MARIBE

Marine Investment for the Blue Economy

WP 5: Technical and non-technical challenges, regional and sectoral

Deliverable 5.4

Comparative review of the situation in the 4 basins

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About MARIBE

MARIBE is a Horizon 2020 project that aims to unlock the potential of multi-use of space in the offshore economy (also referred to as Blue Economy). This forms part of the long-term Blue Growth (BG) strategy to support sustainable growth in the marine and maritime sectors as a whole; something which is at the heart of the Integrated Maritime Policy, the EU Innovation Union, and the Europe 2020 strategy for smart, sustainable growth.

Within the Blue Economy, there are new and emerging sectors comprising technologies that are early stage and novel. These are referred to as Blue Growth sectors and they have developed independently for the most part without pursuing cooperation opportunities with other sectors. MARIBE investigates cooperation opportunities (partnerships, joint ventures etc.) for companies within the four key BG sectors in order to develop these companies and their sectors and to promote the multi-use of space in the offshore economy. The sectors are Marine Renewable Energy, Aquaculture, Marine Biotechnology and Seabed Mining. MARIBE links and cross-cuts with the Transatlantic Ocean Research Alliance and the Galway Statement by reviewing the three European basins (Atlantic, Mediterranean, and Baltic) as well as the Caribbean Basin.

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Legal Disclaimer

1 Executive Summary

This deliverable analyses the results of tasks T5.3 and T5.4, which are included in deliverables "D5.2 Current and expected technical challenges" and "D5.3 Current and expected non-technical challenges". In these two documents, different barriers that could affect the development of blue growth sectors were identified and classified according both to the basin in which they appear and the combination of sectors analysed.

In this report an analysis of these limitations in terms of two different aspects is made: by basins and by combination. To achieve this, the barriers associated with each individual sector are analysed. To complete the analysis, a number of possible proposals that should help to solve, if not all, some of the barriers encountered are attached.

The discussion between technical and non-technical limitations shows an essential asymmetry between them. These limitations to sectors should be seen by a dual perspective. From one point of view, limitations are identified by their cause, the physical barrier. But from another perspective, limitations are seen by their visualization by stakeholders, by the driver of these limitations. Technical barriers are commonly perceived by stakeholders as financial, administrative, regulatory limitations.

Non-technical barriers derived from political restrictions or administrative regulations are not expected to be relaxed in the short time. They are structural issues that act as boundary conditions and need political and legislative actions to be solved. Technical barriers derived from physical limitations or from a lack of knowledge or technology applicable can be overcome through research and investment. Technical barriers, where relevant, are then bounded to become financial barriers.

Beyond this general comment, the first remarkable conclusion of the analysis is that barriers are usually sector specific, and they do not rely heavily on neither the basin nor the combination being analysed. The analysis of the individual sectors considered allows to remark some general conclusions:

- Spatial issues related to the use of areas for various sectors may exist, especially those who have traditionally been users of marine areas.
- The environmental impacts must be studied in depth, as new projects may be perceived as harmful by society and limit its development.
- The distance to the coast, or service ports, can be limiting from the perspective of the operation in sectors that require some often maintenance.
- Development costs of blue growth sectors are still high and its future profitability uncertain, so the lack of funding can be a particularly important barrier.
- Some sectors are still in early stages of development. More investment in research is needed.
- The lack of adequate, consistent and common regulatory frameworks throughout the marine environment limit the development of new sectors, because these involve increased efforts and costs.

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In the analysis by basins, four of them have been considered: Atlantic, Baltic and North Sea, Caribbean and Mediterranean and Black Sea. The main conclusions that have been obtained from this analysis are:

- The Atlantic basin does not seem suitable for the development of sectors requiring foundations, anchors or moorings, mainly due to its high depth. Weather conditions limit the development of offshore aquaculture, limiting its development to the nearshore areas. Although potential exists, the development of marine energy is still at an early stage. The same applies to seabed mining, which appears only in research projects. Weather conditions (high waves and winds) can limit both the construction and the operation and maintenance of offshore developments in all sectors.
- In the Baltic basin, the Baltic Sea appears not to be suitable for the development of aquaculture, although in the North Sea it can be proposed in appropriate areas. The basin has a large wind energy development, although there are some limiting factors (grid connections, energy mix, national policies) that reduce their full development. As in the case in the Atlantic, weather conditions in the North Sea may be presented as a major constraint for all sectors.
- In the Caribbean, the existence of hurricanes can be a barrier of special consideration. Water quality can also be seen as problematic for the development of those sectors which need clean waters.
- Aquaculture in the Mediterranean is widespread. The climatic and physical conditions help the development of this sector. However, problems begin to emerge related to spatial planning and licensing in most suitable areas. These same weather conditions (low wind and waves) limit the development of industries related to marine energy. On the contrary, the great biodiversity that presents the basin makes it ideal for a sector such as biotechnology.
- Problems arise in all basins due to the lack of a clear definition of administrative and legal proceedings related to the implementation of offshore projects. A common regulatory framework would greatly facilitate the growth of blue sectors, and due to the early stage of BG activities we are still on time to create such a common framework.

From the analysis based on the combinations of two or more sectors, there are some barriers that must be especially commented:

- Environmental constraints may occur. Some sectors can produce compounds and other pollutants, while others may need a certain environmental quality conditions. This could be a barrier to the development of some combinations (e.g. aquaculture with oil&gas).
- Social perception problems can arise related to the image that some sectors have (e.g. oil&gas have a general bad social perception). Any sectors trying to combine with them, can result socially damaged.

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- Problems related to financing may occur, due to the uncertainty that some sectors have with respect to their economic viability. Combinations with weak sectors can jeopardize stronger sectors.
- Problems related to technological development may appear, because some sectors are already commercially viable, while others are still in early stages of development.
- Since some sectors need specific environmental conditions (high levels of marine energy like winds or waves), this can be problematic for the safety of other sectors problems.

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2 Contents

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3 Limitations analysis by basin

From the analysis of Deliverables "D5.2 Current and expected technical challenges" and "D5.3 Current and expected non-technical challenges", the main conclusion obtained is that most of the barriers identified affect one sector and are due to one sector, but they do not depend on the combination or the basin. We can conclude that no specific barriers can be argued to differentiate between basins, as the main restrictions observed can be applied to sectors in all basins (see section 4).

Despite these common barriers to all basins, some other appears linked with a specific basin. These are presented in the following section. For each of the four basins considered (Atlantic, Baltic, Caribbean and Mediterranean and Black Sea), the main limitations, either technical or non-technical, that emerge from the database are listed and explained shortly.

More suitable combinations for each basin are also presented based on barriers encountered and on combinations presented on MARIBE project.

3.1 Atlantic basin

Atlantic basin comprises the Atlantic Ocean area situated between the southern coasts of the Canary Islands (Spain) to the northern part of United Kingdom territories, including the Gulf of Biscay and the Celtic Sea. It is a vast area of more than 13 million km^2, and have an important biodiversity due to the different environmental conditions that coexist in it. Five countries are included in this basin, Portugal, Spain, France, United Kingdom and Ireland, and in all of them have extensive coastlines and large populations' resident within the coastal zone.

Maritime resources and economy are an important factor and the basis for a wide range of goods and services. Studies conducted on Blue Growth within the Atlantic Sea Basin indicate that the total size of the Atlantic Blue Economy is at least €26.8 billion in gross value added (GVA) and accounts for more than 800,000 jobs, excluding maritime economic activities that could not be quantified (ECORYS, 2014).

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Aquaculture is one of the blue growth sectors which have increased its importance over time in this basin. France and Spain are the countries with more production, followed by Portugal and Ireland. Water physical and climatic conditions limit the species that can be farmed along marine areas. Also the physical availability of suitable production sites appears as a limitation. Due to the previous conditions sites are very limited, and these are commonly in competition with other users of marine space. No problem in this sector related to workforce should appear, so main aquaculture areas of the Atlantic basin all have training centres that can provide knowledge and vocational training for this sector workers.

Problems can arise for offshore sites, where there are not adequate systems developed yet for the prevention of escapes from cages and protection from predatory wildlife and submergible cages that allow aquaculture installations in sites with high waves and current speeds should be developed. Also technological solutions are needed to make offshore aquaculture sustainable and economically viable. Industry is moving towards “integrated multi-trophic aquaculture” (IMTA, mixed farming), but it is currently at an early pilot stage.

In the case of fisheries, there is a pivotal barrier for the growth of the sector: stock sustainability. European Union promotes environmental sustainable fisheries in the long term by adapting exploitation rates so as to maintain populations. This barrier can be translated into an important opportunity for aquaculture, making out the environmental sustainability of the sector.

Although a clear potential for the installation of offshore wind energy projects exists, no large scale projects have been developed yet. The main activities in this sector are located in UK. The major limitation that appears in this basin is water depth, which is a disadvantage in comparison with other basins with more shallow waters (North Sea and Baltic). The development of floating devices should help to overcome this barrier.

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For seabed mining, the main limitation in this basin is also water depth. Due to this physical characteristics the projects are relatively limited and are focused mainly in exploration and research projects. This could be due to the lack of suitable mining zones, which are mainly located in Indian and Pacific Oceans.

In biotechnology sector, the area is richly endowed with Centres of Excellence in science, technology and innovation, has a strong engineering base, a stable political and governance system and many knowledge based SMEs. A long standing maritime heritage; an acknowledged competence in marine sciences; extensive marine territories comprising highly diverse marine habitats (including the deep ocean) represent opportunities to collaborate on the development and commercial exploitation of marine bio-resources. General limitations to the sector (see section 4.7) apply.

Another important limitation that could appear in this basin is related to O&M operations. Rough sea with strong waves and winds are likely presented in the area. This requires quite experienced employees who must be able to deal with this kind of offshore conditions and difficulties. The experience shows that lack of skilled workforce is a relevant limitation for BG sectors. Hence it is expected a fierce competition between companies and projects to get this experienced and skilled workforce. Personnel and companies with experience in offshore oil and gas can help to transfer their knowledge.

The complexity of administrative and legal procedures, especially for developing new technologies, can appear as an important barrier for the development of BG sectors. IEA-OES report (2012) indicates that many countries have complex and different administrative processes. Also, a lack of clarity on which administration is responsible for ocean economic sectors have been identified. Existing regulations are primarily result of the raising awareness of environmental impacts that marine industry can imply. Lastly, the inexperience dealing with developing sectors is present in administrative and legal organizations, elevating costs.

In the case of aquaculture, the combination of the administrative burden with the limited number of suitable sites available has had the effect of increasing costs and efforts to develop new projects in the basin.

MORE SUITABLE COMBINATIONS FOR ATLANTIC BASIN
WAVE ENERGY with WIND ENERGY
AQUACULTURE with WAVE ENERGY or/and WIND ENERGY

More suitable combinations are linked with those in which energy sectors (wind and wave/current) are presented. Beyond technical limitations (depth, weather conditions) which can be presumably solved by research and funding, the basin has good resource conditions for the development of these sectors.

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3.2 Baltic basin

Baltic basin includes the areas of the Baltic Sea and the North Sea. This zone comprises the following European countries: United Kingdom, Belgium, the Netherlands, Germany, Denmark, Poland, Latvia, Lithuania, Estonia, Finland, Sweden and Norway. The region is highly industrialised with major ports along the shores and an increased level of offshore activities.

The North Sea is one of the most heavily used sea basins in Europe. It supports a large number of traditional activities, such as fishing, shipping & trade, energy, sand mining, defence and recreation. Increasing economic activity in the sea, such as growing shipping traffic and the development of offshore wind farms, has led to increased competition for space.

In this basin, it does not appear to exist natural suitable conditions for marine aquaculture due to climate, sheltered sites and historical levels of pollutants. Only the Scandinavian countries (Denmark, Finland, Sweden, and Norway) present suitable hydrological conditions for open cage systems, which are the dominant. The overall political acceptance of aquaculture in countries where the sector is not important is low, which translates into an important image problem and limited access to financing.

The North Sea has become the most important concentration in the world of offshore wind. The sector is mostly installed in UK, Denmark, Germany and Sweden. This sector is strongly dependent on national energy policies and public financial support, being this why the sector has low importance in some countries. The lack of a proper energy mix structure (distinguishing between offshore and onshore or even on-land) translates into the low development of marine power sectors. The poor grid infrastructures becomes into a barrier to energy sectors development, limiting its installation to those areas where energy is needed and with the capacity to handle energy fluctuations. Finally, the high costs of energy production are still quite high (150 €/MW for offshore wind).

Blue biotechnology still remains too limited to compete with other more established marine sectors. Only Germany have some developed projects in the basin. This is the main reason why biotechnology often falls out of funding programmes, being this fact a substantial barrier to development. Furthermore, there are no specialised training centres in the area, so workforce is

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under-skilled. The main problem to this sector is the general lack of knowledge which translates into low support.

For the basin, and especially for the North Sea, rough weather conditions in the sea can be understood as an important limitation. It could lead to technical challenges to be faced, and an important increase in operation and maintenance costs. Skilled labour will be needed, which besides the cost, should be translated into an overall pressure on availability in workforce market.

From the administrative perspective, in general terms in the basin it is quite protracted to follow the permitting process to obtain licenses for running marine projects. Marine spatial planning is done in local scale, and conflicts of interest are presented with environmental protection and other industrial and service sectors.

MORE SUITABLE COMBINATIONS FOR BALTIC BASIN
AQUACULTURE with WIND ENERGY
AQUACULTURE with OFFSHORE FIXED TERMINAL / SHIPPING

More suitable combinations include aquaculture and wind energy, which are sectors with an important actual presence in the basin. Offshore fixed terminal is seen as a potential sector to develop if reuse of oil and gas infrastructures can be developed, as a way to reduce decommissioning and new infrastructures construction costs.

3.3 Caribbean basin

The Caribbean basin is included in the maritime basins assessed as it is in line with the Atlantic Ocean cooperation in support to the new Atlantic Ocean Cooperation Research Alliance. The MARIBE proposal includes 'third country' maritime basin, in accordance to the Atlantic Research Alliance. This basin chosen is Caribbean, of strategic interest to EU and USA, as well as to FAO, one of the key MARIBE partners. It includes an area of more than 2.5 million km^2, and the population along the countries that limit with it are of near 40 million person.

The region is characterised by a large number of small neighbouring countries, which have different sovereignty levels and important socio-economic inequalities. The economies of the countries included in the basin are characterised by the lack of industrial fabric and dependence on natural resources, being especially important tourism and those other provided by the sea resources.

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Weather conditions in the basin could be seen as calmed and warm. But the Caribbean is a focal area for hurricanes. This could be translated into an important technical barrier, so developments must be mainly carried on low risk zones, and technologies and devices must adapt to possible extreme bad weather conditions. Blue growth developments that require good weather conditions (e.g. aquaculture) could find in this issue a limitation to its deployment.

There is an important anthropic pressure in the zone due to spatial dissemination of population in small areas with very little sewage infrastructure. Hence, a significant amount of pollution is produced and the lack of waste and sewage infrastructures translates into an environmental quality barrier.

Countries in the basin are not as developed as countries in the European basins. This can be translated into an important technical limitation when considering to develop a new technology sector. Shipyards, construction facilities, deployment equipment and skilled labour force will be needed to carry on with a project and it could be difficult to find in the basin.

Administrative burden could be also seen as a barrier. The lack of regulations about marine affairs adapted to new technology sectors can affect the development of projects, increasing their costs and differing finalisation dates. Though some experts consider this lack of regulation could also be seen as a positive issue for the development of BG sectors in the area.

MORE SUITABLE COMBINATION FOR CARIBBEAN BASIN
AQUACULTURE with OFFSHORE FIXED TERMINAL / SHIPPING
AQUACULTURE with TOURISM

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The development of aquaculture with offshore fixed terminal (associated with other sectors, possibly tourism) is seen as the most promising sector in the basin.

3.4 Mediterranean and Black Sea basin

Mediterranean Sea is bounded by over 20 countries, much of it lies outside national jurisdictions. The Black Sea is bordered by 6 countries, including EU members Bulgaria and Romania. In this report, this basin includes both and also Adriatic and Ionian seas. Italy, Spain, Turkey, Greece and France are the countries which present a higher economic activity in Mediterranean coastal areas (over 150 billion EUR).

Aquaculture in the Mediterranean is a favourable sector in the area. The good water quality with the favourable climate conditions makes it suitable to present a rapid development, not only in terms of fish production, but also research capacity. Nevertheless, an important limitation in accessing funding and licenses appears in the basin. Also support to gather access to the supply-chain can be seen as a barrier to the sector, as these facts limit access to feed and export markets. The lack of Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP) systems is critical for the development of the sector, because the institutional capacity in this area is still building up.

Energy in the basin is not a well-developed sector. The basic reason for this is the lack of ideal conditions for the production of energy. Discordance between available areas and other zones where potential resource availability is present, can be perceived as a relevant barrier in the basin, making these sectors projects non-viable in almost all possible areas. There are some research projects, but with a relatively low importance compared to other European developments. It could be suitable for providing energy to in-site locations with low demand levels.

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The great biodiversity of the Mediterranean Sea, the potential market for the products from biotechnology and the existence of countries in the basin leading marine biology research can result in a significant opportunity for the basin in the biotech sector. But blue biotechnology is still at a very early stage of development. More research and development is crucial for this sector. Economic support is needed, both from public and private funds.

No specific projects of seabed mining in the basin has been developed yet. As in other basins, water depth can be a limiting barrier in some areas. Wide research and mapping of the area should be also made though main deposits are expected to be in other basins or oceans.

As in other basins, if new sectors development is planned, a limitation can appear related to the availability of skilled people for projects. This basin in particular presents an important degree of seasonality in some activities (tourism, fisheries).

MORE SUITABLE COMBINATIONS FOR MEDITERRANEAN AND BLACK SEA BASIN
WAVE ENERGY with OIL AND GAS
AQUACULTURE with WAVE ENERGY
AQUACULTURE with BIOTECHNOLOGY

Wave energy can be a relevant sector in the basin, mainly associated with the development of other offshore sectors and as an energy source for them (providing energy in remote areas where the connection to existing infrastructures could appear as limiting). Aquaculture and biotechnology should be important sectors due to the high biodiversity existing in the basin.

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4 Limitations analysis by sector

In this section, barriers that arise from the limitations database and that are repeated for each sector in all combinations and basins are presented. Also some general limitations that affect all sectors are described.

To complete the analysis, a number of possible proposals that should help to solve, if not all, some of the barriers encountered, are attached.

4.1 General/common limitations:

- Marine areas have been the traditional domain of fishing and sea transport communities. The possibility of establishing any interference may lead to conflicts.
- The existence of impacts on the environment can be understand by the public as a threat to the natural environment. Public opinion on large projects may be crucial for its final development approval. Misinformation, lack of understanding and not-in-my-yard syndrome toward technology by government or general public may slow down any development.
- The marine environment, and the economic activities it sustains, is subject to an extremely complex regulatory framework (see Figure 1). A wide variety of international, regional and national policies, laws and agreements act upon it.

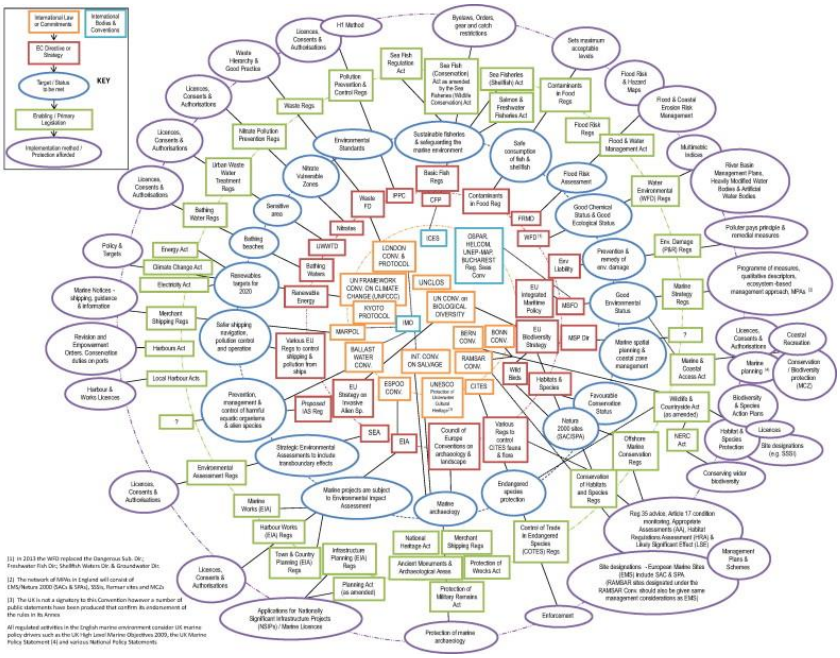

Figure 1. International, European and English legislation giving protection to the marine environment (Boyes, 2014).

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- Coastal areas tend to be perceived as pristine although they concentrate high anthropic pressures. Public debates focusing on the preservation of this areas for esthetical reasons are commonly observed.
- In sectors which need moorings or solid foundations, water depth can appear as a strong technical limitation for site evaluation. This fact can limit the region of interest due to the high impact on technical viability and project costs.

GENERAL RECOMENDATIONS
Accelerating developments and reducing the costs of blue growth sectors should be priority. To achieve this, concerted research efforts are crucial. To stimulate the sectors, public policies involving political coordination, public knowledge or more structural actions should be adopted.
Investment in research projects which allows to increase knowledge on technical limitations will help the development of the sectors.
Administrative procedures are still very complex and in many cases even unknown. According to article 13 of the RES Directive Member States should ensure that national authorisation and licensing rules applied to RES installations are “proportionate and necessary”, which is in reality only poorly implemented.
Marine Spatial Planning. A proper management of maritime space not only works to avoid conflicts, but it can also contribute to the identification of possible synergies between activities, ensuring at the same time both socio-economic development and the protection and sustainable use of marine resources.
Issues of marine responsibilities (accidents, search and rescue, spills…) need to be defined between all users of marine space, including shipping.

4.2 Aquaculture

- The development of sustainable aquaculture is dependent on clean, healthy and productive marine and fresh waters. Main criteria (and limitations) for aquaculture site selection are water temperature, chlorophyll-a concentration, depth and current speeds.
- Distance from coast can make O&M unsustainable. Aquaculture requires frequent visits for maintenance, monitoring and harvest, so it will have to maintain shore proximity to service installations.
- For near shore sites, low priority in spatial planning assignation of priority zones to minimize conflicts with other sectors more developed and economically more important.

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- For offshore sites, there are not adequate systems developed yet for the prevention of escapes from cages and protection from predatory wildlife.
- Submergible cages that allow aquaculture installations in sites with high waves and current speeds should be developed.
- Technological solutions are needed to make offshore aquaculture sustainable and economically viable. Industry is moving towards "integrated multi-trophic aquaculture" (IMTA, mixed farming), but it is currently at an early pilot stage.
- Marine fish aquaculture is characterised by being generally capital intensive, with high input and high labour productivity. Its environmental impacts are generally higher than those of other aquaculture segments
- Climate change will create new environmental challenges and situations that directly affect site selection, species to farm and interactions between biological and physical factors.
- There are substantial inconsistency implementation of EIA between regions and responsible authorities for authorizations.
- Long and complex processes for obtaining site licenses in the EU.
- Contamination by human activities like sewage treatment or other polluting activities. This crashes with the need of rigorous health rules for animal products.
- High development costs with insufficient incentives and support.
- Lack of long term view by industry and government for strategic plans, including R&D.
- Food quality concerns by society about final aquaculture products. Need to guarantee the quality and traceability of aquaculture products.
- Aquaculture sector presents a degraded industry image because of some parts of the sector and anti-aquaculture campaigns. It has been further undermined by the promotion of sustainably caught capture fisheries in opposition to responsibly farmed product.
- Safety to protect natural biodiversity levels from possible escapes of species from the cages. Farm fish has normally less biodiversity than natural fish, so escapes from cages can lead into an affection on natural species.

AQUACULTURE RECOMENDATIONS
Guidance and reliable data from spatial planning, regulatory and political processes will provide assurance to investors.
Research and scientific work must be done to optimise the use of natural environmental resources by aquaculture, allowing to increase and improve production levels and quality.
Simplification of administrative procedures to unlock potential of the sector.
Access to funding in innovation areas is limited, especially for SMEs. EU RTD programmes should help research and also economic performance of the sector, which is important for both public and private financial organizations to assess future investment projects in the sector.

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The industry needs to focus on meeting the wants and needs of consumers and ensuring that their products meet expectations.
Governments and other public and private institutions should work together on the image of the sector, enhancing human health and environmental benefits from farmed seafood consumption.

4.3 Wave energy

- Wave energy has not reached a complete developed stage. The most advanced existing research projects (Mermaid and Marina) are at maximum TRL 5 stage at some prototypes. Some private companies (Carnegie Wave Energy) offers technology to develop wave capture projects. But systems and components still need more development.
- Site limitations. Several requirements have been identified to characterize the available areas. 1st a maximum wave height for 50 years area required to delimitate zones where survivability of systems is possible. 2nd An appropriate seabed geological and geotechnical conditions are required as they can increase the construction cost if seabed is not suitable for moorings or foundations.
- In all offshore energy sectors, the connection to electrical grid can appear as a two ways problematic issue. On one hand if we face a local isolated grid (i.e. island or remote areas), the proximity between the consumers and the production centre avoids long distance connections, but at the same time the dependence on uncertain supply sources may represent a serious issue. On the other hand, if the aim of the project is to produce energy and sell it through general grid, two issues appear. 1st the connection to grid from offshore location (high costs) and the need that grid have capacity to deal with new energy levels. 2nd the existing limit to renewal sources to avoid high volatility of the supply that may compromise the stability of the grid.
- In offshore sites, far and isolated, a high cost of maintenance and exploitation operations should be expected, especially when less mature technologies as wave energy is involved.
- Extreme weather conditions could limit installation and maintenance operations. Knowledge on acceptable weather conditions windows to allow access and operations are required. And an assessment of workability based weather conditions is also critical in terms of safety, punctuality and feasibility.
- The sector is relatively new, so there is a lack of knowledge and experience with regards to wave energy that could be translated into a defensive position by financiers and banks to assume financial risks. A reluctant attitude can be expected waiting from third's experiences to learn from it.

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- There is uncertainty on regulatory conditions that can generate tortuous licensing processes. Under this conditions, all financial, environmental and political aspects can be expected and high uncertainties on time schedule and cost may exist.

WAVE ENERGY RECOMENDATIONS
Creation and development of apprenticeship programmes to increase skilled workforce markets.
Timely marine spatial planning and reservation of most suitable areas.
Enhance public perception of new marine energies and their environmental benefits.
Create funding mechanisms to facilitate access to investment funds. Incentives such as feed-in tariffs should help to make investments in the sector more attractive.
Administrative procedures are still very complex and in many cases even unknown. According to article 13 of the RES Directive Member States should ensure that national authorisation and licensing rules applied to RES installations are "proportionate and necessary", which is in reality only poorly implemented (*common to all energy sectors*).
High intensity of research and work in different test centres will help to reduce construction and operation costs, allowing the sector to become competitive within the following years (*common to all energy sectors*).
Invest in the development of a robust power grid along the coasts and with a reliable interconnection with principal mainland power grids (*common to all energy sectors*).

4.4 Tidal capture

This sector is based in the "Tidal Lagoon Swansea Bay" project. The main limitations that have been identified from this project are the following:

- Though the lagoon set-up is novel, the power generating technology is well understood and has already past TRL 8 pre-commercial stage (e.g. OpenHydro).
- The resource is highly dependent and generally is situated near coast. This makes more difficult possible combinations with other sectors.
- A very long operational lifespan for maintenance is expected. This could be seen by investors as a disincentive to participate in the projects.
- The scale of this development is the main challenge. No previous test at limited scale has been developed as research and validation model. As the first site test is going to be a great infrastructure as projected, problems may arise if some redefinition are required.

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- Big impact on ecosystems and the environment. Development of a complete EIA is required to assess and reduce possible impacts.
- Financial plan is a relevant limitation. The long-term investment (50 years planned) could appear as a limitation for capital investors although the limited risk associated to a predictable resource may facilitate the funds availability.
- Subsidies will be required to guarantee an acceptable price of energy. This price must be set before investment plans are approved. To obtain this contract, political consent and social consensus has to be reached.
- When applying this sector beyond the case study of Wales, subsidies can be linked to new taxes, so social perception could harm project interests.

TIDAL CAPTURE RECOMENDATIONS
Establishment of a common governance and transparency framework for the approval process.
Establishment of compensation and mitigation environmental measures.
Creation of scalable designs which allow to increase future capacity.
Creation and development of apprenticeship programmes to increase skilled workforce markets.
Administrative procedures are still very complex and in many cases even unknown. According to article 13 of the RES Directive Member States should ensure that national authorisation and licensing rules applied to RES installations are "proportionate and necessary", which is in reality only poorly implemented (*common to all energy sectors*).
High intensity of research and work in different test centres will help to reduce construction and operation costs, allowing the sector to become competitive within the following years (*common to all energy sectors*).
Invest in the development of a robust power grid along the coasts and with a reliable interconnection with principal mainland power grids (*common to all energy sectors*).

4.5 Wind energy

- If blue economy undergoes a successful path and manly of the demand is spatially concentrated in some areas, specific equipment (i.e. installation vessels) will be rivalled by different sectors, and its limited availability (in time and space) can limit projects development at least on the short term.
- Wind energy resource can be very variable, though in open sea presents not so large variability.

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- For fixed structures, an appropriate seabed geology is needed. The construction cost can be a limiting factor if seabed is not suitable for moorings or foundations.
- In far and isolated offshore sites, a high cost of maintenance and exploitation operations is expected and any successful project has to address this issue
- Bad weather conditions could limit installation and maintenance operations. Weather windows for access and an assessment of workability are critical in terms of safety, punctuality and feasibility.
- In all offshore energy sectors, the connection to electrical grid can appear as a two ways problematic issue. On one hand if we face a local isolated grid (i.e. island or remote areas), the proximity between the consumers and the production centre avoids long distance connections, but at the same time the dependence on uncertain supply sources may represent a serious issue. On the other hand, if the aim of the project is to produce energy and sell it through general grid, two issues appear. 1st the connection to grid from offshore location (high costs) and the need that grid have capacity to deal with new energy levels. 2nd the existing limit to renewal sources to avoid high volatility of the supply that may compromise the stability of the grid.

WIND ENERGY RECOMENDATIONS
Develop national measures to increase the use of offshore wind generation in energy mixes.
Increase public investment in infrastructures: port facilities and grid connection. This should help the developing of high scale projects.
Administrative procedures are still very complex and in many cases even unknown. According to article 13 of the RES Directive Member States should ensure that national authorisation and licensing rules applied to RES installations are "proportionate and necessary", which is in reality only poorly implemented (*common to all energy sectors*).
High intensity of research and work in different test centres will help to reduce construction and operation costs, allowing the sector to become competitive within the following years (*common to all energy sectors*).
Invest in the development of a robust power grid along the coasts and with a reliable interconnection with principal mainland power grids (*common to all energy sectors*).

4.6 Seabed Mining

This sector is in a very conceptual stage and although it can even seem a bit futuristic the increasing demand for rare earths is increasingly focusing on the seas as a new source. The core business is still in a development and embryonic state so innovations topped on that state will automatically seem difficult to reach.

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Main limitations identified are:

- Deep-sea deposits typically contain a 0.2 percent concentration of Rare Earths; deposits on land can have 5 to 10 percent concentrations. Obtaining these resources can involve an important effort for few amounts of materials. An exhaustive viability study seems crucial prior to any development.
- Difficulties to design an appropriate technical developments to ensure correct operation and exploitation of marine submarine resources.
- Difficulties to design the most cost-effective logistics for the sector.
- Need of a proper EIA. There is a lack of information from assessments about possible impacts, but it is thought that deep sea environment present a high biodiversity. The impact of economic activities need to be assessed and maintained in acceptable levels.
- Some countries have regulation about this sector, but in other areas it does not exist. A general seabed mining legislation is required.
- The lack of past projects translates into an unfamiliarity with the sector for investors and financiers. This could mean a higher risk and even the impossibility of reaching required investment capital.
- Lack of knowledge of the whereabouts of deposits. Better knowledge of fish spawning sites could allow better assessments of potential impact on the ecosystem.
- The ignorance of society about the sector can be translated into a rejection due to bad social perception.
- Unlike for land mining, where investment can be made gradually, offshore mining requires a very high initial investment to start the operations. The initial capital expenditure (CAPEX) is easily 1000 million dollars.
- The technologies required are at different stage, prospective, extraction and mineral processing are essentially different.
- Access to finance is also crucial for the sector.

SEABED MINING RECOMENDATIONS
Research on technology seems to be a priority in the sector. Limited scale pilot projects with less stringent constraints in order to see in practical terms what the impact would be a good initial approach.
Support research into environmental and archaeological-cultural-heritage possible impacts. A test site could be also useful for testing theses environmental impacts.
Environmental protection of sensitive areas should be done prior to the development of the sector.
Support research on seabed mapping.
Public financial support to help industries to estimate the potential of the resources, improve knowledge of the neighbouring ecosystems, develop efficient technologies and increase knowledge of their impact.

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4.7 Biotechnology / Blue Life Sciences

Research and elaboration of products are developed in laboratories, hence blue biotechnology sector is focused in obtaining the biological resource, being the main marine task to harvest the seas. The main barrier then for marine biotechnology sector is the access to the resource and obtaining new biological material.

Apart from this main challenge, it is important to note that blue biotech has been sponsored and promoted mainly by policy bodies and rather ignored by "the sector" (i.e. large companies) which has all the means to make it a success. It might be the case that incentives will be needed for all key players to ensure that the whole innovation and development pipeline is established.

Other relevant barriers in the sector appear are:

- Exploration and sampling in areas of environmental extremes (e.g. high seas) is difficult and expensive. Furthermore, in this areas, discoveries are not subject to benefit sharing.
- Low public acceptance, due to the common relationship between biotechnology, transgenic and low quality food. This is related to the low visibility of the sector.
- The sector is complex and from the outside there is little understanding of what it is exactly. Therefore, it is unattractive to investors.
- Cooperation barriers: platform oriented connection of biotechnology infrastructures is still lacking and only few centres of excellence have been initiated. The research in the field is fragmented, there is a lack of cooperation between research, SMEs and upscale businesses, and common projects. This has been described by stakeholders as the biggest barrier for the sector.
- There is low investment in R&D, and access to finance is problematic due to the high risks in the sector. SMEs assume risk and often run out of funds before product development is complete (especially for second and third rounds of product development).
- Lack of basic research into ecology of marine species and organisms from unusual and extreme environments decreases chances of finding novel bioactive compounds.
- There are no clear institutional framework (legislation…) about the exploitation of biological material from seas. This involves an unclear process to achieve permissions for development and exploitation of marine resources. Where this framework exists, there are lot of varying national policies, strategies, initiatives and programmes.
- Culturing marine microorganisms is problematic as culture techniques are specific for marine organisms. New culture methods and media needed to accommodate the complex and symbiotic nature of marine organisms.
- Productivity of original organisms is often too low to make commercial production possible. In general terms, the technical related issues present a lack of development to allow commercial viability.
- The OECD recommends an earlier collaboration with industry that can help to ensure that the products of marine biotechnology research are suitable for scaling up to industrial production. But this might also create concerns in terms of divulgating

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knowledge of downstream research, and therefore impede the development of research itself, due to confidentiality issues that the industry might want to push forward.

RECOMENDATIONS
Promote the knowledge of marine biotechnology sector and its benefits for the environment, economic development and general society.
Promote the integration of research groups across Europe, a encourage basic research into ecology of marine species and organisms from unusual and extreme environments
Facilitate financing across the value chain, supporting investments in R&D and in SMEs.
Facilitate the access to resources, mainly by improving clarity and completeness of the legal framework, but also facilitating the exploration and sampling in extreme weather areas.

4.8 Offshore fixed terminal / Shipping

- Depth can be a limiting factor. In some conditions, floating terminals might be used.
- Shipping is a highly cyclical industry, turning it in an irregular industry. To understand how the shipping industry works, a good knowledge of these cycles is needed.
- Long construction and delivery times of ships (2-4 years). Demands for new orders use to take place during economic prosperity, while their delivery can coincide with depression periods (with the subsequent high risk of overcapacity).
- Actual crisis in shipping (shipbuilding and transport) could have a negative impact from the financial perspective. It could be translated into a lack of interest of investors from these sectors.
- Workforce availability. A large part of the workforce is over 50 years old, and a high loss of employees is foreseen due to retirement might be expected in the coming years. Furthermore, industry requires of highly specialised workers. Result of either the ageing/retirement of the workforce or the further technological specialisation degree of the industry, a need for skilled personnel must be expected in the future.

OFFSHORE FIXED TERM./SHIPPING RECOMENDATIONS
The promotion of maritime clusters can improve the image of the sector, and: • make it more attractive for future workers; • increase the transfer of knowledge between maritime economic sectors; • encourage the involvement of women.

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4.9 Tourism and leisure

- Tourism needs locations with some potential attraction to visitors. This issue could limit the development of the sector to some specific areas/zones.
- Selected sites for this sector must ensure several requirements:
    - Land proximity. This will ensure better Health and Safety for visitors and working staff. Long travel time to site the will be discouraging for tourists.
    - Shallow water, stable seabed & moderate met-ocean conditions.
    - Weather and conditions may often prove unattractive to visiting tourists. Areas on inshore may be preferable
- Leisure development also require some Health and Safety infrastructure:
    - Accidents during visitation activities or staff would require emergency transportation provisions (i.e. helicopter landing pad)
    - Fire safety would be an increased risk due to lack of outdoor space for people to get to. Other safety provision required (i.e. Safety boats)
- Tourism expects entertainment, which implies either high levels of engagement or a diverse range of opportunities/activities; may increase the cost of investment substantially.
- The coastal tourism sector is not attracting or maintaining enough skilled personnel due to its seasonality and lack of long term career opportunities which can lead to problems in service quality and hamper competitiveness.

TOURISM RECOMENDATIONS
Expand the network of destinations to areas where BG sectors are or could be developed. The aim should be to put in value these new projects and bring them closer to society.

4.10 Oil and gas

- Oil and gas is located in those areas where deposits are found. These locations could not be suitable for the deployment of other BG sectors.
- New locations are available at areas located in deepwater/ultradeep water zones. The exploitation of these areas involve high costs of production and puts in risk the economic viability of these reserves.
- The sector has an important environmental impact. Measures to reduce risks should be undertaken.
- There is a barrier in the regulation in decommissioning. In theory, once a platform reach the end of its lifecycle oil and gas, infrastructures shall be removed (at least partially). This is often subjected to the specific regulatory characteristics of a country. All of the actual existing facilities will require decommissioning over the next 30 years (RAE, 2013).

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These operations will not only require of a strong economic investment (estimations in the North Sea exceed £30billion over the next 30 years) but also a great human and technical capital.

- Due to the decline of oil and gas industry, there could be a lack of interest in non-profitable investments in the short term future. Even oil and gas companies show a lack of interest in investments which would add risk to their operations without receiving remarkable benefits.
- Some National Oil Companies act as an extension of government are aimed to support national policies, both strategically and financially (e.g., Pemex, Saudi Aramco, Petróleos de Venezuela). Their objectives do not directly relate to the markets, as they seek to boost the national and foreign objectives of their countries (e.g., offering lower prices to domestic consumers or generating long term incomes for their economies).
- The decline in demand and prices can cause a fatal impact in the socio-economic development of countries with National Oil Companies acting as an extension of government.
- Skill shortage will be one of the main problems to be faced by the sector. The rejuvenation of the workforce (added to a poor transfer of knowledge), the retirement of experienced workers, the poor update on technological advances, or strict immigration laws that prevent the access to global talent are among the main causes for this shortage.

OIL AND GAS RECOMENDATIONS
Development of campaigns to improve image sector. Marketing techniques could be used to show the importance of the sector for overall economy and society.
Improvement of environmental problems related to the sector. Reduction of emissions and pollutants.
Development of techniques to ease decommissioning. Study the possibilities of reusing infrastructures, even for other blue sectors.

4.11 Fisheries

- Overfishing is an important barrier in the sector. Quotas have been defined for 27 fish species in the North East Atlantic basin and the North Sea. Also in other parts of the world there are specific rules and policy to stop the decrease of fish populations.
- Fisheries are a moving sector. It could be difficult to match with another sectors analysed which normally are fixed in one specific area.
- Fisheries have their own established rules and legal fields (environmental and general regulation framework) with very limited overlap with other sectors. This could slow

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down the project development and pose problems during operations particularly at the checkpoints by the authorities and/or in case of inspection.

FISHERIES RECOMENDATIONS
International management of fishing capacity.
Development of a marine spatial planning and integrated management trend.

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5 Limitations analysis by combination

The process followed for the selection of the final six-per-basin combinations comprised a rating matrix in which all possible combinations were studied and different criteria were also considered (further information about this process can be found on Deliverable D5.5 – Toolkit and Guidelines). In this rating process shared by all partners and experts involved in the project, the potential and possible viability of all combinations were assessed, considering technical, socio-economic, financial, environmental and commercial viability.

The selected combinations are then those which have low or no restrictions due to the combination itself, so the main limitations that may exist are mainly related to the sector or the basin.

The limitations analysis by combination can be reduced to those special and relevant problems that can appear in some specific combinations. This limitations refers mainly to environmental and social perception issues, but also to different technology development stages between sectors.

- Environmental limitations. Some sectors can produce a harmful impact on the environment. And some other sectors viability depends on the quality of this same environment. The co-existence of both can in this case result problematic. An example of this problem appears in the combination of aquaculture and oil and gas exploitation. Though actual systems for oil and gas to limit the spills, the risk for these to happen persist and represents a serious limitation for aquaculture production.
- Social perception. There are some blue growth and blue economy sectors that can be seen as prejudicial by society. Oil and gas is associated with spills and environmental impacts, and aquaculture is in some cases seen as a rival sector by traditional fisheries. Any sector planned to be developed with any of these two cases can be also seen as problematic by local societies, affecting the political decisions related to permissions and possible subsidies and help.
- Financial assessment. The sectors analysed in this project are planned to experiment an important expansion in the next years, but nowadays are mainly under no full development. Due to this, it is difficult to perform realistic cost and benefit analyses just for one sector. Doing this type of analysis to assess the commercial and financial viability of the projects of two or more sectors combined will result even more difficult.
- Technical maturity. Some of the sectors analysed are in a very low TRL stage. This means that lot of research and development work must still be done. The aim to merge two sectors with very different stages can be problematic for the more advanced sector, limiting its development and even making it impossible. The obvious uncertainties existing in early steps of technology can contaminate.
- Production requirements. Energy sectors (wind, wave) need some weather and environmental requirements that could mean the impossibility of development of other sectors. For example, if high waves are required for energy production and its economic viability, these high waves could be harmful for the survivability of the cages used in

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aquaculture. The compatibility of environmental requirement cannot be taken as given and require a cautious approach.

- Wave energy and aquaculture. This is a recurrent combination analysed (it has appeared in all four basins). For aquaculture, wave height and current speed are key constraints, both physically and with respect to animal welfare. But wave energy requires a minimum wave height in order to present viability. The combination of these two sectors can be problematic in this sense: the minimum requirements for wave can be translated into an important barrier for aquaculture. The use of submergible cages can be a possible solution, but its development is still in early stages and is facing technical difficulties.

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