Blue Growth

Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts

Second Interim Report

Call for tenders No. MARE/2010/01

Client: European Commission, DG MARE

Rotterdam/Brussels, 18th October 2011

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ECORYS

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At Ecorys we aim to deliver real benefit to society through the work we do. We offer research, consultancy and project management, specialising in economic, social and spatial development. Focusing on complex market, policy and management issues we provide our clients in the public, private and not-for-profit sectors worldwide with a unique perspective and high-value solutions. Ecorys' remarkable history spans more than 80 years. Our expertise covers economy and competitiveness; regions, cities and real estate; energy and water; transport and mobility; social policy, education, health and governance. We value our independence, integrity and partnerships. Our staff is formed by dedicated experts from academia and consultancy, who share best practices both within our company and with our partners internationally.

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- Consulting: our consulting activity is covering all the fisheries and fishing activities, from the stock evaluation and catches to the marketing via processing, including Monitoring-Control-Surveillance and fishing port management. ;
- Technical assistance: Oceanic Développement manages scientific observers programs, catches control programs, MCS training programs;
- Expertise and know-how of the company are focused on fisheries sector only.

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Preface

"We never know the worth of water till the well is dry"

Thomas Fuller

More than 70 percent of Earth's surface is covered by water. This truly makes our planet the "Blue Planet". Not only is water a precondition to the existence of life but it also provides resources that directly contribute to our society, ranging from sea transport to the production of raw materials, fisheries, leisure activities etc. The sea is an integral part of the European identity and of the continent's economy. Among the 27 Member States of the European Union, 22 have a coast and two thirds of the European frontiers are set by the sea.

In this light it is essential that Europe recognizes the true potential of its marine resources and develops an integrated policy that acknowledges the inter-linkages that exist between the different domains and functions of its seas, oceans and coastal areas. The Integrated Maritime Policy (IMP) that has been pursued by the European Commission since 2007 is an important step in realising Europe's future strategies and policies.

The Blue Growth project -"Scenarios and Drivers for Sustainable Growth form the Oceans, Seas and Coasts"- builds on earlier policy initiatives to recognize the potential of these marine resources and thus aids in realising the Europe 2020 strategy towards smart, sustainable and inclusive growth.

The current report is the second interim report in a series of three interim reports that will be delivered during the project. It builts on the sub-functions selected in the First Interim Report and elaborates the potential of these promising sub-functions of oceans, seas and coast and their underlying drivers, response capacity and framework conditions that affect this potential. It thus provides a solid basis to assess various policy options and their impacts that will be elaborated in subsequent work-packages.

For this second interim report we have conducted a large number of interviews with many different stakeholders. We would like to thank them for the valuable insights offered by them to this study.

It should be noted that this report represents the views of the consultant, which do not necessarily coincide with those of the European Commission.

Rotterdam/Delft/Concarneau, 18th October 2011

The Blue Growth Consortium:

- Ecorys
- Deltares
- Océanic Développement

1 Introduction and State of Play

1.1 The Blue Growth project

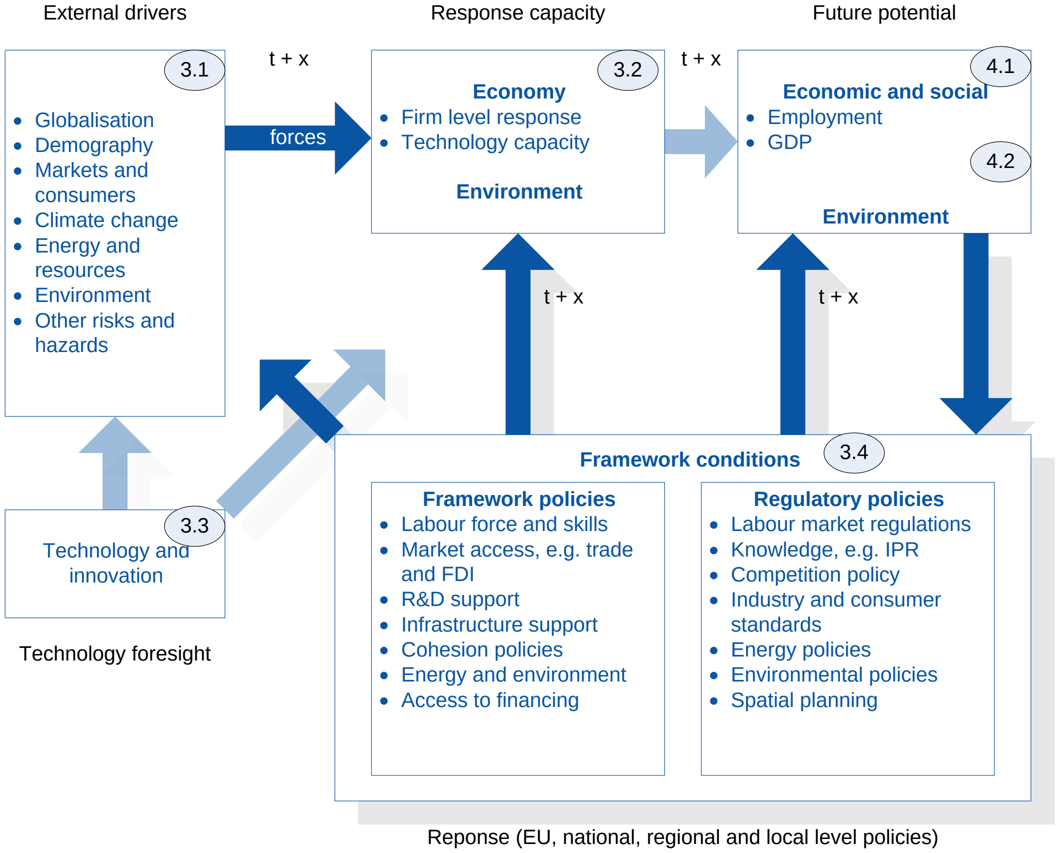
The main aim of the Blue Growth project is to provide policy-makers at EU and sea-basin level with a comprehensive, robust and consistent analysis of possible future policy options to support the maritime sectors in the EU.

For this purpose the project will:
- provide insight into the state of the art within maritime sectors;
- present knowledge of innovation and technological developments that influence these sectors;
- create an understanding of key external drivers that influence their potential;
- identify key economic areas for the future sustainable growth of oceans, seas and coasts; and
- Assess the impacts of policy interventions that may contribute to reaping the existing potential.

Analytical framework applied

To answer these questions we have adopted an analytical approach which is based on a chain of causal links and takes the best insights from both socio-economic and environmental aspects of sectoral policies.

Figure 1.1 Analytical framework (numbers indicate sections in report where these blocks are being addressed)



Note: t = time, t + x indicates that impacts may materialise later in time.

Based on this approach the study has been structured in such a way that it links specific tasks to match the analytical approach. Starting point are the maritime functions which are defined as the possible uses of seas and oceans by mankind. The external drivers and technological developments are identified and clustered into scenarios which have a direct influence on the potential of the different (sub-)functions. At the same time policies may be developed which have an impact on realising potentials. The overall impact of both autonomous developments (under different scenarios) and policy interventions are eventually assessed to arrive at overall findings with respect to the Blue Growth potential.

Current report and status

The above structure has been elaborated in a specific roadmap for the study. This project will have an expected duration of 20 months and consists of 4 Work packages (see Figure 1.2):

- Work Package I: Work Plan and Data Collection;
- Work Package II: Analysis and Classification of Material;
- Work Package III: Qualification of Material and Definition of Scenarios;
- Work Package IV: Finalisation of project.

This report is the second of three interim reports of the project. This report describes Micro-Futures, which specifically determine the potential of the selected promising sub-functions. They are elaborated in conjunction with the further analysis of these sub-functions conducted within the second Work Package. In essence, this report presents overall findings on the future potential of sub-functions of oceans, seas and coasts at a general level and assesses underlying drivers, response capacity and framework conditions affecting this potential. Herewith it provides the basis for the definition of policy options and impact analysis in the subsequent work packages of the study.

This report only provides a synthesis of the research carried out in Work package 2 within the 13 sub-functions identified. The specific research findings from each of these subfunctions is bundled in so-called subfunction profiles. Readers are recommended to consult these profiles in case more depth and information is required on specific subfunctions.

Figure 1.2 Roadmap for the study

	Level of Analysis: General level	Level of Analysis: Maritime functions	Level of Analysis: Clusters and sea basins	Scenario-related activities	Methodologies applied
WP I	Task I.1 Refine work plan	Task I.2: Prepare maritime function profiles Task I.3: Draft scenario logic		• Elaborate scenario-method • Review existing scenarios & main external drivers • Create a framework for future expectations (Level I)	• Data analysis • Desk review • HSS, team workshop
WP II			Task II.1: Cluster-specific desk rsearch Task II.2: Cluster-specific interviews Task II.3: Comparing and ranking clusters	• Rigorous imagining (Level II) • Assess implications • WP II for scenario's	• Data analysis • Desk review • interviews • Technology mining • In-depth interviews • HSS
WP III	Task III.1: Prepare intermediate hearing Task III.2: Intermediate hearing Task III.3: Elaborate scenarios Task III.4: One-day presentation			• Develop and construct (Level III) • Refinement process • Validate & define policy options	• HSS • Presentation and discussion
WP IV	Task IV.1 Execute IA Task IV.2 Draft Final report Task IV.3 Final report			• Test robustness of policy options by scenario	• Impact assessment • Input/Output analysis • MCA

Structure of the second interim report

First, this report presents Micro-Futures for 13 maritime sub-functions. These Micro-Futures indicate the possible future potential and underlying assumptions about the response capacity of the industries involved as well as about the framework conditions under which this takes place (Ch.2). In Chapter 3, the components on which these Micro-Futures are built are assessed. This covers external drivers, the response capacity of the sub-functions and the role of Research & Development. Finally, in this chapter also the framework conditions are assessed. Synergies and tensions as well as environmental and economic impacts of the Micro-Futures are presented in Chapter 4. The report concludes with conclusions and an outlook to the subsequent phase of the study (Ch.5).

Terminology applied

The approach to the development of seas and oceans is built around the concept of **maritime functions**, which are defined as broad groups of economic activities that are related to sea or sea-resources. Maritime functions thus cover the possible uses of seas and oceans by mankind.

Sub-functions are sub-sets within a function that can be clearly separated, as they are covering a specific value chain (for example oil exploration, deep-sea mining, wind-energy, short-sea shipping, etc.).

For each (sub-)function **economic sectors** can be identified that are relevant to each function. For example for oil exploration it is building offshore drilling platforms, offshore services to install these platforms, oil exploration activities and as a follow-up activity oil refinery and distribution – some of these activities are sea-based (the focus of this study) and some of them are land-based. In fact, all these activities are interrelated in one **value chain** which describes the relations between economic activities that are relevant for a sub-function.

External drivers: External developments that affect the future development of a maritime (sub-) function, research area or sea basin. These include globalisation, climate change, energy & resources, demography and other risks and hazards; some of these external developments will be relatively certain (based on foresight), others will be rather uncertain. Drivers can be considered as trends, both in terms of opportunities and threats. Some drivers are rather sub-function specific.

On the basis of the available information we have defined **micro-futures** for each of the sub-functions. These are futures, selected from the wide range of possible developments, which are desirable, ambitious, but at the same time within the realms of realism. These micro-futures indicates the potential of a sub-function. Whether they are realised is depending on whether the rights conditions in terms of external drivers, response capacity and framework conditions are reached. As such, micro-futures are foresights, not forecasts. They can be used, in a sharing and negotiating process with stakeholders, to design a desirable future perspective from which to backcast. What can or should we (the stakeholders) do, and when, to make this future come true?

Response capacity: The capacity and capability of a sub-function to respond to external drivers and global market conditions. This response capacity is determined by a variety of elements, such as firm strategies and business models, production processes, innovation and technological development, industry structure and organisation, and supply and value chain relationships. It is through the interplay between these elements that the 'resilience' of EU marine sub-functions is determined, and that market performance is attained – with profitability, productivity and employment as important outcomes.

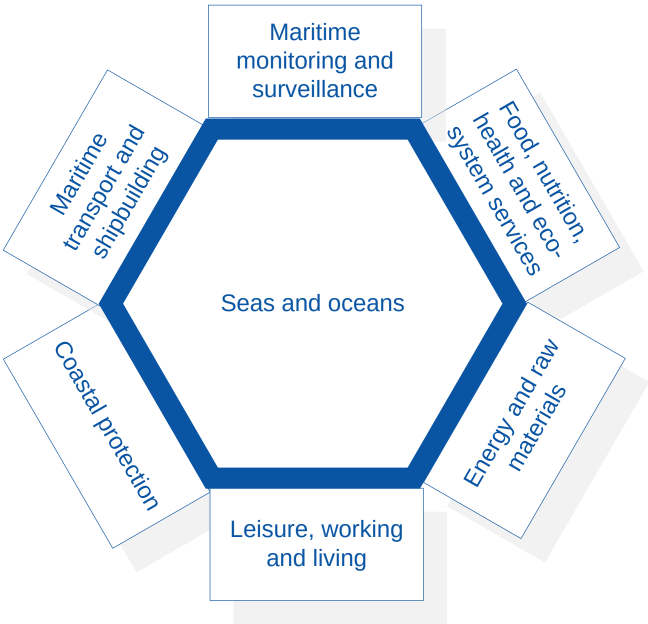
Outcome (potential development): As a result of external drivers and sub-function responses, the outcome or 'impact' of the sub-function can be measured in terms of economic (GDP and employment) and environmental indicators (e.g. water quality, air quality, waste production). We call this the 'potential development' in our micro-futures.

Framework conditions cover a broader range of determinants shaping the business environment and therefore the response capacity of industry. They may be influenced directly or indirectly by policy measures. Essentially this covers aspects of the business and operational environment that are external to individual (and collective) business operations of firms within the sector, but internal to policy makers at national and EU level, such as legal and regulatory frameworks, infrastructure, knowledge, labour force and skills, access to finance.

1.2 Sub-functions selected in WP1

The Blue growth study started from the perspective of six global maritime functions: Maritime transport and shipbuilding, Food, nutrition, health and eco-system services, Energy and raw materials, Leisure, working and living, Coastal protection, and Maritime monitoring and surveillance.

Figure 1.3 Maritime functions



In the first work package of the study, these maritime functions were elaborated and a set of 28 sub-functions was defined. The approach to sub-functions was chosen as the level of analysis required asked for a more specific assessment than the six global functions did allow for. Furthermore it provided the basis for selecting the top-7 sub-functions of today, the top-7 fastest growing and the top-7 most promising in the near future.

In WP1, sub-function factsheets have been drafted as part of the First Interim Report, which in WP2 have been elaborated through additional desk study and holding of interviews with key players from each sub-function.

In the First Interim Report, a selection of 13 sub-functions has been made based on top rankings with regard to current size, recent growth and future potential. This resulting set of 13 sub-functions is presented in Table 1.1.

Table 1.1 Selected 13 sub-functions

No.	Sub-function	Short description
1.2	Shortsea shipping (incl. RoRo)	National and international freight transport within Europe and to/from neighbouring countries with medium sized ships that often sail fixed routes (containers, major bulks) or tramp shipping.
2.3	Algae Aquaculture	Farming of micro- and macro-algae with a focus on production and extraction activities; excluded are transformation of raw material (fish skin, fish bone, algae products...) by biotechnological processes (included in 2.4.)
2.4	Blue Biotechnology (health, cosmetics, well-being, etc.)	Using wild and farmed aquatic living resources as precursors of bio-molecules used for high value products. It is about unravelling the potential of the biodiversity of a specific earth compartment for the benefit of the rest of the economy.
3.1	Oil, gas and methane hydrates	Extraction of liquid or gaseous fossil fuels from offshore sources
3.2	Offshore wind energy	Construction of wind parks in marine waters, and exploitation of wind energy by generating electricity offshore
3.3	Ocean renewable energy resources (wave, tidal, OTEC, thermal, bio-fuels, etc.)	Offshore development and exploitation of a variety of renewable energy sources excluding wind, including wave energy, tidal energy, Ocean Thermal Energy Conversion, Blue energy (osmosis) and biomass.
3.6	Marine mineral resources	Deep sea mining of raw materials other than aggregates., including critical materials which have a risk of supply shortage
3.7	Securing fresh water supply (desalination)	Desalination of sea water for fresh water usage (agriculture irrigation, consumer & commercial use)
4.1	Coastline tourism, including yachting and marinas	Shore based sea related tourist and recreational activities, as well as the construction and servicing of seaworthy leisure boats and the required supporting infrastructure including marina ports.
4.3	Cruise including port cities	Tourism based on people travelling by cruise ship, having the ship itself as their home base of holidays and making visits to places passed during the trip.
5.1	Protection against flooding and erosion	Monitoring, maintaining and improving the protection of coastal regions against flooding and erosion.
6.1	Maritime security and surveillance	Security and surveillance products and services in different maritime domains, ranging from pollution and fisheries control, to Search & Rescue and customs and border control
6.3	Environmental monitoring	Marine environmental monitoring is not a clear-cut function. It may cover water quality, temperature, pollution, fisheries etc.

1.3 The product life cycle applied to sub-functions

In the second phase of this project, the selected 13 sub-functions have been assessed in-depth. Clearly they differ with regard to their state of development. Some sub-functions consist of mature industries, while others are still in their development stage. This distinction is deemed relevant as it will affect the current strengths and weaknesses of the sub-function, the importance of external drivers as well as their response capacity. Finally other fields of policy involvement may be relevant for these sub-functions.

The product development cycle

The theory on the development stages comes from the marketing domain related to product life cycles (Levitt, 1965; Perreault, 2008, Frost & Sullivan, 2011; UK Business Link, 2011). Every product that is brought to market passes four phases of development. These phases are:

- *Introduction*: products that have successfully passed the product development process will be brought to market. In this phase the number of products sold will be relatively low, price will be relatively high and no profit is being made yet. There is limited competition. Marketing actions focus on informing consumers on the product.
- *Growth*: in this phase sales substantially increase, and suppliers' profit is rising. Competitors will also enter the market with other versions of the product. Gradually price will be lowered as to attract also people less willing to pay for having the product.
- *Maturity*: in this phase, most consumers will have purchased the product, and competition will become fiercer to attract those that have not yet, or those that need to replace it. Suppliers will try to lengthen this phase by introducing upgrades. Marketing costs rise and profits fall.
- *Decline*: finally, every product will end in this phase. Sales decline, competitors will retract. Often this phase is sped up by introducing new products (e.g. the Compact Disc replacing the music cassette). The phase ends with the removal of the product from the market.

Others apply other names for the same phases, or sometimes phases are split in two (for example within Maturity a distinction is made between maturation and saturation, as do Frost & Sullivan (2011).

The theory on market phases can be extended with the stages of product development before introduction. These phases are therefore related to the level of technology development and the technical feasibility of new applications. We propose to introduce two phases, building on the approach of the FP7 programme where fundamental research as well as demonstration/pilots are identified. The two phases are:

- *Pre-development*: this phase contains all steps from initial idea to prototype design and necessary R&D.
- *Development*: this stage brings the pre-developed product towards a commercial viable product, through testing, pilots and further refinement of the design.

While other literature structures this cycle in phases with different names, the principle is similar.

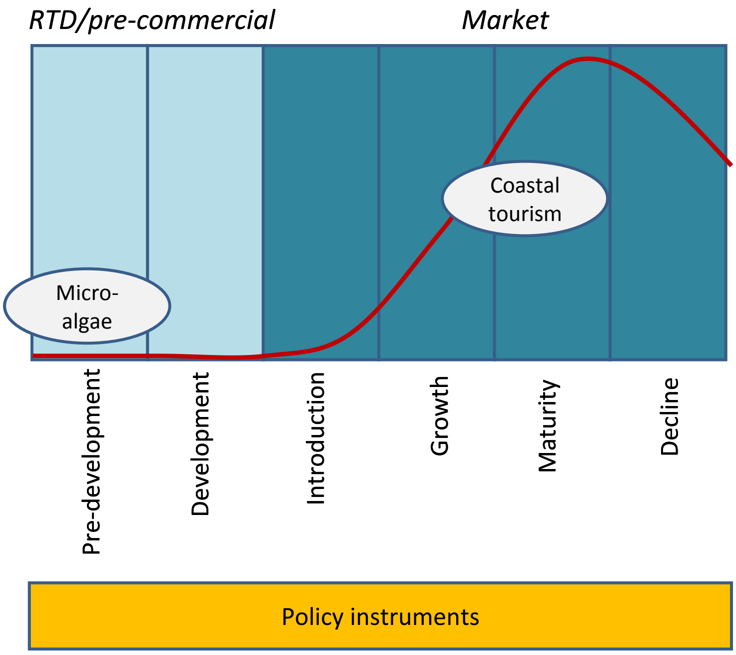
Translating the product life cycle to sub-functions

The product life cycle can also be transposed to entire sectors or – with the scope of Blue growth – sub-functions. The assessment of phases then does not relate to specific products, as they can cover multiple products, nor does it link to one sector only, as sub-functions contain multiple sectors of which some may be well-developed/mature and others may still be in their early development phases. When applying the development phases, the understanding is as follows:

- Pre-development: inventions have been made, but most promising outputs still to be defined. Much R&D required.

- Development: the possible outputs of the sub-function are clear, but commercial viability still needs to be proven.
- Introduction: sub-function's output are just about to become commercially attractive. Market is still small, but promising. Not clear yet which players will dominate the market, no profits made yet.
- Growth: sub-function is showing (strong) economic growth and/or employment growth. Smaller sized companies can enter the market, prices of technologies gradually go down.
- Maturity: sub-function does not show economic growth but stays stable in size. Market positions of main players are clear and competition is fierce.
- Decline: sub-function's economic activities are declining, no major innovations are being made, it is clear which players are dominating the market.

Figure 1.4 Development phases for sub-functions



Source: Ecorys

The type of policy instruments that are most effective depend on the development phase of a sub-function. The choice of the instrument can be crucial for the future of a sub-function. Especially with regard to the shift from development to exploitation or market introduction, the "valley of death" is seen as a trap in the development pipeline. Often this relates to the shift from (public) R&D support to market investment. [1] In Work Package 3 the relevant policy options will be further explored.

1.4 Position in development lifecycle

Applying the theory of the product development cycle to the sub-functions investigated in WP2, the development stage of each of the sub-functions has been assigned using the indicators mentioned above, including current size, recent growth and future potential, as well as technology factors such as innovativeness and patenting (also refer to section 3.3 for further analysis of patenting and publications).

[1] Bloomberg Businessweek (2010), S.K. Markham et. al., 2010, The Valley of Death as context for role theory in product innovation, Journal of Product Innovation Management

Box: Measurement of current size, recent growth and future potential

In Workpackage 1 of the Blue Growth study, data has been gathered on three criteria for selecting sub-functions:

- *Current size*: data concerns value added and employment levels in the EU27, and is taken from Eurostat or secondary data sources. For some sub-functions no statistical data could be obtained and own estimates were made. Argumentation can be found in the First Interim Report
- *Recent growth*: the growth of each sub-function over the past five years in terms of added value and employment is again based on statistical data, if these were available, or on secondary sources. If no data was available, qualitative scores have been applied based on interviews and consortium’s own expertise.
- *Future potential*: this has been assessed qualitatively. Scores (+, 0 or -) were given to six indicators, namely Innovativeness, Competitiveness, Employment creation, policy relevance, spill-over effects, and sustainability. The sum of scores was used to rank the sub-functions on future potential. The focus of scoring is considering a time horizon of 10 years.

Source: Ecorys, First Interim Report Blue Growth study

One should realise however that a sub-function consists of a variety of economic activities that are connected through their value chain. This means that some parts of the value chain may be rather mature while other parts are still developing. An example is shortsea shipping, which is considered mature in terms of market structure and technology, but in terms of size (transported volumes) is expected to grow. Also one should bear in mind that the sub-functions often contain several sub-sub-functions, underlying economic activities that have similarities but also differences in nature. An example is sub-function 3.3 on Ocean renewable energy sources, which groups OTEC, wave, tidal and osmotic energy. Some of these are more advanced than others.

Table 1.2 Development stages of the sub-functions

No.	Sub-function	Maturity level	Size (bn €)	Recent growth	Future potential
2.3	Algae Aquaculture (micro-algae)	Pre-development	3.3	4.6%	**4+**
2.4	Blue Biotechnology	Pre-development	0.6	+	**6+**
3.3	Offshore renewable energy sources	Development/ introduction	<0.25	+	**5+**
3.6	Marine mineral resources	Development	<0.25	0/+	**4+**
3.2	Offshore wind	Growth	1.3[2,3]	**21.7%**	6+
3.7	Desalination	Growth	0.7	**+**	2+
4.3	Cruise	Growth	14.1	**12.3%**	5+
6.1	Maritime security & surveillance	Growth	1.7-2.1	**+**	5+
6.3	Environmental monitoring	Growth	0.1-0.2	**+**	5+
1.2	Shortsea shipping	Mature	**63**	6.1%	2+
3.1	Oil, gas & methane	Mature/decline	**107-133**	-4.8%	+
4.1	Coastal tourism & yachting	Mature	**144**	3-5%	4+
5.1	Coastal protection	Growth / mature	**1.0-5.4**	4.0%	6+

Note: Data on size, recent growth and future potential are taken from the First Interim Report

2 Source: Total wind power capacity in 2009 was 84 GW, of which 2.9 GW was installed offshore (EWEA, 2010). If we apply this ratio to the total employment figure of 203,100 FTE and a total turnover of € 38,222 million in 2009 (EurObserver, 2010), there were around 7,000 jobs in the offshore wind energy industry in 2009, creating a turnover of around € 1.3 billion. This is reasonably in accordance with the estimation of EWEA, which assessed the offshore wind energy employment in Europe at 2800 fte in 2007 (EWEA, 2009).

3 Other estimate suggests the size is much bigger, ranging from € 5-10 bn. This could however not be confirmed by written sources. In any case it does not affect the resulting list of selected sub-functions derived in WP1.

2 Micro-Futures

What are the kinds of futures that European policy makers should be prepared for? That is the key question that is addressed in this chapter and in chapter 3.

Foresight studies are driven by an interest in the probability, but also the uncertainty of future developments. In this study, all of these aspects play a role. In the Micro-Futures that we present in this chapter, the focus is on the potential of subfunctions (with an eye on the uncertainty that is present at any future). In Work Package 3, the key factor that determine the uncertainty will be further addressed.

This chapter describes the futures of the 13 sub-functions as 'future potentials'. That means: we choose, from the wide range of possible developments, one version which is deemed desirable, ambitious, but at the same time within the realms of realism. Desirable in terms of EU2020 policy goals: supporting sustainable growth. Ambitious and realistic in terms of aiming at above-average estimates, but always rooted in the best available information from literature and interviews. The resulting storylines are a mixture of negotiated creativity and as solid a scientific basis as can be provided. The background information is provided in the Sub-function profiles. The emphasis is on the next one or two decades, until 2020/2030, with an occasional outlook on the further future.

The following paragraphs describe the future potential of the 13 sub-functions, ordered by their development phase. In each of the descriptions four entries are used:

- **Potential development**: storylines about how the sub-function could develop in terms of focus, size, impact, under the right conditions, ambitious but realistic. First the development is sketched world-wide; then the potential within Europe and the export potential for European enterprises are characterised.
- **Assumptions about the external drivers**: if the potential development were to come true, what would be required from the relevant drivers in the outside world? How should they develop?
- **Assumptions about the response capacity**: what is required from the response capacity of the sector (in terms of internal organisation, technical development, market development, lifting of non-physical constraints) in order to render the potential development possible.
- **Assumptions about the framework conditions**: which conditions have to be met, which non-physical constraints lifted, and what is required from the legal, organisational and regulatory framework, in order to render the potential development possible.

The Micro-Futures that we present here are foresights, not forecasts. They can be used, in a sharing and negotiating process with stakeholders, to design a desirable future perspective from which to backcast. What can or should we (the stakeholders) do, and when, to make this future come true?

At the same time, the question 'what happens if the assumptions prove not valid, and what will we do then?' should not be lost. This question is partly addressed in chapter 3, and will be the leading question in the development of scenarios in Work Package 3.

In the next sections sub-functions are further elaborated, following their categorisation by phase in the RTD/product life cycle.

2.1 Sub-functions in the (pre-)development phase

The future is bright, the future is blue. That appears to be the commonality for the sub-functions in the (pre-)development stage. Based on intensive R&D, piloting and testing, blue biotechnology and algae growing have entered the mainstream by the year 2030, while a substantial part of the world's minerals will be mined from the ocean floors. But how successful will European companies and players have been in embarking on this growth? And will they have sufficient scale to compete with global players who may have spotted opportunities much earlier or who have deeper pockets?

2.1.1 Prospects for Algae Aquaculture (2.3)

Key characteristics

While still small in size the sub-function has already shown recent growth and its future is assessed positive. The product outputs of the sub-function are clear but commercial exploitation seems not viable yet and additional R&D and piloting is necessary. Therefore the sub-function is considered to be in the (pre-)development stage.

Potential development

By 2030, the algae sector will have significantly grown, in a three stage progression. In the years between 2010 and 2015, the sector is expected to emerge as a niche market focused on high-priced products for the health and cosmetic sector[4]. It will then grow as a medium-sized market producing metabolites and primary compounds (lipids, sugars) to be incorporated by the food and feed processing industry (for human consumption and animal feeding) (around 2020).

In a third stage, the algae sector will become a provider for mass product markets, with two major applications: green chemistry and energy (2025-2030). Groundbreaking photo-bioreactor designs and extraction processes will allow the micro-algae production to scale up within viable economic conditions. Popular food products are omega-3 and omega-6 fatty acids. Macro-algae farms are developed along the coast, sharing space with other sectors on multi-purpose platforms combining several activities such as integrated multi-trophic aquaculture[5] (also called IMTA), and other activities (wind, coastal protection).

Assumptions about external drivers

- A growing demand for food products and energy will drive this sub-function forward.
- Strong competition from Japan and North America; the competition for space / land will be disadvantageous for European players.
- Energy provision from algae will only be viable if it is able to compete with other alternative energy sources and their prices.
- Technological breakthroughs would need to have taken place – allowing for significant cost reduction in the extraction phase. Essential is the technological ability to enable a constant high yield of productivity (macro-algae);
- Progress would also need to be made in the photo-bioreactor design and the overall energy balance of the production: less energy will need to be used in pumps and extraction processes than produced by photosynthesis.

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[4] To avoid overlap, the sub-function "High value use of marine resources" is focusing on the different activities aimed at developing new usages of marine resources and is limited to R&D for the purposes of this study.

[5] Multi-trophic aquaculture is based on interlinked productions of fish, seaweed and shellfish.

Assumptions about response capacity

Important is the capacity of the sector to avoid a second boom and bust cycle: algae developments were high on the agenda during the 1980s before an almost complete blackout during the 1990s[6]. The recent regain in interest is seen as a potential risk: if current biofuel demonstrator projects are not achieving their objectives, the negative signal sent to investors might divert funding from the sector.

Currently, start-up companies struggle to learn and to share information. SMEs also find it difficult to attract the sufficient amounts of investment and capital. The bulk of the products will therefore be brought to market by large producers (up to 30 within Europe), some of them mergers and conglomerates of small start-up companies, some other producers are part of large food or energy companies. This consolidation process will also help to drive down costs – a key challenge for the sector. Decisive will be the ability of the micro-algae sector to lower its costs at a competitive level to enter mass product markets and 2) the competition of other feedstocks as biofuel precursors like jatropha[7], salicornia[8] or other oil-rich plants.

Assumptions about framework conditions

- Access to finance is secured: the European sector is able to attract private investors to enter the sector on the medium to long term;
- Large energy companies' willingness to invest in developing alternative resources. Most large oil companies have invested in micro-algae pilot productions developed by innovative SMEs, although some key players are currently sending contradictory signals by lowering their support to this sector;
- The availability of potential stimulations by National/European research funds although some interviewees indicated that such stimulus may not be necessary for the micro-algae sector to develop (policy support);
- Policies that stimulate renewable energy production and consumption, increasing costs of GHG emission rights, and increasing prices of traditional fuels will have a stimulating effect on the biofuel market as a whole.

2.1.2 Blue Biotechnology: a bright future for high value marine products (2.4)

Key characteristics

Within this sub-function a variety of outputs seems possible and promising. However most are not commercially viable yet and there is a need for further R&D to define promising products and required conditions.

Potential development

High value marine products will have a wide range of applications that reach the market: new medical molecules, bio-plastics, enzymes or biocides are the main ones. Slowly but surely, the potential of marine organisms not yet known will be discovered. The marine products that will be generated will continue to have a strong appeal – and satisfy a range of diverse consumer needs that will only rise in an ageing society.

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6 It has been mentioned that available funding decreased due to several projects failures. However interviewees stressed the fact that the expectations of funding institutions were too high in comparison to the technology maturity.

7 Jatropha is a tropical shrub which may be exploited for its oil-rich seeds as a precursor for biofuel.

8 Salicornia is a salt tolerant plant which may also be exploited for both its straw and its oil-rich seeds as a precursor for biofuel (Stratton et al. 2010). NASA and the US Department of Energy are currently studying its large-scale cultivation in semi-desert area.

High research and patenting activities over a range of years will pay off and lead to technological breakthroughs: most molecules will be sourced through biotechnology and will not be extracted from wild material: original molecules will be sourced in marine organisms but final compounds will be optimised and produced through biotechnology. The end-product would therefore differ substantially from the marine environment they originate from.

Assumptions about external drivers

- Demand for high-value applications, including medical and cosmetic applications will be strong; underlying driver is the ageing population;
- Oil prices will further increase and close the commercial gap with bio-sourced products.

Assumptions about response capacity

Future response capacity will strongly depend on the sector's ability to prevent boom and bust cycles; a speculative bubble could be detrimental to the development of underlying fundamentals.

Main challenge for the sub-function will be to gain efficiencies in high-output screening, cultivating and transportation of new species.

High value marine products will be brought to market by existing and large players, as small and promising spin-off firms and SMEs will be acquired by them. Small companies will fail to make a critical mass on their own, and will not manage to share knowledge and to fully capitalise on the links with research institutes. But these research institutes will prove to be a real driver, as they continue to discover new species and living organisms at ever greater depths – an effort which is too great for the industrial sector itself. [9]

Key commercial players will be cosmetic companies (L'Oreal, Estée Lauder...), pharmaceutical companies (Merck, Lilly, Pfizer...) but also large chemical players (Novozymes, BASF...). These industries will have preferential ties to the research institutes, through exploration contracts. Unfortunately, these contracts ban researchers to publish about their findings.

Assumptions about framework conditions

- Access to finance is secured; investors will no longer focus exclusively on algae biofuel but also become interested in other blue biotechnology applications.
- The capacity of the European sector to avoid key competencies to be concentrated by competing countries (China, India, South East Asia...).

2.1.3 Ocean Energy: Tidal current is the next wave (3.3)

Key characteristics

Ocean renewable energy sources is in fact a package of four different offshore energy segments[10]:

- Tidal energy, covering tidal range and tidal current, is the most advanced. It has proven to be technically feasible but costs are still too high to compete with other (renewable) energy sources. It is at the threshold of introduction.
- Wave energy is still facing R&D challenges to be overcome before commercialisation comes into view. Technologies are not yet proven. Research is looking to cut down installed and operating costs. Several pioneering players have built up a prominent position over the past 10-15 years, while new entrants are arriving today indicating the segment is entering the market phase (introduction).

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9 World Ocean Review, Chapter 9 "Active substances from marine creatures", p.182.

10 the observations that follow are based on literature and interviews, as reported in the Sub-function Profile document

- Osmotic energy is based on the salinity gradient between salt and fresh water. Technology cannot yet be considered proven; the segment is not yet in its commercialisation stage. Problems to be solved are in the field of prevention of fouling and pre-treatment.
- OTEC (Ocean Thermal Energy Conversion) is based on the thermodynamic potential between the warmer upper water layer and the colder deeper water layer. OTEC is in an early phase of development, but several demonstration projects have been realised the last decades. Examples can be found in Hawaii, Brazil, the Caribbean, West coast of Africa and Japan. Although temperature gradients in the European latitudes are smaller than in these Equatorial areas, still potential for European industry is envisaged.

Overall it is concluded that Ocean renewable energy sources are in their development/ introduction stage, with some clear variations among the underlying segments as pointed out above.

Potential development

At the moment, tidal current energy is the most advanced segment, Growth for the next 5 to 10 years will mainly be attributed to this type of energy generation. Immediately following is wave energy. In the longer run, all options should be kept open, but OTEC and forward osmosis still need time and technological development to prove themselves. Tidal range is the only technology with long-term proven viability, but we consider the environmental implications of any new schemes to be prohibitive, at least in the European seas.

The yearly installed capacity for tidal current energy will increase from 3.4 MW in 2010, to 22 MW in 2012, to 32,5 MW 2014 and 2015, with continued growth perspectives in the further future[11]. Employment will increase accordingly, from 1000 fte in 2010 to potentially 20,000 fte in 2035
The turnover has increased from € 4 million in 2005 to € 37 million in 2010, and will grow further to € 360 million in 2015[12]. The most optimistic (and rather coloured) scenario even mentions € 45 billion in 2050.

The development of the ocean energy sector will start in the North East Atlantic Ocean. With the technological development, economies of scale, increasing fossil fuel prices and the sustainability requirements from the EC, other marine regions are following.

Assumptions about external drivers

- Fossil fuel prices will have to show a modest to strong regular increase; if not, the price gap between fossil and renewable energy remains too wide. Price level, but especially price volatility has ignited a strong political will to become less dependent from oil imports. This is reflected in a level of feed-in tariffs that stimulates development. EU environmental regulations are strict and enforced, leading amongst others to heavy taxation of CO_2-emissions, thus favouring renewable energy sources.
- New technological developments from 'outside' (as opposed to innovations brought about by the sector itself) may play a role in this sub-function, most notably in the immature technologies such as forward osmosis and OTEC. For the coming decade this is not expected to change the overall picture markedly.
- The EU will develop a stable and predictable price policy and a platform for exchange and cooperation.

Assumptions about response capacity

The main market is the construction, operation and maintenance of medium-scale production parks, often combined with wind farms. An important niche market is small-scale, near-shore energy

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[11] source: Renewable UK (2011)
[12] source: Douglas-Westwood (2010)

production in remote coastal areas. An important niche market for Blue Energy is the combination with freshwater production.

Technological development will lead to a limited number of 'winning', broadly accepted technologies, which have been proven in practice. Energy production costs will be reduced to reach comparable levels as fossil fuels.

European industry has a strong position in both wave and tidal energy conversion technology and construction. Europe may be expected to hold its ground as long as the sub-function is small in size and focus is on research and development. If the sector takes off, similar developments may be expected as in offshore wind, where joint ventures are formed between Asian and European partners.

Assumptions about framework conditions

- Infrastructure (physical: grid connection, port facilities), a sound legal framework, transparent and simplified permitting procedures and development of educational curricula will be in place for the future situation and planned for the next decade.
- Environmentally friendly technologies will be available and in use. The balance between positive and negative impacts during the complete device life cycle is favourable.
- Financing will no longer be a problem, due to reduced risk perception of now proven technology and the outstanding image of Ocean Energy in the public's perception.
- Marine spatial planning is of key importance for the timely reservation of suitable areas, the identification of synergetic activities and for solving tensions with competing activities.

2.1.4 Marine mineral resources: EU as a player on the ocean floor at last (3.6)

Key characteristics

With the rise of the computer and mobile communication era, the demand for rare earth has steepened, and shortages are imminent – mostly for geopolitical and not for geological reasons. Meanwhile, mineral prices have been soaring and land mines are no longer sufficient to meet growing demand, especially from China. In ocean floors around the globe, vast stocks of minerals are expected to be found. Exploitation and mining are, however, still in a nascent stage. To date, no excavation of solid minerals has taken place beyond 200 m below sea-surface. Technological challenges are to carry out mining at depths up to 3 to 5,000m, requiring adaptation of existing techniques. A number of companies active in adjacent sectors are investigating this field. Therefore the sub-function is considered to be in its development stage.

Potential development

It will be a long haul, but with the help of entrepreneurialism, long trial and error with excavation and extraction techniques, and after quite some failures, 10% of the world's precious minerals including cobalt, copper, zinc as well as rare earth can come in the year 2020 from the ocean floors (up to 15% in 2030). Overall global annual turnover value of marine mineral mining can be expected to grow from virtually nothing up to € 10 bln in the next 10 years. It is estimated that if 20% of the total number of known mines existing in the ocean floors (4000 mines world-wide of 1km^2 each) were exploited, 100 simultaneous ships would operate and 10,000 people worldwide would be directly employed – without taking into account the shipbuilding and the upward and downward value chain elements.

Mining will focus above all on polymetallic suphides: deposits which are the result of hot fluids being discharged through fractures (vents) between tectonic plates.[13] A surge in marine mineral mining is expected to start after 2013, when the first commercial venture for polymetallic sulphides ('Solphara 1') is expected to succeed in commercial excavation of copper and gold from the Exclusive Economic Zones of Papua New Guinea, by the Canadian mining company Nautilus Minerals Inc. The mining company has thereto designed and built a dedicated ship from the German Harren & Partners company. It will also use state-of-the art extraction tools, such as ROVs, cutters and risers developed for deepsea oil winning – supplied by European partners. This success will coincide with the start of the exploration of the largest known sulphide concentration, namely in the Red Sea. [14] The Saudi company Manafa has already been given exclusive exploitation rights and early estimations valuating the deposits to $ 3.11 billion to $ 5.29 billion (copper, zinc, silver and gold) proved conservative. In 2020, manganese nodules and cobalt crusts will still not be commercially exploited at a large-scale, due to both technological, commercial and environmental constraints.[15]

Rare earth will be mined as well, mostly from the Pacific, however at a relatively small scale still. In 2010, when the shortage of critical raw materials emerged for the first time on the political agenda, large potentials of rare earths and yttrium were found in sea-floor sediments (mud). At depths down to 50 meters below the seafloor, a Japanese research team estimates that the sea-floor contains more than all the rare earths buried on land (Kato et al, 2011). In certain hotspots, one square kilometre is estimated to contain 25,000 tonnes of rare earths (Jones, 2011) – particularly large deposits are found around Hawaii. Commercial exploitation is however hindered by the fact that deposits are covered my sometimes tens of meters of mud which need to be removed before excavation can begin.

Assumptions about external drivers

- Market prices for minerals remain consistently high on world markets;
- High metal contents are found in deposits on the ocean floor;
- Future costs of land-based mining increase, while political risks and public resistance increase;
- Transport costs for thousands of tonnes of ore and deposits to processing plants over the international waters can be brought down (Hayden (2004) [16]. Price of shipping will however remain a key condition for selection of mining locations.

Assumptions about response capacity

Response capacity will be tested by the successful execution of pilots, notably the Nautilus project at the Papua New Guinea coast. Technological capacity is needed to achieve progress, mostly in the area of excavation devices, cutters and risers

Major mining companies will be in a leading position, most of which from the US, Australia, and Canada, as they are best placed to secure licenses. Mining from international waters will depend on restricting the number of licenses and imposing environmental charges.

Despite the well-known disadvantages and limits of land-mining, European mining companies will be slow in shifting to the oceans. An initial attempt by the UK-based Neptune Minerals plc came to an end already in 2009, in the middle of the economic and financial crisis, to save capital. [17]

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[13] Halfar, J. and Fuijta, Rodney M. (2002) "Precautionary management of deep-sea mining", Marine Policy, v.26, 2, p.103-106

[14] Bertram et al. (2011) "Metallferous Sediments in the Atlantis II Deep – Assessing the Geological and Economic Resource Potential and Legal Constraints. Kiel Working Paper No. 1688, March.

[15] World Ocean Outlook, Chapter 7 "Marine minerals and energy", p. 151.

[16] Hayden (2004) "Exploration for a Pre-feasibiliy of mining Polymetallic Suphipdes – a commercial case study.

[17] Mining Journal "Return to the Deep" , 4/3/2011

European companies are able to take advantage of the surge in marine mineral mining as they are world leaders in key technologies such as dredging, drilling, cutting, transport and ROVs, which will be essential in case large scale mining takes off.

Assumptions about framework conditions

- Successful execution of pilots, notably the Nautilus project at the Papua New Guinea coast,
- Subsequent access to private capital for investment and upscaling
- Environmental impacts remain under control (and cooperation with environmental NGOs)
- Acceptance of local coastal populations exposed to mining activities

2.2 Sub-functions showing market growth

These are the sub-functions which can substantially grow in the years to come, and where most employment growth is expected to come from. However, there are important investments and preconditions required in order to reach the full potential of these sub-functions.

2.2.1 Offshore Wind Energy: anywhere the wind blows (3.2)

Key characteristics

Over the past decades the costs of production have been reduced strongly. The scale of application is still small compared to the more traditional energy sectors. R&D focuses on applying existing techniques in harsh conditions, and raising the energy output that can be realised. Competition is also increasing, especially in the production of equipment (China, Korea and Japan). The number of players active on the market is rising.

Potential development

The future of the offshore wind sector is bright. New developments in floating platform construction and improving robustness have lifted former constraints. Scale effects, combined with raising oil prices and improved public appreciation have provided a sound economic basis. As a result, the capacity installed will in this Micro-Future increase from 3.9 MW in 2009, to 40 MW in 2020, to 150 MW in 2030, with a growth perspective of 460 MW installed in 2050. The employment will triple from 7000 fte in 2009 to about 20000 in 2020.[18] The turn-over of the sub-function will triple from € 1.3 billion in 2009 to 4.5 billion in 2020.[19]

Assumptions about external drivers

Fossil fuel prices will have to show a modest to strong, regular increase. Price level, but especially price volatility has ignited a strong political will to become less dependent from oil imports. EU environmental regulations are strict and enforced, and on balance they favour offshore wind. By heavy taxation of CO_2-emissions, wind energy has become more competitive; coal is no longer used in newly built power stations. Environmental regulations and public resistance will also restrict large-scale installation of wind energy on land, thus posing restrictions on the construction and operation of these wind farms.

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[18] employment in 2020 estimated as tripling, analogous to tripling of turn-over value

[19] estimation based on ratio onshore/offshore in energy production applied to total estimated investments of € 27 billion. Source EWEA (2010). "Other estimates suggest that the sector size in the EU is larger, possibly ranging from € 5-10 bn. However, this could not be confirmed by written sources. In addition, this figure is very much dependant on how one defines the value chain, and what counts as direct, indirect and derived employment. In any case, the decision of the selected sub-functions in WP1 is not affected when a different range is applied."

The EU will develop a stable and predictable price policy and a platform for exchange and cooperation in research and development.

Assumptions about response capacity

The main market is the construction, operation and maintenance of large-scale, remote, deep-water wind farms. Technological development will lead to larger production units, more robust devices, and lower energy production costs. Water depth is hardly a determining factor any more. By going further off the coast, the sub-function has solved most of the problems due to visual pollution and competition for space.

The sector has learned to perform its construction, operation and maintenance in a sustainable way, avoiding intolerable disturbances in terms of soil disturbance, noise, collisions and emissions. The EU has a leading role in new technological development, forming joint ventures with hardware manufacturers in China, Korea and Japan. These joint ventures have a dominant role in the worldwide export market and are pivotal in opening up the Asian market, which is growing quickly. The key challenge for European enterprises is to use their home market to foster R&D, thus keeping up with the SE Asian competition and continuing to be interesting Joint Venture partners.

Assumptions about framework conditions

- Infrastructure (physical: grid connection, port facilities) is in place;
- A sound legal framework is in place, providing transparent and simplified permitting procedures and development of educational curricula;
- Environmentally friendly technologies will be available and in use. The balance between positive and negative impacts during the complete device life cycle is favourable.
- Financing will no longer be a problem; the first privately-financed major projects, started in 2010, have proven sound and have found many follow-ups. Marine spatial planning is of key importance for the timely reservation of suitable areas, the identification of synergetic activities and for solving tensions with competing activities.

2.2.2 Desalination: is the potential already drying up for Europe? (3.7)

Key characteristics

The economic activity of supplying fresh water from salt water already exists for decades, but the recent rise of welfare levels and population numbers in semi-arid regions has provided a strong boost. Technological developments are aiming at capacity increase and reducing energy requirements, while keeping adverse environmental impacts to a minimum. New players are entering this segment.

Potential development

The installed seawater desalination capacity will increase from 42 Mm3/day in 2010 to 55 Mm3/day in 2016 and to 126 Mm3/day in 2020[20]. This represents a growth rate of ca 8.5 % per year. Water can be produced for about 35 cent/m3[21], making it competitive with traditional production methods. Until 2020, the main technology used is Reverse Osmosis (RO) technology. In the longer run, a new growth impulse is caused by the successful development of membrane distillation.
Most of the growth is taking place outside Europe, in North Africa, the Near East, Australia and the USA. Within Europe the southern Mediterranean is the main market, slowly extending northward to the French and Italian Mediterranean coasts.

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[20] sources: GWI (2010); LuxResearch (2009)

[21] source: interview

Assumptions about external drivers

The growth of the population and economic value will continue, especially in coastal areas. This will increase the already existing water stress there. SE-Asia (China, Korea, Japan) will strengthen its position in both R&D and production. Counterbalancing this is the increasing coordinating role of the EU.

The principal drivers for growth of the sector are the factors that increase demand and potential water stress: urbanisation in coastal areas, increasing welfare and the related increase in per capita water use. On the other side, but secondary to increased demand is the decrease in water supply that is expected in some areas as a result of climate change.

Where water production costs have become low enough to economically justify its use in high-value agricultural crops, the desalination capacity is brought to new levels.

The price of fossil fuels must not increase too steaply. At present energy makes up more than 50% of total costs of desalination, although further improvement in energy efficiency are foreseen. Nevertheless strong increases in the oil price would pose a serious threat to the growth potential.

Regulations on sustainability and environmental protection continue to be strong drivers, sometimes impeding new desalination schemes but more often inciting new technological solutions.

Assumptions about response capacity

The strongest growing markets for desalination are outside Europe.

Technological developments continue. Until 2020, Reverse Osmosis is the leading technology, but membrane distillation is rapidly gaining ground. Research and industry must work closer together. The life time of specific technologies is no longer than 10 to 15 years, continuous innovations are mandatory.

In order to keep pace with international competition, European companies must be willing to join efforts. Europe has realised that for large-scale production of destillation units it is not likely to hold its ground, and has identified the areas where it can play a lasting role in the international market. The construction of new, large-scale plants is no longer a European ambition - this sector was lost to Asian competitors. Europe aims at important niche markets which will develop in small-scale, stand-alone desalination units and in application of membrane techniques in wastewater treatment - the latter very relevant for the European market as well as the world market. Very promising are technologies to recover raw materials from brine.

Public resistance to desalination, caused by its high energy consumption and formerly unresolvable problems with brine disposal, have been overcome by improved technologies. That said, desalination will always be secondary to natural freshwater sources.

Assumptions about framework conditions

- No alternative, cheaper water sources will be developed.
- The EU will stimulate the development of concerted actions at EU-level. After thorough examination of world-wide trends, it will have identified the areas where the EU can be strong.
- The EU will have taken the necessary actions to line up available research funds and promote co-operation between research institutes and private enterprise.

2.2.3 Cruising along at high speed: cruise shipping and port cities (4.3)

Key characteristics

This tourism segment already developed since the 1970s, and has become accessible for larger groups since lower cost segments are also accommodated. In North America/Caribbean penetration rates are much higher than in Europe, indicating growth potential here, as is also shown in recent data. Therefore the sub-function is considered to be in its growth phase.

Potential development

The worldwide cruise industry forecasts a strong growth trend in demand; the total number of passengers carried worldwide is estimated to reach 29.7 million in 2020 (+61.4% from 2010). The continued expansion to the European cruise industry will have a significant impact on job generation throughout Europe. Total employment is likely to grow as well, although not at the same rate as passengers carried due to economies of scale. By 2020, employment is expected to reach a level of 400,000, compared to 300,000 in 2010 and 200,000 in 2005. [22]

Europe as a cruise destination will continue to be attractive (for instance, through improved berthing situations in attractive destination ports), while segmentation of the market leads to a broad offer of highly diverse destinations for all sorts of target groups. It is expected that both the Mediterranean and the Baltic Sea Basin will benefit from this development.

Assessment of external drivers

- Welfare development continues;
- Demographic change continues: the ageing population reshapes internal demand
- Fuel prices increase steadily. Although an increase in fuel prices will dampen overall growth, it could provide relative advantage to regions where destination ports are close to each other (North Sea, and especially Baltics).
- Consumer preferences change continually, offering new opportunities for niche markets and forcing the cruise companies to stay innovative
- Environmental awareness continues to be relevant
- Increased competition from non-European players (notably from the US).

Assessment of response capacity

The European cruise business has a strong response capacity, allowing it has to cope with many of the current and future pressures. Cruise companies adapt their strategies, by segmenting the market and by adapting their fleet to them; fleet expansion is under control, which prevents the build-up of overcapacity; labour costs are being curtailed by hiring unskilled labour from non-European migrant workers – which can lead however to socially undesirable practices. Shipyards invest heavily in R&D for modernisation and efficiency measures; port authorities and regional/local governments across Europe adjust their facilities and offer to the changing customer demand.

Assessment of framework conditions

- Infrastructure: port authorities manage to keep pace with demand in providing berthing capacity. Location is key and should be central in port cities close to tourist hotspot sites. This may require relocating other activities.
- Harmonisation of (environmental) regulations geographically (sea basins) as well as across tourism sectors, creating a level playing field for cruise to compete against other segments of the tourism industry.

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[22] Own estimates, based on data provided by the European Cruise Council (2011).

- Clear implementation regimes for new legislation, allowing the shipbuilding industry to adapt timely and gain competitive power against Asian yards and suppliers.

2.2.4 Maritime Security and surveillance (6.1) [23]

Key characteristics

Maritime surveillance consists in the situational awareness of all activities at sea impacting on maritime safety and security border control, the marine environment, fisheries control, trade and economic interests of the European Union as well as general law enforcement and defence so as to facilitate sound decision making. There is growing demand for both segments because the increasing number of (legal and illegal) activities at sea. The last decade has seen an increase in threats over the last decade, including piracy, illicit human and drug trafficking, as well as terrorism. Legislation aiming at reducing risks, includes measures at sea (monitoring of commercial vessels, small boats, oil spills, etc.), coastal areas and in ports (ISPS code, selective scanning of cargoes, port and flag state control, illegal immigration etc.). At the equipment side, many industry players are active, partly building on systems developed for other functions, and partly integrating existing data networks. In the services component of the value chain, still new players enter based on additional applications that are being developed (e.g. satellite capabilities). Overall the sub-function is considered to be in its growth phase.

Potential development

The demand for maritime security and surveillance products is likely to increase in the coming years and thus this will be an important area of growth. However, the development maritime surveillance will depend heavily on both spending of national members states. Further integration and data-sharing data across sectors and across member states (eventually leading to a European system of data sharing), may have a positive impact in this respect as it is expected to lead to higher efficiency and improved cost-effectiveness of maritime surveillance It is likely that this will first start at the level of Sea-basins, following the success of several pilot projects. However such development cannot be done overnight, as it involves institutional learning, technical developments and political negotiation before a fully functioning European integrated maritime surveillance area can be implemented.

This sub-function is a typical facilitating function leading to spin-off in sectors that are supported by enhanced monitoring and surveillance (ranging from fisheries control, to improved SAR operations, piracy prevention, etc.)

Assumptions about external drivers

- Security concerns (including those with a cross-border nature) will lead to continued demand, both directly (e.g. through piracy) and indirectly as a result of increased (illegal) migration pressures from outside Europe;
- Environmental policies that need to be monitored/enforced also support demand
- Public procurement policies will drive demand
- Competitive market entry by emerging economiesremains limited

Assumptions about response capacity

- Government-based activity (political rather than market driven); proneness to public budget cuts
- Slow response due to involvement of bureaucracies (including the military and civil authorities)

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[23] This micro-future is to be refined upon completion of the underlying sub-function profile

- Potential for efficiency due to interoperability and integration measures
- Successful application requires involvement of many maritime sectors and players
- Established position of European industry
- Strong R&D basis rooted in military and security spending
- Immature business models limit response capacity
- Technologies and technological capacity in place – often built up through defence-spending

Assumptions about framework conditions

- Institutional and legal structures will no longer be heterogenous and undermine the linkages between different communities of users;
- Standards and certification for interoperability in place
- FP7 funding as a basis (e.g. Eurosur project)
- International policies to be developed in IMO framework

2.2.5 Environmental Monitoring: cutting across all maritime functions (6.3)

Key characteristics

This sub-function is considered horizontal as it does not capture an economic activity in itself but is serving the needs of other maritime sub-functions. The EU and governmental institutions are important players in driving the structure and components of the sub-function. Private industries providing equipment or services are established players adding to their portfolio.

Potential development

The use of the seas will increase in scope and intensity during the coming decades. This causes an increased demand for information from both the public and the private sector. The public sector is interested to know the status of marine waters and of the impacts of human activities, in order to perform well its role as manager: to define optimum protection levels, judge permissions, etc. The private sector needs monitoring data to find optimal locations and practices for its maritime activities. The result is that the sub-functions' turnover will double from 4 billion €/y in 2010 to 8 billion €/y in 2020. Employment however does not keep in pace with this increase, due to the strong emphasis on the implementation of more efficient, labour-extensive methods.

Assumptions about external drivers

Economic activities world-wide are growing steadily and even strongly on the seas and oceans. The resulting emissions of pollutants, nutrients, noise and heat, and physical disturbances of the marine environment, cause continued pressures on the marine socio-economic and environmental systems.

Public perception appreciates this, keeping continued emphasis on the need for sustainability. EU and national policy are pivotal in translating those sentiments to a regulatory framework.
New technologies in satellite imagery, nanotechnology, miniaturized labs, and ICT make new applications and uses possible, broadening the market for monitoring products. The retreating public sector leaves more room for private enterprise. Globalisation is an important feature of this sub-function. The USA is leading in R&D, Europe covers niche markets.

Assumptions about response capacity

The sector has realised it has to cooperate more closely in order to keep its ground against international competitors. This has led to an overall higher integration level of monitoring and reporting activities, better coordination, sharing of data, sharing and coordination of monitoring methods, locations and frequencies.

The sector is well equipped and prepared to demonstrate the benefits of monitoring, a/o. by increased level of certainty.

A whole new source of finance is found in the commercialisation of public data. New ways for multiple use of data are developed, providing new incentives to private enterprises to share data that were previously kept secret.

New technologies are developed to supply multi-purpose and multi-sectoral monitoring techniques. Automated collection and reporting of real-time data is further developed. Remote sensing is used in new applications. VOS's provide additional, world-wide data.

Assumptions about framework conditions

- Europe can play an important role in lining up and harmonizing the European monitoring efforts, as indicated above. Furthermore, for this sub-function there is a close link between the framework conditions and the external drivers.
- It is assumed that the EU in general and user communities in particular are willing to pay a price for environmental monitoring.

2.3 Mature sub-functions

These are the sub-functions that currently provide high amounts of value added and that employ substantial numbers of employees. Main challenge for these sub-functions is to continue to perform in the light of strong external pressures and fierce competition from global players. Much will depend on the strategies and business models implemented, and in particular on the ability to export competencies and expertise to the world at large or to bring the world to Europe.

2.3.1 Short-sea shipping: reaching out to Europe's neighbourhood

Key characteristics

The size of this sub-function is substantial. It ranks among the largest 7 maritime sub-functions based on current size. The sector still shows economic growth, partly driven by global economic growth and increased intra-EU trade, and partly through fuel prices and policy measures affecting the competition within the maritime field as well as with other transport modes. Technology development, both at the shipbuilding stage and in areas such as security and surveillance, mainly relates to public policy initiatives. Therefore the sub-function is considered to be mature.

Potential development

The transported volumes of cargo will generally develop along with economic development. Additional growth of volume may be realised by stimulating modal shift, provided that the additional costs of complying with emission regulations do not form too much of a countereffect. The emission of SO2 of the sector will drastically reduce, due to the strict regulations in ECAs in particular and in general due to IMO regulations. This will be realised through a mix of measures: using low sulphur content fuel, scrubbers and LNG as a marine fuel. LNG will become an alternative source of fuel for a substantial share of the shortsea vessels once a suitable distribution infrastructure is set up. Experts estimate that this may take at least 5 to 10 years.

Assumptions about external drivers

- Fuel price increases will lead to pressures on the sub-function;
- The European Single Market will contribute to further exports and demand for short-sea shipping;

- Trade with Neighbourhood countries – growth in Turkey, Russia, Ukraine and North Africa will spur the demand for short-sea shipping;
- Congestion of road transport will lead to reduced competitiveness of this alternative (while expectations for rail and inland waterways remain modest).

Assumptions about response capacity

- Price competition drives increasing ship size
- Diversity in player's potential to reach economies of scale – big players will be able to invest and adjust faster than small operators
- Fuel price increases will lead to pressures on the sub-function
- Diversity in capacity of terminal operators to respond
- Low levels of technological adjustment

Assumptions about framework conditions

- Lack of capacity in and around secondary ports and their hinterland connections will be addressed;
- Strong enhancements in external infrastructure (ports and hinterland);
- Environmental regulation will be increased gradually, allowing the sector to invest in the necessary adaptation costs.

2.3.2 Oil, gas and methane hydrates: deeper and farther away (3.1) [24]

Key characteristics

The sub-function is large sized in Europe as well as worldwide. Within Europe it is declining as resources are becoming depleted. The global demand for fossil fuels is however still growing. Several large players are dominating the market, with niche players active in certain fields, both technology-wise and geographically. R&D is mainly focusing on raising the efficiency levels of operations, including raising the share of fields being mined and the commercial exploitation of smaller oil fields. Outside Europe there is growth in production. Therefore the sub-function is considered mature.

Potential development

Offshore oil extraction is a crucial activity on the European waters, but its importance will reduce in the years to come due to the exhaustion of existing oil fields. Offshore gas exploration will stabilise still in the next 15-20 years, while methane hydrates extraction will provide new opportunities. More important still will be the export potential of European energy players in the exploration of oil, gas and methane worldwide, in ever deeper waters.

Assumptions about external drivers

- Increased fuel demand – in line with global economic growth globally and in specific markets (e.g. China, India);
- Major oil discoveries in other parts of the world;
- Fuel prices will increase – thus making deep-sea locations more attractive;
- EU's continued desire to become less dependent on oil imports (Energy security objective).

Assumptions about response capacity

- Large size of the sector - multinational players with a global reach;
- Export potential of a range of players in the value chain, including drillers, surveyors, etc;

[24] This micro-future is to be refined upon completion of the underlying sub-function profile

- Continued boost in environmental impact reduction techniques (often triggered by disasters such as the Deepwater Horizon accident);
- Future efficiency gains in production (currently only 50-60% of fields being exploited).

Assumptions about framework conditions

- New technologies will allow further exploitation of offshore oil fields that are currently considered almost depleted;
- Renewable energy policies will provide room still for oil & gas;
- Regulations regarding the safety and the protection of the environment will be introduced gradually;
- No radical changes in the public opinion with regard to this activity (oil spills, climate change impact, etc.).

2.3.3 Coastal tourism: polarisation between places (4.1)

Key characteristics

Tourism in coastal regions has been strongly related to on the one hand welfare levels allowing people to take holidays and on the other hand climatic conditions attracting people to coastal regions. This is taking place in Europe since the 1950s and has steadily been growing. No major changes are being seen within the segment, although niche innovations and marketing have resulted in certain activities becoming more popular over time. Examples of today are kite surfing or sailing karts. While thus underlying services may face growth, overall the sub-function is considered to be mature, with fierce competition within various segments of the value chain.

Potential development

Increased pressure for CO_2 cuts and fuel costs will reshape the sector, as it is likely that in the long term distant short trips would decrease and local areas will become again the favourite tourism destinations, particularly for the majority of low-middle income individuals. A strategic need for sustainable means of transport will come to the fore. This scenario would imply a greater strategic thinking in terms of sustainable transports and ways to connect coastal regions throughout Europe.

In the medium term, a growing demand for unique experience and value-for-money will shape parts of the sector. Nonetheless, fierce competition amongst regions and places within and outside the EU is expected. The mix of increased air transport prices and stagnant average income of EU citizens might reshape the current EU tourism demand towards higher value for money. Competition will particularly affect areas without specific unique selling point, exposed to competition with other areas in the EU and worldwide with greater quality of the local environment, infrastructures and services, and/or lower labour costs. Europe overall will remain the first global player in tourism, but the Mediterranean predominance will be challenged by Northern and Eastern Member States (including the Baltic, North Sea, Atlantic and Black Sea Basins). The polarisation of performances amongst regions and places will increase, and winners will be those regions and places with strong innovation and marketing capabilities and where skilled labour is available. The potential for marinas including yachting as drivers for long-term growth will remain great - with growth of approximately 2 – 3 percent on average per year. A key driving role of is foreseen for small marinas. Other nautical sports on the other hand, are expected to stabilize over time, also due to relatively low inflow of young people into these sports.

Assumptions about external drivers

- Forceful competition from outside the EU;
- Economic crisis has eroded income potential of certain EU client groups – 35% of European tourists has changed behaviour due to the crisis (e.g. less demand for second homes)

- Ageing population and educated citizens will demand for 'customised experiences'
- Climate change makes many coastal regions exposed to sea-level rise and/or changing weather conditions.
- Increasing fuel prices will challenge existing transport models (e.g. low-cost airlines)

Assumptions about response capacity

- Overall lack of vision on value proposition due to large fragmentation of the sector
- Fragmentation across sea-basins and proliferation of micro companies limit innovation (Baltics and North Sea being well-placed)
- Adjustment and mitigation capacity varies across sea-basins (e.g. large scale of sector induces complacency in parts of Mediterranean)
- Value captured by big players with limited spill-over effects to local and regional players

Assumptions about framework conditions

- Geographical constraints: climate and quality of the built environment
- A dilemma: Lack of skills and training possibilities coincide with limited attractiveness/poor image on the labour market
- Accessibility by sustainable transport modes
- Access to finance
- A need for good governance
- Long-term vision and collective action

2.3.4 Coastal Protection: steadily reinforcing Europe and the world (5.1)

Key characteristics

Demand for coastal protection works relates to population densities and economic assets in coastal regions, which tend to increase. On the other hand growth is limited by available budgets, which are mainly coming from public sources. Climate change and sea level rise is expected to increase the need for protection works. Technology is considered mature, but the size of the market may increase. Therefore the sub-function is assessed to be in its growth / mature phase.

Potential development

Coastal protection will be a slowly but steadily growing sub-function over the coming decades. However, as the underlying drivers of climate change and sea level rise are developing slowly, and public budgets are scarce, the pace of growth will be moderate. Based on interviews an own estimated rise in turnover is set at increasing from 0.88 billion €/y in 2010 to some 1.5 billion €/y in 2020, followed by further growth afterwards. No data are available on growth in employment, therefore we stick to the default assumption that employment will keep pace with the increase in turnover.

Assumptions about external drivers

Climate change, resulting in sea level rise, will continue for decades and even centuries to come. This is now a widely accepted view. Urbanisation, to a large degree concentrated in deltas and coastal regions, continues. Economic activity, leading to increased values to be protected, continues to grow. Urbanisation and economic activity are important determinants for the need for coastal protection. The trends above are relatively certain, i.e. likely to continue in the next decades. Implementation of EU policies plays a role in concerted approaches towards flood risk and coastal protection in Europe.

Assumptions about response capacity

Coastal protection is a mature sector. Genuinely new technologies are not expected, but gradual innovations such as the sand motor, and 'Building with Nature' are vital. They will increase enthusiasm and support for coastal protection. New ways of Public-Private Partnerships will increase the efficiency of funds spent. A technological adaptation will be the increased size of dredging vessels, reacting to larger distances-to-shore.

Experience and know-how of coastal protection is largely concentrated in Europe, with a limited number of large players operating internationally. Growth is expected at a moderate but steady pace, making coastal protection a strong export product to low-lying coastal regions all over the world.

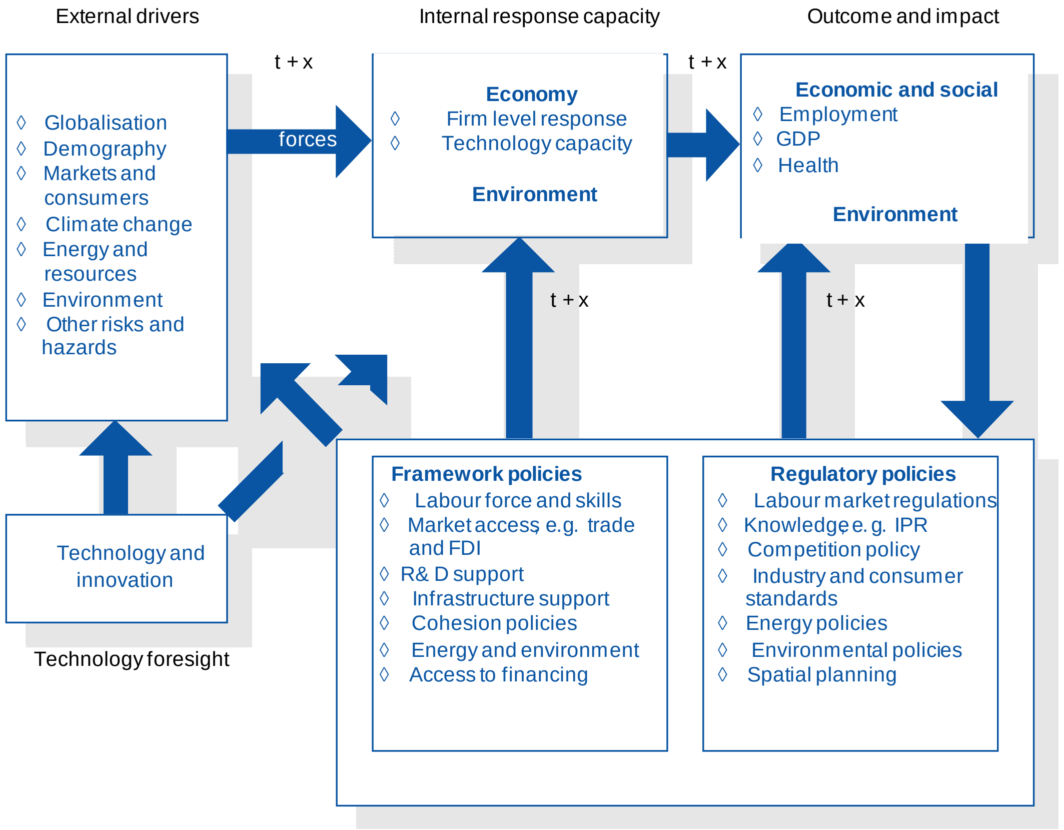
Assumptions about framework conditions

- The most determining framework condition is that EU and national authorities put a firm framework for integrated coastal protection in place. Coastal protection is a sub-function that, due to the slow progress of sea level rise, can be neglected for some time without being punished. An important role for authorities at national and EU level is to make sure that the sub-function receives sufficient attention and funding.
- The required sediments remain available;
- Technology keeps in pace with requirements caused by sea level rise.

3 Components of the micro-futures

In the Micro-Futures in chapter 2 we assumed that the external drivers, the response capacity and the framework conditions develop in such a way that they are in harmony with the desired state of the sub-function. This chapter provides background information to these elements, explaining them in detail, identifying uncertainties in their future state, and comparing their relevance for different sub-functions. The way in which the components are interrelated is schematically presented in the Analytical Framework (see Figure .3.1).

Figure .3.1 Analytical framework (reference is made to relevant sections in report)



Note: t = time, t + x indicates that impacts may materialise later in time.

3.1 External drivers

3.1.1 External drivers of the functional profiles

External drivers are developments in the contextual environment (i.e. the environment that cannot be influenced) which are expected to determine the development of the subject. In each of the functional profiles such drivers are identified. This paragraph presents an overview, organising the drivers in five categories and 21 subcategories (see Table 3.1).

Table 3.1 External drivers for the sub-functions, their estimated relevance and certainty. Certainty scores adapted from Annex 6.3 in the First Interim Report (see also 3.1.3.)

External drivers																
category	subcategory	nr of times mentioned	estimated degree of certainty	2.3 Algae Aquaculture	2.4 Blue Biotechnology	3.6 Marine mineral resources	3.3 Ocean energy	3.2 Offshore wind	3.7 Desali-nation	4.3 Cruise tourism	6.1+6.2 Maritime Security & Surveillance	6.3 Environmental monitoring	1.2 Shortsea shipping	3.1 Oil, gas & methane hydrates	4.1 Coastline tourism incl. marinas	5.1 Coastal protection
Demography	population growth	1	++						x		x					
	ageing	3	++		x					x		x				
	urbanisation	1	++													x
	increasing water and food scarcity*	2	++	x					x							
	increasing international migrations	1	+/-								x					
Economy and market	economic climate, economic crisis	5	--							x	x	x	x		x	x
	globalisation/increasing internat. competition	13	+	x	x	x	x	x	x	x	x	x	x	x	x	x
	striving after self-reliance	4	+			x		x	x					x		
	increasing economic role SE Asia	3	++		x			x	x							
	increasing price volatility	3	-				x	x	x							
	increasing scarcity of raw materials	1	++			x										
	increasing scarcity of fossil fuels	8	++		x		x	x	x	x			x	x	x	
Technology and science	upcoming role SE Asia in R&D	2	+			x			x							
	technology is driver for growth	4	-	x	x		x					x				
Environment, climate change	pressures on environment/space**	5	++				x	x	x			x		x		
	climate change, sea level rise	4	+	x								x			x	x
	freshwater availability / droughts	1	-						x							
Politics and institutions	stricter environmental regulations	9	+/-			x	x	x	x	x	x	x	x	x		x
	increasing role of EU	6	+/-			x	x	x	x		x		x			
	retreating public sector	1	-									x				
	development of 'weak states'	1	-								x					
number of relevant external drivers				4	5	6	7	8	12	5	7	8	5	5	4	5

** increasing water scarcity, caused by increasing demand for water by increasing population and increasing per capita use. This is different from water stress caused by decreasing supply, as a result of climate change, intended under 'freshwater availability/droughts'. ** pressures on the environment/space: physical changes in the environment and reduced availability of space, as a result of socio-economic use and waste discharges.*

Main categories of drivers

Analysing the main categories of drivers, Economy, comprising several sub-drivers, is clearly the most strongly represented driver.

Drivers per development stage

Looking at the drivers per stage of development, it seems that four of the nineteen drivers are strongly linked to the development stage.

The first is technological development, which is most often identified as an external driver for developing sub-functions. This can be explained by the pioneering character of these sub-functions.

The drivers 'increasing economic role of SE Asia' and 'price volatility' primarily affect growing and emerging sub-functions. The first could be explained by the swift adaptation in SE Asia to growing markets. Only in Environmental monitoring SE Asia has not (yet) taken up a similar role which may be linked to the specific nature of this sub-function which is strongly determined by public spending. Price volatility is primarily affecting growing sub-functions as there stability is still rather limited.

The fourth driver is the economic climate, which plays mainly a role in growing and mature sub-functions. This was also shown by the recent financial and economic crisis when, for instance the demand for shortsea shipping services and cruise tourism saw a clear dip in the year 2009.

Looking at the number of drivers per development stage, the table shows that in the growing phase on average more relevant external drivers (which can only be influenced to a limited extent by policy interventions) are active than in the development and maturity phase. This suggests that the growing sub-functions potentially might be more difficult to steer than both developing and mature sub-functions. This issue will be taken up at a later stage in the study.

Most and least frequently mentioned drivers

Globalisation and increasing international competition are relevant for all sub-functions investigated, thus providing a strong urge to look beyond the EU borders. In most, but not all, sub-functions this driver appears to be seen as a threat. The challenge could then be to look for the opportunities that globalisation offers.

Political and regulatory commitments to sustainability are mentioned 9 times. For some sub-functions this is seen as a constraint or a source of unequal playing field (e.g. shortsea shipping), while for others it is a main incentive to growth, because it absolutely (environmental monitoring) or relatively favours the sub-function (offshore wind, ocean energy).

Increasing scarcity of fossil fuels is a recognised and here re-confirmed driver for the majority (8) of the sub-functions investigated. As with sustainability, some sub-functions are favoured by this trend (offshore wind, ocean energy), while others are affected adversely (desalination, tourism). The effect on the oil sub-function itself is ambiguous. Increasing scarcity signals the end of activities, but increasing prices are at the same time incentives to new explorations.

Seven of the drivers are mentioned in one sub-function only, and an additional two in two sub-functions. This gives an indication that in their details, the sub-functions have a quite diverse character. General conclusions and recommendations should therefore be treated cautiously.

Some demarcation issues

For some of the drivers the demarcation between contextual and transactional environment is not sharp, so a choice must be made:

- Technological development is an important factor in virtually all sub-functions. In most cases however, this development is driven by the sector itself, in response to or in anticipation of societal demand. As such, technological development forms part of the Response Capacity, discussed in par. 3.2. Here in par. 3.1 the scope is restricted to world-wide, external technological developments that offer new growth potential, such as ICT, nanotechnology, DNA-technology. With this view, technological development plays a role only in sub-functions Micro-algae, Marine resources, Ocean Energy (most notably in Forward Osmosis technology) and Environmental Monitoring.
- EU policy is an external driver for non-governmental stakeholders, while for DG Mare it is part of both the contextual and the transactional environment. On balance the bias is on the external character, so we will in the following consider EU policies as external drivers.
- In public opinion on and acceptance of certain technologies, the bias is on acting as a constraint, assuming that public opinion can be influenced (e.g. in the acceptance of near-shore wind farms). In such cases public opinion is aroused by the technology, rather than by a broad societal trend. This is different in matters of environmental protection; here one can discern a broad growing pre-occupation with sustainability over the past decades. Summarizing: because the bias is on constraint, in the follow-up, we will look upon matters of public opinion and public acceptance as constraints.

3.1.2 A check on completeness - comparison with the First Interim Report

As a check on completeness, the external drivers of the sub-functions were compared to those in Annex 6.3 of the First Interim Report. This leads to the following observations:

- Only one of the socio-cultural trends as mentioned in the FIR was mentioned in the functional profiles: increasing migrations. This trend is included in table 3.1 under Demography. A second trend can be regarded as at least related to socio-cultural trends, namely the trend towards ever stricter environmental regulations. This is part of the political and institutional trends, thereby putting the emphasis on the formalized outcome of a change in public opinion. We conclude that the involvement of society in maritime affairs is too indirect to make these trends clearly visible.
- Droughts resulting from climate change causing severe ecological damage (and hence migrations); marginalization of certain countries vs. integration in a world economy; and emerging multi-lateralism between several power blocks, as opposed to the bi- or monolateralism of the past decades, were not identified as relevant external trends. We conclude that for these trends the link with the selected maritime functions is not sufficiently obvious.
- Resource efficiency is not identified as a trend in table 3.1, but it is represented in water stress, scarcity of fossil fuels and scarcity of raw materials.

3.1.3 Estimated certainty of the trends identified

In chapter 2 we assumed that the external drivers would all develop in such a way that they favoured or at least were non-obstructive to the potential developments. Of course the questions 'what will happen if these drivers develop in a different direction' and 'what will we do when that happens' still need to be properly addressed.

In Work Package 3, scenarios will be developed for some of the sub-functions. Instrumental in the construction of scenarios is the identification of external drivers which are both relevant and uncertain. As a prelude to that, in table 3.1 the external drivers are scored on relevance and certainty. The indicator for relevance is the number of times a trend was mentioned in the functional profiles, thus giving an impression at the combined level of all sub-functions. The degree of certainty was estimated by the authors in Annex 6.3 of the First Interim Report, copied here in slightly adapted form. The considerations are:

- Demographic trends: there is broad consensus in the literature cited in the First Interim Report on the general direction and pace of these trends.
- Economic and market trends are more controversial. In the long term, growth may be expected and the financial crisis will be overcome, but for the time horizon of 2025 developments are very uncertain, especially in Europe. Globalisation and striving for self-reliance are both quite persistent trends in themselves, therefore rated a '+'. The uncertainty arises where these two trends meet, counteracting each other. The increasing economic role of SE Asia is regarded as a relative certainty, at least for the coming decade; related to that, also increasing scarcity of fossil fuels and raw materials are regarded rather certain. Price volatility will depend on the way global governance will be shaped. That can develop in very different ways, also in the short term, therefore rated as '-'.
- Technology and science: the upcoming role of SE Asia seems clear (see amongst others the R&D mining results, section 3.3), therefore '+'. New technologies on the contrary will still have to prove their (economic) viability for the sub-functions, therefore rated '-'. Technological innovation, as explained, is a relative certainty, but part of the Response Capacity.
- Environment and climate change: pressures on the environment and on the available space are consequences of economic and demographic trends. As these are growing, so are the expectations for the resulting environmental pressures. A possible way to reverse the trend would be a transition to sustainable practices world-wide, and though this is a desired future state, it is not expected within the time horizon of this study. Climate change and sea level rise are expected to continue. Relatively uncertain is increased droughts by climate change. If, where and when these will occur is not clearly discernible yet from natural variability.
- Politics and institutions is overall the most uncertain category of drivers. By its nature it should include normative uncertainties, i.e. uncertainty in the ways the general public looks on the tasks and roles of EU-, national and local authorities. Recent developments in Finland and the Netherlands show that in this respect, different courses can be taken. At the same time, the trends in the recent past of increasing environmental regulations, increasing role of the EU and retreating public authorities cannot be denied.

Conclusions from table 3.1, in terms of combined estimations of relevance and certainty:
- The top-5 for combined scores on relevance and uncertainty are: economic climate, technology, increasing price volatility, stricter environmental regulations, and increasing role of the EU. These trends will provide the differentiating factors between scenarios.
- The top-5 for combined scores on relevance and certainty are: increasing scarcity of fossil fuels, globalisation, increasing pressures on the environment, increasing role of SE Asia and ageing population. These trends will need to be included in all of the scenarios.

3.2 Response capacity of sub-functions

The capacity and capability of sub-functions to respond to the above external drivers is crucial for shaping the future – the so-called response capacity of the sub-function. Similar terms are resilience or adaptative capacity. The focus is here on the EU-parts of the sub-function, taking into account the non-EU-parts as a reference. The response capacity is determined by a variety of elements, which include:
- *Adjustment capacity to new regulation,* including those in the area of environment, energy and emission;
- *Structure and organisation*, covering the overall structure of the sub-function in terms of, for example, enterprise composition (size), specialisation and segmentation, economies of scale and scope, geographical clustering, company formation, growth and closure, etc.;
- *Firm strategies and business models*, covering the different strategies followed by companies and organisations (e.g. cost-based, innovation-driven, branding & marketing);

- *Production process,* including the economies of scale and existing (in-)efficiencies in the sub-function
- *Industrial innovation and technological development*, covering the management and organisation of production processes within the sector including, for example, technology utilisation, but also product and service development;
- *Value chain relationships*, covering the upstream (backward) and downstream (forward) linkages between industry (and other) sectors and markets.

It is through the interplay between the above elements that the 'resilience' of EU industry is determined, and that industrial competitiveness and market performance is attained – with profitability, productivity and employment as important outcomes.

Adjustment capacity to new regulation: crucial for the mature sub-functions

New regulations are affecting in particular the mature functions including Shortsea shipping, Oil and gas exploration, Coastline tourism and Coastal protection. The Oil and gas exploration sector appears to be responding well to the 2010 Deepwater Horizon oil spill and its aftermath, including new regulation on safety. Oil and gas exploration is a large sector with deep pockets, allowing it to make the necessary investments and adjust to new realities and pressures.

Quite different is the situation in short-sea shipping, where adjustment to comply with new emission regulation is slow – especially from individual ship operators who have already major problems to keep up in a very competitive environment. By the same token, Coastline tourism is demonstrating a rather modest capacity to respond to new regulations, although there is much differentiation by Sea basin: response capacity of tourism operators in the Baltics and the North Sea is considered higher than in other Sea basins. In Coastal protection, response capacity can be limited due to the involvement of (local) bureaucracies in the environment and planning domain.

Structure of the sub-function: a crucial variable that differs between development stages

The structure of the sub-function differs markedly between the sub-functions, and the development stage is an important differentiator here. Sub-functions in the *(pre-)development stage* all suffer from the limited size of the sector and the limited critical mass (e.g. Algae Aquaculture, Blue Biotechnology). EU players tend to be more fragmented and tend to depend on other players in the value chain, e.g. mining companies (Marine mineral resources) or utility companies (Ocean renewable energy).

Sub-functions which are in a *growing phase* tend to be better structured: EU players tend to be leading in the business through several large multinational companies (e.g. Offshore wind) or by a strong command over the supply chain. Not all sub-functions in this phase are equally well-placed, and Environmental monitoring is for instance suffering from a limited size of the sector, while EU players in the Desalination sub-function face major competition from Korean, Japanese and Chinese players, which prevents them to upscale.

Mature sub-functions have had time enough to establish a solid industry structure. Mature sub-functions can be dominated by large-scale operators (Oil & gas, Coastal protection) or consist of a mix of fragmented operators with some large players supplemented by a large number of small operators (Shortsea shipping, Coastal tourism).

Table 3.2 Overview of elements of response capacity by sub-function

Response capacity and commercialisation potential	2.3 Algae Aquaculture	2.4 Blue Biotechnology	3.6 Marine mineral resources	3.3 Ocean energy	3.2 Offshore wind	3.7 Desalination	4.3 Cruise tourism	6.1. + 6.2. Maritime Security and Surveillance	6.3 Environmental monitoring	1.2 Shortsea shipping	3.1 Oil, gas & methane hydrates	4.1 Coastline tourism incl. marinas	5.1 Coas
Adjustment capacity to new regulations													
Structure of subfunctions										- Slow adjustment to comply with emission regulations	- Good response to Deepwate Horizon oil spill	Adjustment/institutional capacity to new regulation varies (strong in Baltics, poor in Mediterranean and Black Sea)	- Slow re involvem
	- Limited critical mass	-Limited size of sector	- EU has limited mining companies in a leading position	- Dependence on utilities, industrial strength, financials including venture capital	- Leading manufacturers are from EU	-EU players face major problems in competing with Korean, Japanese and Chinese players (10-fold investments)	- Fleet expansion slowing down	- Potential for efficiency due to interoparability and integration measures	- Limited size of sector	- Further pressure due to concerns over refineries' ability to meet demand for alternative fuels (inputs)	-Large size of sector & export potential (with much investment power)	- Lack of homogeneity / proliferation of micro-companies leads to limited critical mass required for innovation and change	- EU dred globally
							- Competitive and dedicated EU shipyards, operators and port authorities	- Slow response due to involvement of bureucracies (incl. military and civil authorities)	-Increased competition will lead to responsiveness, value added and efficiency of commercial actors and services	- Power of shippers larger than of ship operators		- Lack of vision on value propositions at territorial level due to large sector fragmentation	
Business models												- Large scale of sector induces complacency (Mediterranean)	
	Large industrial players to enter this business (pharmaceutical, cosmetic, chemical)	Large industrial players to enter this business (pharmaceutical, cosmetic, chemical)	EU players are leading in dredging, drilling, cutting, transport and ROV	- Involvement of large companies in RD&D	- Dedicated ship development	- No clear response to global competition	- Inclusion of port authorities in serving the sector	- Government-based activity (political rather than market driven, proneness to public budget cuts)	- Government-based activity (political rather than market driven, proneness to public budget cuts)	- Diversities in player's potential to reach economies of scale, since bigger ships more capacity to invest and adjust faster	- Boost In Environmental impact reduction techniques (often event triggered, e.g. following Deepwater Horizon oil spill)	- Few big and innovative players capture value / limited spill-over to local economy (Turkey, S. Italy)	- Govern (political market d public bu
		Lack of market focus of new start-ups		'- Players are mobile and shift to places with energy potential and financial incentives (UK)			'- EU cruise business has strong response capacity: market segmentation incl strong marketing	-Established position of European industry	- Commercialisation potential in use of Public data	-Price competition drives increasing ship size			- Environ consider innovatio models (techniqu
							- Flexible and competitive labour (migrant workers)	-Immature business models					-Increasi vessels
Production processes							- Fleet expansion slowing down - to prevent overcapacity						
	- Production processes require upscaling	-Highly specialized production processes	-To be tested by first pilots (New Papa Guinea) (2013)		- Full life-cycle approach, C2C				-Integration of monitoring efforts in other subfunctions (e.g. offshore wind)		- Limited efficiency of production (now only some 50-60% of field exploited)		- PPP-cor improve response
Innovation Capacity / technology / innovation					- Efficiency and cost gains due to increasing unit size								
	- Lack of knowledge-sharing	Lack of knowledge-sharing between companies		- Research efforts still fragmented	- Strong in-house R&D capacity	- Research aims at further concentration of brine; and recovery of raw materials from brine	- Increased effort in energy efficiency improvement	Strong R&D basis rooted in military and security spending		-Low levels of technological adjustment	- Strong in-house investment power CCS / techniques to raise field outputs	- Fragmentation across sea-basins and proliferation of micro companies limit innovation (Baltic and North Sea well-placed)	- EU dred strong in
	- Strong academic basis (Germany and France)	-Limited cost-competitive sequencing solutions			- Limited cooperation between research and industry	- R&D capacity currently fragmented		Technologies in place (depending on defence-spending)		- Diversity in capacity of terminal operators to respond due to low level of organisation	- CCS / techniques to raise field outputs		
		- Strong academic basis (Germany and France)			- Technological capability to move further off the coasts and to go into deeper waters	- Improved technologies will lead to further cost reduction							
value / supply chain		- Hotspots appear close to existing research centres Gap between research community & small and large commercial players											
			- Limited cooperation in the value chain	- Dependence on port and harbour facilities and specialised vessels				Successful application requires involvement of many maritime sectors and players		- Marine equipment manufacturing present in Europe (value chains)			- Integra

Business models making all the difference

Future development potential strongly depends on the ability of the economic actors to find a business model which fits the developmental stage and the global developments. Sub-functions in the *(pre-)development stage* are still exploring for the right business models, and often have a lack of market focus. They tend to have labour- and capital-intensive production processes (e.g. Blue Biotechnology). A typical phenomenom in business in this stage is the “Valley of Death” where depleted cash resources impede entering the market. However, once confidence of the future potential is established, new players can easily enter the business, invest, upscale and grow the business. Large industrial players (e.g. from pharmaceutical, chemical and cosmetics) are expected to enter the blue biotechnology business as well as the adjacent micro-algae business. Once a pilot and demonstration project in front of the Papua New Guinea coast is successful, large mining companies are likely to rush into the marine minerals business and so will utility companies jump onto the promising parts of the ocean renewable sub-function (e.g. Tidal current).

Business models in the *growing sub-functions* tend to focus on economies of scale and efficiency gains: Offshore wind is scaling up and increasing efficiencies, while applying a full life cycle approach. Cruise tourism is growing rapidly due to the increased size in ships, which leads to sharp cost reductions per passenger, allowing to tap into new mass consumer markets. At the same time, it develops a different business model catering to niche markets. Security and environmental monitoring activities need to align their business models with government spending and procurement practices. They focus on the integration of monitoring functions across various user communities. It is difficult to grow without a clear business model: EU operators in the desalination business do not appear to have a coherent and effective answer to the global competition, which comes predominantly from Asia.

Mature markets can keep up economic activities for longer period of times, as long as their business models remain fit for new and existing challenges. Oil and gas extraction can reach new peaks once it has found techniques to explore more than the current 50% or 60% of resources. Large tourism operators keep innovating their offer, and are successful to capture the value created and limit the spill-over to other (local) economies. Adjusting existing business models to environmental concerns is another option, e.g. by closing public private partnerships, allowing dredgers to continue to be successful in the large coastal protection business. Short-sea shipping companies will also need to adjust to such pressures, e.g. by making environmental investments, by shifting to LNG, etc.

Innovation capacity: an extra-ordinary strong variety across sub-functions

Before presenting the results from Research and Technology mining below, it is noteworthy to mention the extra-ordinary strong variety across sub-functions when it comes to innovation capacity. The following patterns can be observed:

- Fragmented capacities: common in (pre-)development stage, in micro-algae and in blue biotechnology, but also in desalination and in tourism; knowledge sharing is not widespread, and research efforts are fragmented across the EU; walls between public and private sector are particularly high;
- Strong in-house capacity: typical for offshore wind, but also for oil & gas, coastal protection and to some extent cruise tourism;
- Strong academic basis: in algae aquaculture but also in various energy-based sub-functions.
- Reliance on other R&D sources: typical for security (reliance on military knowledge).

Clearly, there is no 'one size fits all' here and this diversity of innovation capacity and patterns needs to borne in mind in the further analysis.

3.3 Research and technology mining

Introduction to Research and technology mining

The technical proposal already stated that an important part of the study consists of the identification and assessment of technological capacity and potential of Maritime functions and sub-functions in Europe. However, the scope of the subject matter is so wide that technology mining could be easily a sheer endless task. We have therefore focused this exercise on 10 sub-functions where we expect a reasonable or high amount of research and development. [25] [26]

When defining the sub-functions retained, we have defined the set of economic activities and Science & Technology domains that are related to the maritime sub-function and defined as detailed as possible 'keywords' that will set out the 'perimeter' of each cluster.

We have collected the relevant information from the Thomson Reuters service as indicated in the proposal, and have asked Thomson Reuters the following questions:

For Patents:

- List of leading European and Non-European institutions/actors (universities, companies etc) in terms of numbers of patents;
- Citation analysis: ranking of institutes/actor by patent citation frequency; ranking of countries by patent citation frequency;
- Geographic analysis: number of EU single country patents, intra-European and extra-European patents.

For Scientific Articles:

- List of the top institutes/actors within the cluster in Essential Science Indicators in terms of citations, number of papers and citations per paper;
- List of the leading European institutions/actors in terms of numbers of citations, number of papers and citations per paper;
- Number of domestic, intra-European, extra-European co-publications by leading research institutions / actor;
- Number of EU single country publications, intra-European co-publications and extra-European co-publications;
- Number of citations, number of papers and citations per paper by country.

Below, we present the main outputs of this analysis. The relevant background sub-function reports provide more details.

[25] Shortsea shipping, cruise tourism and coastal tourism not included.

[26] We have made use of an analysis carried out for this study by Thomson Reuters, and the activity has been supervised by IDEA Consult, a sister company of Ecorys.

Strong increase of patent activity over time

Table 3.3 Overview of patent activity in the period 2001-2010

Patents				increase in %	increase in %	% of total	% of total
Year	*2001*	*2006*	*2010*	*2001 - 2010*	*2006 - 2010*	*2001*	*2011*
Offshore Wind	28	62	210	750%	339%	2%	6%
Ocean Renewable Energy	110	166	730	664%	440%	8%	20%
Maritime Security & Surveillance	51	160	186	365%	116%	4%	5%
Environmental Monitoring	127	195	382	301%	196%	10%	10%
Desalination	202	284	590	292%	208%	15%	16%
Algae Aquaculture	218	241	534	245%	222%	17%	14%
Blue Biotechnology	169	223	408	241%	183%	13%	11%
Oil & Gas	156	182	340	218%	187%	12%	9%
Marine Mineral	93	103	193	208%	187%	7%	5%
Protection against flooding	155	119	166	107%	139%	12%	4%
Total of the subfunctions analysed	1309	1735	3739	286%	216%	100%	100%

Source: Thomson Reuters, 2011

Conclusions: What becomes clear from the table above is the high amount of patents in pre-development sub-functions: Ocean Renewable Energy (20% of total), Algae Aquaculture (14%) and in Desalination (16%); other high amounts can also be noticed in Blue Biotechnology (11%)and Oil & Gas extraction (9%).

Also noticeable is the strong increase (286%) in patent activity for all sub-functions analysed in the period 2001-2010. Overall patent activity worldwide has roughly doubled in this period, but has almost quadrupled for these maritime sub-functions. Spectacular increases are observed in patenting in Offshore wind, Ocean renewable energy, and to a lesser extent Maritime Security & Surveillance and Environmental Monitoring over this period.

Overall, the amounts of patents[27] filed demonstrates the high degree of innovation and research taking currently place in the marine sub-functions.

A boom in publications on marine sub-functions

Table 3.4 Overview of publication activity in the period 2001-2010

Publications				increase in %	increase in %	% of total	% of total
Year	*2001*	*2006*	*2010*	*2001-2010*	*2006-2010*	*2001*	*2011*
Environmental Monitoring	116	90	1724	1486%	1916%	9%	36%
Offshore Wind	75	11	266	355%	2418%	6%	6%
Blue Biotechnology	227	417	684	301%	164%	17%	14%
Oil & Gas	233	374	673	289%	180%	18%	14%
Maritime Security & Surveillance	12	21	34	283%	162%	1%	1%
Ocean Renewable Energy	143	257	392	274%	153%	11%	8%
Desalination	30	23	80	267%	348%	2%	2%
Algae Aquaculture	241	349	494	205%	142%	18%	10%
Protection against flooding	38	46	76	200%	165%	3%	2%
Marine Mineral	200	277	378	189%	136%	15%	8%
Total of the subfunctions analysed	1315	1865	4801	365%	257%	100%	100%

Source: Thomson Reuters 2011

27 The count of patent records refer to patent families or inventions, and not to individual patent documents, e.g. the European granted patent, and the US granted patent for a single invention familiy is counted as "1" in aggregate in all the analyses.

Conclusions: The strong R&D activity in the marine sub-functions analysed is confirmed by the boom in publications: from an overall 1,300 publications in 2001 to almost 5,000 publications in the year 2010. This increase has been particularly strong in environmental monitoring, now responsible for more than 1/3 of all publications analysed. Other much publicised sub-functions are Algae Aquaculture, notably in growing aquatic products and Blue Biotechnology. Oil & gas is currently also a subject of strong academic interest.

Varying strength of EU patenting within the global context

The relative strength of the EU varies strongly by sub-function. A geographic patent analysis has been carried based on priority country filing in the period 2001 - 2010. Priority countries are typically the countries where the invention was carried out and therefore used as a proxy to determine levels of patenting output by a particular country. This measurement is used in the absence of an inventor country within the patent data, as this field is not present across many authorities.

A number of important observations should be made in this analysis. A specific roleis played by China. Whereas in most countries the number of patents that is filed in a country reflects domestic applicants, in China the share of foreign patentees has been growing compared to domestic applicants.[28] This points to another important aspect in this analysis, i.c. there might be a difference between the country where the invention has emerged and where it is carried out (filed). Finally there may be different patenting cultures between countries. This not only reflects the decision to patent an invention (e.g. the lack of a European patent may have an influence in this respect), but may also regard the level at which patents are filed[29].

Table 3.5 **Share of EU in global patents (priority country analysis) and global citations per sub-function**

Patents 2001-2010	Patents EU	Non-EU	PCT*	Citations EU	non-EU
Offshore Wind	37.5%	45.9%	16.5%	44%	56%
Ocean Renewable Energy	35.5%	49.2%	15.3%	44%	56%
Algae Aquaculture	31.2%	53.2%	15.6%	46%	54%
Oil & Gas	22.1%	58.2%	19.8%	47%	53%
Maritime Security & Surveillance	17.6%	64.5%	18.0%	35%	65%
Environment Monitoring	17.5%	67.9%	14.5%	28%	72%
Marine Mineral resources	16.0%	70.3%	13.7%	40%	60%
Desalination	15.0%	73.2%	11.7%	38%	62%
Blue Biotechnology	12.7%	70.8%	16.5%	46%	54%
Protection against flooding	10.5%	83.7%	5.8%	37%	63%

* PCT = Patent Co-operation Treaty (global patents)

Conclusions: Based on the above patent analysis, the EU is clearly leading in offshore wind and ocean renewable energy sources, where more than 1/3 of all global patents counted have been filed. An almost similar performance can be recorded in the sub-functions Ocean Renewable and Algae Aquaculture, where over 30% of patents are filed in the EU. The EU patent activity is less dominant in other areas, with still reasonable performance in Oil & Gas but less so in other sub-functions analysed. The share of patents filed with the Patent Co-operation Treaty is rather stable across sub-functions (with the exception of Coastal protection).[30]

28 Eve Y, Zhou, and Bob Stembridge (2011) "Patented in China: The present and future state of innovation in China. Thomson Reuters.

29 For example Japan is generally regarded to patent innovation at a lower component level than European countries.

30 Costs of filing a patent within the Patent Co-operation Treaty can differ from filing costs and documents required within the respective national / EU Patent Offices.

The EU's dominance is however much stronger in the area of publications, as measured through the number of citations. It has brought forward the authors of at least 4 out of 10 authors in a wide range of sub-functions, from those in the energy and raw materials to the living resources domains. Environmental monitoring is the only domain where the EU has generated less than 30% of global publications analysed.

The above findings point to major discrepancies between the patent and publication patterns. An emerging conclusion is that the EU has excellent academic and scientific capacities in the sub-functions analysed, but considerably less commercial potential to commercially exploiting scientific research better in terms of patent output.

EU leading on a number of subfunctions in global patenting

The Table 3.6 below shows that in the sub-functions analysed the EU is leading in terms of total patents carried out on EU-27 territory, with slightly more patents than in the US. Japan (19%) is ranking third, followed by China.

However, this is not valid in all fields. In fact Europe’s leadership is only shown in a number of subfunctions. In terms of global patent output, Algae Aquaculture has generated the most patents filed (5627 patents) in the last decade. Equally interesting for patenting seems to be Desalination (5364 patents), Oil & Gas (4820 patents) and Blue Biotechnology (4227).

In terms of global share of patenting, China is leading in Desalination (21%) and the US is strongest in Oil & Gas with nearly 1 in 3 patents carried out in the US, but also leading in Environment Monitoring (38%) and Maritime Security & Surveillance (35%) and Marine Minerals. The picture of Europe’s strength in algae aquaculture, ocean renewable and offshore wind is also apparent.

Table 3.6 Priority countries of patents (absolute – upper table, relative – lower table) 2001-2011

Global patent concentration - EU vs. competitors	EU Member States + EU Patent Office	China	US	Japan	South-Korea	Worldwide
Algae Aquaculture	1755	756	1022	1416	261	5627
Desalination	792	1129	921	1069	301	5364
Oil & Gas	1063	371	1415	213	53	4820
Blue Biotechnology	537	570	563	1181	269	4227
Ocean Renewable Energy	1380	631	526	425	403	3886
Environment Monitoring	576	331	1241	669	237	3287
Maritime Security & Surveillance	404	153	800	325	80	2301
Marine Mineral	361	339	424	336	196	2254
Coastal Protection	209	109	185	842	374	1983
Offshore Wind	479	156	170	133	43	1276
Total	**7556**	**4545**	**7267**	**6609**	**2217**	**35025**

Global patent EU vs. competitors in % of global	EU Member States + EU Patent Office	China	US	Japan	South-Korea
Algae Aquaculture	31%	13%	18%	25%	5%
Desalination	15%	21%	17%	20%	6%
Oil & Gas	22%	8%	29%	4%	1%
Blue Biotechnology	13%	13%	13%	28%	6%
Ocean Renewable Energy	36%	16%	14%	11%	10%
Environment Monitoring	18%	10%	38%	20%	7%
Maritime Security & Surveillance	18%	7%	35%	14%	3%
Marine Mineral	16%	15%	19%	15%	9%
Coastal Protection	11%	5%	9%	42%	19%
Offshore Wind	38%	12%	13%	10%	3%
Total	**22%**	**13%**	**21%**	**19%**	**6%**

EU leading on all domains in scientific citations

Regarding priority countries in terms of scientific citations, EU research institutes and scientists working for EU research institutes[31] are leading in all fields. They are even issuing over 40% of global publications in the Environment Monitoring (46%), Algae Aquaculture (44%), Oil & Gas (44%), and Ocean Renewable Energy (43%), followed by Blue Biotechnology (40%). Only in the case of Desalination (28%), it scores lower than one third of global publications.

Overall, it can be concluded, that the EU is accountable for twice as many publications as the US, both continents still far ahead its main competitors.

Table 3.7. Priority countries of scientific citations (absolute – upper table, relative – lower table)

Scientific citations - EU vs. competitors	EU Member States	China	US	Japan	South-Korea	Worldwide
Algae Aquaculture	13359	866	4620	1322	417	30577
Desalination	892	175	502	107	73	3179
Oil & Gas	14392	1388	5441	1801	487	32837
Blue Biotechnology	19451	1180	12915	917	585	48693
Ocean Renewable Energy	6170	243	2417	647	256	14466
Environment Monitoring	17513	642	8114	1585	291	38414
Maritime Security & Surveillance	2024	38	1769	379	0	5422
Marine Mineral	7377	1559	2943	1076	262	19861
Coastal Protection	1970	532	1050	100	23	5367
Offshore Wind	5499	454	2453	190	42	11932
Total	**88647**	**7077**	**42224**	**8124**	**2436**	**210748**

31 Publications are counted regardless the citizenship of the scientist, but considering the location of the research institute/university

Scientific citations - EU vs. competitors in % of global	EU Member States	China	US	Japan	South-Korea
Algae Aquaculture	44%	3%	15%	4%	1%
Desalination	28%	6%	16%	3%	2%
Oil & Gas	44%	4%	17%	5%	1%
Blue Biotechnology	40%	2%	27%	2%	1%
Ocean Renewable Energy	43%	2%	17%	4%	2%
Environment Monitoring	46%	2%	21%	4%	1%
Maritime Security & Surveillance	37%	1%	33%	7%	0%
Marine Mineral	37%	8%	15%	5%	1%
Coastal Protection	37%	10%	20%	2%	0%
Offshore Wind	46%	4%	21%	2%	0%

Asia has the strongest position in companies that are filing patents

When looking at leadership of the individual top 20- organisations in patenting (the assignees), Analysing all patents registered by the 20 most important organisations worldwide in each sub-functions makes clear that Asia is by far the most active companies in the marine sub-functions analysed, with 60% of patents filed by all top-20 companies in all subfunctions together, followed by the EU with 19% and the US third place (18%) . The US is only leading in environmental monitoring and also in maritime security & surveillance – due mostly to the strong military innovation capacity in these areas. This can be influenced by the size of the assignees and the distribution of patenting patterns (equally divided among a large group of a few top institutes).

Within the below context, the EU is clearly in a leading position in all energy related sub-functions: it has generated around half of the reviewed patents in Oil & gas, Offshore wind, and Marine mineral resources, while 1/4 of the reviewed patents in Ocean renewable energy sources.

The EU's leadership position is much smaller in the remaining areas, and this is likely to be for two reasons: either EU players are not able to compete with the innovative strength of other global players (e.g. the Desalination and Coastal protection sub-functions – where all big innovators are Asian) or EU players are relatively small and fragmented, so that individual players are not able to compete with global players (e.g. Algae aquaculture, Blue biotechnology).

Table 3.8 Geographical distribution of top-20 assignees patents (absolute numbers)

Top-20 assignees	EU	US	Asia	Other	Total
Oil & Gas	8	6	3	3	20
Marine Mineral	10	2	7	1	20
Offshore Wind	9	3	7	1	20
Ocean Renewable Energy	6	4	10	0	20
Algae Aquaculture	2	0	17	1	20
Environmental Monitoring	2	8	10	0	20
Blue Biotechnology	2	1	13	4	20
Desalination	2	2	16	0	20
Maritime Security & Surveillance	2	9	9	0	20
Protection against flooding	0	0	20	0	20
Total subfunctions analysed	43	35	112	10	

Table 3.9. Geographical distribution of top-20 assignees patents (share in total)

Top-20 assignees	EU	US	Asia	Other	Total top 20
Oil & Gas	52%	27%	17%	4%	100%
Marine Mineral	46%	8%	32%	13%	100%
Offshore Wind	45%	15%	37%	3%	100%
Ocean Renewable Energy	31%	25%	45%	0%	100%
Algae Aquaculture	14%	3%	80%	3%	100%
Environmental Monitoring	6%	42%	53%	0%	100%
Blue Biotechnology	11%	6%	62%	21%	100%
Desalination	3%	4%	92%	0%	100%
Maritime Security & Surveillance	4%	47%	49%	0%	100%
Protection against flooding	0%	0%	100%	0%	100%
% of total	19%	18%	59%	3%	100%

US has a lead position in institutes that publish

Opposite to the strong position of Europe in scientific publications, the US represents the top publishing institutions. When linking publications for the sub-functions to the geographical locations of respective research institute or university, where the scientist is located, the US is clearly in a leading position overall. in all energy related sub-functions. The US dominance can be concluded from the fact of being attributable of 52% of global publications for all sub-functions analysed. With at least 1 in 3 of the top-20 research institutes and universities being located in the US. Again this deviation may be linked to a more fragmented institutional structure in Europe where publications are distributed among more institutes and a few top institutes are lacking.

The only exceptions to this rule being Algae aquaculture, where EU research institutes account for 2/3 of publications, and marine mineral resources (45%) and Desalination (34%) in which Asia is leading compared to the US and the EU.

Table 3.10 Geographical distribution of top-20 assignee research institutes combined (absolute numbers)

Publications of top-20 assignees	EU	US	Asia	Other	Total
Oil & Gas	3	9	3	5	20
Marine Mineral	5	5	9	1	20
Offshore Wind	5	10	3	2	20
Ocean Renewable Energy	6	10	2	2	20
Algae Aquaculture	10	1	5	4	20
Environmental Monitoring	3	13	3	1	20
Blue Biotechnology	7	9	1	3	20
Desalination	3	5	7	5	20
Maritime Security & Surveillance	8	12	0	0	20
Protection against flooding	7	7	3	3	20
Total subfunctions analysed	57	81	36	26	

Table 3.11. Geographical distribution of top-20 assignee research institutes publications (share in total)

Publications of top-20 assignees	EU	US	Asia	Other	Total top 20 global
Oil & Gas	11%	50%	19%	20%	100%
Marine Mineral	22%	30%	45%	3%	100%
Offshore Wind	29%	50%	14%	6%	100%
Ocean Renewable Energy	22%	56%	10%	11%	100%
Algae Aquaculture	66%	5%	25%	4%	100%
Environmental Monitoring	13%	72%	15%	0%	100%
Blue Biotechnology	34%	44%	8%	14%	100%
Desalination	16%	29%	34%	21%	100%
Maritime Security & Surveillance	36%	64%	0%	0%	100%
Protection against flooding	33%	31%	30%	6%	100%
% of total	23%	52%	18%	7%	100%

3.4 Constraints and framework conditions

Framework conditions cover a broader range of determinants shaping the business environment and therefore the response capacity of industry. They may be influenced directly or indirectly by policy measures. Essentially, this covers aspects of the business and operational environment that are external to individual (and collective) business operations or firms within the sector, such as knowledge, labour force and skills, but also access to finance.

When reviewing the sub-functions, the following elements appear essential.

Geographic constraints: taking into account natural handicaps

Certain functions are faced with geographic constraints, such as water depth (cruise tourism), limits to the types of cargo to be handled and distances to be travelled (short-sea shipping), but also freshwater and space requirements (algae) and depletion of natural resources within the European waters (oil & gas). These geographic constraints act as barriers, although the exact limits may be shifted by innovations (e.g. improved techniques to boost outputs from oil fields) or changes in business models (e.g. closed photobioreactors in the case of micro-algae growing).

Access to finance: crucial in the (pre-)development stage

Access to finance is amongst the most important barriers for the sub-functions in the (pre-) development stage. Clearly, investment risks are substantial in this phase, but so can be the rewards. The economic and financial crisis has made access to finance even more difficult, as traditional banks are more prudent than ever before. Furthermore, banks are often not well-placed to assess business plans and make risk assessments in these specific sub-functions. In the marine mineral resource mining, one mining initiative (Neptune) had to end its activities for this very reason. The investments required in this sub-function easily amounts to € 400-500 mln. per project, similar to those in the Ocean renewable energy sector. In itself, these amounts could be secured by investments from large companies (mining companies, utility companies), however the risk profile is currently still considered too high by these companies. Hence, and in the absence of public financial support for these activities, a chicken-egg dilemma easily emerges and progress is only possible once bold investors are stepping into this activity – e.g. the Nautilus mining company in the case of marine mineral resources.

Access to finance is equally constraining in the living resources functions: upscaling of algae production requires additional funding, and so does research and developmental work in blue biotechnology. Typically, scientific research in these areas is generously funded by public and leading research institutes, often co-funded by FP7 grants. However, the commercial and developmental activities take place in small spin-off companies, which are more reliant on private capital. Venture capital is available at small scale and in certain locations, however not sufficiently widespread to provide an overall boost to the sector. Again, large companies (including cosmetic, health and pharmaceutical companies) are monitoring the developmental activities carefully, but they will only step in once pilot and demonstration projects have been successfully completed. They are then likely to acquire start-up companies, and invest in their upscaling. So, in conclusion, it is exactly the developmental stage – in between research and full commercial development – where funding proves to be a main bottleneck.

For other sub-functions, funding is only a bottleneck where economic actors are small and therefore without direct access to loans (e.g. shortsea shipping, coastal tourism).

Infrastructure: essential for rolling out maritime sub-functions

A range of infrastructure elements are required for the growth and expansion of maritime sub-functions – more so than in the (pre-)development stages. Evidently, port infrastructure and sufficiently deep waterways are quintessential for shortsea shipping and cruise tourism as well as coastal tourism. But inland waterways and hinterland connections are equally important. For shortsea shipping especially, such infrastructure needs to be developed not only in the EU, but also in Neighbourhood countries such as Turkey, Russia, the Ukraine and North Africa – and it is in these regions that major investments are yet to be made.

Further development of renewable energy (offshore wind energy as well as ocean renewable energy sources) relies strongly on the availability of high-voltage power grid infrastructure, including cross-border connections.

Skills required: engineers wanted

Various sub-functions require high-skilled staff to overcome complex technological problems (offshore wind, ocean renewable energy sources, shipyards). Attracting these engineers is not so much a problem for larger companies, including global energy and engineering conglomerates, but much more so for smaller operators and start-ups. In some areas, such as micro-algae and high value use of marine resources, it is above all the (lack of) entrepreneurial culture which is limiting fast growth.

Coastal tourism is suffering from a dilemma: many operators are not able to generate the value added needed for attracting qualified personnel. At the same time, such qualified personnel is essential for providing the necessary value added. Low-skilled jobs are also common in the cruise ship segment, where working conditions tend to be poor. Health and safety conditions are concerns for several sub-functions, including the energy-related sub-functions.

Public acceptance: increasingly important to take into account

A range of maritime activities analysed is new to the public, living in coastal regions. Many of them are attached to the qualities of the natural environment, and likely to resist any change in their pristine surroundings. Offshore wind, oil & gas exploration and coastline tourism tend to face public resistance, and can obstruct activities if not accompanied by stakeholder consultation and mitigation measures. Large companies are especially 'suspect' and are at a disadvantage vis-à-vis local populations. Mining of mineral resources is another activity prone to public disapproval, if not carefully recognised and accounted for. It remains to be seen how pilots in developing countries succeed in this respect.

(External) policies have the power to shape the conditions for many maritime sub-functions
A wide range of policy levels is of importance to the future prospects of the maritime sub-functions studied. At the global level, the UNCLOS is the crucial legislative framework for mining mineral resources in the international waters. At the EU-level, heterogeneous institutional legal structures and a lack of standards limit the interoperability for tracking and tracing as well as environmental monitoring. A politically stable environment (particularly but not only at Member State level) is important too, for instance when rolling out offshore wind parks.

Several of the mature sub-functions rely strongly on local planning and good local governance. Coastal protection measures as well as port extensions require local permissions at the least, and are often delayed due to stringent local planning regulations and procedures. Sustainable coastline tourism requires a cooperative and transparent local government, and so does the installation of desalination plants or ocean renewable energy facilities.

Evidently, environmental regulations and their correct implementation (e.g. the ICZM and Flood directive) are important conditions for sub-functions. The linkages between such regulations and the maritime sub-functions can be diverse and complex: they tend to pose challenges to shortsea shipping and oil & gas exploration, but provide strong opportunities for environmental monitoring and coastal protection.

The subsequent chapter will present more findings on the expected environmental impacts of the sub-functions analysed.

4 Impacts, synergies and tensions

4.1 Economic impacts

In the First Interim Report, the future potential of each of the sub-functions was assessed qualitatively using '+' and '-' scores. In the detailed analysis of the 13 sub-functions undertaken within Work Package 2, assessments of the future have been made which allow for a more specific indication of the economic impacts that this future might bring. For some sub-functions a quantitative indication is derived, for others it is still qualitatively, but made more specific. Table 4.1 presents an overview of the resulting estimates for the horizon until 2020 derived from the sub-functions analysis. Subsequently, explanation behind these estimates is given.

Table 4.1 Estimated economic impacts of the future potential of the sub-functions (time horizon 2020)

Devt. stage	No.	Sub-function	GDP growth/yr	Employment growth/yr	Notes
(Pre-) dev.	2.3	Algae Aquaculture (micro-algae)	Phased growth, medium-sized by 2020		
	2.4	Blue biotechnology	Slow growth		
	3.3	Offshore renewable energy sources	7%	7%	Doubling by 2020
	3.6	Marine mineral resources	High growth		5-10,000 jobs in 2020
Growth	3.2	Offshore wind	13%	13%	Tripling from € 1.3 to 4.5 bn in 2020
	3.7	Desalination	Ca. 8.5%	Ca. 8.5%	
	4.3	Cruise	5%	5%	60% growth over the next decade
	6.1	Maritime security & surveillance	No quantification possible		
	6.3	Environmental monitoring	7%	4%	Doubling of turnover from € 4 to 8 bn in 2020; employment assumed to rise by 50%
Mature	1.2	Shortsea shipping	3-4%	0	
	3.1	Oil, gas & methane	-5%	-10%	Growth outside Europe (export)
	4.1	Coastal tourism & yachting	2-3%	2-3%	
	5.1	Coastal protection	Slow but steady growth	Less than GDP due to rising productivity	Both within and outside EU

Note: Data on size, recent growth and future potential are taken from the First Interim Report

Explanations to the estimated economic impacts

Estimation of economic growth of sub-functions in the *(pre-)development phase*:

- 2.3 Algae aquaculture: No quantification of the future potential of this sub-function is possible at this stage.
- 2.4 Blue biotechnology: growth is expected to be very much dependent on use of products in other sectors (pharmaceuticals, healthcare products). For the coming decade a slow but steady

increasing role is expected, while faster growth will only become realistic in the period thereafter.

- 3.3 Offshore renewable energy sources: based on the assumption that worldwide yearly installed capacity is expected to double yearly, but on the other hand that part of the technologies within this sub-function are expected to take off only after 2020. A doubling of turnover and employment in ten years time implies an average annual growth of around 7 percent.
- 3.6 Marine mineral resources: global annual turnover is expected to rise from virtually nothing to € 10 bn in 2020. If we assume the EU industry to capture a modest 10% this would imply already € 1 bn. In terms of employment this would result in the range of 5-10,000 jobs. Percentage wise this could be an extreme growth figure since the current level is very low.

Estimations on economic growth of sub-functions in the *Growth phase*:

- 3.2 Offshore wind: a tripling of value added of the sub-function from € 1.3 bn today to € 4.5 bn in 2020 is expected. This implies an average annual growth of around 13%.
- 3.7 Desalination: growth of GDP and employment is based on the expected growth in installed capacity, assuming the EU players can keep pace with non-EU competitors.
- 4.3 Cruise: Although the cruise industry like other sectors suffers from the economic crisis, growth expectations for the next few to ten years are favourable, mainly due to an increased penetration rate. The growth in other world regions (Caribbean) will also benefit the European shipbuilding and supply industry. An increase of 60% until 2020 implies an average annual growth of around 5%.
- 6.1 Maritime security and surveillance: The demand for maritime security and surveillance products will increase in the coming years mainly driven by increased attention for security threats and supported by increasing focus on efficiency and effectiveness in surveillance activities. Efficiency improvements will result in a somewhat slower growth in supply patterns than demand.
- 6.3 Environmental monitoring: while a doubling of turnover within the next decade is expected (implying some 7% growth year on year), employment will grow at a lower pace due to the focus on labour-extensive technologies. An estimated growth of half the turnover is expected (50% increase by 2020, or 4% year on year).

Estimated economic growth of *Mature sub-functions*:

- 1.2 shortsea shipping: transported volume will generally grow along with economic development, but with a multiplier (trade growth usually being a factor higher than GDP growth). The factor is taken to be 1.5 and therefore annual growth in the range of 3-4 percent is expected. Employment is considered to remain relatively stable due to efficiency increases taking place along the value chain. Growth expected in the supply industry related to technologies addressing the environmental impacts of shipping.
- 3.1 Oil, gas and methane hydrates: the sub-function's GVA is already declining within Europe and trying to lessen the decline through production efficiency increases. This will result in a rising decline of employment relative to GVA. Shift to gas and methane hydrates also lowers the decline rate. The recent trend is expected to continue with some 5% decline per year in value added and employment assumed to be twice this rate. *Further elaboration of this sub-function is in progress*
- 4.1 Coastal tourism: Overall size may growth a little following welfare growth, but trends affecting GVA and employment will mainly affect segments within the sub-function. The gross average is therefore set at about 2-3 percent growth. As labour intensity is rather high the growth of employment is expected to be similar to this rate.
- 5.1 Coastal protection: while climate change and sea level rise will increase the demand for coastal protection works, this trend will take decades if not centuries and only slowly increase

the need for protection works. Public budgets on the one hand and pressure from economic assets increases will define the push for increasing spending. Because of its market leadership EU marine contractors will continue exporting their services and capture part of the growth in the rest of the world.

4.2 Environmental impacts

The marine environment is under threat from the continued and rising demand for ecosystem goods and services. The Marine Strategy Framework Directive (MSFD), developed as a vital component of the Maritime Policy (EC 2008), aims at achieving an integrated and holistic approach to exploit the full economic potential of Europe's oceans and seas in a sustainable way. The implementation of the MSFD by the Member States relies on the definition of eleven descriptors[32] for sustainable development with the objective of achieving Good Environmental Status (GES) of each aspect by 2020. These descriptors integrate a number of indicators that quantify the ecological characteristics of the environment, and/or pressures and impacts associated with human activities (Cardoso et al .2010)[33].

4.2.1 Environmental impacts per sub-function

In this section, the environmental aspects of each sub-function, including both environmental benefits and negative impacts are presented (Table 4.2) and discussed. Whenever possible, a link to the MSFD pressures -impact descriptors is made. Note that the environmental aspects of sub-functions 6.1 Maritime security and surveillance, and 6.3 Environmental Monitoring are not considered in Table 4.2 , due to the specific character of these functions which are of a stronger facilitating nature. Indirectly, however, these subfunction will have a positive environmental impact as improved monitoring and surveillance data will have enable more dedicated and specific actions (e.g. in the field of combatting marine pollution and oil spills).

Table 4.2 Overview of the environmental aspects per sub-function[34]

		Benefits		Adverse impacts					
	Sub-function	Creation of new habitat	Reduction of CO2 emis-sions	High energy require-ments	Atmospheric emissions	Habitat destruction	Invasive species	Negative effects of eco-system	Water quality issues
1.2	Shortsea shipping (incl. RoRo)				X		X	X	X
2.3	Algae Aquaculture (micro-algae)		X	X			X		X
2.4	Blue Biotechnology (health, cosmetics, well-being, etc.)								
3.1	Oil, gas and methane hydrates				X				X
3.2	Offshore wind energy	X	X					X	

[32] The eleven MSFD descriptors are:
1. Biodiversity; 2. Non-indigenous species; 3. Commercial fish; 4. Food web; 5. Eutrophication; 6. Seafloor integrity; 7. Hydrography; 8. Contaminants; 9. Contaminants/Human consumption; 10. Litter; 11. Energy (noise)

[33] Cardoso, A. C., S. Cochrane, H. Doerner, J. G. Ferreira, F. Glagani, C. Hagebro, G. Hanke, N. Hoepffner, P. D. Keizer, R. Law, S. Olenin, G. J. Piet, J. Rice, S. I. Rogers, F. Swartenbroux, M. L. Tasker, and W. van der Bund. 2010. Scientific support to the European Commission on the Marine Strategy Framework Directive. International Council for the Exploration of the Sea, Copenhagen, Denmark.

[34] an update of the table is envisaged, based on the related Annex 4 of the Marine Directive (forthcoming)

		Benefits		Adverse impacts					
	Sub-function	Creation of new habitat	Reduction of CO_2 emis-sions	High energy require-ments	Atmospheric emissions	Habitat destruction	Invasive species	Negative effects of eco-system	Water quality issues
3.3	Ocean renewable energy resources (wave, tidal, OTEC, thermal, biofuels, etc.)		X			X		X	
3.6	Marine mineral resources					X		X	
3.7	Securing fresh water supply (desalination)			X				X	X
4.1	Coastline tourism, including yachting and marinas			X		X		X	
4.3	Cruise including port cities				X		X	X	X
5.1	Protection against flooding and erosion							X	

Shortsea shipping

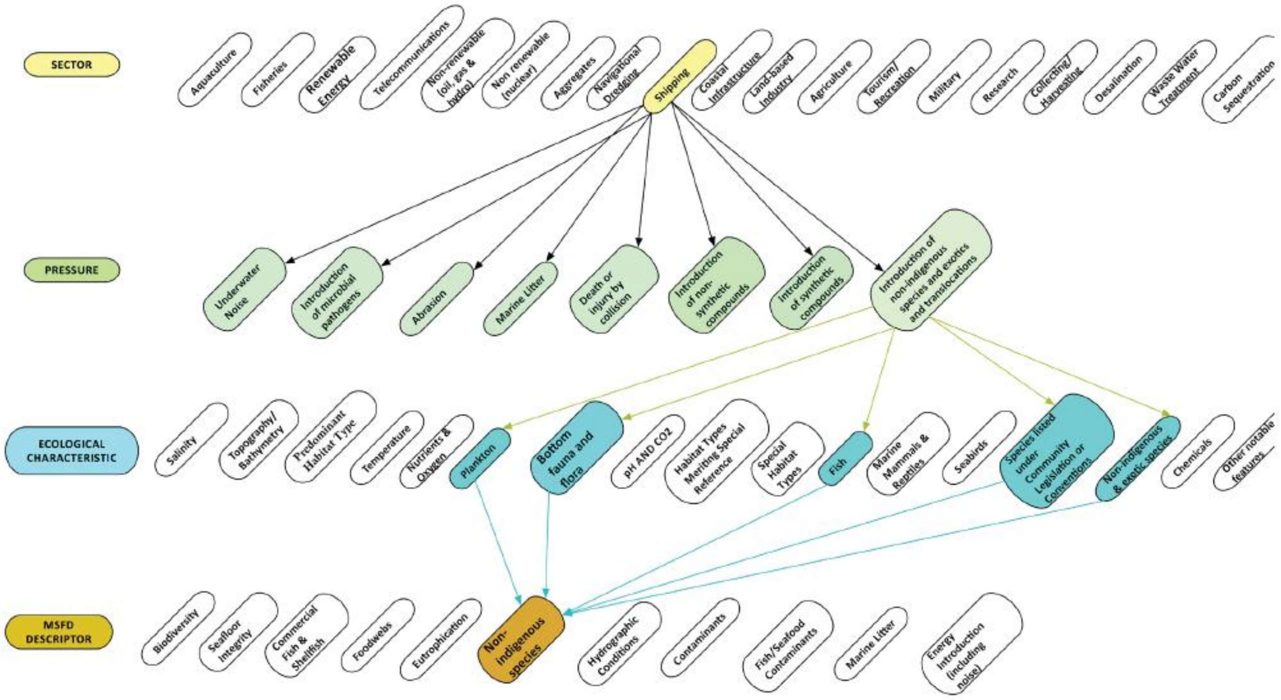
The major impacts of shortsea shipping on the environment are chemical pollution due to oil spills, discharge of oil and ballast waters and pollution by anti-fouling agents such as tributyltin (TBT). Other impacts include emissions of NO_x, particulate matter and sulphide to the atmosphere.

The number of shipping accidents in European seas due to sinkings, groundings, collisions/contacts, fires/explosions and other accidents shows that such incidents are not infrequent.

Noise has recently also become an issue of concern. Noise from ships' propellers and engines dominates the low frequency background noise in many parts of the world's oceans and seems to be growing by about 3–5 decibels per decade in deep offshore waters. There is concern that this is having an impact on marine life, particularly marine mammals.

The practice of discharging ballast waters, used for ship stabilization is considered as a major vector for the introduction of invasive species threatening the marine food web. In some cases, these species find an ecological niche in which they do not have natural predators, causing serious ecosystem damage by altering food web structure. Figure 4.1 Pressures from Shipping Sector (yellow) to ecological characteristics (blue), and bottom flora and fauna. below shows the relation between the pressure exerted by the subfunction and the MSFD descriptor 2, non-indigenous species.

Figure 4.1 Pressures from Shipping Sector (yellow) to ecological characteristics (blue), and bottom flora and fauna.



Source: FP7 ODEMM project Deliverable 1: Options for Delivering Ecosystem-Based Marine Management project

As emissions of NO_X from land-based sources decrease, there is a growing awareness of the increasingly important contribution to Europe's NO_X emissions from national and international shipping.

Algae Aquaculture

The main pressures are discharges of nutrients, in particular in coastal areas with relatively small total nutrient discharges, antibiotics and fungicides. Algae production is a rather new sector and therefore knowledge on environmental impacts is still limited.

The level of local impact varies according to production scale and farming practices, as well as local and regional hydrodynamics and chemical characteristics.

Oil and gas

Discharges of oil from offshore installations can occur from the production water, drill cuttings, spills and flaring operations. Apart from oil spillages, huge quantities of water bearing complex mixtures of salts including toxic metals and organics, both from the natural formation and from additives to facilitate production, issue from wells during oil and gas exploration. Contaminated subsurface fluids may also mix with otherwise usable groundwater.

The oil industry causes air emissions of volatile organic compounds, nitrogen oxides, hazardous air pollutants and solid wastes. Deposition of cuttings on the sea floor can have adverse effects on the marine ecology in the vicinity of the waste. Also, noise from air guns used for seismic surveys and high intensity military sonar have resulted in increased underwater background noise levels, which are also thought to have adverse effects on marine mammals.

Offshore wind energy

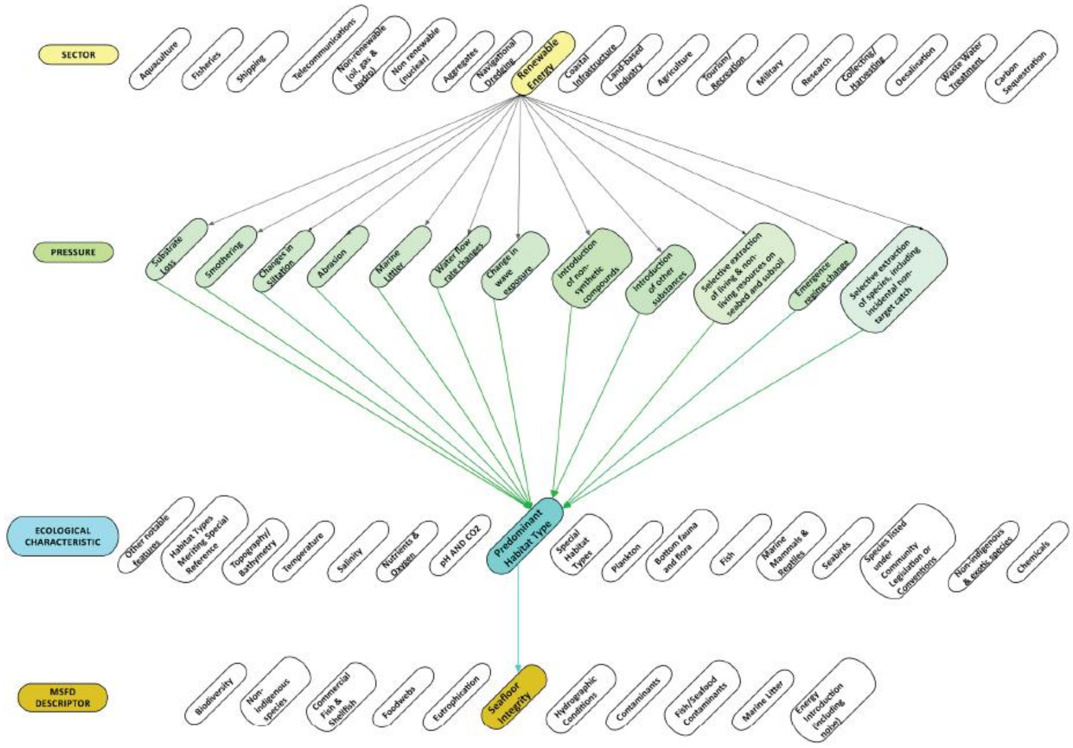
The environmental impact of individual wind parks has been studied in numerous site-specific environmental impact assessments, and is generally found to be small. In some cases favourable impacts are envisaged because of the ability of the platforms to become artificial reefs and to create new habitats. In general wind energy does not present a serious threat to marine ecosystems.

Other environmental impacts are related to the construction and installation. During the construction phase, noise and vibration from pile-driving and other works may affect the animals over a large area. The operational noise of wind farms is also thought to be audible to some marine mammals, but, unlike pile-driving, the impacts of this noise are expected to be small and localized, although knowledge in this area is still limited.

Renewable resources (wave, tidal OTEC, thermal, biofuels etc.)

This sub-function is less mature and presently not used commercially. The main concerns relate to tidal range energy: the impact of tidal barrages on flora and fauna, as well as on changes in geomorphology and processes, patterns and rates of sedimentation and erosion, transport and accretion. Adverse environmental impacts of tidal current, wave, OTEC and osmosis are thought to be small. Research is still required to confirm this. During the construction of energy parks, the same considerations may apply as mentioned under offshore wind energy. The relation between the pressures and impacts exerted by renewable energy on the marine environment and ecosystem, included in the MSFD descriptor seafloor integrity is shown in the figure below. (Source: ODEMM)

Figure 4.2 Pressures (green) from Renewable energy (yellow) to ecological characteristics (blue)



Source: ODEM

Marine mineral resources

There are considerable environmental concerns on the disturbance of deep-sea (> 400 metres) ecosystems through the extraction of mineral resources. The deep-sea and sea floor forms an extensive and complex system which is linked to the rest of the planet in exchanges of matter, energy and biodiversity. The functioning of deep sea ecosystems is crucial to global biogeochemical cycles upon which terrestrial life and human civilization depend. Notwithstanding its remoteness and relative inaccessibility, the deep sea is far from pristine. Operations on the sea-floor may destroy unique habitats and disturb deep-sea ecosystems which could entail changes in fish stock and primary production. Pressure and impacts may also emerge from future activities related to mining, as well as carbon sequestration and gas hydrate extraction. These activities might have consequences on loss of biodiversity and on the flow of deep-sea ecosystem goods and services provided by these environments. The risk of ecosystem shifts in the deep sea due to multiple large pressures has not yet been assessed.

Desalination

The main issue here is the environmental impact of brines. Other impacts include the use of chemical products for membrane cleaning, the release of traces of heavy metal by the installations and noise caused by high-pressure pumps and certain energy recovery systems, such as turbines.

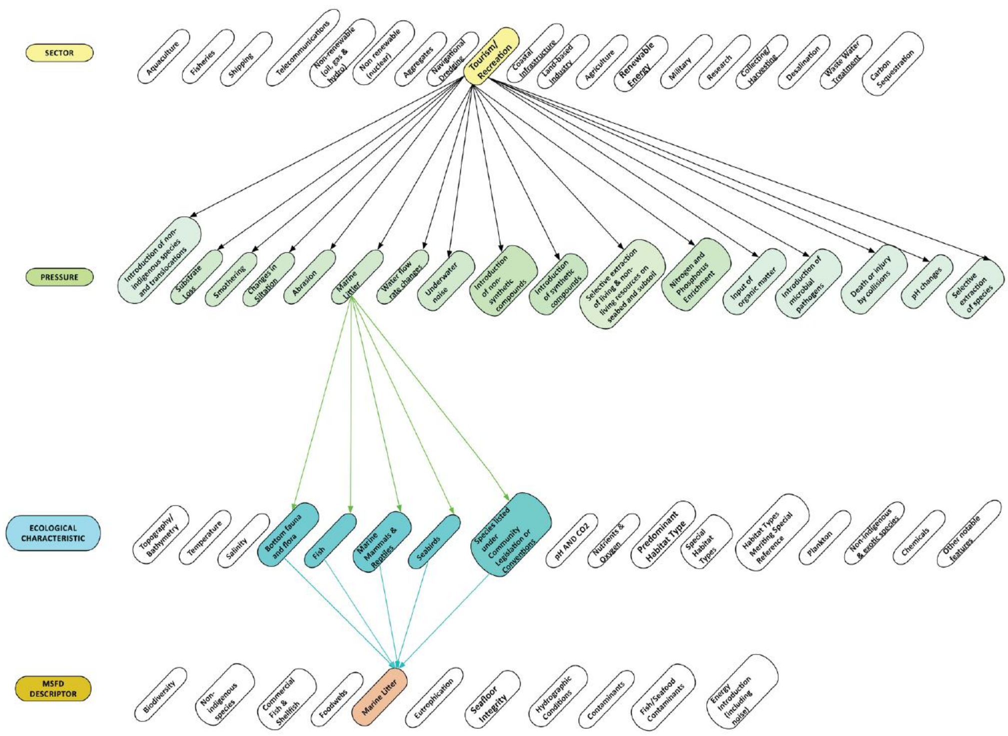
High-concentration brine discharges (around 70 g/l) and insufficient dilution can impoverish or destroy water ecosystems and cause deterioration of water quality. In order to mitigate this environmental impact, the solution currently adopted consists in installing diffuser systems allowing control over the dilution of brine in sea water and thus limiting the scope of the impacted area.

Energy requirements for drinking water production are strongly on the increase for pumping, transfer, treatment and desalination. This implies that if electrical energy generated by fossil fuels is used, this will also increase greenhouse gas emissions.

Coastal tourism

The growth in tourism increases the pressure on natural areas and fragile ecosystems. Tourism contributes to pollution, marine litter and coastal erosion. These impacts are strongly aggravated by their seasonal concentration (summer and school holidays) and spatial concentration (coastline, certain cities, a few major sites). The relationship between the pressures exerted by the sector coastal tourism and the MSFD descriptor 10 Marine Litter, is schematically shown below.

Figure 4.3 Pressures from Coastal Tourism to marine litter



Source: ODEMM

Cruise including port cities

Concerns over the sustainability of the development of the cruise industry are growing. Increased pressures on water resources, waste management, import of consumer goods/services which themselves create traffic, traffic flows, CO_2 emissions etc. are inevitable.

In particular in Arctic regions, cruise tourism represents a source of disturbance and pollution in areas that are otherwise pristine. The biggest single threat caused by ship-based activities comes from the risk of a major oil spill. Other environmental impacts include degradation of regularly-visited sites, air pollution, discharges of sewage and waste water and introduction of non-indigenous species.

Coastal protection

The main adverse environmental impacts of coastal protection are related to dredging: CO2-emissions, disturbance of the soil causing harm to geomorphology and fish.

4.2.2 Environmental Impacts at the basin-scale

The protection of marine environment at the basin-scale falls under the four regional conventions for the Baltic Sea (cf. HELCOM), North-East Atlantic Ocean (cf. OSPAR), Mediterranean Sea (cf. Barcelona Convention) and the Black Sea (cf. Bucharest Convention). The implementation of these conventions ensures the sustainable use of the regional seas through the application of the ecosystem approach and in line with the MSFD. The results of the risk assessment in each of the European regional seas for the different MSFD (sub)descriptors show that impact the risk associated to the exerted pressures on the environment and ecosystems varies at the basin-scale (FP7 ODEMM)

GES Descriptor (and characteristics)	NE Atlantic	Mediterranean Sea	Baltic Sea	Black Sea
Biodiversity - Plankton	Low-moderate	Moderate	Moderate	Moderate
Biodiversity - Fish	Moderate	Moderate	Moderate	Moderate
Biodiversity - Mammals and reptiles	Low-moderate	High	Moderate	Moderate-high
Biodiversity - Seabirds	Moderate	Moderate	Moderate	High
Biodiversity - Predomi-nant habitats	Moderate	Moderate	High	Moderate-high
Non-indigenous species	High	High	High	High
Commercial fish and shellfish	High	High	High	High
Food webs	High	High	High	High
Eutrophication	Moderate	Moderate	High	Moderate
Seafloor integrity	High	High	High	High
Contaminants	Moderate	Moderate	Moderate-high	Moderate-high
Contaminants in fish and shellfish	Low	Low	Moderate	Moderate
Marine litter	High	High	High	High
Underwater noise	High	High	Moderate-high	High
HD Habitats and Species	High	High	High	N/A

(HD- Habitat Directive)

4.3 Synergies and tensions between (sub-)functions

The future Blue Growth potential can be reinforced once synergies between them are likely to emerge. We will explore these synergies from a functional perspective below, and investigate both synergies within the broader functions and those with other functions. However, with a wide range of functions being developed, there are likely to emerge a range of tensions, which will be mostly of a spatial nature – and specific to sea-basins.

4.3.1 Expected synergies within the functions

Below we will report the most important synergies as they are emerging within the 6 main functions as distinguished at the beginning of our study. Most important here are the synergies within the Living resources function, the Energy and raw materials sector and the Leisure, working and living function and Marine monitoring & surveillance. Our starting point will be the sub-functions studied, and their impacts on other sub-functions within that function.

Maritime shipping and transport

In many ways, shortsea shipping provides the linking pin in the EU's maritime shipping and transport business. There are strong synergies with deepsea shipping, which not only provides the overseas cargo, but also shapes the main ports. Passenger ferries provide synergies with shortsea shipping (e.g. RoRo), while inland shipping is another essential component of the chain.

Living resources

Aquaculture and growing algae have important synergies with catching fish and blue biotechnology, as they will all be able to take advantage of R&D developments in the processing phase.

Energy & raw materials

There is strong synergy between oil &gas exploration and offshore as well as other renewables through the sharing of platforms and other infrastructures. Both literature and interviewees stress the importance of synergies with related functions and value chains in this domain.

The commercial viability of a tidal range scheme may be deemed greater if a wider range of functions and related economic benefits could be incorporated (Royal Haskoning, 2009). Examples of such functions are infrastructure (improved transport networks), leisure and tourism, or flood control. Related observations that come forward from the interviews:

- combining OTEC with Sea Water Air Conditioning (SWAC);
- application of OTEC-technology in the production of LNG
- combining OTEC with production of drinking water and extraction of minerals

Table 4.3 Overview of synergies between sub-functions analysed (note to the reader: follow the columns down)

Function	Subfunction	1.2 Short-sea	2.3 Algae Aquacult	2.4 Blue Biotechno	3.1 Oil & gas	3.2 Offshore wind	3.3 Ocean rene-wable	3.6 Marine mine-rals	3.7 Desa-lina-tion	4.1 Coas-tal tour.	4.3 Cruise	5.1 Prot. against flood.	6.1.+6.2. Maritime Security Surveillance	6.3 Env. monit.
1. Maritime transport and shipbuilding	1.1 Deepsea	++			+			+	+		+		+	+
	1.2 Shortsea				+						+	+	+	+
	1.3 Passanger ferries	+								+	+		+	+
	1.4 Inland waterway	++												
2. Living resources	2.1 Fish for humans		+	+		+	+			+			+	+
	2.2 Fish for animals		+	+		+	+						+	+
	2.3 Aquaculture		++	+		+								+
	2.4 Blue Biotechnology		++											
	2.5 Agriculture on saline soils		+	+										
3. Energy & raw materials	3.1 Oil and gas	+	++	+		+		+					+	+
	3.2 Offshore wind	+			++		+		+					+
	3.3 Ocean renew. energy		++	+	+	+			+	+				+
	3.4 CCS				++									+
	3.5 Aggregate mining	+			+			+				+		
	3.6 Marine minerals	+		+	+	+								+
	3.7 Desalination			+		+	+			+				
4. Leisure, working and living	4.1 Coastline tourism	+	+				+				++	+		+
	4.2 Yachting and marinas			+						++	+	+	+	+
	4.3 Cruise and ports	+		+		+				++		+	+	
	4.4 Working	+	+		+	+	+	+		++	++	++		
	4.5 Living		+						++	+	+	++	+	+
5. Coastal protection	5.1 Protection against flood.		+				+			+				+
	5.2 Prevent salt intrusion		+				+					+		+
	5.3 Protect habitats		+	+						+		+		+
6. Marine surveillance	6.1. + 6.2. Maritime Security & Surveillance	+			+	+				+	+			++
	6.3 Environm. monitoring	+	+	+	+	+	+	+	+	+		+	++	

One of the interviewees urges the importance of searching for combinations, trying to solve multiple problems at once, e.g. combining OTEC on floating installations with reducing the problem of the plastic pulp in the oceans.

Given the high energy demand of desalination plants, the relevance of renewable energies for the desalination technology is obvious, although one of the interviewees expresses severe doubts as renewables are still too expensive. According to researchers, the most promising perspectives are in combining desalination with Concentrated Solar Power (CSP). Desalination also provides important potential synergies with osmotic power.

Leisure, working and living

Coastal tourism and the cruise sector are important sources of income for local communities, creating jobs in them, due to the important amounts of money they attract.

Marine monitoring & surveillance

The strength lies in the combination of the three aspects of observations (namely remote sensing, in situ observations and modelling) and the integration of monitoring strategies at a European scale. Together this will generate new powerful insight and forecasts, and coherence. The implementation of integrated monitoring systems will not only benefit the producers of instruments and services, but also provide added-value and societal benefits. Monitoring can then generate a large macro-economic effect.

4.3.2 *Expected synergies with other functions*

Below we report on the most important synergies as they are emerge between the 6 main functions as distinguished at the beginning of our study. Our starting point will be the 13 sub-functions studied, and their impacts on other sub-functions outside that function (see above Talbe 4.3).

Living resources

Aquaculture and growing of algae can play a role in wave attenuation and erosion reduction (5.1). This is expected to increase with development of large-scale aquaculture installations in erosion-sensitive coastal areas, mostly in the Atlantic and the North Sea. The aquaculture sector may also provide useful raw material (algae by-products, fish bones) for research and new molecule production.

Blue biotechnology (2.4) can provide bio-sourced products such as coating with anti-fouling or anticorrosive properties (maritime transport and shipbuilding). Growing of the algae aquaculture segment would benefit from advances in fish medications but also benefit from shelf life improvements achieved through marine bacteriological progress.

Oil, gas and methane hydrates (3.1) can benefit from blue biotechnology by new applications that may provide solutions to improve the extraction yield of oil (“Enhanced Oil Recovery”).

Underwater constructions for ocean renewable energy sources (3.2) (wave, tidal, OTEC, thermal, biofuels, etc.) could benefit from marine bio-sourced coatings with anti-fouling or anticorrosive properties. All of these sub-functions can benefit from their spatial clustering on multi-purpose platforms.

Recent developments show that mineral nodules may partly be of biogenic origin (Wang & Werner 2010). Unlocking the metal fixating properties of selected bacteria could improve the potential of blue biotechnology vis-à-vis this sub-function.

Blue biotechnology can also contribute to the development of specific biopolymers and bio membranes that improve the overall efficiency of the desalination process (3.7).

Ships (cargo, passenger as well as yachting) can benefit from marine bio-sourced coatings with anti-fouling or anticorrosive properties.

Bio stimulation can also be used to protect natural habitats (5.2) by fostering bioremediation after important pollutions (as for the Exxon Valdez oil spill when bacteria were stimulated to degrade hydrocarbons).

Bio-discovery activities can improve the knowledge of specific biomarkers for environmental monitoring.

Energy & minerals

Other types of synergy exist with on-land activities that depend on membrane technology, such as drinking water production from waste water and waste water treatment in industry (AMTA, website). An indirect relation exists with agriculture, often the main user of fresh water supplies. If agriculture should find ways to make more use of brackish water, this could result in increasing availability of fresh water for municipalities and hence decreased demand for desalination capacity.

Oil & gas provides synergies with shipping and ports (imports, oil & gas terminal development).

Desalination offers advantages to (deep-sea) shipping, as sea-going vessels are equipped with small-scale desalination units.

The development of offshore wind parks will demand for new developments in environmental monitoring, such as new measuring set-ups, new constructions, new traffic to database, extra database services and data validation needs.

Leisure, working and living

Sustainable tourism is affecting demand for renewable energy sources and re-use of water.

Some of the interviewees stress the importance of looking for synergies with coastal protection, e.g. marina infrastructure contributing to coastal protection of land and property from erosion by the ocean.

The cruise sector has important synergies with other shipping functions as it uses the same port facilities as regular shipping. Synergies with the maritime transport cluster are also related to shipbuilding, where the supplier industry located in Europe can serve a wider market of ship types.

Coastal protection

Coastal protection decreases the risk for erosion and flooding, but the protection work can also interfere with coastal tourism, shipping and offshore energy (wind and other renewables). As approaches to coastal protection design have been more and more integrated with other functions, solutions currently developed often benefit both protection and other functions as well as coastal eco-systems. This is considered an important synergy.

Performing coastal protection works requires the involvement of dredging fleet hosted by nearby ports, creating addition berth demand and associated services. Vice versa works in ports often also contain a protection component. In the case of oil and gas facilities in ports this is especially visible.

Dredging can facilitate coastal aquaculture, through intelligent design of coastal protection works.

Marine monitoring & surveillance

As can be seen in table 4.3, environmental monitoring provides synergies and benefits for a wide range of maritime functions and sub-functions: from algae growing and blue biotechnology to all energy sub-functions as well as leisure and tourism functions. Environmental monitoring services and also be used for coastal protection purposes. Vice versa – the risk for erosion and flooding may result in increased efforts in environmental monitoring.

4.4 Expected tensions between sub-functions

4.4.1 Generic tensions

Table 4.4 Overview of possible tensions between sub-functions analysed (note to the reader: follow the columns down) gives an overview of the main tension between (sub-)functions. A short description of the major tension per (main) function is described below.

Table 4.4 Overview of possible tensions between sub-functions analysed (note to the reader: follow the columns down)

Function	Subfunction	1.2 Short-sea	2.3 Algae Aquacult	2.4 Blue Biotechno	3.1 Oil & gas	3.2 Offshore wind	3.3 Ocean rene-wable	3.6 Marine mine-rals	3.7 Desa-lina-tion	4.1 Coas-tal tour.	4.3 Cruise	5.1 Prot. against flood.	6.1 Maritime Security Surveillan ce	6.3 Env. monit.
1. Maritime transport and shipbuilding	1.1 Deepsea				-	-	-				-	-		
	1.2 Shortsea		-	-	-	-	-				-	-		
	1.3 Passanger ferries		-	-		-	-				-	-		
	1.4 Inland waterway													
2. Living resources	2.1 Fish for humans	-		-	-				-			-		
	2.2 Fish for animals	-		-	-							-		
	2.3 Aquaculture								-					
	2.4 Blue Biotechnology													
	2.5 Agriculture on saline soils									-				
3. Energy & raw materials	3.1 Oil and gas			-						-				
	3.2 Offshore wind				-					-				
	3.3 Ocean renew. energy					-								
	3.4 CCS													
	3.5 Aggregate mining	-	-		-		-							
	3.6 Marine minerals													
	3.7 Desalination													
4. Leisure, working and living	4.1 Coastline tourism	-	-											
	4.2 Yachting and marinas													
	4.3 Cruise and ports	-										-		
	4.4 Working													
	4.5 Living		-							-				
5. Coastal protection	5.1 Protection against flood.													
	5.2 Prevent salt intrusion													
	5.3 Protect habitats	-	-		-	-		-	-	-	-	-		
6. Marine surveillance	6.1. + 6.2. Maritime Security & Surveillance													
	6.3 Environm. monitoring													

Maritime transport and shipbuilding

Tensions with other functions emerge on or around shipping routes, while competition of space can be fierce in ports and surroundings. Tensions apply to fishing, aggregate mining, coastal tourism and protection of habitats mostly.

Living resources

Overfishing may reduce the volume of raw material delivered to the blue biotech sector (cosmetic and nutraceutical).

Aquaculture could also have a negative impact on water quality in the surrounding environment. With R&D developments in the field of mitigating measures, these tensions are expected to decrease, but will remain an issue when the sector grows.

Oil& gas (and to a less extent offshore wind, and ocean renewables) can lead to mild tensions due to competition for space, and is expected to be more stringent in basins where competition for space is more important (North Sea, Baltic).

Aggregates mining (sand, gravel, etc.) can lead to competition for space, which is expected to be more stringent in basin where competition for space is more important (North Sea, Baltic). Coastline tourism is also competing for space – including need for visual quality (Mediterranean, Black Sea).

Energy and minerals

Oil & gas provides tensions with virtually all other sub-functions because of competition for space. The confidentiality of resource locations and the levels of security desired around are factors complicating this tension. Furthermore oil & gas winning can cause pollution and infrastructure development can have a negative impact on the eco-system (also tension with Natura2000). Accidental spills may reduce locally marine biodiversity, and threaten function.

Leisure, living and working

Cruise and ports can lead to spatial tensions with maritime transport, in crowded ports (competition for terminals) and sea-corridors. This can provide synergies (e.g. access channel already deepened), but also cause conflicts.

Litter from cruise-ships can cause damage to food, nutrition, health and ecosystem services, e.g. through marine litter affecting ecosystem services.

Coastal tourism and related infrastructure development can lead to pollution and adverse impacts on natural and living environment (also tension with Natura2000);

Coastal protection

As dredging and nourishment affects the seabed, it may impact certain segments of the fisheries sub-functions.

Marine monitoring & surveillance

No tensions with other maritime sub-functions have been recorded to date.

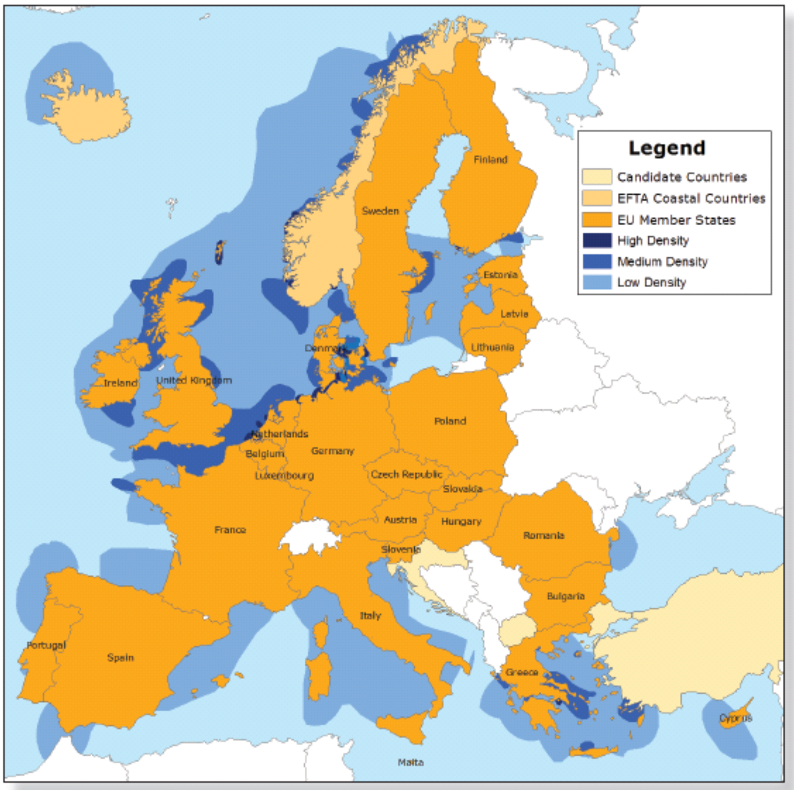
4.4.2 Selected tensions

Besides tensions between maritime functions, there are tensions caused by the pressure of function on the wider marine environment, both in environmental and safety terms. Three examples are elaborated here to illustrate this:

Safety at sea

Intensive use of oceans and seas by man causes the probability of accidents to increase. In Europe, a number of **accident blackspots** can be identified in the vicinity of major harbours, along major navigation routes and in areas that are difficult to navigate especially in bad weather. In the North Sea, critical areas include the English Channel, in particular the Port of Antwerp and the Kiel Canal in Germany. In the Baltic Sea, the Danish and Swedish coastlines are particularly prone to shipping accidents, whereas in the Mediterranean Sea, the Aegean Sea is the major blackspot.

Figure 4.4 **Overview of the spatial distribution of the shipping incidents around the EU for 2009 (Source: EMSA, 2010[35])**



Marine waste

Litter is a main problem amongst Europe's coasts, with strong variations and differences in measurement – which make comparisons across Sea-basins difficult. Plastic litter is common in the (Northern) North Sea, the Mediterranean and the Black Sea – where glass litter is also widespread.

Table 4.5 **Quantities of marine litter found on Europe's beaches[36]**

Region	Sea	Litter (items/100 meter beach)
North East Atlantic (OSPAR, 2009b)	Northern North Sea	600–1 400
	Southern North Sea	200–600
	Celtic Seas	600–800
	Bay of Biscay and Iberian coasts	100–300
		Most common items on all beaches in this region were small plastic/polystyrene pieces
Baltic Sea (HELCOM/UNEP/RSP 2007)		High: 700–1 200 Low: 6–16 30–60 % were plastics
Sea	**Location**	**Litter (kg/km²)**
Mediterranean (Koutsodendris et al., 2008)	Greek Gulfs of Patras, Corinth, Echinades and Lakonikos	6.7–47.4 Plastic litter: 56 % Metal: 17 % Glass: 11 %
Black Sea		Plastics: 333–6 250 Glass litter: 222–1 455

Although above table does not comprise all European beaches, it is likely that litter volumes on other seas/coast within Europe have similar ranges (see e.g. OSPAR, 2011, UNEP, 2011).

[35] European Maritime safety Agency (2010) Maritime accident review 2009

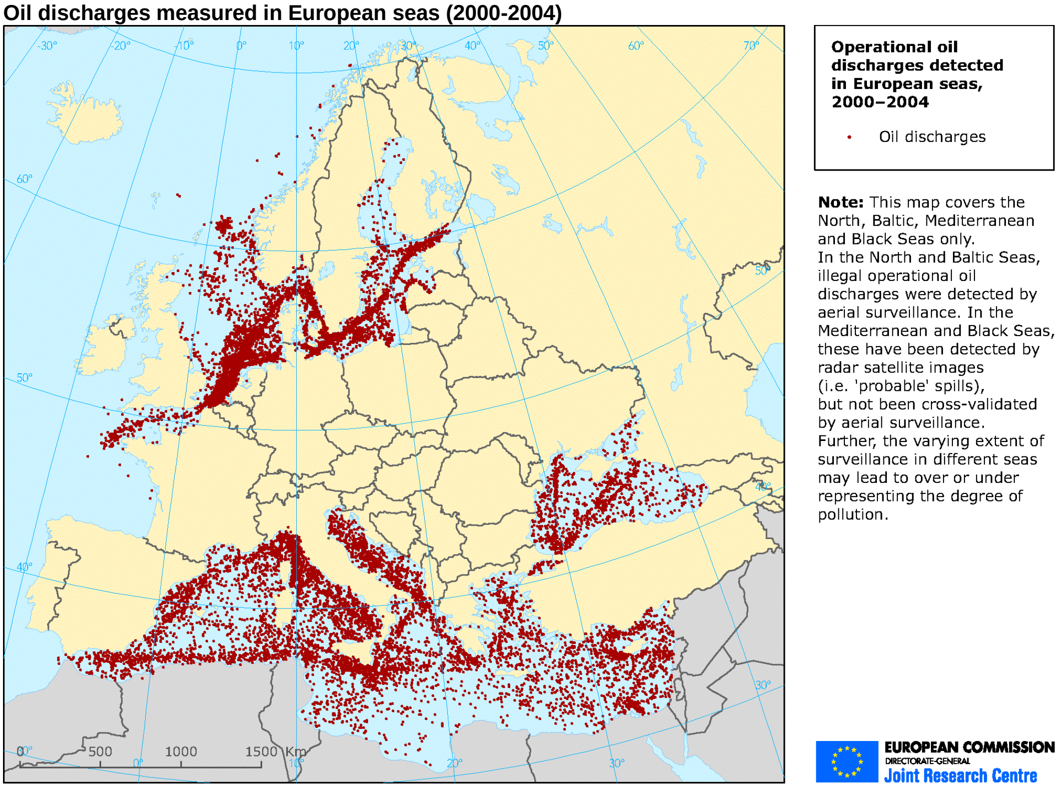
[36] EEA 2010, The European Environment State and Outlook 2010- Marine and Coastal Environment

Besides litter found on coasts, plastics in open sea, especially in pelagic zones, is a possible threat to marine eco-systems, and measurements indicate that as much as 94 percent of seabirds living in the Northsea region have plastic particles in their stomachs (OSPAR, 2011).

Oil spills

Leakage or spilling of oil can be by accident or on purpose. Monitoring data indicate the spills are found mainly along the shipping routes across European waters, as Figure 4.5 shows.

Figure 4.5 Oil discharges measured in European seas (2000-2004)



Source: European Commission, Joint Research Centre

5 Conclusions

Sub-functions selected provide true economic and employment potential

The research carried out as part of Work Package 2, centred around 13 selected sub-functions, has generated a wide range of new insights. The results have strengthened our confidence in the choice of the sub-functions, as they provide true economic and employment prospects. For example, the numbers of patents and scientific publications within these sub-functions have seen a remarkably strong increase – far above the average - , thus demonstrating the innovative dynamics and potential of these sub-functions. Therefore, all sub-functions are important, and none can be neglected.

Micro-futures: desirable, ambitious but realistic

For these selected 13 sub-functions, we have developed an equal number of 'Micro-futures': futures which are deemed desirable and ambitious but realistic. Desirable in terms of EU2020 policy goals: supporting sustainable growth. Ambitious and realistic in terms of aiming at above-average estimates, but always rooted in the best available information from literature and interviews. The resulting storylines are a mixture of negotiated creativity and as solid a scientific basis as can be provided when it concerns the future. The emphasis is on the next one or two decades, until 2020/2030, with an occasional outlook on the further future.

Global marine economic and employment growth estimates are promising….

We have grouped the sub-functions by developmental stage, and have identified important commonalities and patterns. Estimation of economic growth of sub-functions in the **(pre-) development phase** has been challenging, as economic estimates about Algae Aquaculture and Blue Biotechnology remain under the surface. Yearly installed capacity in offshore renewable energy sources could be doubled, and although new technologies are expected to break through only after 2020, a doubling of turnover and employment in ten years time implies an average annual growth of around 7 percent. Global annual turnover in marine mineral resources is expected to rise from virtually nothing to at least € 10 bn in 2020, if we assume the EU industry to capture a modest 10% this would imply already € 1 bn. In terms of employment this would result in the range of 5-10,000 jobs.

Estimations on economic and employment growth of sub-functions in the **growth phase** are certainly favourable: a tripling of value added of the sub-function offshore wind from € 1.3 bn today to € 4.5 bn in 2020 is expected. This implies an average annual growth of around 13%. For desalination, growth of GDP and employment is based on the expected growth in installed capacity, assuming the EU players can keep pace with non-EU competitors. Growth expectations for the cruise industry are favourable for the next five to ten years, mainly due to an increased penetration rate and export potential of European businesses. An increase of 60% until 2020 implies an average annual growth of around 5%. Within environmental monitoring, a doubling of turnover within the next decade is expected (implying some 7% growth year on year); employment will however grow at a lower pace due to the focus on labour-extensive technologies. An estimated growth of half the turnover is expected (50% increase by 2020, or 4% year on year).

For the **mature sub-functions**, transported volume by shortsea shipping will generally grow along with economic development, but with a multiplier (trade growth usually being a factor higher than GDP growth). The factor is taken to be 1.5 and therefore annual growth in the range of 3-4 percent is expected. Employment is considered to remain relatively stable due to efficiency increases taking place along the value chain. A decline in GVA and employment is foreseen in Oil, but can be dampened by production efficiency increases and the relative growth of gas and methane hydrates. Growth will need to come from export and exploration in other oceans and seas. Gradual employment and GVA growth in coastal tourism is still foreseen, both at a rate of 2-3 percent per year. With regard to protection against flooding, EU marine contractors are leading worldwide and expected to continue to export their services and capture part of the growth in the rest of the world.

A range of uncertainties apply though…..

Prognoses are dangerous in today's rapidly changing world, and a number of uncertainties will be of influence on the above micro-futures. The global economic climate, external technological developments, the price volatility of energy, food and commodities are amongst the most crucial one's. But also important are the pace for implementing stricter environmental regulations, and the extent to which the EU's own role will be shaped. All these factors are likely to have an impact on the micro-futures, and we will analyse these further as part of Work package 3.

But Europe will be far from alone when faring on the world's oceans and seas…

However, the above micro-futures are also based on a number of relatively certain external drivers. These include the increasing scarcity of fossil fuels, increasing pressures on the environment, and an ageing population. Also certain is that Europe will be far from alone on the world's oceans and seas. Further globalisation is bound to happen, and an increasing dominance of Asia seems unavoidable. For example, analysis of patents (top assignees), points to Asian players already now being the dominant innovators in the marine sub-functions analysed: 62% of selected patents analysed were from Japanese, Chinese or Korean origin, followed by the EU with 21% and the US in third place (16%). Other than in the cruise-business, the US is only leading in environmental monitoring and to some extent in security/tracing – due mostly to the strong military innovation capacity in these areas.

EU companies are leading in marine energy and mineral innovation

Within the above context, the EU is clearly in a leading position when it comes to innovations in all energy-related sub-functions, both renewable and non-renewable: it has generated around half of the reviewed patents in Oil & gas, Offshore wind, and Marine mineral resources, while 1/4 of the reviewed patents in Ocean renewable energy sources. A strong performance can also be recorded in the algae field (algae aquaculture).

Strong marine scientific and academic competencies, but major knowledge transfer gaps

The EU has strong marine scientific and academic competencies, as demonstrated by high numbers of publications and citations. It has brought forward the authors of at least 4 out of 10 authors in a wide range of sub-functions, from those in the energy and raw materials to the living resources domains.

However, the discrepancies between patent and publication patterns points to an emerging conclusion which is fully supported by interviewees: the EU has excellent academic and scientific capacities in the sub-functions analysed, but considerably less commercial potential to embark on these. Especially activities in the developmental stage are mostly carried out by small companies, spin-offs or suppliers which are strapped from cash, wary to share knowledge, and unable to control the value chain. EU-players tend to linger in this developmental stage longer than strictly necessary, while large industrial players (mining companies, pharmaceutical, cosmetic, food companies, energy companies, and utilities) are standing aside – in the waiting room until the moment is there to acquire or buy equity positions. Meanwhile, non-EU players (often backed by their governments) tend to invest more and faster in these developmental stages (e.g. the US investing in micro-algae, China in desalination techniques, Japan in mining rare earth from the

Pacific, etc.). The EU's future success in the maritime economy will therefore largely depend on its own technological as well as strategic response capacity, and its ability to bring promising and sustainable maritime innovations fast and decisively to the global market place. Current initiatives related to strengthening Europe's innovation potential (including smart specialisation) should be seen as essential in this respect.

'Smart' combinations can trigger maritime innovative developments.

Lack of critical mass is a bottleneck for many nascent maritime activities. But making 'smart' combinations can help to overcome this constraint. A large number of compelling synergies has already been identified around the subfunctions analysed. Many interviewees have pointed to the importance to search for such smart combinations, e.g. combining OTEC on floating installations while reducing the problem of the plastic pulp in the oceans. Blue biotechnology can be of service to maritime transport and shipping, living resources, or energy & raw materials. By the same token, marine monitoring & surveillance can facilitate and support a wide range of maritime functions.

As a consequence of all of the above factors, Blue Growth is likely to emerge across a wide range of economic sectors – and will not be limited to predefined statistical classifications.

Sustainability: driving and conditioning the future.

Many of the identified maritime activities themselves are driven by the need for sustainability: climate change will lead to global warming, give rise to sea-level rise, droughts and food scarcity – on top of scarcity for energy and commodities; giving impulses to new maritime activities. At the same time, new maritime activities and growth of existing one's bears the risk of adverse environmental impacts, whether through high energy requirements, atmospheric emissions, habitat destruction, negative effects of eco-systems or water quality issues. The interview results point to the conclusion that those maritime businesses and actors that recognise the environmental risks and potentials in an early enough stage, willing to address these and to communicate these to society at large, are likely to be more successful – in a world where less and less room will exist for unsustainable practices.

Blue Growth: will it all fit on our oceans and seas?

Expanded maritime economic activities – whether inside or outside the European waters – are likely to generate tensions: on or around shipping routes and near congested ports, but also where renewable energy will be generated, where leisure activities take place, and where natural habitats are to be protected.

Clear is that more geographic differentiation is needed in the analysis: developments differ strongly by sea-basin, and this variety is yet to be carved out from the material. Yet, an increased need for Maritime Spatial Planning can already be anticipated.

Blue Growth is bound to take place in the years to come: the question is where

In summary, we are confident that Blue Growth will take place across a wide range of functions. The key question is: will it take place in Europe or rather elsewhere? Here the importance of policy and political will becomes essential. Policy implications are yet to be drawn in the subsequent Work Packages. Yet, we already know that some geographic constraints are difficult to address, such as lack of space or depletion of natural resources. But the report does indicate that Blue Growth in Europe requires a range of framework conditions to be fulfilled: adequate transport infrastructure, high-voltage and cross-border electricity grids, high-skilled staff as well as access to low-skilled workers are amongst the obvious ones. But public acceptance, a solid international legal framework regarding the international waters, and good governance at local and regional levels are essential as well. Above all, access to finance is amongst the most important barriers for sub-functions in the (pre-) development stage. Addressing these and other bottlenecks will become an important subject for discussion and subsequent action if Blue Growth is to be realised in Europe.

Annexes

The following annexes are included

- Annex 1: Literature
- Annex 2: Overview tables summarising sub-function findings (matrices of external drivers, response capacity and framework conditions)
- Annex 3: Final agenda intermediate hearing 9+10 November

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Annex 2 External drivers per sub-function

External drivers		2.3 Growing aquatic products - Micro-algae	2.4 High value use of marine resources	3.6 Marine mineral resources	3.3 Ocean energy	3.2 Offshore wind	3.7 Desalination	4.3 Cruise tourism	6.1+6.2 Security	6.3 Environmental monitoring	1.2 Shortsea shipping	3.1 Oil, gas & methane hydrates	4.1 Coastline tourism incl. marinas	5.1 Coastal protection
Demography	population growth						population growth and increasing per capita water use							
	ageing		Demand for high-value applications (ageing population)					- Ageing population and changing consumer preferences					Ageing leads to only limited changes in demand	
	urbanisation							- Gradual growth of markets near source regions (population densities)						- Increasingly high value economic activities in coastal regions to be protected
	increasing water and food scarcity	Micro-algae for food industry					urbanisation in coastal areas							
Economy and market	general economic climate, economic crisis							welfare development - Volatility vis-à-vis business cylces (financial crisis)		- Public budget restrictions	- global economic climate & trade patterns/relation to deepsea shipping?		Impact of economic crisis (2008-2009) - now slow recovery Potential erosion of middle-class purchasing power (e.g. second-homes)	increasingly high value economic activities in coastal regions economic crisis (budget cuts expected, other priorities)
	globalisation, international competition	strong international competition	strong competition from China, India, USA and Australia	- Geo-political considerations wrt self-reliance		geo-political considerations wrt self-reliance	demand for locally controlled water supply	- Increased competition from non-EU players (e.g. MSC Cruises)	Competitive market entry by emerging economies	USA leading in patents and technology EU covers niche markets	- Economic potential of Neighbourhood countries (Turkey, Russia, Ukraine, N. Africa?)	energy security: EU desire to become less dependent on imports	Increased competition from non-EU destinations (e.g. Asia)	
	upcoming BRIC		strong competition from China, India, USA and Australia			China's anticipated expansion	- Strong global players (Korea + Japan + China)							
	price volatility availability raw materials			price of raw materials - Metal content found in future exploration of sea floor - Transport costs for shipping ore	volatility of fossil fuel price	volatility of fossil fuel price	volatility of fossil fuel price							
	availability fossil fuels		crude oil price		level of fossil fuel price	level of fossil fuel price	level of fossil fuel price	fuel prices			fuel price	fuel demand (following economic growth globally and in specific markets (China, India)) fuel prices (trend to go up) uncertainty about viability of deep water offshore fields	Fuel prices and charges affect low-cost travel models (reduced mobility)	
Technology and science	upcoming BRIC			US, China, Japan are leading in patents, followed by EU (France, Germany, UK)			USA and Germany still leading, but this is changing China and Korea invest 10-fold the EU budgets							
	technological development	- Strong increase in global patent activity	strong increase in patent applications	significant progress in deep-sea drilling technology made		research needed to increase scale, to overcome marine environment	membrane destillation	shipbuilding (esp. energy efficiency & fuel types)		innovation	aimed at emission reduction	production not yet in deepsea waters		soft nourishment techniques
				strong increase in patent applications in period 2003-2009		development of foundations, vessels	further concentration of brine, use brine as source of raw materials, source of osmotic energy	marketing concepts			Innovation in sulphur reduction techniques (including LNG)	efficiency of production (now only some 50-60% of field exploited)		use of natural processes (working with nature)
					technological development still required	technological development still required				policy		environmental impact reduction techniques (often event triggered, e.g. following Deep Horizon accident)		creating long term coastal stability
	biotechnology ICT													
Environment, climate change	pressures on the environment					competition for space with other functions	environmental protection	environmental awareness and legislation		- Environmental problems and degradation as a key driver				strict regulations raising costs (environmental sensitive areas)
	climate change, sea level rise	climate								climate change			Climate change reshapes the climate conditions (flooding)	- Global warming leads to rising sea-levels sea level rise, flooding events
	freshwater availability / droughts						- Climate change will lead to more drought -> demand							
Politics and institutions	commitments to sustainability			legal framework including ISA 'taxes'	development of EU legislative frame	development of EU legislative frame	environmental protection	environmental awareness and legislation		- Willingness to pay for these services	- environmental regulations (ECAs, ETS, EEDI, etc.)	regulations protecting environment		strict regulations raising costs (environmental sensitive areas)
								environmental policy (affecting competitive position vis a vis other tourism sectors)		- retreating public sector		renewable energy policy (less focus/interest in traditional fuel)		- Flooding events will increase awareness for coastal protection
	increasing role of EU			- Geo-political considerations wrt self-reliance	development of EU legislative frame	development of EU legislative frame	- Demand for locally controlled water supply will go up		Public procurement policies will drive demand		- modal shift policies (EU and national) EU internal trade - European Single Market will provide further boost to internal trade			

Annex 3: Strengths and Weaknesses per micro-futures

Micro-futures	2.3 Growing aquatic products - Micro-algae	2.4 High value use of marine resources	3.6 Marine mineral resources	3.3 Ocean energy	3.2 Offshore wind	3.7 Desalination
Strengths		-Potential of marine organisms not yet known	-Potentially large stocks of minerals which are in high demand	-High potential yield	- High potential yield	-Reliable source of supply
		-Strong appeal of marine labelled products	-Scarcity of land-based mining locations for rare earth	-Strong position of Europe in wave and tidal	- Strong position of Europe	-Supply under local control
		-Key technological progress	-EU companies are leading in dredging, drilling, cutting, transport and ROVs	-Synergy potentials with offshore	- Synergy potentials with offshore wind and other offshore Oil & Gas	-High quality water
			-International legal framework in place		-Sector recently becoming capable of attracting investors	
Weaknesses		-Fragmentation in applications and lack of focus	-EU is not in full control of value chain	-Technology not yet proven	- Less predictable source of energy generation due to dependency on weather conditions	- Energy consumption of the desalination process
		-Gap between research community, small and large commercial players	-Uncertainty about the amount of minerals that can be commercially exploited	-High (perceived) costs for exploitation of technology	- Still high (perceived) costs	- Environmental impacts: problems in dealing with brine flows, CO2, chemicals
		-Small companies fail to make critical mass	-Technological capabilities to be proven still	-Environmental impacts not yet fully known	- Competition for space with other functions	- High costs
		-EU weak on cost-competitive sequencing solutions	-Environmental concerns and technologies		-Energy supply during peak (production) times	
			-Buy-in from coastal communities in trial regions			

4.3 Cruise tourism	6.1. + 6.2. Maritime Security and Surveillance	6.3 Environmental monitoring	1.2 Shortsea shipping	3.1 Oil, gas & methane hydrates	4.1 Coastline tourism incl. marinas	5.1 Coastal protection
- Strong domestic market	-Increasing demand because of globalisation of security threats	-Advanced technologies	- Low per tonkm transport costs	- Size (EUR 80 bn in Europe only)	-Diversity of destinations is one of Europe's competitive strengths	- Long history of protection, particularly in NW Europe
- Safe destination	-Basis for other functions of the maritime economy	-Improved ways of dealing with uncertainties	- Low per tonkm environmental impact	- Therefore investment power	Strong domestic market	- Export product, well-known worldwide
- Excellent port and supply facilities	-Established position of European industry and cross fertilization with defence sector	-Improved forecasting techniques	- Marine equipment manufacturing present in Europe	- Mature technology	-Established tourist destinations	- Integrated approach, knowledge of related functions and environment
- High concentration of diverse cruise tourism destinations		-Value added by free access to data		- Export (5 of top-6 companies are EU based)	-Dense cultural and historical heritage	
- Leading shipyards in EU		-Integrated approaches		- Norway key player in offshore oil reserves	-Global leaders	
- Leading cruise operators non-EU	-Fragmented market	-Budget restrictions	- High dependency on fuel (30-50% of operating costs if not more)	- Depleting energy source	-Strong dependence on certain regions	- Liable to political priorities (budget cuts)
- Capital intensity to run cruise tourism business	-Limited national budgets	-Lack of standardization, fragmented activities	- Dependent on global economic climate & trade patterns	- Size declining in Europe (-5%/year on average), but booming outside Europe	-Seasonality	- Ineffective governance in various countries
- Environmental burden	-Lack of existing standards and certification	-Lack of longterm vision and continuity of activities	- Dependent on respective terminal operators, which have a low level of organisation	- Polluting image (incl. events in press - Deepwater Horizon, Nigeria, etc.)	-Often rely on energy and resource intensive	- High capital investment required
- Lack of skilled engineers for maintenance			- Power of shippers larger than of ship operators	- More expensive than onshore production	-Uneven geographical distribution	
- Port investment break-even point is difficult to achieve					-Institutional capacity of tourism players	

Annex 4: Final Agenda Intermediate Hearing 9th – 10th November 2011

Background and aim

ECORYS/Deltares/Océanic Développement have been requested by the European Commission's DG MARE to conduct in-depth analysis and foresight of cutting-edge knowledge, technology and innovation as a basis for harnessing the resources of the oceans, seas and coasts scenarios, and to inform future policy strategies.

The Intermediate hearing is a crucial moment in the Blue Growth study – and has two aims:
1) Validation of the key findings on the potential development within the subfunctions studied to date (day one).
2) Assessment of constraints and framework conditions; identification of areas for policy intervention (day two).

Results expected from this meeting will be to:

- Provide feedback on the findings to date;
- Provide further understanding of future technology potential for maritime sectors;
- Discuss, extend and finalise the main emerging policy recommendations;
- Present and discuss key "dilemmas" emerging for the most promising technology/clusters.

This two-day hearing will target an audience of approximately 30 participants, such as

- Experts in the field of marine research;
- Business leaders in the area of marine economy;
- Other interested stakeholders, including local governments;
- Representatives from the EC (DG MARE).

The meeting will be held in English and there will be no simultaneous translation into other languages.

The Intermediate Hearing will take place in the Hotel Bloom, Rue Royale 250, 1210 Brussels.

8th November: Welcome cocktail

21:00 – 22:00 **Hotel Bloom, foyer**	A welcome drink will be offered by the consortium for early arrivals: • Invited experts of the Intermediate Hearing • European Commission representatives

9th November 2011: Day 1 – Validation of key findings

9:30 – 10:00,	**Coffee and registration** 1st floor, in front of conference rooms

10:00 - 10:45 **Plenary**	**Emerging scenarios conducive for blue growth** • Introduction to the "Blue Growth" study and its methodology (objectives) • Key findings of the microfutures • Presentation on four background scenarios • Organisational aspects of working groups

10:30 - 12:30 **Break-out sessions**	**Discussion on functions and findings**		
	Leisure / Transport • Coastline tourism • Cruise & ports • Short-sea shipping	**Food, Nutrition** • Algae Aquaculture • Blue Biotechnology	**Energy** • Oil & gas • Offshore wind • Ocean renewable energy
	Following a presentation, 8 key questions will be discussed: 1) Plausibility of the microfutures? 2) Most important assumption(s) required to make the microfuture happen? 3) How to position this microfuture within the background scenario? How robust will this microfuture be in the case other microfutures materialise? 4) Most important external drivers in the future? 5) Rating of the response capacity of EU actors? 6) Barriers to realise the microfuture? 7) Functional connections (synergies) with other maritime activities? 8) Any (spatial) tensions with other maritime activities?		

12:30 – 14:00	**Lunch break**

14:00 - 16:00 **Break-out sessions**	**Marine resources** • Marine Mineral resources • Desalination	**Coastal protection** • Coastal protection	**Maritime Monitoring and Surveillance** • Surveillance • Environmental monitoring
	Following a presentation, the same 8 key questions will be discussed (see 10.30 – 12.30 session)		

16:00 – 16:15	**Coffee break**

16:15 - 17:45 **Plenary**	**Emerging key findings** Rapporteurs will present the key findings which can be subsequently refined • Key messages with regard to potential future development • Key messages with regard to uncertainties • Key messages regarding synergies and tensions

17:45 - 18:00 **Plenary**	**Closing of the day – outlook Day 2** Outlook on Agenda – Day 2

19:00	**Walking Dinner** in the restaurant of the Hotel Bloom

10th November 2011: Day 2 – Constraints, framework conditions and areas for policy intervention

9.00 - 09:30 **Plenary**	**Resume and introduction to the day** • Presentation of day one main findings • Presentation of key findings with regard to cross-cutting constraints and framework conditions • Announcement of working groups

09:30 - 10:30 **Break-out sessions**	**Discussion on constraints and framework conditions**		
	• R&D	• Public acceptance	• Skills
	The following key questions will be discussed: 1. What is the barrier for Blue Growth? How will this barrier develop over time? 2. What role for public policy? 3. What will happen without such policy actions? 4. What role for the EC?		

10:30 – 11:00	**Coffee break**

11:00 - 12:00 **Break-out sessions**	• Access to finance	• Cluster support & standard-setting	• Environmental challenges
	Key questions will be discussed similar to those from the session from 9.30 – 10.30.		

12:00 – 13:30	**Lunch break**

13:30 - 14:00 **Plenary**	**Presentation of key findings**

14:00 - 15:30 **Plenary**	**Roundtables: "Blue Growth: making it happen"** Experts will be invited to take part in one or more of the following themes: 1. "Europe will be far from alone when faring on the oceans – how to be successful?" 2. "Transferring potential into jobs" 3. "Making smart combinations and building critical mass" 4. "The need for sustainable approaches – the role of maritime spatial planning"

15:30 - 16:00 **Plenary**	**Closure** • Wrap-up of the two-day hearing • Reflections from EC DG MARE

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