel}$ were calculated by multiplying the total fuel consumed times the fuel cost [EUR/l] C_{Fuel}

$$C_{Total\ Fuel} = Fuel_{Tot} * C_{Fuel} \quad (3)$$

Port costs are calculated by multiplying the cost of the marina per night C_{Marina} times the number of nights spent on the marina N_{Nights}

$$C_{Port} = C_{Marina} * N_{Nights} \quad (4)$$

It was considered that the yacht does not make any stop on scenario 1, due to brevity of the leg, and it stops for one night in Valencia, which is almost at half of the voyage, on scenario 2.

Crew cost is negligible because it is constant on the two scenarios. Therefore, for the sake of completeness, it is reasonable to consider 4 crew members while customers or owner are not onboard and 7 crew members, which is the maximum, while they are onboard.

Finally, sailing cost was obtained:

$$C_{Sailing} = C_{Total\ Fuel} + C_{Port} \quad (5)$$

Following, on Table 33 and Table 34, are reported the data obtained from the numerical calculations presented above of the first leg of scenario 1.

Numerical Method For Calculation of Sailing Costs (Scenario 1)	
Port of Departure	Genoa
Port of Arrive	Cannes
Route [miles]	102
Economic-Cruise Speed [Kn]	15
Sailing Time [h]	6,8
Sailing Time [Day]	0,3
Fuel Consumption (at economic-cruise speed) [l/h]	300
Sea Margin	20%
Total Fuel Consuption [l]	2448
Fuel Cost (Normal Diesel) [EUR/l]	1,6
Crew Members [N°]	4
Cost of Marina [EUR/Day]	////
Number of Nights Spent on the Marina	0

Table 33 – Numerical Method For Calculation of Sailing Cost of the First Leg of Scenario 1

Voyage Costs (Scenario 1)	
Fuel Cost [EUR]	3917
Port Cost [EUR]	0
Total Cost [EUR]	3917

Table 34 – Voyage Costs of the First Leg of Scenario 1

Here below, on Table 35 and Table 36, are reported the data obtained from the numerical calculations presented above of the first leg of scenario 2.

Numerical Method For Calculation of Sailing Costs (Scenario 2)	
Port of Departure	Portimão
Port of Arrive	Cannes
Route [miles]	923
Economic-Cruise Speed [Kn]	15
Sailing Time [h]	61,5
Sailing Time [Day]	2,6
Fuel Consumption (at economic-cruise speed) [l/h]	300
Sea Margin	20%
Total Fuel Consuption [l]	22152
Fuel Cost [EUR/l]	1,5
Crew Members [N°]	4
Cost of Marina [EUR/Day]	200
Number of Nights Spent on the Marina	1

Table 35 - Numerical Method For Calculation of Sailing Cost of the First Leg of Scenario 2

Voyage Costs (Scenario 2)	
Fuel Cost [EUR]	33228
Port Cost [EUR]	210
Total Cost [EUR]	33438

Table 36 - Voyage Costs of the First Leg of Scenario 2

For each scenario, the voyage costs obtained are referred to just one leg, so in order to obtain the total voyage costs for each scenario (roundtrip) it is necessary to double the voyage costs obtained for one leg. The only difference between the two legs is the price of the marina in Valencia (scenario 2), which have two different prices due to the different period of transit (high season in May and low season in October. The price taken into account is the average of the two prices, in order to obtain the total round-trip voyage costs by doubling the one obtained for one leg.

Analyzing the results, it is possible to see how the differences of the values obtained depends in the first place on the different lengths of the routes (102 miles for the first scenario and 923 for the second), that influence mainly fuel consumption, and also the port cost which is zero on the first scenario and present on the second, even if it is relatively insignificant, and on the second place on the different cost of the fuel.

6.6 Numerical method for calculation of semi - submersible ship costs in the routes Genoa – Caribbean and Portimão – Caribbean

On this section are analyzed the costs related to yacht transportation by the semi-submersible ship chosen. The datasheet of the ship is shown on Table 32 and it is not reported on this section again. The objective of performing these calculations is to determine the difference in costs between the two routes, from the point of view of the shipowner (semi-submersible company) and using such result to establish how much cheaper could potentially be a voyage from Portimão, rather than from Genoa.

The calculation method consists on analyzing the costs, with the same criteria, for each leg of both scenarios:

- Scenario 1: first leg is from Port St. Vincent to Genoa, second leg from Genoa to Port St. Vincent.
- Scenario 2: first leg is from Port St. Vincent to Portimão, second leg from Portimão to Port St. Vincent.

The costs are mainly divided into three parts: operating costs, voyage costs and capital costs. The following formulas and coefficient are taken from (Santos, Economics of Ship Operations, 2019) and (D'Almeida, 2009).

Operating costs (O_c) are calculated using the following formulas and represent all fixed costs related to the maintenance of the ship. It is composed by five different costs: manning (M), stores and consumables (ST), maintenance and repairs (MN), insurance (I) and administration costs (AD):

$$O_c = M + ST + MN + I + AD \tag{6}$$

Manning costs depend on the number of crew members $Crew_{N°}$ and a known coefficient (K) for different types of ships:

$$M = K * {Crew_{N°}}^{0,95} \tag{7}$$

Stores and consumables costs depend on the number of cabins, which are directly related to the number of crew members $Crew_{N°}$, on the quantity of lubricating oil consumed which depends on the power of the main engine P_{ME}, on the cubic number *CN* of the ship, which is the product of length between perpendicular L_{BP} times the breadth *B* times the depth *T.* K_1, K_2, K_3 are given coefficients:

$$ST = K_1 * Crew_{N°} + K_2 * CN^{0,25} + K_3 * {P_{ME}}^{0,7} \tag{8}$$

Maintenance and repair costs include all daily repairs, as well as spare equipment and unexpected mechanical failures. On the following equation, P is the estimated newbuilding price of the ship, K_1 and K_2 are given coefficients and P_{ME}, is the power of the main engines:

$$MN = K_1 * P + K_2 * {P_{ME}}^{0,66} \tag{9}$$

The costs of the insurance can be estimated as following, where K_1 and K_2 are given coefficients, V is the estimated actual value of the ship and GT is the gross tonnage:

$$I = K_1.V + K_2.GT \tag{10}$$

Administrations costs are considered fixed and depend on several aspects, such as registration fee and flag state, show based administrative and management costs, communications costs, etc. In this case, it will be considered as 120.000 [EUR] per year.

Regarding voyage costs, they are made by fuel costs and port costs. The calculation of the total fuel costs $C_{Total\ Fuel}$, is composed by the costs of the fuel consumed by the main engines and by the costs of the fuel consumed by the diesel generators.

In both scenarios, however, for a small part of the routes nearby US Virgin Islands, the ship will sail through a Sulphur Emission Control Area (SECA), where it is necessary to use a Low Sulphur Fuel (LSIFO) which is more expensive than normal fuel burned in open sea, which is IFO 380. This particular was taken into account on the calculation.

Thus, firstly it was calculated the total fuel consumed by the main engines in tons $Fuel_{Tot,ME}$ by multiplying sailing time [Days] $Time_{Sailing}$, fuel consumption of the main engines at cruise speed [g/hp*day] $Fuel\ Cons._{cruise\ speed}$ and the power of the main engines P_{ME}:

$$Fuel_{Tot,ME} = Time_{Sailing} * Fuel\ Cons._{cruise\ speed} * 10^{-6} * P_{ME} \tag{11}$$

Then, the total fuel costs of the main engines $C_{Total\ Fuel,MN}$ were calculated by multiplying the total fuel consumed $Fuel_{Tot,MN}$ times the fuel cost [EUR/t] C_{Fuel}:

$$C_{Total\ Fuel,ME} = Fuel_{Tot,ME} * C_{Fuel} \tag{12}$$

In order to obtain the cost of the fuel consumed by the main engines while sailing in open sea, it was considered 95% of sailing time (and so of the fuel consumed), and the cost of IFO 380:

$$C_{Total\ Fuel;Open\ Sea} = Fuel_{Tot,ME} * 0{,}95 * C_{Fuel,IFO} \tag{13}$$

Therefore, for the cost of the fuel consumed by the main engines while sailing through SECA, it was considered 5% of the sailing time (and so of the fuel consumed), and the cost of LSIFO:

$$C_{Total\ Fuel;SECA} = Fuel_{Tot,ME} * 0{,}05 * C_{Fuel,LSIFO} \tag{14}$$

The same calculations are computed for the diesel generators: firstly it was calculated the total fuel consumed by one the diesel generator in tons $Fuel_{Tot,DG}$ by multiplying sailing time [Days] $Time_{Sailing}$, fuel consumption of the diesel generators [g/hp*day] $Fuel\ Cons_{DG}$, the power of the diesel generators P_{DG} and by 0,65 which represents the fraction of the installed generator power used while sailing:

$$Fuel_{Tot,DG} = Time_{Sailing} * Fuel\ Cons._{DG} * 10^{-6} * P_{DG} * 0{,}65 \tag{15}$$

Then, the total fuel costs of the diesel generators $C_{Total\ Fuel,DG}$ were calculated by multiplying the total fuel consumed $Fuel_{Tot,DG}$ by MGO cost [EUR/t] $C_{Fuel,MGO}$:

$$C_{Total\ Fuel,DG} = Fuel_{Tot,ME} * C_{Fuel,MGO} \tag{16}$$

For what concern port costs, it was considered that both in Port St. Vincent in the Virgin Islands and in Portimão the ship will load and unload outside the port, due to the shallow depth inside the port, so they are not taken into account. In Genoa, on the other hand, the port is big and depth enough to let the semi-submersible ship operates inside it so it is considered. The ship needs 3 days to complete unloading operations and 3 days to complete loading operations N_{Days}, positioning all the yachts and be ready to sail. The total costs of the port of Genova $C_{Port\ Daily}$ for this ship is around 10000 [EUR/Day], so the total port costs $C_{Port\ Tot}$ were calculated:

$$C_{Port\ Tot} = C_{Port\ Daily} * N_{Days} \tag{17}$$

About capital costs, which are made by two components, that is the initial purchase price (newbuilding cost) and periodic cash re-payments to banks or equity of investors, it is the annualized cost divided by 350, considering 15 days of not operation of the ship, and multiplied by the number of days of the voyage. The Newbuilding Cost of the ship considered was $NC = 40000000\ [EUR]$, and the expected life of this type of specialized ship it was estimated $N = 25\ [Years]$; the discount rate considered was $i = 0{,}08$, and a Scrap Price of $SP = 5000000\ [EUR]$. Thus, the Capital Recovery Factor (CRF) was calculated as following:

$$CRF = \frac{i*(1+i)^N}{(1+i)^N-1} \tag{18}$$

Then, the Annualized Newbuilding Cost (ANC) was obtained by multiplying the Newbuilding Cost times CRF:

$$ANC = CRF * NC \tag{19}$$

After that, the Present Worth Factor was calculated by the following formula:

$$PW = (1+i)^{-N} \tag{20}$$

Thus it was possible to obtain the Present Worth of Scarp Price (PWSC) by multiplying PW times the Scarp Price:

$$PWSC = PW * SP \tag{21}$$

Then, the Annualized Scarp Price (ASP) was calculated by multiplying PWSC times CRF:

$$ASP = PWSC * CRF \tag{22}$$

So the Annuity was calculated by subtracting the ASP from the ANC:

$$Annuity = ANC - ASP \tag{23}$$

Finally, the Daily Cost was calculated dividing the Annuity by 350 days:

$$Daily\ Cost = \frac{Annuity}{350} \tag{24}$$

On Table 37 are reported the calculation of capital costs (Santos, Economics of Ship Operations, 2019).

Capital Costs			
Years (N)	25	**Scrap Price [EUR]**	5000000
Discount Rate (i)	0,08	**Present Worth Factor (PW)**	0,146
Capital Recovery Factor (CRF)	0,094	**PW of Scrap Price [EUR]**	730090
Newbuilding Cost [EUR]	40000000	**Annualised Scrap Price [EUR]**	68394
Annualised Newbuilding Cost [EUR]	3747151	**Annuity [EUR/Year]**	3678757
Daily Cost [EUR/Day]		10511	

Table 37 – Calculation of Capital Costs

Here below, from Table 38 to Table 41 , are presented the ship's cost for the first leg of scenario 1.

Numerical Method For Calculation of Ship's Voyage Costs (Scenario 1)	
1st Leg	
Port of Departure	Port St. Vincent
Port of Arrive	Genoa
Route [miles]	4180
Cruise Speed [Kn]	16
Sailing Time [h]	261,3
Sailing Time [Day]	10,9
Power of Main Engines [hp]	27720
Fuel Consumption of Main Engines [g/hp*day]	3600
Power of 1 Diesel Generator [Kw]	1080
Fuel Consumption of Diesel Generators [g/Kw*day]	2500
Total Fuel Consuption of Main Engine [t]	1086
Total Fuel Consuption of Diesel Generator [t]	29,4
IFO 380 in Port St. Vincent [EUR/t]	446
MGO in Port St. Vincent [EUR/t]	730
VLSFO in Port St. Vincent [EUR/t]	583
Crew Members	28
Estimated Newbuilding Cost [EUR]	40000000
Estimated Value of the Ship [EUR]	32000000
GT	17951
K (for manning costs)	30000
K1(ST)	3500
K2(ST)	4000
K3(ST)	200
K1(MN)	0,0035
K2(MN)	105
K1(I)	0,006
K2(I)	2,5

Table 38 - Numerical Method for Calculation of Ship's Voyage Costs of the First Leg of Scenario 1

Operating Costs (Scenario 1)	
1st Leg	
Manning [EUR]	21501
Store and Consumables [EUR]	12418
Maintenance and Repairs [EUR]	6950
Insurance [EUR]	7308
Administartion Costs [EUR]	87083
Total Operating Cost [EUR]	135259

Table 39 – Operating Costs of the First Leg of Scenario 1

Voyage Costs (Scenario 1)	
1st Leg	
Fuel Cost of Main Engine in Open Sea [EUR]	460256
Fuel Cost of Main Engine in SECA [EUR]	31665
Fuel Cost of Diesel Generator [EUR]	21455
Total Fuel Cost [EUR]	513376
Port Costs [EUR]	30000
Total Voyage Costs [EUR]	543376

Table 40 – Voyage Costs of the First Leg of Scenario 1

Capital Costs (Scenario 1)	
1st Leg	
Capital cost [EUR/Day]	10647
Sailing Time [Day]	10,9
Total Capital Costs	115897

Table 41 - Capital Costs of the First Leg of Scenario 1

Looking at the data obtained, it looks clear how the main variables of the two scenarios are the length of the routs, which influence sailing time, the quantity fuel consumed, etc., and the cost of the different types of fuel, depending on the port of bunkering.

Once calculated all the costs for each of the voyage, in order to obtain the cost per meter of length of cargo transported, which is the most common unit of measure for this type of goods, it was calculated the total capacity of the ship in linear meters of cargo by analyzing a typical fully loaded voyage of this ship, as shown in Figure 40 and Figure 41.

Figure 40 – Semi-Submersible Ship Fully Loaded 1

Figure 41 – Semi-Submersible Ship Fully Loaded 2

Table 42 shows the capacity of the ship in linear meters of cargo.

Capacity of the Ship			
Rows	Loa Yachts [m]	N° of Yachts	Total Linear Meters of Cargo
1st Row	40	3	120
2nd Row	40	3	120
3rd Row	30	4	120
4th Row	30	4	120
Total	140	14	480

Table 42 - Capacity of the Ship in Linear Meters of Cargo

Then, the total costs of each leg were calculated by making the sum of operating costs, voyage costs and capital costs. Knowing it, assuming a gross income forecast of about 70% the total costs per each leg and knowing the total capacity of the ship in linear meters of cargo and the length of the yacht to be transported, on this case $L_{OA} = 38{,}40$ [m], the costs of each voyage for shipping the superyacht understudy was finally obtained. From Table 43 to Table 46 are shown the results obtained

Total Cost 1st Leg (Scenario 1) [EUR]	794387
Income Forecast [EUR]	556071
Total Cost 1st Leg (Scenario 1) Per linear Meter of Cargo [EUR]	2813
Total Cost 1st Leg (Scenario 1) For Grenadines III [EUR]	108037

Table 43 – Total Costs of First Leg of Scenario 1

Total Cost 2nd Leg (Scenario 1) [EUR]	821550
Income Forecast [EUR]	575085
Total Cost 2nd Leg (Scenario 1) Per linear Meter of Cargo [EUR]	2910
Total Cost 2nd Leg (Scenario 1) For Grenadines III [EUR]	111731

Table 44 - Total Costs of Second Leg of Scenario 1

Total Cost 1st Leg (Scenario 2) [EUR]	587005
Income Forecast [EUR]	410904
Total Cost 1st Leg (Scenario 2) Per linear Meter of Cargo [EUR]	2079
Total Cost 1st Leg (Scenario 2) For Grenadines III [EUR]	79833

Table 45 - Total Costs of First Leg of Scenario 2

Total Cost 2nd Leg (Scenario 2) [EUR]	538723
Income Forecast [EUR]	377106
Total Cost 2nd Leg (Scenario 2) Per linear Meter of Cargo [EUR]	1908
Total Cost 2nd Leg (Scenario 2) For Grenadines III [EUR]	73266

Table 46 - Total Costs of Second Leg of Scenario 2

Analyzing the results obtained, it looks evident how the first scenario is the most expensive, due mostly for the grater length of the route. In addition, second leg of scenario 1 appears the most expensive of the four understudy. The results obtain and shown on the tables above are a bit lower than the data found on the literature. In fact, on the examples reported on Table 1 the costs per linear meter of length are ≈ 3500 – 4000 [EUR/m] for the two bigger yachts (similar to the one taken into account) and ≈ 1300 [EUR/m] for the smallest one. This is probably caused by the fact that the costs of shipping a yacht is not just a function of length and, in addition, the revenue it might be greater than what has been assumed.

6.7 Numerical method for calculation of marina costs and shipyard costs

In this section marina costs and shipyard costs were calculated for both scenarios. On scenario 1, it was considered that the superyacht will spend all its permanence in Cannes, until leaving to Genoa. On this case, the pricelist of Port De Cannes was taken into account and, the only option available was the daily price, including water and electricity. Thus, the daily price was extrapolated for the right yacht category and right period understudy. Once knowing it, in order to calculate the total marina cost, it was multiplied the daily price by the number of days of permanence in the marina. Table 47 shows the results obtained:

Cost of Marina Scenario 1	
Marina	Port De Cannes
Period	From 15-10 to 30-11
Number of Days	45
Price for 30+ Days [EUR/Day]	113
Total Cost [EUR]	5085

Table 47 - Cost of the Marina Of Scenario 1

On the second scenario, it was considered that the yacht, during both voyages from Portugal to France and back, will spend a night in the port of Valencia Mar, in Valencia. In addition, it will spend around 50 days in Marina De Portimão before being shipped back to the Caribbean. In Marina De Portimão, weekly price and monthly price were considered, both including water and electricity supply, in order to evaluate the total cost of the marina, being these two more convenient then the daily price. Table 48 shows the results obtained for scenario 2

Cost of Marina Scenario 2	
Marina	Valencia Mar
Period	From 01-05 to 02-05
Number of Days	1
Price [EUR/Day]	230
Total Cost [EUR]	230
Marina	Valencia Mar
Period	From 16-10 to 17-10
Number of Days	1
Price [EUR/Day]	190
Total Cost [EUR]	190
Marina	Marina de Portimão
Period	From 18-10 to 8-12
Number of Days	51
Monthly Price [EUR/Month]	1756
Weekly Price [EUR/Week]	432,5
Total Cost [EUR]	3054
Total Cost of all Marinas [EUR]	3474

Table 48 - Cost of the Marina Of Scenario 2

Looking at the results obtain, it looks clear how the second scenario is more convenient compared to the first one. This might be caused by, other than the different location, the fact that Port De Cannes does not have long term prices options available, which facilitate this type of cases. On the contrary, Marina de Portimão offers both monthly and weekly options.

Regarding shipyard costs, a pricelist of all the works to be undertaken, described in section 6.4, was obtained for both scenarios, respectively of a typical Italian shipyard for scenario 1 and of a typical Portuguese shipyard for scenario 2. The pricelist of the Portuguese shipyard was obtained with the same method described on section 5.4. On Table 49 is presented the list of the costs per each voice of the works to be undertaken on scenario 1 and the total costs for the superyacht understudy and on Table 50 is presented the list of the costs per each voice of the works to be undertaken on scenario 2 and the total costs for the superyacht understudy.

Cost of Shipyard Scenario 1 (Itialian Shipyard)				
Service	**Price [EUR]**	**Units**	**For the Superyacht Understudy**	**Total Costs [EUR]**
Haulage	2500	Per Operation	1	2500
Cleaning and Polishing of the Hull	80	m2	350	28000
Revision of Main and Auxiliary Engines	50	Man Hour	20	1000
Megger Test and Revision of Electroinical Installation	50	Man Hour	15	750
Revision of Air Conditionig/Ventiliation System	50	Man Hour	15	750
Revision of Watermaker and Sewage Treatment Plant	50	Man Hour	15	750
Repairs in Teak Decks	600	m2	200	120000
Revision of Radio and Navigation Equipment	50	Man Hour	20	1000
Check of Fire-Extinguishing Equipment	50	Man Hour	20	1000
Revision of Life-Saving Aplliance	1000	Per Operation	5	5000
Revision of Fire Detection Equipment	50	Man Hour	15	750
Launching	2500	Per Operation	1	2500
Spares & Materials	////			100000
Tot	////			264000

Table 49 – Costs of the Works to be Undertaken on Scenario 1

Cost of Shipyard Scenario 2 (Portuguese Shipyard)				
Service	**Price [EUR]**	**Units**	**For the Superyacht Understudy**	**Total Costs [EUR]**
Haulage	1350	Per Operation	1	1350
Cleaning and Polishing of the Hull	50	m2	350	17500
Revision of Main and Auxiliary Engines	27	Man Hour	20	540
Megger Test and Revision of Electroinical Installation	27	Man Hour	15	405
Revision of Air Conditionig/Ventiliation System	27	Man Hour	15	405
Revision of Watermaker and Sewage Treatment Plant	27	Man Hour	15	405
Repairs in Teak Decks	350	m2	200	70000
Revision of Radio and Navigation Equipment	27	Man Hour	20	540
Check of Fire-Extinguishing Equipment	27	Man Hour	20	540
Revision of Life-Saving Aplliance	700	Per Operation	5	3500
Revision of Fire Detection Equipment	27	Man Hour	15	405
Launching	1350	Per Operation	1	1350
Spares & Materials	////			100000
Tot	////			196940

Table 50 - Costs of the Works to be Undertaken on Scenario 2

Even if for some types of works there are different types of unit of measures for the prices, it looks evident how, looking at the man-hour costs, second scenario would be more convenient than the first one. In addition, it is important to say that the cost of spares and materials is just an estimation, that can vary a lot depending on drawback, suppliers, etc.

6.8 Summary of results obtained for the yearly cycles

Analyzing the results obtained it looks evident how the second scenario appears more convenient than the first one for almost every aspect considered, economically speaking. Firstly, the shorter voyage from US Virgin Islands to Portugal, which counts 3210 miles against the 4180 miles of US Virgin Islands to Italy, plays an important rule on the different costs of the two scenarios. In fact, all the costs related to the shipping are reduced, form the costs of the fuel to the capital costs and the operating costs, due to the less voyage days. In addition, the prices of the fuels in Portimão are lower than in Genoa, this implies an additional save of money.

At the end, the results obtained are 2813 [EUR/m] and 2910 [EUR/m] for scenario 1 against 2079 [EUR/m] and 1908 [EUR/m] for scenario 2, which is a significant difference. In fact, the total costs for the superyacht understudy to be shipped amounts to ≈ 108000 [EUR] and ≈ 112000 [EUR] for scenario 1 and to ≈ 80000 [EUR] and ≈ 73000 [EUR] for the second scenario.

The costs related to the voyage of the yacht from Portimão to Cannes of scenario 2, on the other hand, which obviously is way longer than the voyage from Genoa to Cannes of scenario 1 and requires also one stop per each leg, does not compensate the saving of money of the shipping but reduce significantly the differences. Therefore, the voyage costs are ≈ 4000 [EUR] per each leg of scenario 1 and ≈ 33000 [EUR] per each leg of scenario 2, including the price of the marina in Spain. So, the total voyage costs per each leg (shipping + sailing) amounts to ≈ 112000 [EUR] and ≈ 116000 [EUR] for the first scenario and to ≈ 113000 [EUR] and ≈ 107000 [EUR] for the second scenario, as reported on Table 51.

Summary of Shipping Costs Calculation & Voyage Costs of the Superyacht				
Shipping				
Type of Costs	Scenario 1		Scenario 2	
	Leg 1	Leg 2	Leg 1	Leg 2
Voyage Costs [EUR]	543376	570539	394243	345961
Operating Costs [EUR]	135114	135114	103760	103760
Capital Costs [EUR]	115897	115897	89002	89002
Gross Income Forecast [EUR]	575085	575085	410904	377106
Shipping Costs for Case Study [EUR/m]	2813	2910	2079	1908
Shipping Costs for Case Study [EUR]	108037	111731	79833	73266
Voyage of the Superyacht				
Fuel Costs [EUR]	3917	3917	33228	33228
Port Costs [EUR]	0	0	210	210
Total Costs [EUR]	3917	3917	33438	33438
Shipping + Voyage				
Total Costs [EUR]	111953	115648	113271	106704

Table 51 - Summary of Shipping Costs Calculation and Voyage Costs of the Superyacht

Regarding marina costs, the difference between the two scenarios is again an advantage to the second scenario, with ≈ 5000 [EUR] of scenario 1 against ≈ 3000 [EUR] of scenario 2, even if these costs do not influence a lot the total costs of the scenarios.

Finally, shipyard costs are once again lower in the second scenario: ≈ 264000 [EUR] for scenario 1 and ≈ 197000 [EUR] for scenario 2. This consistent difference of costs, on equal terms, is attributable to the different costs of the grunt work, both specialized and not, which influence also the operation like haulage and launching. In addition, a difference on the costs of spares and materials would be reasonable, to the benefit of scenario 2, due to the different GNP and economy of Portugal and Italy but, on a first phase of calculation it was decided to not take it into account.

At the end, considering all the costs taken into account of the two scenarios, the costs obtained are the following and reported on Table 52:

- Total costs of scenario 1: 496687 [EUR] ≈ 500000 [EUR]
- Total costs of scenario 2: 420389 [EUR] ≈ 420000 [EUR]

Total Costs of Each Scenario		
Type of Costs	Scenario 1	Scenario 2
Shipping [EUR]	219767	153099
Voyage of the Superyacht [EUR]	7834	66876
Marinas [EUR]	5085	3474
Shipyard [EUR]	264000	196940
Total Costs [EUR]	496686	420389

Table 52 - Total Costs per Scenario

The total savings amounts to 80000 [EUR] which is a great results consistent with what it was expected to obtain after the previous studies already done.

7 CONCLUSIONS

After reviewing the literature about the superyacht market segment, it was understood how this sector has undergone an incredible development throughout the years, in particular in the recent past. Due to the increase of the superyacht fleet and to the huge economic impact of this business, a study about the migration and repositioning of superyachts has been undertaken, analyzing the most common routes, the criteria from which they are chosen, the influence of weather forecast and the limits of the yachts. For those yachts that are not able to sail across the Atlantic Ocean, in order to have an alternative way to cross the Ocean, shipping options have been analyzed regarding the type of ships used, the average costs and routes.

The potential of Portugal in this business was explained, in particular due to its geographical position, which makes it a strategic point and a perfect hub for superyacht traffic, not only for the superyachts crossing by themselves, but also for the traffic between North Sea and Mediterranean. The operation of shipping companies carrying yachts all over the world was also described.

After that, a complete database of the major marinas and shipyards in the Mediterranean and North Sea was built, in order to be able to understand the distribution of these infrastructures along the coasts and to compare the level of development between the countries under study. In addition, the characteristics of these infrastructures have been analyzed and collected, in order to be able to understand which are the most important specifications of these shipyards and marinas.

It was concluded that Portugal is the country with the lower number of both marinas and shipyards specialized on superyachts, which require very particular characteristic for these infrastructures. This helps to understand why, despite the potential, Portugal is behind compared to Spain, France and Italy in the yachting world. Regarding costs, Italy, Spain and France are more or less in line as regards marina costs, while Portugal reveals itself cheaper. For what concerns shipyard costs, France is the most expensive, due to the greater labour costs, followed by Italy and Spain, which are at the same level; once more, Portugal is the cheapest option analyzed, which is another point in favor to this country.

Finally, using all the information collected, a case study for a superyacht yearly cycle has been developed, analyzing and comparing two scenarios: an existing typical scenario, in which a certain superyacht is shipped to Italy, makes there the yearly maintenance and repairs, then sails to Cote D’Azur and then it is shipped back from Genoa to the Caribbean; a new scenario in which the same superyacht is shipped in Portugal and takes there the yearly maintenance and repairs, then it sails to Cote D’Azur and sails back to Portugal where it spends a short period before be shipped back.

Comparing these two scenarios, the information, data and conclusions collected were confirmed, with the results obtained being consistent with what was expected. In fact, comparing the costs of the two scenarios, the second one turns out to be the most convenient. Firstly, the shorter voyage of the ship to deliver the superyacht in Portugal rather than in Italy causes a consistent reduction of the costs, which are, on the other hand, almost compensated by the difference of the costs of sailing from Portugal to France rather than from Italy to France.

Also as expected, reduced costs of marina was obtained for the second scenario compared to the costs of marina in the first scenario. But the most significant difference between the two cases, which is also the greater saving in costs, is the different costs of the shipyard. In fact, assuming to undertake the same works on the same superyachts, the difference of the costs calculated amounts to around 25% from scenario 1 to scenario 2, with a saving of around 65000 [EUR] for the case understudy.

At the end, comparing the total costs of the two scenarios under study, it was obtained a difference of almost 80000 [EUR] from the existing scenario to the new scenario. Such a consistent difference, to the advantage of the second scenario, demonstrate that, even in a preliminary study like the one developed in this thesis, there is a definite saving on choosing Portugal as a hub for superyachts.

The general conclusion of this work is that Portugal could play a significant role in the future of superyachts, becoming a hub for those superyachts that transit between the Mediterranean and the Caribbean and the North Sea. It was also demonstrated that a consistent improvement of the infrastructures, marinas and shipyards is needed along all the Portuguese coast, in order to be ready to manage the flux of these luxury vessels, and that already, economically speaking, Portugal is a valid option for those superyachts that can be managed by the existing infrastructures.

As recommendation for further work, it is suggested to focus on the feasibility study, both economic and technical, for the construction of modern superyacht marinas and shipyards, located in some strategic position in Portugal. It will also be important to take into account the issues related to the weather conditions, swell, wave motions and typical current, as well as the economical sustainability of these investments considering a reasonable amortization and future investments.

REFERENCES

212° Yachts. (2021). *Grenadines III*. Retrieved from 212° Yachts: https://www.212-yachts.com/yacht-charter/luxury-yacht-charter-cannes-grenadines-iii/

Aurora Yachts. (2021). *Majesty Yachts, Majesty 125*. Retrieved from Aurorayachts: https://www.aurorayachts.net/listings/majesty-125/#1468238791521-8e8c0611-a354

Barchemgazine. (2020, Dicembre). *Majesty 175 di Gulf Craft, lo yacht in composito più grande del mondo*. Retrieved from Barche.it: https://www.barchemagazine.com/majesty-175-di-gulf-craft-lo-yacht-in-composito-piu-grande-del-mondo/

Bees, N. (2020, June 12). *Yachting Pages Media Group*. Retrieved from Yachting Pages Media Group: https://yachting-pages.com/articles/what-is-a-superyacht.html

Bottero, S. (2002, December 27). *Nautica Alta Marea .* Retrieved from RINNOVO CERTIFICATO DI SICUREZZA: https://www.nauticaltamarea.it/rinnovo-certificato-di-sicurezza/

Bunting, E. (2019, April 9). *Yachting World.* Retrieved from How to cross the Atlantic from the Caribbean to Europe: Everything you need to know: https://www.yachtingworld.com/sailing-across-atlantic/eastward-caribbean-europe-120203

Burchia, E. (2013, April 6). *«Azzam» lo yacht più grande del mondo*. Retrieved from Corriere della Sera: https://www.corriere.it/cronache/13_aprile_06/azzam-lo-yacht-piu-grande-del%20mondo-spodesta-eclipse-di-abramovich_435bde76-9ea2-11e2-8717-9b3e51409b57.shtml

Carrier, J. (2013, February 5). *Crusing World* .

Ceglia, V. D. (2021, June 22). *La Repubblica.* Retrieved from https://www.repubblica.it/dossier/economia/i-gioielli-del-made-in-italy/2021/06/22/news/la_nautica_batte_il_covid-19_italia_in_vetta_nei_superyacht-307219060/

Charter World. (2021). *Grenadines III, Majesty 125*. Retrieved from Charter World: https://www.charterworld.com/index.html?sub=yacht-charter&charter=mygrenadines-iii-6119

Chauvin, O. (2020, April 22). *BOAT OSMOSIS*. Retrieved from Band of Boats: https://blog.bandofboats.com/en/boat-osmosis-how-to-prevent-it

Cione, C. (2021, July 17). *Daily marine magazine*. Retrieved from Close-up Engineering: https://marinecue.it/yacht-azzam-lusso-record-500-milioni-2021/29725/

Clima e Viaggi. (n.d.). Retrieved from Guida ai climi nel mondo: https://www.climieviaggi.it/clima/portogallo

Cocheril, M. A. (2012). *Deign Catecories of Watercrafts.* Retrieved from Europarl.europa: https://www.europarl.europa.eu/RegData/etudes/note/join/2012/475122/IPOL-IMCO_NT(2012)475122_EN.pdf (June 1st)

Colombo, A. (2020). *TIpi di barche a vela*. Retrieved from iNautia: https://www.inautia.it/blog/vela/tipi-barche-vela/#megayacht (November 13th)

Complete Marine Freight (2021). Making your adventures happen. Retrieved from http://www.completemarinefreight.com.

D'Almeida. (2009). *Arquitectura Naval - o Dimensionamento do Navio.* Lisboa: PrimeBooks.

Dazert, R., Herman, A., Webster, F., Dowling, K., & Sabbadin, C. (2021). *Monaco Yacht Show Market Report 2021 by SuperYacht Times.* Amsterdam: SuperYacht Times.

DYT; Super Yacht Transport. (n.d.). *DYT*. Retrieved from https://www.yacht-transport.com/

ECORYS SCS Group. (2009). *Study on Competitiveness of the.* Rotterdam: Directorate-General Enterprise & Industry.

Fiorentino, F. (2014). *Alto Mare Blu*. Retrieved from Eliche di superficie – eccellenti sconosciute: https://www.altomareblu.com/eliche-di-superficie-eccellenti-sconosciute/ (January 13th)

FPT Powertrain Technologies . (2021). *FPT Powertrain Technologies* . Retrieved from FPT Powertrain Technologies : https://www.fptindustrial.com/global/en?gclid=Cj0KCQjwtrSLBhCLARIsACh6RmhXsFttrNaGzPMRI23uOvw49o3jz5ExoNaGN2DQXC1G4JpUff_PvhYaAghhEALw_wcB

Frank, R. (2013). *Need to Ship Your Yacht? There's a Boat For That.* Retrieved from https://www.cnbc.com/world/?region=world (May 22nd)

Global Petrol Price. (2021). *Global Petrol Price*. Retrieved from Global Petrol Price: https://www.globalpetrolprices.com/gasoline_prices/

Heppell, T. (2018). *Sailing Today.* Retrieved from Heikell's guide to an Atlantic crossing: https://www.sailingtoday.co.uk/cruising/cruising-tips/heikells-guide-atlantic-crossing/ (March 17th)

ICOMIA (Internatioal Council of Marine Industry Associations). (2021). Retrieved from ICOMIA SMALL CRAFT STANDARDS BULLETIN 2021 - EDITION 15: https://www.icomia.org/content/icomia-small-craft-standards-bulletin-2021-edition-15 (August 19th)

ICOMIA. (2020). *International Council of Marine Associations*. https://www.icomia.org/ (14th September)

Ingiosi, D. (2019). *Magellano Blog.* Retrieved from In Gommone Dalla Sicilia a New York: Bravo Davì!: https://blog.magellanostore.it/in-gommone-dalla-sicilia-a-new-york-bravo-davi/ (October 2nd)

Marchetti, C., & Palmas, F. (2020). *Flussi di mobilità nel mercato superyacht: una proposta di studio ed una prima valutazione.* Università degli Studi di Sassari. Sassari: SIET.

Marina Barcelona 92. (n.d.). *Marina Barcelona 92*. Retrieved 2021, from Marina Barcelona 92: https://mb92.com/barcelona/shiplift

Marina di Porto Cervo. (2021). Retrieved from https://www.marinadiportocervo.com/wp-content/uploads/2021/04/NEW-PORT-2021.pdf (May 1st)

Marina Vela - Marina Nautic Center. (n.d.). *Marina Vela - Marina Nautic Center*. Retrieved 2021, from Marina Vela - Marina Nautic Center: https://www.bcnnauticcenter.com/en/

Marine Traffic. (2019). *The Yacht and Superyacht Migration .*

Matheison, W. (2019). *Superyacht Migration Report 2015-2019.* Rory Jackson.

Mondinelli, A. (2014). *Boat Magazine* . Retrieved from Barche e Yacht: https://www.boatmag.it/3701-cesare-cancelli-alluminio-superyacht/ (May 7th)

Moretti, P. (2015). *Boat International.* Retrieved from RIna: https://www.boatinternational.com/yachts/luxury-yacht-advice/yacht-classification-definitions--587 (January 21st)

Moser, J. (2019). *New Boat: Cigarette 59 Tirranna*. Retrieved from Power and Motoryacht : https://www.powerandmotoryacht.com/boats/new-boat-cigarette-59-tirranna (April 16th)

Redazione. (2021). *Quanto Costa Un Superyacht, Tutte Le Spese Da Considerare*. Retrieved from Sailbiz: https://sailbiz.it/quanto-costa-un-superyacht-tutte-le-spese-da-considerare/ (January 7th)

Redazione Abimis. (2018). *Materiali settore navale: quali sono quelli più utilizzati?* Retrieved from Abimis: https://abimis.com/materiali-settore-navale-piu-utilizzati/ (January 29th)

Santos, T.A. (2019). Economics of Ship Operations. Lecture Notes of TMPI course Lisbon, Lisbon, Portugal.

Santos, T.A. (2020). Superyacht Market Segment. Lecture Notes of TMPII course, Lisbon, Portugal.

Sea Rates. (2021). Retrieved from Dp World: https://www.searates.com/it/services/distances-time/ (September 20th)

Springer, B. (2019). *Forbes.* Retrieved from What Makes A Superyacht A Superyacht?: https://www.forbes.com/sites/billspringer/2019/08/07/what-makes-a-superyacht-a-superyacht/?sh=69179c0e71c6 (August 7th)

Storgaard, M. (2019). *Go Downsize*. Retrieved from Go Downsize: https://www.godownsize.com/yachts-pacific-atlantic-ocean/ (June 12th)

Superyachts. (2020). *World is not Enough*. Retrieved from Superyachts.com: https://www.superyachts.com/fleet/world-is-not-enough-4077/ (October 4th)

Tamara Hardingham-Gill. (2021). *CNN Travel.* Retrieved from CNN: https://edition.cnn.com/travel/article/hidden-costs-of-owning-a-superyacht/index.html (June 1st)

Today, S. (n.d.). *Sailing Today*. (C. TIbbs, Editor) Retrieved from Sailing Across the Atlantic: https://www.sailingtoday.co.uk/practical/technical-guides/atlantic-weather/

Vesselfinder. (2021). *Vesselfinder*. Retrieved from Yacht express: https://www.vesselfinder.com/it/vessels/YACHT-EXPRESS-IMO-9346029-MMSI-244870311

Vitorino, A. P. (2017). *Portugal and the Ocean Economy*. Retrieved from United Nations: https://www.un.org/en/chronicle/article/portugal-and-ocean-economy

Worth Avenue Yachts . (2019). Retrieved from Megayacht vs. Superyacht : https://www.worthavenueyachts.com/05-08-2019/megayacht-vs-superyacht/ (May 8th)

Yacht Express, Dockwise Yacht Transport. (2021). Retrieved from Ship Technology: https://www.ship-technology.com/projects/yachtexpress/

Appendix 1 – Numerical method for calculation of semi - submersible ship costs in the routes Genoa – Caribbean and Portimão – Caribbean

Numerical Method For Calculation of Ship's Voyage Costs (Scenario 1)	
2nd Leg	
Port of Departure	Genoa
Port of Arrive	Port St. Vincent
Route [miles]	4180
Cruise Speed [Kn]	16
Sailing Time [h]	261,3
Sailing Time [Day]	10,9
Power of Main Engines [hp]	27720
Fuel Consumption of Main Engines [g/hp*day]	3600
Power of 1 Diesel Generator [Kw]	1080
Fuel Consumption of Diesel Generators [g/Kw*day]	2500
Total Fuel Consuption of Main Engine [t]	1086
Total Fuel Consuption of Diesel Generator [t]	29,4
IFO 380 in Genoa [EUR/t]	480
MGO in Genoa [EUR/t]	599
VLSFO in Genoa [EUR/t]	508
Crew Members	28
Estimated Newbuilding Cost [EUR]	40000000
Estimated Value of the Ship [EUR]	32000000
GT	17951
K (for manning costs)	30000
K1(ST)	3500
K2(ST)	4000
K3(ST)	200
K1(MN)	0,0035
K2(MN)	105
K1(I)	0,006
K2(I)	2,5

Operating Costs (Scenario 1)	
2nd Leg	
Manning [EUR]	21501
Store and Consumables [EUR]	12418
Maintenance and Repairs [EUR]	6950
Insurance [EUR]	7308
Administartion Costs [EUR]	87083
Total Operating Cost [EUR]	135259

Voyage Costs (Scenario 1)	
2nd Leg	
Fuel Cost of Main Engine in Open Sea [EUR]	495343
Fuel Cost of Main Engine in SECA [EUR]	27591
Fuel Cost of Diesel Generator [EUR]	17605
Total Fuel Cost [EUR]	540539
Port Costs [EUR]	30000
Total Voyage Costs [EUR]	570539

Capital Costs (Scenario 1)	
2nd Leg	
Capital cost [EUR/Day]	10647
Sailing Time [Day]	10,9
Total Capital Costs	115897

Numerical Method For Calculation of Ship's Voyage Costs (Scenario 2)	
1st Leg	
Port of Departure	Port St. Vincent
Port of Arrive	Portimão
Route [miles]	3210
Cruise Speed [Kn]	16
Sailing Time [h]	200,6
Sailing Time [Day]	8,4
Power of Main Engines [hp]	27720
Fuel Consumption of Main Engines [g/hp*day]	3600
Power of 1 Diesel Generator [Kw]	1080
Fuel Consumption of Diesel Generators [g/Kw*day]	2500
Total Fuel Consuption of Main Engine [t]	834
Total Fuel Consuption of Diesel Generator [t]	22,6
IFO 380 in Port St. Vincent [EUR/t]	446
MGO in Port St. Vincent [EUR/t]	730
VLSFO in Port St. Vincent [EUR/t]	583
Crew Members	28
Estimated Newbuilding Cost [EUR]	40000000
Estimated Value of the Ship [EUR]	32000000
GT	17951
K (for manning costs)	30000
K1(ST)	3500
K2(ST)	4000
K3(ST)	200
K1(MN)	0,0035
K2(MN)	105
K1(I)	0,006
K2(I)	2,5

Operating Costs (Scenario 2)	
1st Leg	
Manning [EUR]	16512
Store and Consumables [EUR]	9536
Maintenance and Repairs [EUR]	5337
Insurance [EUR]	5612
Administartion Costs [EUR]	66875
Total Operating Cost [EUR]	103871

Voyage Costs (Scenario 2)	
1st Leg	
Fuel Cost of Main Engine in Open Sea [EUR]	353450
Fuel Cost of Main Engine in SECA [EUR]	24317
Fuel Cost of Diesel Generator [EUR]	16476
Total Fuel Cost [EUR]	394243
Port Costs [EUR]	0
Total Voyage Costs [EUR]	394243

Capital Costs (Scenario 2)	
1st Leg	
Capital cost [EUR/Day]	10647
Sailing Time [Day]	8,4
Total Capital Costs	89002

Numerical Method For Calculation of Ship's Voyage Costs (Scenario 2)	
2nd Leg	
Port of Departure	Portimão
Port of Arrive	Port St. Vincent
Route [miles]	3210
Cruise Speed [Kn]	16
Sailing Time [h]	200,6
Sailing Time [Day]	8,4
Power of Main Engines [hp]	27720
Fuel Consumption of Main Engines [g/hp*day]	3600
Power of 1 Diesel Generator [Kw]	1080
Fuel Consumption of Diesel Generators [g/Kw*day]	2500
Total Fuel Consuption of Main Engine [t]	834
Total Fuel Consuption of Diesel Generator [t]	22,6
IFO 380 in Portimão [EUR/t]	390
MGO in Port St. Portimão [EUR/t]	716
VLSFO in Port St. Portimão [EUR/t]	497
Crew Members	28
Estimated Newbuilding Cost [EUR]	40000000
Estimated Value of the Ship [EUR]	32000000
GT	17951
K (for manning costs)	30000
K1(ST)	3500
K2(ST)	4000
K3(ST)	200
K1(MN)	0,0035
K2(MN)	105
K1(I)	0,006
K2(I)	2,5

Operating Costs (Scenario 2)	
2nd Leg	
Manning [EUR]	16512
Store and Consumables [EUR]	9536
Maintenance and Repairs [EUR]	5337
Insurance [EUR]	5612
Administartion Costs [EUR]	66875
Total Operating Cost [EUR]	103871

Voyage Costs (Scenario 2)	
2nd Leg	
Fuel Cost of Main Engine in Open Sea [EUR]	309071
Fuel Cost of Main Engine in SECA [EUR]	20730
Fuel Cost of Diesel Generator [EUR]	16160
Total Fuel Cost [EUR]	345961
Port Costs [EUR]	0
Total Voyage Costs [EUR]	345961

Capital Costs (Scenario 2)	
2nd Leg	
Capital cost [EUR/Day]	10647
Sailing Time [Day]	8,4
Total Capital Costs	89002