Ministerie van Infrastructuur en Waterstaat

EXPLORING THE FUTURE TOGETHER

A scenario analysis for the OSPAR region

26th of February 2021

Author
Kyra Bekhuis

Supervisors
Rob van der Veeren
& Xander Keijser

1 Summary

Issues that affect the environmental status of the North East Atlantic Ocean stems from anthropogenic sources in and around this region. Effective and efficient management of the oceans requires insight into how these will develop in the future. However, the mechanisms that cause environmental pressures are not straightforward and therefore hard to capture in a single forecast about the future.

The DAPSIR (Drivers, Activities, Pressures, State, Impact, Response) model being applied in the Quality Status Report 2023 provides a framework that helps to structure the complexity of the interplay between human activities and the North East Atlantic Ocean´s marine environment. The objective of this scenario analysis report is to provide more insight into the level of uncertainty about the interplay between drivers and pressures of various economic sectors in and around the North East Atlantic Ocean.

In order to indicate and structure the uncertainty about this interplay, a scenario analysis is conducted (the approach of this scenario analysis is described in chapter two ´Scenario analysis'). Scenarios are based on assumptions on drivers. In this scenario analysis, drivers are socio-economic factors that influence how human needs could be fulfilled in the future through production and consumption practices. Examples of drivers are changing values (such as environmental awareness, level of societal trust), level of innovation (either technical or social), changing policies (such as fish-quota), different levels of globalization (or protectionism), possible long term impacts of COVID-19, and different levels of economic growth (and the related ability to invest Each scenario combines drivers in a different way to create a possible image of the future. This is important because all these drivers contain uncertainty. Scenario analysis structures this uncertainty in a way that allows to discuss and explore the future developments in economic activities and related environmental pressures in the OSPAR region.

This research intends to respond as thoroughly as possible to the following questions:

- What are possible future states of the OSPAR's blue economy in 2030?
- What are the main socio-economic uncertainties in understanding possible drivers of change for various economic activities in and around the North East Atlantic Ocean?

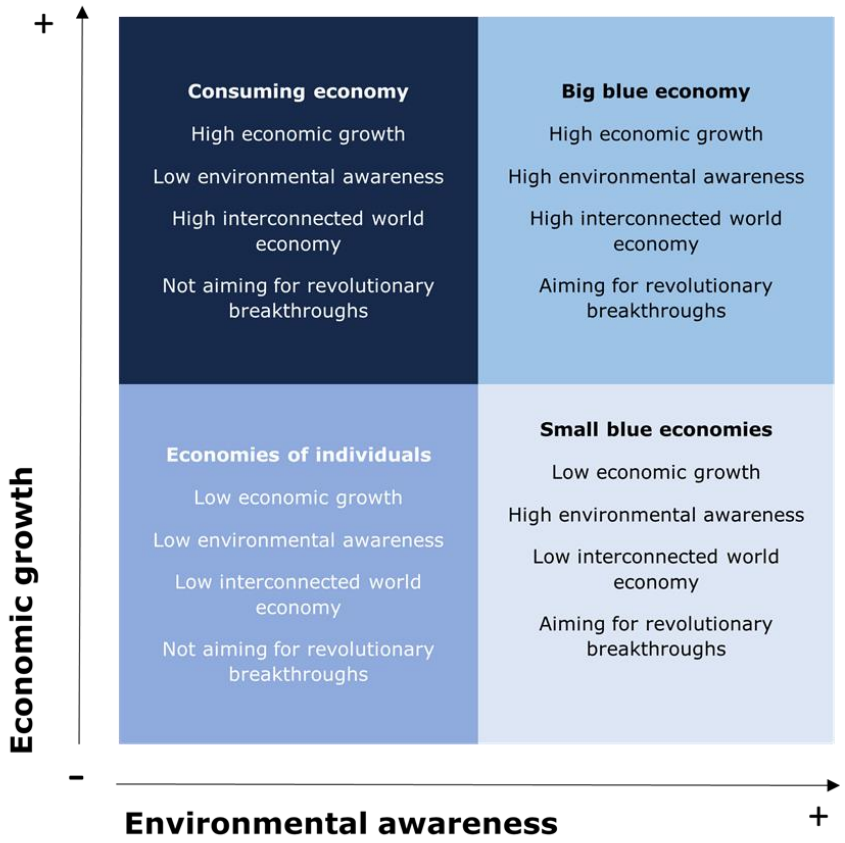
The possibility space for creating future images is in itself unlimited. Looking from today's perspective, some developments may be seen as more realistic and important than others to take place in the future. In order to be able to handle as many uncertainties around trends and developments as possible in a structured way, assumptions have to be made. By making assumptions about the linkages between important drivers, the possibility space becomes more structured and manageable. The following assumptions are made in this report (a more detailed discussion about these assumptions can be found in chapter four ´Managing Uncertainty'):

1. Individual values determine once's behaviour and therefore economic developments.
2. The level of macro-economic growth for the coming ten years is largely determined by COVID-19 and the level of an interconnected world economy, with a more interconnected world economy leading to more economic growth.
3. To what extent population growth is a driver for economic activities in the OSPAR region, is largely determined by the level of globalization.
4. A high level of risk aversion makes people more willing to follow precautionary principles and less willing to invest.
5. The level of societal trust leads to a certain adoption rate of new consumption and production practices and therefore determines the adaptation rate towards a new economy.

Based on the assumptions listed above, the future 'possibility space' is divided along two axes or dimensions. These two axes represent the two driving forces with the greatest importance and the highest uncertainty. In this analysis, economic growth and environmental awareness are considered

to be the most important underlying driving forces of change. Derived from their position in the quadrant model, assumptions are made about how the other drivers would align. The four-quadrant model beneath is representing the four scenarios (a detailed description of these scenarios can be found in chapter five `Constructed Scenarios´).

Figure 1 Four-quadrant model. Source: author



Starting from the upper left, the Consuming Economy is charaterised by high economic growth and low environmental awareness. In this scenario, the OSPAR region is assumed to be highly connected to the rest of the world, and technology is assumed to be mainly aimed at fast and cheap production at the costs of the environment.

In the upper right hand corner the OSPAR region forms the Big Blue Economy where high economic growth is combined with high environmental awareness. Due to technical innovation up to 2030 it is assumed to be possible to maintain high levels of consumption while protecting the environment.

In contrast, in the Small Blue Economies scenario in the lower right hand corner, it is assumed that it will not be possible to achieve the same level of technical innovation. This means society had to reduce their consumption in order to protect the environment. It is also assumed that this economy is less globalised in contrast to the former two scenarios.

Finally, the lower left hand corner represents Economies of individuals. This scenario assumes serious consequences of COVID-19 and a succeeding recession, including a significant decrease in economic growth and the worlds ability and appetite to innovate and tackle environmental issues.

In each of these four scenarios certain sectoral developments may be more or less likely. For this scenario analysis, the following sectors were selected in order to discuss how economic activities in and around the OSPAR region would respond to each of the four scenarios:

- Agriculture (AGR)

- Aquaculture (AQU)
- Fishery (FIS)
- Mineral extraction (MEX)
- Oil and gas production (OGP)
- Plastic production (PLP)
- Shipping (SHI)
- Tourism and recreation (TRE)
- Renewable energy production (REP)

The following table summarizes the level of uncertainty for economic and environmental development of the economic activities listed above. The results are based on data retrieved from interviews, literature and open source research, and a workshop. In this workshop, the respondents were asked to explore sectoral developments together by interpreting the four scenarios and use them as a reference point for the discussion.

Table 1 Prospective development of economic sectors (Source: author)

	Main Drivers[1]	The prospective total production quantity[2]	Bandwidth size of prospective total production quantity[3]	The prospective total environmental pressures[4]	Bandwidth size of prospective total environmental pressures[5]	The prospective environmental pressures per unit of production[6]
AGR	- Diet shifts - Global food chains - Regulation	80-120	40	70-130	60	Moderate decrease – moderate increase
AQU	- Innovation - Investments - International trading	115-150	35	100-155	55	Major decrease – minor increase
FIS	- Political stability - Fishing culture - International collaboration	90-105	15	80-100	20	Moderate decrease – minor decrease
MEX	- Consumer demand - Deep sea mining technology - Regulation	105-150	45	100-165	65	Minor decrease – major increase

1 A more comprehensive list of drivers for each sector is given in chapter seven 'Results'.

2 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

3 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

4 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

5 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

6 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

OGP	- Oil supply runs out - Demand and price for oil - Renewable energy - Political stability	80 – 115	35	75 - 115	40	Minor decrease – minor increase
PLP	- Demand for convenient products - Global vs. local value chains -Innovation -Regulation	95 - 200	105	90 – 170	80	major decrease – minor decrease
SHI	- Global vs. local value chains - Location of recycling plots - Oil and gas price - Innovation	80-105	35	70 - 110	35	moderate decrease – minor increase
TRE	- Type of tourists - Geopolitical threats raising safety concerns - COVID-19	90-130	40	60 - 150	90	Major decrease – major increase
REP	- Limited space - Innovation - Preferred investment - Securing energy supply	200-300	100	160 – 340	80	major decrease – major increase

Compared to other activities, aquaculture, mineral extraction, plastic production and renewable energy production have relatively the highest potential economic growth since their maximum estimated prospective total production quantity varies between 150 and 300. However, the level of uncertainty about economic growth varies between this group of activities: the maximum growth of renewable energy production and plastic production falls within a bandwidth of 100 and 105 respectively while this value is 35 for aquaculture and 45 for mineral extraction.

It is expected that the same level of economic growth of aquaculture would result in less environmental pressures compared to the growth of mineral extraction. This is because it is expected that the aquacultural sector would have a more rapid pace of innovation aimed to protect the environment compared to the mineral extraction sector. The environmental pressures of mineral extraction have a relative high level of uncertainty because the field of environmental pressures related to deep sea mining (an important driver for the expected sectoral growth) is understudied.

The environmental pressures per unit of plastic production is very likely to decrease while the same is less certain for renewable energy production: this could vary between a moderate decrease and

moderate increase. This uncertainty is mainly due to the additional environmental pressures caused by sustainable energy production: while this industry does reduce greenhouse gasses, it can also negatively affect biodiversity and natural habits. Since this aspect is still understudied, uncertainty is relatively high.

While exploring to the future, it seems that the OSPAR area is likely to become more industrialized; the density of activities will grow. However, the environmental pressures of this growth have a higher level of uncertainty since environmental research about these future activities is currently in an early stage of development. Therefore, it is important to allocate enough time and resources to this type of research. For instance, precautionary principles could be developed in order to safeguard that the transition towards a future similar to the scenario of Consuming Economy is limited.

It is important to stress that it is not possible to include and describe all possible drivers of change, but the most important ones are presented in this study and summarised above (the limitations of this research are discussed in chapter eight ´Discussion, conclusion and recommendations´). This document can be used to discuss and assess uncertainties about the extent economic activities and related environmental pressures may increase or decrease in the future. Based on this knowledge, it is easier to determine whether additional measures are necessary to protect the marine environment in the OSPAR area in the future. Preferably measures are taken that are robust and flexible enough to protect the environment in as many alternative scenarios as possible.

The results of this research provide a framework for future examinations of possible socio-economic drivers for economic activities by painting dots on the horizon. In order for future research on this topic to be comprehensive, it would be advisable to employ a team of researchers; the level of detail necessary to produce operational scenarios is simply too great. This course of action is supported by experts in the field of scenario writing[7].

Scenarios have different purposes (the different purposes for using scenario analyses are given in chapter three ´Scenario analysis´). Therefore, the four scenarios of this report could be used as a reference point to help guide other important complex discussions OSPAR is facing today (a more detailed description of these research recommendations are given in chapter eight ´Discussion, conclusion and recommendations´).

First, the four scenarios could be used to explore to what extent the OSPAR objectives will be met in the future. For example, it could be explored to what extent activities/pressures are too high in certain scenarios to meet the conservation targets while in other scenarios the targets could easily be met.

Second, these scenarios can function as normative scenarios and could help to structure the discussion about how OSPAR could guide the way forward in protecting the North East Atlantic region in the future. For instance, by choosing Big Blue Economy as the prescriptive vision, stakeholders could start discussing how OSPAR could help to arrive in such a future state.

Third, this scenario analysis aimed to explore drivers and environmental pressures of economic activities. During the workshop, many participants gave voice to the social outcomes of sectoral developments towards 2030. Therefore, it might be interesting to adjust these scenarios to further explore the social impact of these economic activities in 2030 (such as labour force, labour conditions etc.).

And finally, in another research, it would be interesting to focus on what role OSPAR might play in the future. The future could be explored through the four scenarios of this report. Thus, instead of focusing on the economic sectors, it could be explored how OSPAR would respond to each of the four scenarios. In chapter five 'Constructed scenarios', a brief first response of OSPAR to the four scenarios is written. These could be discussed and elaborated more in further research.

7 Such as Gerbert Romijn from the department CPB Netherlands Bureau for Economic Policy Analysis.

2 Introduction

"The power of expectations to shape modern economies in the future should not be underestimated. It is the images of the future that shape present decisions" (Beckert, 2013).

Problem

Over the past decades, marine pollution and other pressures (extraction of fish, loss of habitat) are threatening the North East Atlantic Ocean's biodiversity (Álvarez-Fernández et al., 2017). Issues that affect the environmental status of the North East Atlantic Ocean stems from anthropogenic sources in and around this region. Effective and efficient management of the oceans requires insight into how these anthropogenic resources will develop in the future. However, the mechanisms that cause environmental pressures are not straightforward and therefore hard to capture in a single forecast about the future. First of all, the plethora of human activities creates a complicated interplay of supporting and damaging the natural environment. Secondly, the natural environment is not a single system but consists of many different processes and elements. Thirdly, due to high dynamic of economic markets, it is hard to forecast the influence of human activities on the North East Atlantic Ocean. For example, technological advances and the pace of innovation, which have increased the quantity of information, improved the quality of knowledge, and compressed time and distance through globalization, influence markets. Therefore, the long term developments of the North East Atlantic Ocean are uncertain. This makes it hard to prepare for the future. For example, it is difficult to develop policies that are robust enough to protect the environment, but flexible enough to anticipate on future developments that differ from what was previously anticipated on.

Aim

The OSPAR commission, the international organization responsible for the management of the North East Atlantic Ocean, is aiming to create sustainable development of human activities within and around the OSPAR region from an ecosystem perspective. Application of the ecosystem approach in OSPAR integrates conservation and management approaches to work coherently towards a holistic approach to the problems addressed by the different OSPAR strategies. The OSPAR Convention requires that Contracting Parties periodically review the condition of the maritime area, the effectiveness of the measures being adopted, the priorities and the need for any additional or different measures. This is done through assessment and publication of Quality Status Reports, the next of which will be published in 2023. However, as detailed above, OSPAR has to operate in a world of uncertainty that makes it difficult to make decisions in order to achieve the desired sustainable long-term developments. The DAPSIR[8] (Drivers, Activities, Pressures, State, Impact, Response) model being applied in the Quality Status Report 2023 provides a framework that helps to structure the complexity of the interplay between human activities and the North East Atlantic Ocean´s marine environment. For instance, driving forces (the need for food, energy, water) lead to activities (agriculture, shipping) and cause pressures (emissions, waste) on the North East Atlantic Ocean. The objective of this report is to provide more insight into (the level of uncertainty about) the interplay between drivers and pressures of various economic activities in and around the North East Atlantic Ocean.

In order to indicate and structure the uncertainty about this interplay between drivers and pressures of various economic activities, a scenario analysis is conducted.

This scenario analysis tries to capture the uncertainty by exploring the *underlying* drivers of change. These are defined as follows: "Factors that influence how human needs could be fulfilled in the future through production and consumption practices". Examples of drivers are changing values, the level of protectionism, the impact of COVID-19, the level of economic growth and the speed of innovation.

8 The Guidance and Thematic Assessment templates for the Quality Status Report 2023 require the assessment of Drivers, Activities, Pressures, State, Impacts and Response (DAPSIR).

This report focusses on the underlying drivers of change for various economic activities. While drivers of the DAPSIR framework are defined as human needs, underlying drivers determine how this need is fulfilled in society. For a citizen a driver may be a primary need such as shelter, food and water or secondary needs, i.e. the need for mobility, entertainment and culture. It is assumed that these human needs will always exist. However, it is uncertain how these needs are fulfilled in the future. For instance, society might find it more important to eat local instead of cheap or convenient food in 2030; or citizens are increasingly buying boats in order to recreate.

In this scenario analysis, the scenarios are based on different dominant ways to fulfil human needs. These dominant ways of production and consumption are mainly determined by the values of society at that moment. For instance, in one scenario, society wants to fulfil their needs as cheap and fast as possible, while in another scenario, society wants to fulfil them in an environmental friendly way.

However, while values are an important underlying driver for economic development, other underlying drivers are important as well. For instance, economic growth, investments, technological breakthroughs or international policies. What the most important underlying drivers of change are, is highly dependent on the perspective: Different economic activities have different underlying drivers that determine the way they will produce goods and services and use resources in the future.

Eventually, the output of the scenario analysis is input for the DAPSIR framework. With this framework the linkages between different aspects of marine pollution in the OSPAR region can be analysed in more detail. In addition to providing input for the DAPSIR framework, scenario analysis can also help to structure the complexity of environmental problems and consequently help to raise awareness of stakeholders and policymakers alike about the uncertainty of the future. In this way, this report helps to develop a common understanding about which environmental pressures have a high degree of uncertainty, so this information can be taken into account when thinking about future developments and potential measures.

Approach

In-depth information on important drivers and pressures of economic activities at sea is obtained through desk and literature research and interviews. This information is used to assess the degree of uncertainty of certain developments. This is used as input for the scenario analysis. Four storylines are created that all represent different possible outcomes of the North East Atlantic Ocean's future. These storylines differ not only in regard to possible developments within the dimensions of economy and technology, but also due to different values and beliefs, such as the level of environmental awareness. Each scenario is aimed to create a consistent and coherent storyline of various socio-economic developments. The sum of the four different scenarios aims to capture the range of possible future outcomes as best as possible. It is expected that the actual future developments will be somewhere between these different outcomes.

The complexity of the North East Atlantic Ocean's future state can be captured by the definition of the blue economy: The sum of products and services delivered by the marine environment (water purification, fish population) and how they are used by economic activities on sea (European Commission, 2020). This report will use the terminology of blue economy in order to stress its focus on both economic and environmental consequences of certain developments in and around the North East Atlantic Ocean. Also recognising, that the OSPAR definition of the ecosystem approach includes the sustainable use of ecosystem goods and services and the maintenance of ecosystem integrity.

The blue economy is vast and in order to structure the wide range of potential futures of the North East Atlantic Ocean's blue economy, it is necessary to construct scenarios that consist of coherent socio-economic underlying drivers. As such, through scenario analysis, the high level of uncertainty can be structured. Only then, it is possible to make the potential long-term developments of the North East Atlantic Ocean's blue economy more clear and measures to protect the marine environment more effective.

This research intends to respond as thoroughly as possible to the following questions:

- What are possible future states of the OSPAR's blue economy in 2030?
- What are the main socio-economic uncertainties in understanding possible drivers of change for various economic activities in and around the North East Atlantic Ocean?

Geographical representation of OSPAR region[9]

The OSPAR maritime area consist of five OSPAR Regions, i.e. Arctic Waters (Region I), Greater North Sea (Region II), Celtic Seas (Region III), Bay of Biscay and Iberian Coast (Region IV) and Wider Atlantic (Region V). The North-East Atlantic can be subdivided in six regional seas, seen in Figure 1. The sub-regions will shortly be introduced.

Region I: Arctic Waters

The Arctic Waters is the most northerly OSPAR region, characterised by its harsh climate and ice coverage. However, ecosystems of this region are still rich. Furthermore, this region is very low in population density, resulting in relatively small impacts of human activities.

Region II: Greater North Sea

The Greater North Sea is surrounded by densely populated, highly industrialised countries and is one of the busiest maritime areas.

Region III: Celtic Sea

The Celtic Seas region contains wide variations in coastal topography, from fjordic sea lochs, to sand dunes, bays, estuaries and numerous sandy beaches. The large range of habitats in the region supports a diverse fish fauna. Although traditional maritime activities, such as fishing, take place in the Celtic Seas, there is ongoing development of tourism.

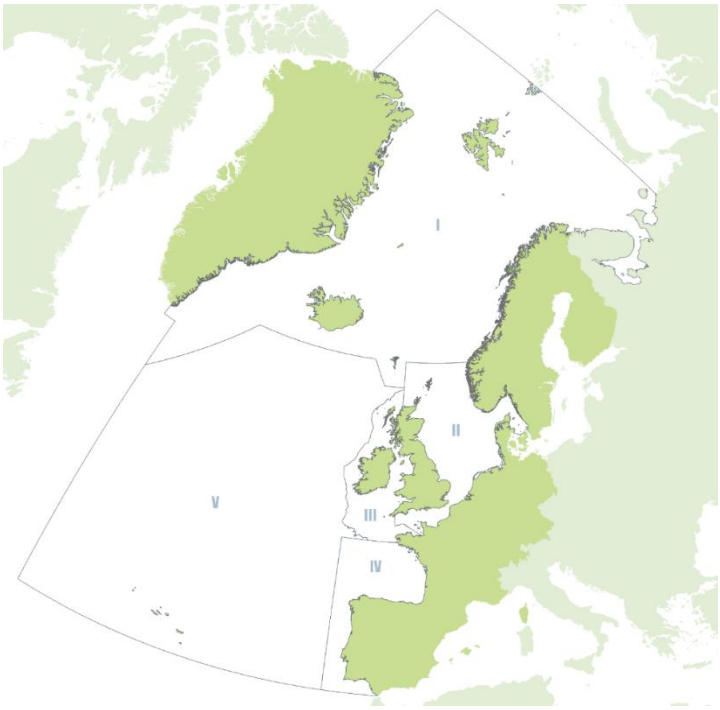


Figure 2 OSPAR region. Source: OSPAR Commission (2020).

Region IV: Bay of Biscay and Iberian Coast

The Bay of Biscay and the Iberian Coast extends from the coastlines of France, Portugal, and Spain.

Region V: Wider Atlantic

Region V represents the deep waters of the North-East Atlantic, where human population in the region is restricted to the Azores Archipelago.

Report structure

The next chapter, chapter two, will describe the approach of this scenario analysis more in depth. For instance, how the scenarios are constructed. In addition, it operationalizes the time and geographic coverage of this scenario analysis.

In order to develop scenarios for the OSPAR region, it is necessary to map out the different factors influencing the various human activities and how these are linked to the to the marine environment of the North East Atlantic Ocean. This is done in chapters three and four.

Chapter three discusses the relationship of this scenario analysis with the DAPSIR framework and explains why certain economic activities are selected for this analysis. Chapter four analyses what factors lead to uncertainty about the development of these economic activities and their environmental pressures. The findings from these chapters inform the following scenario analysis.

9 This description of the OSPAR region is a short version of the description written by Pia Pachernegg (2020)

Chapter five describes the constructed scenarios and how each results in different outcomes of marine impact in general. Chapter six discusses the economic and environmental developments for each of the selected human activities. Finally, chapter seven discusses the most important and uncertain developments and their possible implications for making policy decisions in advance of the future developments related to the North East Atlantic Ocean's economy. Furthermore it is explained how this assessment is linked with the other assessments and projects of OSPAR. For example, the Joint Assessment & Monitoring Programme (JAMP B14 project), the Quality Status Report 2023 (QSR 2023) and the North-East Atlantic Environment Strategy (NEAES).

3 Scenario analysis

This chapter describes what scenario analysis is about in general and the approach of this scenario analysis in specific.

3.1 Why scenario analysis is used

Scenario analysis does not reveal one exact road to successful decision making, nor does it assume that historical data patterns and past observational findings will replicate themselves in the future. For example, by analysing the drivers of economic activities and to what extent these can cause uncertain developments, it avoids the mistake to construct one single forecast. Because many variables influence the future of the North East Atlantic Ocean, neither all variables can be taken into account, nor the interrelationships between these variables. The aim is to indicate and structure the most important ones.

This analysis is carried out against a background of highly complex issues, involving many stakeholders and activities. This complexity renders the common approaches to uncertainty analysis inadequate: there are simply too many variables involved, and too many interlinkages between them, for a Worst-Case Analysis or a Monte-Carlo Analysis (Groeneveld et al., 2018).

Scenario analysis is about how to cope with high levels of uncertainty. It can provide a clearer understanding of what is plausible and should be taken seriously, and what is not. In the end, it is about describing various futures. Scenarios help managers anticipate what's possible within existing constraints and uncertainties, and this increases the likelihood of successful long-term strategies (Snellen et al., 2019). For example, it could help to find a suitable balance between making policies that are robust enough to protect the environment, but flexible enough to anticipate on future developments that differ from what was previously anticipated on.

Scenarios help to counteract the common biases of expecting the future to resemble the past and expecting that change will occur only gradually (Snellen et al., 2019). For example, the COVID-19 coronavirus is causing disruption across the globe. In the wake of SARS, which caused quarantines and travel bans, people began to realize the benefits of online shopping and online shopping developed rapidly. By demonstrating how and why things could quite quickly become much better or worse in new and unexpected ways, scenarios improve readiness for the range of possibilities the future may hold (Snellen et al., 2019). 'Systemic Shocks' (p.14), a textbox in chapter four, describes how this scenario analysis deals with systematic disruptions, such as pandemics and financial crises.

Furthermore, scenario analysis creates well-written storylines that can act as a platform to communicate information about the future in an understandable and interesting way (Snellen et al., 2019). For example it can be useful for gathering views from experts or policy makers on possible future societal developments and their environmental implications.

In addition to the benefits mentioned above, scenario analysis helps stakeholders and policymakers to think big about an environmental issue. For example, to take into account large time and space scales. Therefore, scenarios can raise awareness about (future) environmental problems. Scenarios might help to overcome these environmental problems because they act as a source of inspiration. Scenarios help to make new connections and encourage to think outside the box because they take into account a large time and space scale, include many human activities and explain how these interact with each other and the environment in a clear and consistent way. In other words, they encourage to make new connections between a large range of elements. For example, it encourages stakeholders to think about synergies, such as how to combine aquaculture with the generation of wind energy (Matthijsen, J. et al. 2018). However, experience shows that thinking outside the box is difficult for many participants because it requires them to go beyond historical data patterns and past observational finding. Scenario development requires a certain degree of speculation that academics are commonly trained to avoid. As such, it takes a certain amount of courage to propose a storyline that is not business as usual (Groeneveld et al., 2018).

3.2 Approach for the development of the OSPAR scenarios

The scenarios developed in this report are mainly qualitative. Furthermore, they are exploratory as they first describe the departure point of the analysis and then describe the steps that lead to a possible future situation (Alcamo, 2001). Unlike predictive scenarios, which focus on the most likely outcome, explorative scenarios are designed to examine the range of possible outcomes of an uncertain future (Groeneveld et al., 2018). Instead of focussing on the question "what will happen?", explorative scenarios are directed at the question "what can happen?".

Therefore, explorative scenarios could help to gain more insights into possible drivers of change. This analysis can allow OSPAR to form a better understanding of the major variables that may significantly impact and shape the North East Atlantic Ocean's future, in both positive and negative ways.

There is no single, strategically best way to work with scenarios (Pinnegar et al., 2006). However, according to Groeneveld et al. (2018), well-designed explorative scenarios do seem to share some common features including:

- Scenarios are best created through a collaborative process that takes into account the necessary expertise across disciplines;
- The time horizon is sufficiently distant that the future situation is uncertain;
- The scenarios are credible in the sense that those involved should be able to imagine living in such a future world;
- Scenarios are internally consistent whereby the combination of social, political, economic, environmental, technical and cultural developments makes more or less sense in terms of their magnitudes and trajectories of change;
- Scenarios are focused on conceptualising a few key developments or events which are of prime concern;
- Scenarios do not merely represent a single view of the future but plural views;
- Scenarios are often striking and sometimes uncomfortable with the objective of stakeholders so that they become engaged and excited about the findings;
- Good scenarios are dramatized in various ways, i.e. brought to life by scene-setting, stories, case-studies metaphors or encapsulated in memorable and vivid catch-phrases;
- Good scenarios lead to outcomes that at least test and may help change preconceived visions or plans.

This scenario analysis tries to produce consistent, or at least harmonized, qualitative and quantitative output. This requires the conversion of qualitative knowledge to quantitative knowledge and vice versa. For example, moderate technological innovation has to be translated into a certain percentage of environmental impact per unit of production or low economic growth has to be translated into a certain prospected change in total production value. The following quantitative indicators are used in order to satisfy the need for numerical information:

- The prospective total production quantity,
- The prospective environmental pressure,
- The prospective environmental pressure per unit of production.

There is an impression that storylines are unscientific even though they may be based on a more sophisticated concept of the drivers and pressures of an environmental system than portrayed by any mathematical model (Alcamo, 2001). Therefore, it is key to make the assumptions behind the storylines transparent enough to allow stakeholders to understand why certain choices are made and reconstruct the storylines for themselves. Thereby, they can analyse how various economic activities would act in each scenario. Furthermore, it gives stakeholders insight about the plausibility of each scenario and enables them to analyse whether the futures make sense and how it would have impact on their field of expertise. For example, a company can assess better what the impact on their economic activity would be in a certain image of the underlying developments of change. This report will therefore present the assumptions behind the storylines as much as possible. For instance, chapter four 'Managing uncertainty' identifies what assumptions are made regarding the different ways of interaction between relevant (underlying) drivers of change.

The scenarios in this analysis follow a four-quadrant approach, whereby the future 'possibility space' is divided along two axes or dimensions. The basis of the four-quadrant model involves the identification of the two driving forces with the greatest importance and the highest uncertainty. For example, the scenario analysis of European Lifestyles and Marine Ecosystems (ELME) project defines their possibility space with an axis representing 'local to global' and an axis representing societal/and or economic intervention (from community to consumerism). These axes represent the biggest assumptions. For example, it is assumed that in one scenario a more local economy is established, while in another a more global economy has developed in time[10].

The four scenarios should be considered as four possible alternative states of the world, but do not represent a complete list of alternative futures and should not be perceived as forecasts. These scenario's mainly aim to make a *more* comprehensive list of drivers, to show how uncertain the future is and to make a best estimated guess of how these drivers may cause economic activities and environmental pressures to grow or not.

The following steps are taken in order to narrow down the virtually unlimited scope of the scenario exercise. These steps are in line with the work of Alcamo (2008). According to him, clear and consistent storylines can be made via the following steps (Alcamo, 2008):

1. **A base year or period** and a description of the state of things at that moment.
2. **A time horizon** – the end point in time of the scenario
3. **A geographic coverage** – the spatial coverage of the scenarios
4. **A description of step-wise changes** – A description of the events between the base year and time horizon which explains how the future situation occurred from the present.
5. **Driving forces or uncertainties** – The main factors that influence the step-wise changes of the scenario.
6. **Storyline** – A narrative that presents the important aspects of a scenario, including the relationship between driving forces and events of the scenario.

The next paragraph operationalizes step one, two and three in accordance with the context of this scenario analysis. The last three steps (step four, five and six) are mainly based on the information that is described in chapter five 'Managing Uncertainty' and are operationalized in chapter six 'Constructed Scenarios'.

Setting the boundaries: Step one, two and three

Step 1: Base period
The current state of things about the various economic activities (information on scale and distribution of each activity, economic value, trends, and measures to reduce potential impacts) is described in the feeder reports, for the period 2010-2020. Those data will be used as starting point for this scenario analysis[11].

Step 2: Time horizon
The context of a scenario analysis has to deal with a time horizon for which many developments are highly uncertain. Social sciences and environmental sciences can differ considerably regarding the time scale at which processes take place: physical drivers (e.g., climate change) take place over much a longer time scale than social drivers. Changes in the global climate diverge considerably between different scenarios only on a time scale of 50 years or more (Groeneveld et al., 2018). Scenarios of societal development on that time scale, however, would require a degree of speculation that verges on science fiction. This scenario analysis mainly focuses on socio-economic drivers of the

10 The axes used in this scenario analysis differs from the axes of ELME and are explained in chapter four and five.

11 Since the feeder reports were not finished by the time the scenarios were drafted, additional sources were used to fill in informational gaps. The author has tried to incorporate incoming data from the feeder reports as best as possible; however, as normally scenarios are written on completed feeder reports, the conclusions from this analysis are necessarily provisional.

environmental state of the North East Atlantic's blue economy. The time horizon is justified in accordance with its aim to identify possible socio-economic drivers of change.

To be consistent with the time scale used in the Qualitative Status Report and the feeder reports, this scenario analysis focusses on a time horizon until 2030 . However, for some economic activities it is more relevant to look at a larger time scale because it is expected that they have a slower pace of development (e.g., wind energy production).

Step 3: Geographic coverage

The spatial coverage is the OSPAR region (in chapter one, a brief description of the OSPAR region can be found). While this scenario analysis focusses on the OSPAR region in general, some particular outcomes for sub-OSPAR regions may be described in the scenarios when they are deviating from OSPAR's general future images[12]. This is important because most of the time shocks, such as the impact of COVID-19, have significant regional effects (Van Den Toren & Cloosterman, 2020). For example, while some regions are not directly affected (shock resistant regions), others regions are strongly affected by the initial shock (non-resilient regions). The main reason for these regional differences is the distribution of the economic sectors and their activities across regions (Van Den Toren & Cloosterman, 2020). Because various economic activities are unevenly spread across the OSPAR region, for instance due to the distribution of small and large ports, there may be significant regional differences that are worth mentioning. More in-depth information about the scale and distribution of economic activities in and around the OSPAR region can be found in the OSPAR feeder reports.

Textbox 1: Exporting environmental problems

It is important to be aware that the geographic coverage of this report might lead to an significant distinction between the degree of environmental pressures measured on OSPAR level and on a global level.

This scenario analysis tries to assess to what extent environmental pressures may increase or decrease in the OSPAR region towards 2030. Various socio-economic drivers are likely to export production activities towards locations outside the OSPAR region. This might result in less environmental pressures in the OSPAR region, but more environmentally pressures on global level. For instance, the relocation of agricultural production towards countries outside the OSPAR region, might lead to less nutrients in the North East Atlantic Ocean, but more environmental pressures on a global level. In various countries in Europe, agricultural production is very efficient, with relatively low emissions per kilogram product. However, due to environmental restrictions that apply at the national level, those efficient farms have to stop. Production is taken over by farmers elsewhere, where (most likely) less stringent environmental restrictions apply. This means an increase and export of environmental problems (at the global level) instead of reducing them. Therefore, the interconnectedness of the world, may cause more land use change in locations outside the OSPAR region because the high interconnectivity between places made it more profitable to produce goods there instead of within the OSPAR region.

To summarize, scenarios are based on assumptions on drivers. In this scenario analysis, drivers are socio-economic factors that influence how human needs could be fulfilled in the future through production and consumption practices. Examples of drivers are changing values (such as environmental awareness, level of societal trust), level of innovation (either technical or social), changing policies (such as fish-quota), different levels of globalization (such as protectionism), long term impact of COVID-19 and different levels of economic growth (specifically the ability to invest). Each scenario combines drivers in a different way to create four distinct possible futures. This is important because all these drivers contain uncertainty. Scenario analysis structures this uncertainty in order to discuss and explore the future of the environmental pressures in the OSPAR region. This

12 Due to a lack of time, this aspect (the generation of more in-depth knowledge about future regional disparities within the OSPAR area) is understudied in this analysis. Therefore, it is recommended to use the general sectoral responses drafted in this report (see chapter seven 'Results'), as a reference point for discussing future regional disparities between the five smaller OSPAR regions.

would make it easier to anticipate on future developments of economic activity in and around the OSPAR region.

4 The DAPSIR framework and the economic activities involved

This chapter explains how this scenario analysis fits in the DAPSIR framework, the framework that is used for the Quality Status Report (QSR) of OSPAR. Also, this chapter explains why certain economic sectors are included in this scenario analysis.

4.1 DAPSIR framework

The DAPSIR framework (Drivers-Activities-Pressures-State-Impacts-Responses) can assist in clarifying the linkages between the different aspects of an environmental problem under consideration (Elliott et al., 2017). OSPAR are applying a variant of DAPSIR to consider the connectivity of pressure and state indicators and the consequences for the North East Atlantic within workstreams for the Quality Status report 2023 (Figure 2).

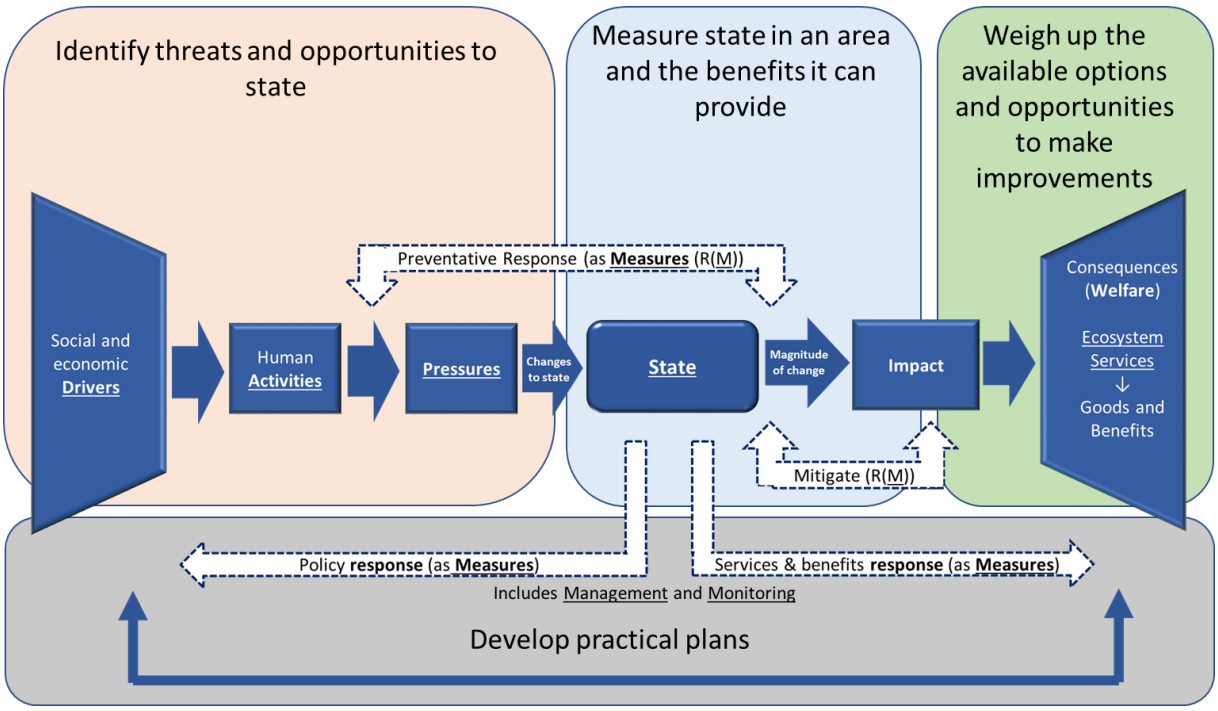


Figure 2. Recommended framework to underpin thematic assessments (developed by Cefas (Judd & Lonsdale, submitted) within the OSPAR ICG-EcoC - this amalgamates thinking from NCC1 , UK NEA2 , Elliot et al., 20173 , Hooper et al., 20194 , Maes et al., 20135 , CICES6). This schema is compatible with the European Commission Staff Working Document DAPSES-MMM framework.

According to the DAPSIR framework there is a chain of causal links starting with 'driving forces' (e.g. the need for food, energy, water) that lead to 'activities' (e.g. agriculture, shipping) through 'pressures' (e.g. emissions, waste) to 'states' (e.g. physical, chemical and biological) and 'impacts' on ecosystems, eventually leading to political 'responses' (e.g. prioritisation, target setting). Figure 3 depicts an example of how the DAPSIR framework is used in this scenario analysis about the future of the North East Atlantic Ocean.

Drivers

A driving force is a need and what this entails is highly dependent on the perspective. For an individual a need may be a primary need such as shelter, food and water or secondary needs, i.e. the need for mobility, entertainment and culture. However, for an industrial sector a driving force

could be the need to be profitable, while for a nation a driving force could be the need to keep unemployment levels low. To take a more holistic viewpoint on anthropocentric factors affecting economic activities and the environment into account, Elliot et al. (2017) defines drivers as human needs within the DAPSIR framework. According to him, there are three types of human needs, (I) basic human needs (food, water), (II) psychological needs (love, friendship) and (III) self-fulfilment needs (seeking personal growth and unique experiences).

This scenario analysis feeds into the DAPSIR framework; it establishes scenarios based on different dominant ways to fulfil human needs. These dominant ways of production and consumption represent the values of society at that moment in time. For instance, in one scenario society wants to fulfil their needs as cheap and fast as possible, while in another scenario, society wants to fulfil them in an environmental friendly way. However, values do not necessarily determine production and consumption processes. For instance, economic growth, investments, technological breakthroughs or international policies determine this a well. As seen in the figure below, the underlying drivers feed the drivers dimension of the DAPSIR framework. The underlying drivers also influence the relationships between drivers, activities and pressures.

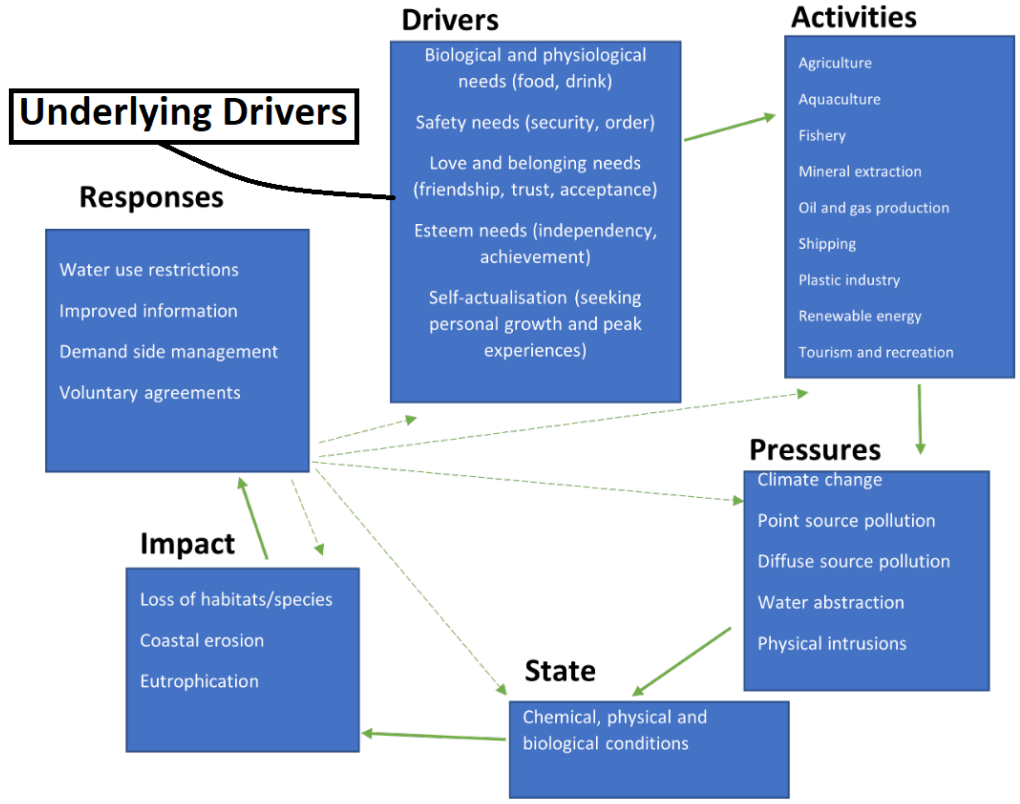


Figure 3 DAPSIR framework applied in context with this report. Source: author

Activities

An activity fulfils human needs. This report has a macroeconomic scope and perceives various economic sectors to fulfil these needs (e.g. agriculture, oil and gas production and aquaculture). However, Elliot et al., (2017) argue that for marine management, researchers should look at activities instead of sectors. Using the term sector is considered to be too ambiguous. For example, the fishery sector has many types of fishing activities (trawling, potting, long-lines, etc.) which each result in different pressures. Therefore, it would be more appropriate to identify individual activities rather than sectors for a scenario analysis about the future of the OSPAR region. However, because of the macroeconomic scope of this report and limited time, it was decided to assess economic sectors instead of activities.

In accordance with the DAPSIR framework, this analysis mainly focusses on the relationship between the activity (read sector) concerned and its (underlying) drivers and pressures. This scenario analysis tries to assess the (underlying) drivers of economic sectors and does not focus on the relationships between economic sectors. However, the development of certain sectors may be of significant importance for one another because of different reasons. The two most relevant relationships between the various sectors are included in this analysis. These are significant demand-supply dependencies and geographical space relationships.

First, one sector may have significant impact on another due to demand-supply relationships. For example, tourism may be seen as a primary driver behind the economic activities of agriculture, as is the case in the Netherlands, where increased meat consumption is mainly due to increased tourism (LINK). Another example is that the shipping sector is highly dependent on activities such as mineral extraction because the transport of minerals is mainly done over sea. Significant demand-supply dependencies are included as much as possible in the analysis.

Second, even in an area that is as big as the OSPAR region, space is limited. Therefore, the geographical expansion of one sector may cause less space for another sector. The wider North Seas are is one of the most intensively used marine areas in the world, this is an important issue in the OPSAR region. For example where offshore windfarms are built, there is less room for fisheries Significant geographical space relationships between sectors are also included in this study.

Pressures

Driving forces lead to human activities, such as transport or food production as a result of fulfilling a need. Because of production or consumption processes, human activities impose pressures on the environment (Bottero & Ferretti, 2010). Pressures can be split into three main categories: (i) excessive use of environmental resources, (ii) changes in land use, and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil. Due to the scope of this scenario analysis, the scenario analysis focusses on wider categories of environmental pressures. A more detailed description on environmental pressures of various economic activities can be found in the feeder reports.

The environmental pressures resulting from human activities are influenced by the level of human activities, and the technology applied in these activities. Discharge of waste water from domestic sources, for instance, depends on the size of the population and their consumption (activity) and on the proportion of population connected to sewers and different levels of waste water treatment (technology). Technological improvement is not always sufficient to (partially) offset the impact of production growth. For example, if a financial crisis would make organizations less willing to implement sustainable technologies, a reduction in production could lead to a higher emission level. Moreover, next to technological innovation, activities do not necessarily lead to pressures if mechanisms of prevention, mitigation or compensation are put in place by management (Elliott et al., 2017). In other words, the degree of environmental pressure is not necessarily directly related to the development in the production size.

State, impact and responses

Because this report focusses on drivers, activities and pressures, the other dimensions of the DAPSIR framework (states, impacts and responses) are described only very briefly. The state of the ecosystem is influenced as a result of pressures. This is measured by keeping track of physical, chemical or biological conditions of the environment (Bottero & Ferretti, 2010). In case of OSPAR, this is done in the OSPAR Quality Status Report 2010 and 2023 and the Intermediate Assessment 2017. State changes may have impacts on the functioning of ecosystems, their life-supporting abilities, and ultimately on human health, as well as on social and economic performance. Undesired impacts may be a trigger for society and/or policy makers to respond by implementing measures that can be focussed on any part of the chain between driving forces and impacts. In this scenario analysis, certain (inter)national collaboration is included as input for the storylines because it has a large geographical scale that includes a complex web of policies. The degree of cooperation between these actors can therefore be seen as another element of uncertainty for the future development of the various economic activities. However, it is emphasised that the storylines are mainly used to reflect on possible drivers instead of testing different ways of management.

For instance, the OSPAR organization is not taken into account in the scenarios because OSPAR's influence is assumed to be constant while exploring diverse scenarios for the future. This was decided because by excluding them in the scenarios, the scenarios could be used as a starting point for discussion about how the organization of OSPAR should manage uncertainties and use their range of influence accordingly. Furthermore, other OSPAR reports focus on the responses dimension of the DAPSIR model. This report tries to fill the knowledge gap about the drivers-pressures-activities relationships.

Textbox 2: Drivers defined

What might be confusing is that the way 'drivers' are operationalized in the DAPSIR framework differs from its operationalization in scenario analyses. As explained in the former paragraphs, the drivers in a scenario analysis can be perceived as *underlying* drivers in relation to the drivers of the DAPSIR framework. In the rest of this report, drivers are operationalized in the scenario analysis context. Drivers are defined as follows: *factors that influence how human needs could be fulfilled in the future through production and consumption practices.*

Examples of drivers are changing values (such as environmental awareness, level of societal trust), level of innovation (either technical or social), changing policies (such as fish-quota), different levels of globalization (level of protectionism), long term impact of COVID-19 and different levels of economic growth (and more specific, the ability to invest).

4.2 Economic sectors

For this scenario analysis, the following sectors are selected in order to discuss how economic activities in and around the OSPAR region would respond to each of the scenarios:

- Agriculture
- Aquaculture
- Fishery
- Mineral extraction
- Oil and gas production
- Plastic production
- Shipping
- Tourism and recreation
- Renewable energy

These sectors seem to be the most appropriate sectors to select for this scenario analysis. This is partly due to the fact that they presently have, or are expected to have, the largest effect on the North East Atlantic Ocean 's marine environment. In addition, some of these sectors have a high social value since they are responsible for a large proportion of employment or are expected to have this in the future. On the other hand, these sectors were selected because initially they seem to face the most uncertainty. For instance, they are influenced by a lot of different underlying drivers that are dynamic.

The feeder reports provide detailed descriptions about the current state of these economic sectors. For instance, their historical patterns. Whereas the feeder reports mainly focus on the question how the current state of things could lead to certain developments, this scenario analysis takes a wider perspective on what the most important prospective underlying drives of these economic sectors may be up to 2030. This scenario analysis tries to structure the discussion about to what extent the environmental developments of each of the nine sectors are uncertain.

5 Managing uncertainty

The possibility space for creating future images is in itself unlimited. Looking from today's perspective, some developments may be seen as more realistic and important than others to take place in the future. In order to be able to handle as many uncertainties around trends and developments as possible in a structured way, assumptions have to be made. By making assumptions about linkages between important drivers, the possibility space becomes more structured and manageable. For instance, it is assumed that a more interconnected world economy goes hand in hand with economic growth.

This chapter discusses the most relevant underlying socio-economic trends that influence the future state of the various sectors involved in the North East Atlantic Ocean's economy. Firstly, the linkages between environmental awareness, economic growth and environmental pressures are discussed in this chapter. Secondly, it is discussed how globalization is interlinked with economic growth and environmental awareness. Thirdly, the influence of population growth is discussed. Throughout the chapter, the impact of COVID-19 and other crises on the drivers is taken into consideration.

Textbox 3: Systemic shocks

Scenarios are always limited by our current understanding, and are necessarily a simplification of the world. Because of how scenarios are created, aiming to create coherent and consistent storylines, transitions are often expected to develop smoothly. History, however, shows that system changes can be much more sudden and disruptive; the so called systemic shocks. The OSPAR scenarios do not capture such game-changing events. However, in order to prepare for the future, the uncertainty about the impact of COVID-19 is taken into account. The ways COVID-19 may disturb the status quo (the conventional way of doing things) is uncertain. Therefore, the long-term impact of COVID-19 is uncertain as well. While some say that COVID-19 is a game-changer and will disrupt the status quo of producing and consuming for a long-term, others describe its impact as minor; looking from a long-term perspective, it will only be a temporal disruption. For example, people thought at first that COVID-19 would have major impact on the GHG emissions, but now the GHG emissions are going back to normal. Even though some say that (COVID) pandemics will occur more often in the future, this scenario study excludes such disruptions. It only takes uncertainty about the impacts of COVID-19 into account.

5.1 Environmental awareness and economic growth

Assumption: Individual values determine once's behaviour and therefore economic developments

In this scenario analysis, it is assumed that individual values determine the macro-economy. For instance, it is undesirable, from the viewpoint of climate change, that fossil energy resources will play a significant role in future activities such as shipping and transportation. Therefore, in an economy that is driven by a high level of environmental awareness, for example the doughnut economy of Kate Raworth, planetary and social boundaries are the starting point for assessing how economic activities should take place, rather than treating social and environmental stresses as economic externalities (Groeneveld et al., 2018). Therefore, it is assumed that the extent in which sustainable economies will be developed in the future, is mainly determined by the level environmental awareness among the general public, governments and stakeholders. In scenarios with low level of environmental awareness, non-sustainable economies will be developed, while high environmental awareness scenarios support a trajectory towards more sustainable economies.

Individual values may change over time and therefore have a high level of uncertainty. There are different ways how individual values can effect economic activities and their pressures. For instance,

next to being an important driver for an environmental friendly economy, individual values also influence the degree of a globalized economy. For example, it is assumed that consumers who appreciate local consumption symbols, feel an obligation to protect local experiences and to buy less foreign goods.

The linkages between environmental awareness and environmental pressures is shown in figure four.

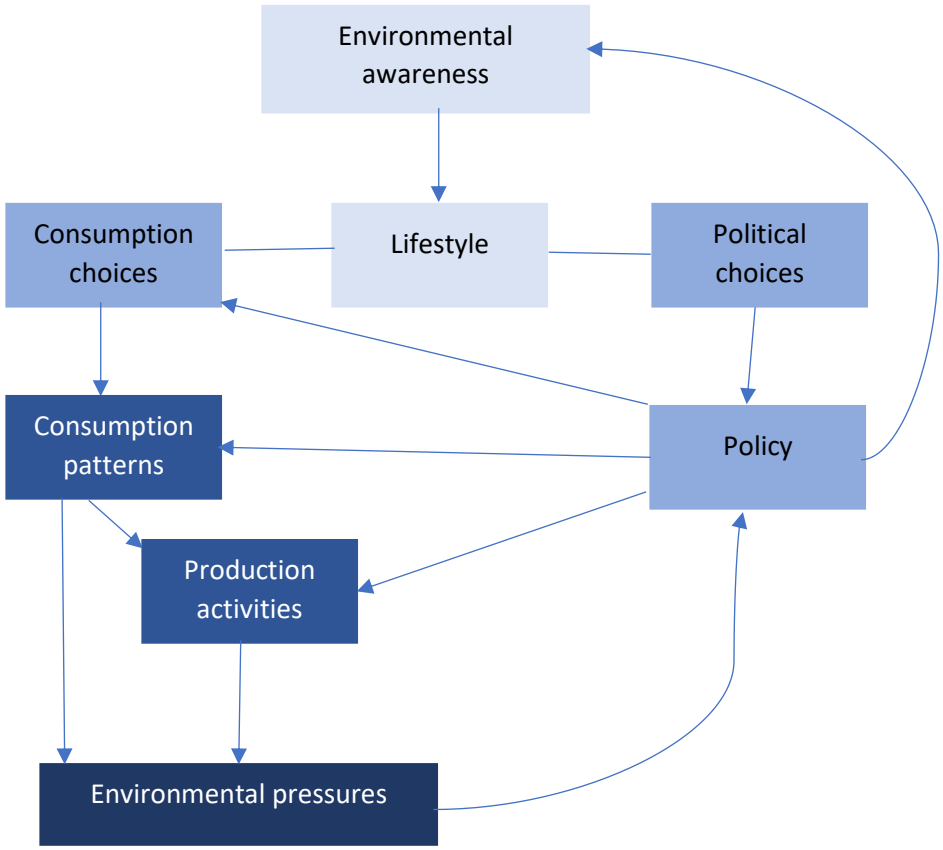


Figure 4: Linkages between environmental awareness and environmental pressures. Source: author)

In the past decades, there has been a shift from 'economy first, second and third' towards a broader concept of wellbeing. Targets that are directly related to health, social justice and the environment are developed for marine environments as well (Snellen et al., 2019). For example, the policy documents of (inter)national organizations emphasize that blue-economy activities should not exceed thresholds of good environmental status (GES) indicators (European Commission, 2020; HELCOM, 2018; Matthijsen, J. et al. 2018). Consumers are starting to get knowledge about industries' impact on environment as well as that public and animal health pays heavy prices for overconsumption of resources and energy (Pringle et al., 2016; Quina et al., 2017). This places pressure on industries to develop sustainable economies (Ilić & Nikolić, 2016). For example, consumer perception towards remanufactured products is one of the most important factors that influence the implementation of a sustainable economy (Govindan & Hasanagic 2018). However, most of these (inter)national environmental objectives that have been set in the past decades have not been accomplished yet. For instance, the number of electric vehicles is growing steadily, but not quick enough to meet the global climate targets (Snellen et al., 2019).

Some scientists believe that COVID-19 could accelerate the movement towards transnational environmentalism. Manzanedo & Manning (2020) perceive COVID-19 as a wakeup call for immediate acting against climate change, because society can learn to better deal with future global crises. Climate change and COVID-19 are both external shocks with catastrophic consequences (Manzanedo & Manning, 2020). Climate change models and long-term forecasts are hard for the public and policy makers to grasp, as they challenge intuition and short-term thinking. Scientists have long cautioned

about anthropogenic climate change and emphasized the need for strong and early action to prevent its worst consequences. But, as with the muted response to early warnings of the spread of SARS-CoV-2 in China, and even earlier warnings of the pandemic potential of SARS-CoV-like viruses, much needed early action has not been taken. In such cases, the crisis may only become obvious when it is too late to prevent it (Manzanedo & Manning, 2020).

> *"Again, acting now to establish international agreements and road maps to deal with future global crises will decrease the chances of nationalistic policy responses, egotistic behaviours or political leaders prioritizing powerful or wealthy individuals over the World's general population"* (Manzanedo & Manning, 2020).

Therefore, in scenarios with high environmental awareness, COVID-19 made it obvious that society had to take immediate action against climate change. In scenarios with low environmental awareness, society postponed measures against climate change because it is believed this is not the most pressing concern at the time.

Next to environmental awareness, economic growth is another key factor of uncertainty about the possible ways how environmental pressures may be generated by human activities in the future.

Assumption: The level of macro-economic growth for the coming ten years is largely determined by COVID-19 and the level of an interconnected world economy

In this scenario analysis, different assumptions are made about the degree of economic growth. Uncertainty about the economic impact of COVID-19, for example about the duration of the pandemic, is seen as one of the most important determinants for economic growth in the future (Vos et al., 2018). In scenarios with high economic growth it is assumed that containment measures are effective enough so that the main economic impact of COVID-19 is a major, but short-lived disruption of global economic activity. Current developments show that this assumption is perhaps somewhat optimistic. A wider perspective of the possible COVID-19 impact is included in low economic growth scenarios. In low economic growth scenarios it is assumed that the global spread of the virus was more difficult to contain and that the global economy fell into a recession.

The level of economic growth has impact on the level of investments and socio-technological innovation. For example, compared to economic booms, it is assumed that recessions lead to less investments for the development of new technologies. Furthermore, more economic growth leads to more economic activity and thus more environmental pressures. This may partially be offset by technology aimed at reducing environmental pressures. However, this is dependent on the level of environmental awareness because technological innovation is not necessarily aimed at decreasing environmental impact caused by human activities; for instance, the dominant trajectory of innovation could be dominated by other goals (e.g., decreasing labour costs, increasing market share). Note that innovation in this scenario analysis is not only determined by technological improvement, but also social improvement. An example of socio-technical innovation is carsharing. For carsharing you need new technology (for instance, an app to unlock the car), but also new forms of social relationships (innovation that focusses on how to share cars between citizens and how to manage this).

In a scenario with low level of environmental awareness, innovation is mainly aimed at improving efficiency. This is known as incremental innovation because it focuses on improving the established way of consuming and producing (e.g. quicker, cheaper, etc.). In a scenario with a high level of environmental awareness, technological improvement goes hand in hand with more rigorous innovation. This is known as radical innovation. In high environmental awareness scenarios, society believes that rigorous change in consumption and production is necessary in order to become sustainable. Radical innovation is not aimed at making it smoother or cheaper, but at creating a completely new way of serving human needs. Radical innovation can lead to a new dominant design

and paradigm shift. For instance, The smartphone itself was radical, but the upgrades and shifts from year-to-year are incremental.

In this scenario analysis, it is assumed that there is an important interplay between economic growth and environmental awareness in order to achieve a sustainable economy in and around the North East Atlantic Ocean. For instance, for scenarios with high environmental awareness the dominant trajectory of innovation is sustainability. However, it is assumed that, in addition to high environmental awareness, economic growth is another necessity for the development of sustainable innovation (since one needs money to be able to pay for the innovations). Therefore, scenarios with high environmental awareness *and* high economic growth have more sustainable innovation than scenarios with high environmental awareness but low economic growth.

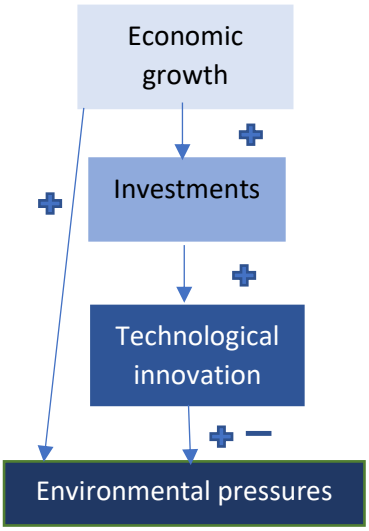


Figure 5: Linkages economic growth and environmental pressures. Source: author

5.2 Globalization

Assumption: more globalization leads to more economic growth

For this scenario analysis, it is assumed that globalization is correlated to economic growth. The world economy is an important driver for economic development because it is assumed that a high degree of competition stimulates efficiency, cost-reduction and innovation. As a result this leads to higher productivity to eventually increase economic growth (Renes & Romijn, 2015). For example, within scenarios with a high degree of economic growth, the various economic activities are situated in an integrated world economy.

This section discusses how this scenario analysis manages the uncertainty about the extent in which various economic activities in and around the OSPAR region will have to cope with a more or less globalized world in the future. Firstly, globalization is defined. Next, the uncertainty about the future interconnectedness of the various economic activities in and around the OSPAR region with the world economy is discussed. Thereafter, the environmental effects of globalization are discussed. Note that economic effects of globalization are not discussed thoroughly because it is assumed that globalization goes hand in hand with economic growth.

Globalization defined
Most often, globalization is described as the increase of the worldwide interconnectedness of places and people through markets, financial capital flows, transfer of knowledge and technology, human

migrations, and social and political institutions. This report focusses on economic globalization and defines this as follows: *the shift towards a more interconnected world economy*.

The globalization of the OSPAR region

The various economic activities in and around the OSPAR region may be more interconnected with the rest of the world in the future. This possible development is highly influenced by what kind of trading policies (free trade vs. protectionism) will emerge between nations. Successful trade agreements facilitate market access, by including tariff cuts and other market access concessions, and contribute to a larger trade response (Santeramo & Lamonaca, 2020).

The uncertainty about the prospected interconnectedness of the OSPAR region with the world economy can for a large extent be extrapolated from the trading policies of the European Union. First of all, because eleven out of the fifteen contracting parties of the OPSAR conventions are countries that are part of the European Union (i.e., Belgium, Denmark, Finland, France Germany, Ireland, Luxembourg, The Netherlands, Portugal, Spain and Sweden). Secondly, because the European Union is one of the contracting parties of the OSPAR convention itself. Besides these European members states, Iceland, Norway, Switzerland and the United Kingdom are part of the OSPAR convention. For these countries, the EU is an important trading partner. Therefore, this section focusses mainly on the trading policies of the European Union.

Today, the EU is the most important trading partner for some 80 economies (WTO, 2019). The EU is the world's largest trading bloc and the world's largest trader of manufactured goods and services. The export growth in the volume of world merchandise trade in the European Union grew with 2.3% between 2010 and 2018; import grew with 1.8%. Trade in services expanded faster than expansion of trade in goods (on yearly average a 5.4%, and a 4.6% increase since 2005).Industry accounts for 25% of EU's GDP. Services are the main contributors to the GDP of the EU, accounting for nearly three quarters (75%) of the output. The EU's main trading partners in service trade are the United States and China (WTO, 2019).

It seems plausible that the EU will continue to extend free trade policies and will live in a more interconnected world economy in the future. The EU is a world leader in terms of the number of free trade agreements (FTAs): On 30 September 2019, the EU had 41 FTAs in force with 72 countries. The largest FTA partners - based on data on trade in goods - were Switzerland, Turkey and Norway (WTO, 2019). In 2019, the EU-Japan FTA went into force, which was described as a message of Europe and Japan to the world about the future of open and fair trade: *"We are opening a new marketplace, home to 635 million people and almost a third of the world's Gross Domestic Product, bringing the people of Europe and Japan closer together than ever before."* (European commission, 2019).

However, while the EU continues to extend the range of free trade, at the same time, on a worldwide scale, the share of EU trade in the world export and import is on a decline (WTO, 2019b). This might be explained by the fact that China is becoming a more important world player. Furthermore, more than two thirds of EU countries their total trade is between other EU member States. This partially has to do with the enlargement of the EU. This made the new European countries important suppliers of intermediate goods to key EU producers, in particular, German manufacturers (European Union, 2017).

The trajectory of more economic globalization in the coming years is questionable

There is uncertainty about the extent to which the ongoing trend of economic globalization will proceed in the future. The next section provides an in depth explanation of six key factors that contribute to this uncertainty: protectionism, self-sufficiency, online consumption, COVID-19, superpower China and knowledge intensive economies.

Protectionism

The world has seen the emergence of populist, protectionist movements in many advanced

economies. The (possible) elections of political parties an persons that advocate a more defensive industrial strategy for their national economies may halter the trend towards a more interconnected world economy. The overall promise behind these protectionistic policies it to deliver better results for national citizens, and is related to strong societal attitudes to buy domestic instead of foreign products. For example, the America first movement intended to protect the US manufacturing sector. Furthermore, there is a looming trade tension between the United States and its major trading partners, especially China, the second largest economy in the world (PDF). This has significant effects on the growth opportunities in economies, including the various activities in the OSPAR region, but also with the EU. Lastly, some argue that the trading policies of the EU are developing towards protectionism; a development towards 'Fortress Europe' (PDF). Current values may become more regional than international oriented. For example the Exit-Europe movement or America First.

Self-sufficiency
It seems that countries are increasingly focused on becoming food and energy self-sufficient. For several years now, global trade systems have been increasingly distorted by various protectionistic measures and trade restrictions. Governments seek to make their countries self-sufficient in food (Erokhin & Gao, 2020). For instance, during the 2007–2008 global economic downturn, the doubling of world food prices was mainly attributed to trade restrictions imposed by the largest exporters of rice, wheat, and soybeans. The actions aimed to avert national shortages in some countries contributed to breaking the logistics chains for staple foods in many national markets (Erokhin & Gao, 2020).

Furthermore, for many countries, reduced dependence on imports of energy for both economic and strategic reasons continues to be a major driver for economic activity. Improved technology for offshore oil exploration and extraction brings within reach the goal of producing from previously impossible geological provinces, including those in the Arctic. For some countries, sovereignty is a major driver for exploration. Greenland, which has gradually gained increasing independence from Denmark, is economically secure because of a block grant from Denmark, but, seeking economic independence towards a goal of full sovereignty, is pushing for mineral exploration, including oil and gas (Andrew, 2014).

Online consumption
COVID-19 has accelerated the trend of digitalisation which makes people less dependent on time and space. For instance, backed up by technological support, people, can have more flexible working hours (Snellen et al., 2019). Due to COVID-19, people became more familiar with using online communication instead of offline. Furthermore, COVID 19 seems to accelerate the trend of online shopping, which is associated with globalisation. This might increase the transport of products over sea. However, on the other hand, the corona virus makes people more dependent on their local environment because they are obligated to stay in and around their place of living. As a consequence, COVID-19 may accelerate the trend of consuming local products and services, such as recreation. Furthermore, a lot of local businesses ask consumers to support them by buying their products. This might accelerate the consumption of local products as well.

COVID-19
Piekutowska and Marcinkiewicz (2020) claim that the liberalization of international trade cannot be taken for granted because of COVID-19.

- Over the past three decades global value chains (i.e., production is shared between at least two countries) have expanded greatly, whereas in the years immediately after the global financial crisis the expansion of global value chains significantly slowed (PDF).
- The limited increase in global GDP from 2012-2016 was almost entirely due to the growth of pure domestic production; international trade contributed very little during this slow recovery period (PDF).
- The WTO argues that globalized production chains (i.e., the production stages of end-products is diffused over nations) are more sensitive to external economic shocks, such as a pandemic (PDF).

At the moment of writing (early 2021), the ongoing COVID-19 pandemic is a global crisis. The call for social distancing has affected all aspects of everyday life and work, and heavily impacted the global economy (Manzanedo & Manning, 2020). The current COVID-19 crisis may be one of the first faced by a highly globalized world where all nations directly compete for the same limited resources. Therefore, nations (or even states within a country) might become more tempted to protect their own citizens at whatever cost to others. There are clear examples of this behaviour:

- Actions such as restricting the export of sanitary material (LINK);
- Alleged attempts to guarantee exclusive access to a vaccine in development (LINK);
- Disagreements within the European Union about the scale of economic solidarity needed to deal with the current crisis (LINK);
- Governments are pursuing stockpiling, in several cases with the double objective of making food available to the poor and of helping agricultural producers (i.e., by purchasing unsold products and/or guaranteeing a minimum revenue to farmers).
- Many countries chose to revive, enhance or expand purchases under their public stockholding programmes (e.g., Egypt, India, Morocco, Philippines, the Kingdom of Saudi Arabia), and to increase procurement prices (LINK).

The behaviour to protect their own citizens can also be seen on a consumer level. This behaviour is reflected by 'panic buying' and increased home-based consumption (PDF). Erokhin & Gao (2020) argue that COVID-19 made consumers more worried about potential disruptions in food supply chains:

> *"As the virus spreads and public health protection measures tighten, there are many ways in which the global food system has been strained (border closures, quarantines, supply chain disruptions, etc.); the pandemic is affecting food systems directly by distorting supply and demand internationally, and indirectly by degrading the purchasing power of the population and by undermining the capacity to produce and distribute food"* (Erokhin & Gao 2020).

In line with the above, it seems that the disruption of COVID-19 would support the development of economies that focus on domestic demand and production in order to create an secure supply of goods. However, the current globalised economy might just as well be robust enough to continue the globalised production level as it was pre-COVID-19 times. Furthermore, the COVID-19 crisis may increase coordinated global action to help to manage an reduce its dramatic effects.

As the previous paragraphs showed, it is uncertain what dominant believe about the ability of international supply chains to secure a steady supply of goods will dominate. For instance, on the one hand, COVID-19 may accelerate the belief that international collaboration is needed in order to secure the access to goods and services through global value chains. But on the other hand, COVID-19 may accelerate the belief that national supply chains are necessary in order to secure access to good and services. Moreover, COVID-19 might accelerate the trend of individualistic and national behaviour when resources become more scarce in the future. It might strengthen the belief that people have to exploit resources faster than others in order to secure themselves of commodities.

Superpower China

China is no longer just a "factory" exporting huge amounts of final goods to the world; China has emerged as a new "superpower" through rapid industrial upgrading, which is reflected in the large scale of its exports and imports of intermediate goods and services. In the past, China produced low-cost consumer goods and low-tech manufacturing goods, whereas the EU produced high-tech industrial goods and services. Today, European and Chinese companies are increasingly becoming

direct competitors. As a result, China today cannot be considered as simply a developing country anymore – as a matter of fact, it is well its way to become a technological power in the near-term[13].

More countries, especially in Asia, have become highly dependent on China's supply and demand for goods and services. Therefore, it is expected that, given China's potential for positive economic growth, the ongoing process of further opening-up, and its large population size, China will become an important demand of international goods in the near future. However, it is still uncertain whether there will be more import and export between the OSPAR region and China in the future, since China is increasingly focussing on its own domestic market (PDF). As a result, China might increasingly produce more and import less in the future. Furthermore, COVID-19 seems to have increased anxiety about consuming commodities that have their origin in China. This rise in anxiety would make it less attractive for businesses to cooperate with Chinese companies in the future.

Knowledge intensive economies

The production processes in more knowledge intensive sectors extends the depth and scope of international exchange and division of labour. The higher the technology (knowledge) intensity of the sector, the larger the increase in global value chains. This supports the trend towards global production networks.

Knowledge intensive economies are one of the fundamental forces that made domestic economies across the world more interconnected. For instance, in knowledge intensive economies, parts and components of certain products (such as computers, automobiles and airplanes) cross national borders several times (PDF). However, at the same time, it is believed that if the economy of, for instance Europe, would become more knowledge intensive, less trading of goods would be needed because productivity would shift towards providing (online) services.

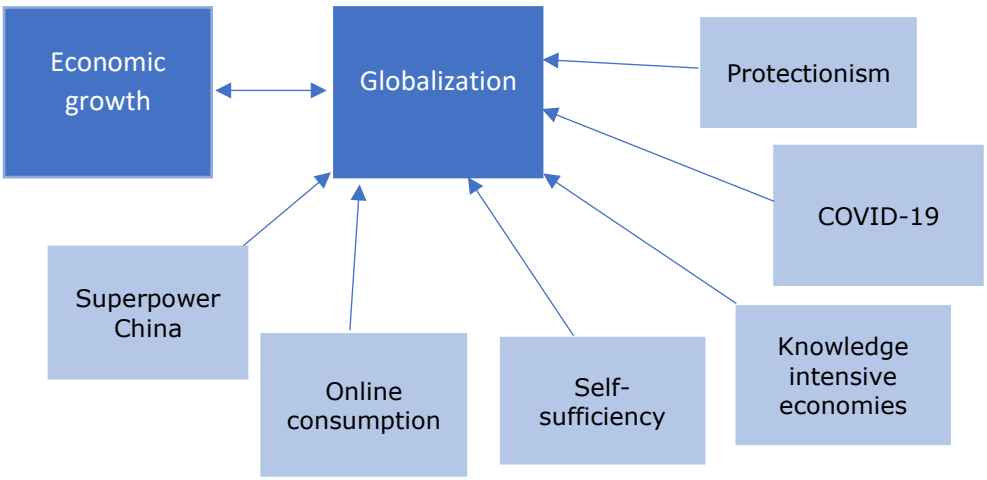


Figure 6: Relationship between economic growth and globalization and factors that influence the level of globalization towards the year of 2030. Source: author

In the scenario of high environmental awareness and high economic growth, there is a high level of trust in international collaboration that is aimed at reaching sustainability goals. In the scenario of low environmental awareness and high economic growth, there is a high level of trust in international collaboration as well, but most international collaboration is aimed at profit maximisation. For the scenario of high environmental awareness and low economic growth, it is assumed that the society prefers to consume local commodities because its believed that local production plays a key role in achieving sustainability goals. Furthermore, people are consuming less due to environmental awareness; they have a more minimalistic lifestyle and prefer to buy high quality products. In the

13 China´s rapid economic growth may lead to more sustainable innovations. China is the world's largest carbon emitter, and recently, a push for greener production of goods and energy solutions by the Chinese government and state owned Chinese companies have propelled the filing of patents around climate change technologies (Bhadola et al., 2020).

scenario of low environmental awareness and low economic growth, globalization was hampered mainly because of protectionism and mistrust towards international collaboration. In the latter scenario, people are more indifferent about consuming and producing sustainable. Instead, they solely focus on their national economies to become more self-sufficient.

Economic globalization is not automatically harmful to the environment

The environmental effects of globalization

The effects of an interconnected world economy that are studied are mostly socio-economic, for example the creation of jobs. Environmental effects are understudied (Shahbaz et al., 2018). Nobody knows all of the environmental effects of a more interconnected world economy because it is impossible to determine the particular contribution of globalization to, for example, the loss of biodiversity (Ehrenfeld, 2003). In order to discuss how the environmental pressures would evolve due to a the degree of economic globalization in the world of 2030 in the various scenarios, this scenario analysis focusses on wider categories of environmental pressures. This section should be perceived as food for thought in the discussion about how the environmental pressures of various economic activities could evolve in the OSPAR region towards 2030.

Most of the time, research describes that globalization is making a great contribution to the reduction in biodiversity via different mechanisms. However, while it might seem clear that globalization goes hand in hand with a reduction in biodiversity, globalization may also support biodiversity (Lambin & Meyfroidt, 2011; Shahbaz et al., 2018). For example, according to Shahbaz et al. (2018) globalization can have both positive and negative effects on greenhouse gas emissions. Lambin & Meyfroidt (2011) perceive globalization as a possible driver for land use efficiency. As explained in chapter three, this scenario analysis mainly focusses on three wider categories of environmental pressures: changes in land use; emissions to air, water or land; and excessive use of environmental resources. Why globalization can stimulate positive and negative effects of economies on the environment in the future, is discussed in the following paragraphs with a special focus on these three wider categories.

Land use change

The effect of globalization on land use change is uncertain. On the one hand, it is believed that globalization could increase the efficiency of land use allocation and stimulate innovation in economic sectors. For example, trade carries the potential to increase global land use efficiency by allowing for regional specialization in land use, and productivity increases as a response to a global shortage of productive land (Lambin & Meyfroidt, 2011). Moreover, the concentration of production sites and waste sites may affect the degree of recycling because it is easier to make it economically feasible to use waste as input for production (Port of Rotterdam, pers. Comm, 2020). However, the environmental gains generated by recycling may be offset by increased transportation of goods. The effect of transportation is dependent on the locations of (production and recycling) plots and consumer markets.

At the same time, the acceleration of economic globalization in combination with a scarcity of productive land globally, may render the perseverance of ecosystems. For example, economic globalization increases the influence of large agribusiness enterprises and international financial flows on local land use decisions. In some cases, this weakens the incentive to preserve the local environment. While most studies related to globalization and land use change focus on specific activities and environments (the replacement of tropical forest by agriculture or wood production), the researched underlying mechanisms can be extrapolated to other environments, including the marine environment. For instance, the effects of globalization on land use can be harnessed if land use is understood as being part of open and complex human-environment systems dominated by long distance flows of commodities, capital, and people (Lambin & Meyfroidt, 2011). This understanding is highly related to the level of environmental ambition. For the agricultural sector, for instance, Europe is a significant importer of food and agricultural commodities, with the potential to lead to unsustainable practices in third countries, as well as the opportunity to export good practice through new sustainability standards (Allen et al., n.d.).

Emissions
In general, globalization is considered to have a positive relationship with emissions because it stimulates economic activities around the world. For instance, it stimulates energy consumption (Shahbaz et al., 2018). However, other research found that trade openness decrease CO2 emissions in advanced economies (Munir & Ameer, 2018).

The main argument for a positive relationship between an interconnected world economy and greenhouse gas emissions is that it increases the separation between the location of production and consumption and therefore enhances the need for international transport and energy (Lambin & Meyfroidt, 2011). Furthermore, energy consumption increases if foreign firms in a domestic economy expand the existing or create new business activities with obsolete or traditional technology (Shahbaz et al., 2018). Sometimes, however, globalization and energy demand have an inverse relationship (Shahbaz et al., 2018). In this case, foreign investors employ sophisticated technology in economic activities that lowers the usage of energy.

Therefore, globalization seems to accelerate (the spread of) economic activities worldwide, but could also diffuse sustainable technologies. In the latter case, globalization would decrease emissions.

Excessive use of environmental resources
Globalization could lead to excessive use of environmental resources. For instance, Deutsch et al. (2007) argues that the stretching of the production chain from local to global, and the ability to switch between marine areas worldwide, seem to undermine the industry's incentives to respond to changes in the capacity of ecosystems to supply resources (fish etc.). During her research she found that aquaculture producers are seldom constrained by local resource inputs, but operate on a global scale with exploitation of rapidly varying locations across the globe. In line with this argumentation, globalization increases environmental pressures.

However, at the same time, it is argued that globalization leads to a global level playing field for producers; globalization would lead to a more universal view on what rules need to be followed to produce sustainable goods. For instance, global sustainable certificates are developed that represents a universal view of what is sustainable and given the relative importance the EU has a significant trading block for the rest of the world, standards set by the EU are often implemented worldwide, since producers worldwide would like to be able to sell their products on the European market. Therefore, it is assumed that standards set by the contracting parties within the OSPAR region, can potentially create the development towards a global level playing field. For instance, in the case of scenarios driven by high environmental awareness and high economic growth.

To conclude, several studies (Lambin & Meyfroidt, 2011; Shahbaz et al., 2018) indicate that the environmental effects of the progress towards a more globalized economy, depend on the desire to preserve nature in the future. Therefore, in a future with a high level of environmental awareness and economic growth, globalization is expected to increase efficient land-use allocation, the spread of sustainable technology and a global level playing field. However, in a future with a low level of environmental awareness and high level of economic growth, globalization is expected to increase land use change, (greenhouse gas) emissions and increase the excessive use of environmental resources.

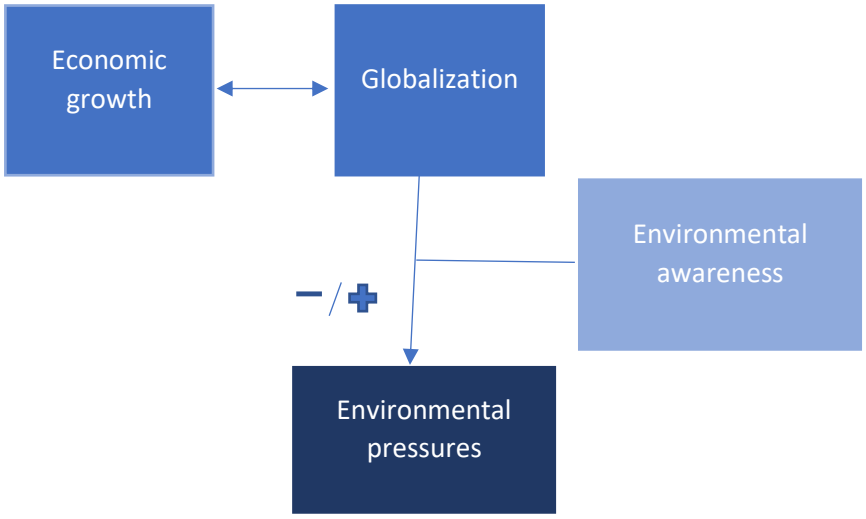


Figure 7: Linkages between economic growth, globalization, environmental awareness and environmental pressures. Source: author

5.3 Population growth

> *Assumption: to what extent population growth is a driver for economic activities in the OSPAR region, is largely determined by the level of globalization*

Several economic studies confirm a positive long-run correlation between population, population growth, and technological change in advanced economies (An & Jeon, 2006). For instance, population growth has an effect on the productivity of a country. The probability to create potential inventors increases if there are proportionally more individuals with new ideas. In addition, a high population growth spurs demand-induced inventions and innovations by larger intellectual networks and greater specialization, which increase the probability that new ideas and new innovations can be introduced and adopted. More innovations support economic growth, which further favours the development of inventions and innovations. This line of argumentation is rooted in the theory of population-push (An & Jeon, 2006).

Education, in particular in science, technology, engineering and mathematics (STEM), is associated with higher levels of innovation activities. Policies to increase the supply of STEM graduates and attract highly skilled immigrants have been shown to boost innovation. For example, in the US, the immigration of scientists and engineers (highly skilled immigration inflows) supported innovation and total factor productivity (Coccia, 2014). Furthermore, the highly skilled scientists and engineers from developing countries who have emigrated abroad to work can also generate net positive gains in their home countries when they go back to their home countries or when they connect with local entrepreneurs there (PDF).

Compared to other factors, population growth has a low level of uncertainty. Furthermore, since the year 2000, welfare replaced population as the largest driver of material extraction globally, although at a regional level population was the most significant factor in both Africa and West Asia (Perman, 2019). However, because resource demand is a function of population, affluence and technology, population growth is still important to take into account in this scenario analysis. For instance, it is assumed that higher population growth leads to greater demand for goods and services, which leads to more economic growth.

Projections for the global human population can be taken from a publication of the UN's Department of Economic and Social Affairs (UN Population Division, 2019). From an estimated 7.7. billion people

worldwide in 2019, it is expected that the global population could grow to around 8.5 billion in 2030. Countries of sub-Saharan Africa could account for more than half of the growth of the world's population between 2019 and 2050 and are expected to continue growing after this century. In contrast, populations in Eastern and South Eastern Asia, Central and Southern Asia, Latin America and the Caribbean, and Europe and Northern America are projected to begin to decline before the end of this century.

The demographic trends projected over the long term reveal that Europe is 'turning increasingly grey' in the coming decades. This implies that the EU would move from having four working-age people for every person aged over 65 years to about two working-age persons (PDF).

Compared to the worldwide population growth, the average population growth of the OSPAR contracting parties is expected to be lower. It is expected that in 2030 the population of the OSPAR contracting parties has aged (the share of the old has increased while the share of the young has decreased) due to low fertility and low mortality. In the European Union, people aged 65 or over accounted for 17.9 % of the population in 2012 (an increase of 0.4 % compared with the previous year). An estimated 23.5% per cent of the total population will be 65 or older in 2030 (European Union, 2016). In line with the above, it is assumed that a blue economy of the OSPAR region that is more driven by domestic demand has lower economic growth then a blue economy more focussed on global demand. Moreover, it is assumed that in an globalized world, more immigrants enter the working population of OSPAR and therefore increase innovation and productivity of the total population of OSPAR. Furthermore, in scenarios with high economic growth, it is assumed that technology is diffused faster partially due to the migration of the working force around the globe.

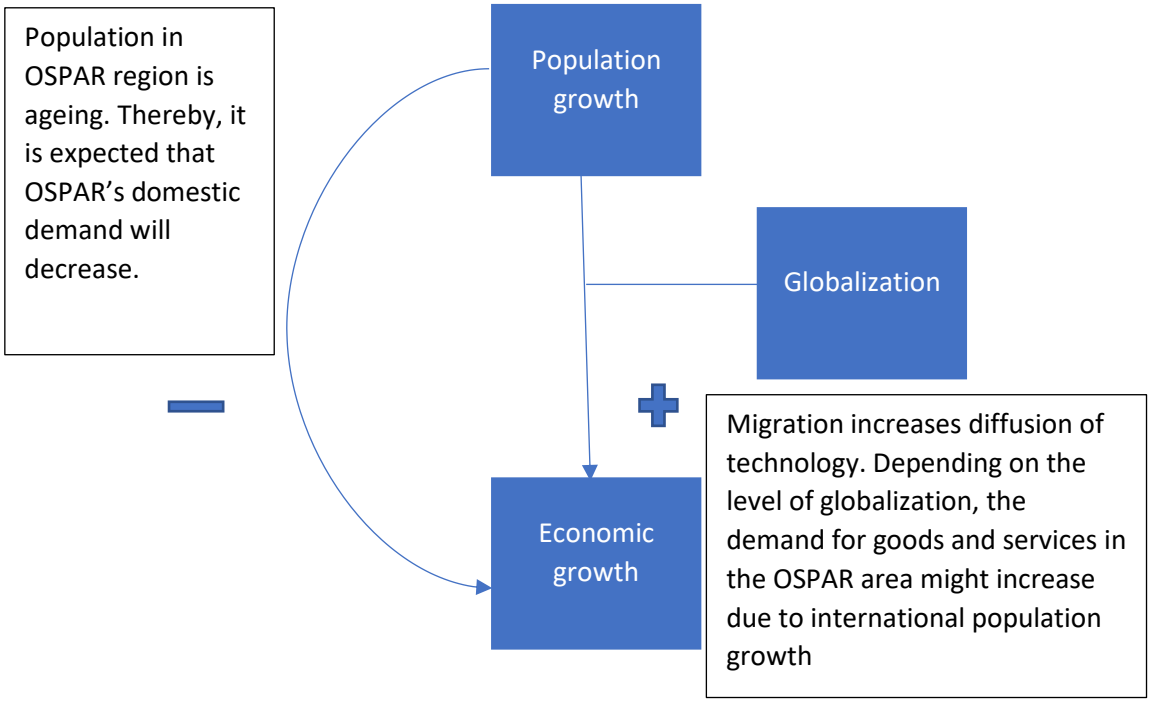


Figure 8: Linkages population growth and economic growth. Source: author

5.4 Risk aversion and societal trust

> *Assumption: A high level of risk aversion makes people more willing to follow precautionary principles and less willing to invest*

The implementation of the precautionary principle is normative and therefore has a high level of uncertainty. It is assumed that precautionary principles (i.e. measures to protect society from likely environmental harm in the future) are more often applied in societies that have a higher level of risk aversion. At the same time, it is assumed that societies with higher level of risk aversion are less willing to invest. This would lower economic growth and hence, decrease the resources to innovate.

Depending on the level of risk people are willing to make, precautionary principles may be applied. Sometimes, the lack of certainty makes people to be careful in their decisions. Overall, there is a tendency to delay measures that should be implemented to cope with uncertainty. For example, risk aversiveness influences the willingness of society to cope with climate change. Most policymakers want to base their decisions on the consequences. Therefore, it is assumed that a high level of risk aversity, makes people more willing to follow precautionary principles. For example, to delay the burning of fossil fuels.

Assumption: The level of societal trust leads to a certain adoption rate of new consumption and production practices and therefore determines the adaptation rate towards a new economy

In this scenario analysis, it is assumed that a high level of trust in the global society is correlated to more economic growth because diffusion of innovation is supported. For instance, trust increases, via mechanisms of contagion, social influence and social learning, the willingness of people to adopt to new ways of production and consumption (An & Jeon, 2006). Therefore, a higher level of trust towards the global society makes people develop a sense of belonging to a global consumer culture by adopting global values, beliefs, lifestyles, and consumption patterns (Dogan & Yaprak, 2017). In other words, a higher level of trust, for example in empirical evidence, makes it easier to convince people that innovation is worth adopting and to change their traditional practices.

However, there is a growing group of people in society that mistrust authorities. For example, some of the causes of vaccine hesitancy, which is a common phenomenon in western countries, are related to mistrust towards healthcare professionals and health authorities (Palamenghi et al., 2020). Science, along with the data it generates, is continually questioned and undermined, perhaps in no nation more so than the United States, where wearing a mask to prevent the spread of the virus became a political weapon.

New ideas, products, and practices take time to diffuse. In this scenario analysis, the level of diffusion is attributed to the level of trust in a society. In scenarios with a high level of trust in society, the rate of adaptation towards new ways of living is more rapid. Overall, in high economic growth scenarios, society has lower level of risk aversion than in low economic growth scenarios. Therefore, in a scenario with low economic growth the rate of adaptation is slower than in a scenario with high economic growth.

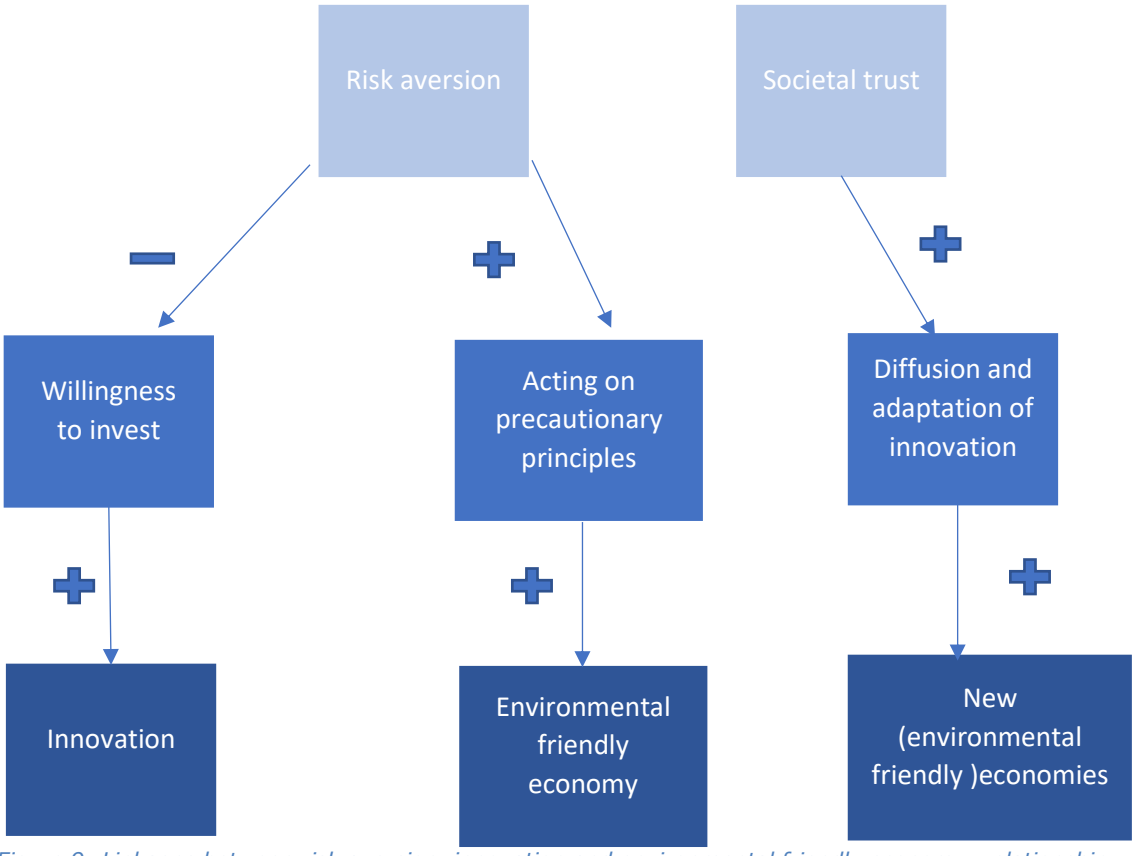


Figure 9: Linkages between risk aversion, innovation and environmental friendly economy; relationship between societal trust and new economies (created by author)

This figure shows that an increase in risk aversion makes people less willing to invest. At the same time, people who are risk averse tend to follow precautionary principles (such as protecting the environment before it is too late).

This chapter discussed the most important and unpredictable drivers of developments. The assumptions about these drivers help to make coherent scenarios; and to build scenarios in a structured way. Furthermore, they provide transparency about the building blocks of the scenarios and thereby, the scenarios can be re-constructed, easily adapted and used more often.

6 Constructed scenarios

This chapter presents four scenarios that are constructed in this analysis. First of all, the four-quadrant model is described. Secondly, the characteristics of the four scenarios are presented in a schematic overview. Thirdly, the four storylines are described in more detail.

Based on the assumptions presented in chapter four, the future 'possibility space' is divided into two axes or dimensions. These two axes represent the two driving forces with the greatest importance and the highest uncertainty. In this analysis, economic growth and environmental awareness are considered to be the most important underlying driving forces of change. The four scenarios differ mainly due to these two drivers. Derived from their position in the quadrant model, assumptions are made about how the other drivers would align. The four-quadrant model beneath is representing the four scenarios.

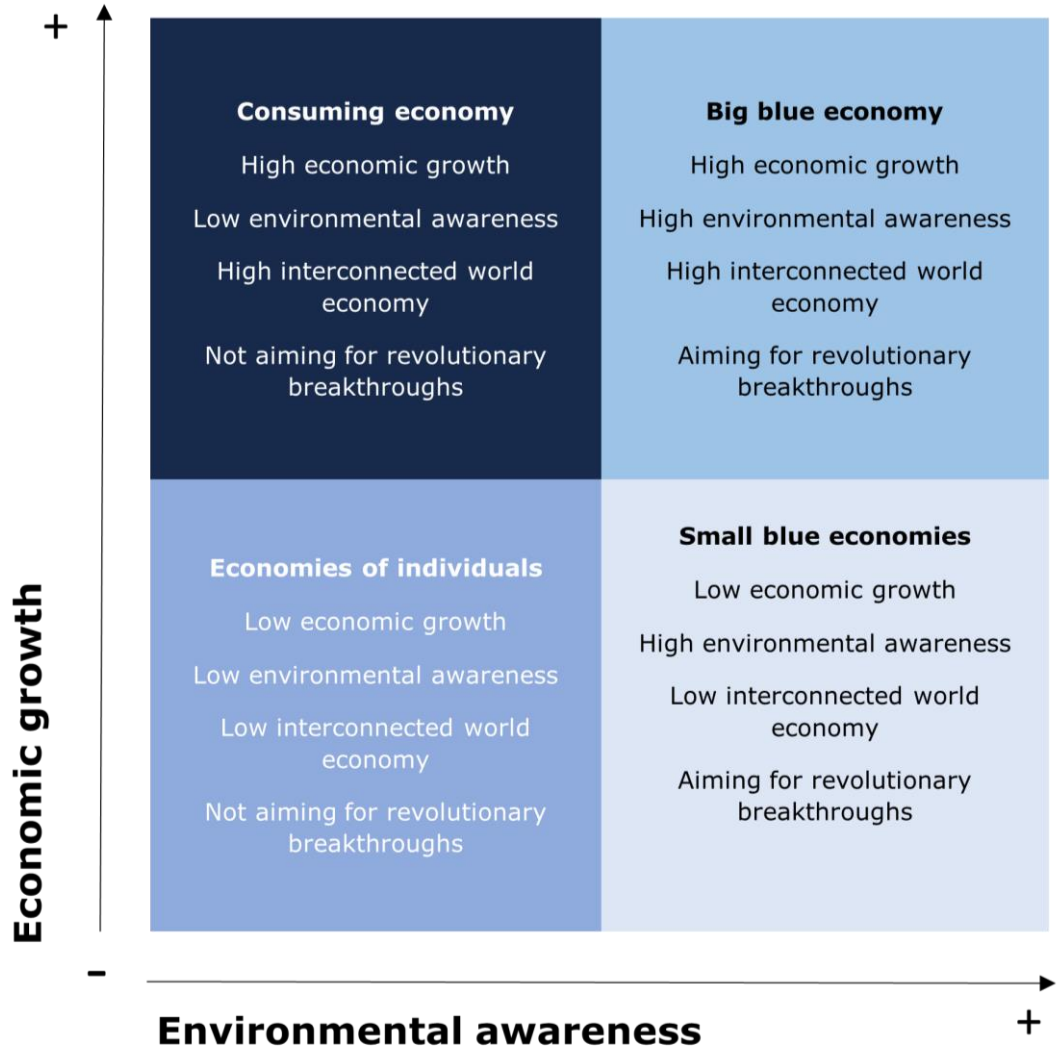


Figure 10: Four-quadrant model (created by author)

Starting from the upper left, the Consuming Economy is charaterised by high economic growth and low environmental awareness. In this scenario, the OSPAR region is assumed to be highly connected

to the rest of the world, and technology is assumed to be mainly aimed at fast and cheap production at the costs of the environment.

In the upper right hand corner the OSPAR region forms the Big Blue Economy where high economic growth is combined with high environmental awareness. Due to technical innovation up to 2030 it was possible to maintain high levels of consumption while protecting the environment.

In contrast, the Small Blue Economies in the lower right hand corner, has not achieved the same level of technical innovation. This means society had to reduce their consumption in order to protect the environment. It is also assumed that this economy is less globalised in contrast to the former two scenarios.

Finally, the lower left hand corner represents Economies of individuals. This scenario is most affected by COVID-19 and the succeeding recession. This has impacted economic growth and the worlds ability and appetite to innovate and tackle environmental issues.

6.1 Schematic overview of future images

Table two summarizes the differences between scenarios. The next paragraphs will present storylines for each of the four scenarios, thereby explaining table two in more detail.

	Big blue economy (BBE)	**Consuming economy (CE)**	**Small blue economies (SBE)**	**Economies of individuals (EI)**
Economic growth	High	High	Low	Low
Environmental awareness	High	Low	High	Low
Interconnectedness of world economy	High	High	Low	Low
Dominant norm	*Together we have the resources to mimic earth's recycling as best as possible. Progress enables us to make our economies sustainable*	*Only money constrains determine how high we climb up the hill. If not known, it does not matter, so let's continue*	*I want to protect the environment because if I am being honest, most stuff is just stuff and money is only money. I try to buy local and only if it's absolutely necessary*	*My biggest aim is to support myself, my friends and family. No matter the costs. Others just want to benefit from my effort and expenses; I won't let them*
Dominant economy	Circular economy	Consumption economy	Minimalistic economy	Economy of strength
Marginal utility of consumption (i.e. the happiness people experience when they buy an extra product)	Moderate	High	Low	High
International collaboration	High	Moderate	Low	Very low
Innovation	Radical	Incremental	Radical	Incremental
Adaptation rate	Fast	Fast	Slow	Slow
Prime focus of innovation	Management of circular economy	Fast delivery and cheap consumption	Offsetting environmental pressures	Exploitation
Precautionary principle	On a moderate level applied	Not applied	On a high level applied	Not applied
Risk aversion	Moderate	Low	High	High
Trust in society	High	Moderate	Higher for fellow citizens then for internationals	Low

Table 2: Schematic overview of how other drivers are aligned to the two main drivers of change; economic growth & environmental awareness. Source: author

6.2 Big blue economy: High economic growth and high environmental awareness

It´s the year 2030 and people believe that life on earth is sustained by its biodiversity. The order of consumption preference is mainly based on environmental friendliness of commodities: Commodities that are more environmental friendly are preferred over less environmentally friendly products, and consumers are more indifferent about non-environmental costs, such as price. COVID-19 accelerated the transnational environmental movement and the level of trust towards science. Today, society believes environmental problems have a strong global dimension and therefore should be tackled through international collaboration.

As a result, compared to the input of production, output levels increased more than double as economies became more efficient and sustainable. Production has become more specialized. Production chains are spread around the globe due to a high level of free trade. Profit stems mainly from benefits due to big economies of scale across the globe (for example, large plots of recycling) and the fast implementation of more efficient technologies. The latter is possible because technologies are easily diffused across the globe since the world is collaborating in order to avoid future global disruptions due to climate change.

Technological innovation is aimed at revolutionary breakthroughs in sustainability. And they succeeded. In time, society has generated more knowledge about how waste can be used as input for products; a circular economy has developed. Innovation is spread fast because it is believed that technological innovation can provide alternative ways to increase economic growth without harming environmental quality and the ecological balance. It is believed that technological innovation can generate larger output from the same resources in order to support sustainable and continuous economic growth. Furthermore, society tries to determine and achieve the acceptable level of pollution as fast and thoroughly as possible. In this world there is both economic and environmental international collaboration.

Due to increased total production, the most important goal for firms is to offset the environmental pressures because branding of products is mainly based on environmental friendliness. For example, global value chains are part of a circular economy. At different locations in the world, commodities are recycled. This transition has been facilitated by new technologies that enable multi-stakeholder collaboration and the recycling of resources in almost every stage of the production chain. The government monitors waste, material level and energy consumption to track the flow of resources. This sets the standard for a circularity label for products.

In this scenario, people strive to live according to sustainable values because they realize that they are part of a larger ecosystem. In time, society has generated more knowledge about how waste can be used as input for products. Due to easy information access about maintenance and repair, products can be used for a long time. This information even includes files for 3D printing of parts if they need to be replaced. It is also easy to return products to producers for recycling or to resale the products in markets due to the interconnectivity between people and stakeholders. People want to contribute to the larger sustainability of society and describe the sum of economic activities by referring to the natural origin of their commodities, for example blue economy. However, technological efficiency can only partially offset the increase in environmental pressures due to higher production levels. As a consequence, there is a minor increase in environmental pressures.

The general attitude of Big Blue Economy can be summarized as follows:

> *"Together we have the resources to mimic earth's recycling as best as possible. Progress enables us to make our economies sustainable."*

OSPAR

Conservation plays the most significant role in the allocation of the use of the marine environment in the OSPAR region. International cooperation and trade are considered to be important to support simultaneous economic growth and environmental protection and use land and sea as efficient as possible. In order to support this, OSPAR has developed a trajectory towards altering ways of

consumption and production in order to contribute to a more circular and sustainable economy. Next to that, far more and larger marine conservation zones in the Northeast Atlantic have been established than ever before.

The objectives of the North East Atlantic Environmental Strategy, signed in 2021, have been reached. In this scenario, even more ambitious environmental targets were made towards the year of 2030. These were achieved as well.

Working together to develop sustainable technologies

Picture 1. Retrieved from LINK
Picture 2. Retrieved from LINK
Picture 3. Retrieved from LINK

6.3 Consuming economy: High economic growth and low environmental awareness

It is the year 2030 and trading is based on monetary constrains because it is believed that time and money are currently more scarce than biodiversity. Goods are traded globally but international collaboration on environmental issues lags behind.

Due to the pandemic of COVID-19 it was decided that climate change mitigation measures should be postponed because people believed that the climate crisis was not the most pressing concern at that time. And also, after the global economy recovered, people were more or less indifferent about the sustainability of commodities. Today, most people's way of thinking is "because we do not really know what is going to happen, we can continue."

Innovations within electronic payments, software and mobile technology are enabling consumers to order goods online from anywhere in the world. This has resulted in a boom in online cross-border sales with many wholesalers and retailers, especially in developed economies. As a consequence, there is fierce competition in order to satisfy consumers' expectations of fast delivery. The dominant idea of the consumer market in developed economies is that goods need to be cheap and easily available.

For most economic activities, the environmental impact they cause are proportional to the level of economic development, because most efficiency gains focus on decreasing labour and capital cost instead of matters related to sustainability. Most innovation is focusing on increased digitalisation and robotisation. Most developments are focussed on making traditional production and consumption patterns more efficient instead of more sustainable. Therefore, technology can only offset a small proportion of the environmental pressures asserted by increased economic activities. As a consequence, the total environmental pressures increased rapidly.

The general attitude of Consuming Economy can be summarized as follows:

> *"Only money constrains determine how high we climb up the hill. If not known, it does not matter, so let's continue"*

OSPAR
The rational planning of economic activities aims to bring benefits for all nations as efficient as possible in terms of economic profit. There are less trading tensions in order to establish fast delivery of products. The ocean becomes more industrial as a result of more intense and diversified land and sea use. This includes new sites for energy generation, mineral exploitation and recreation.

Whereas until recently, OSPAR was primary focussed on environmental protection caused by human activities, the reduction in environmental awareness and the focus on economic development urged OSPAR to focus more on international maritime spatial planning. The primary task of OSPAR has now become to enable as many economic activities to take place in the limited and historically already intensively used maritime areas in the north eastern part of the Atlantic Ocean

Technology helps to increase rate of consumption and aims for low costs and fast delivery.

Picture 4. Retrieved from LINK
Picture 5. Retrieved from LINK
Picture 6. Retrieved from LINK

6.4 Small blue economies: Low economic growth and high environmental awareness

It is the year 2030 and production and innovation has hampered because of money constrains: the economies still had to recover from COVID-19. Economies have started to focus more on domestic demand and supply. Nations try to restrict the supply chain to their own geographical boundaries. The level of trust towards other nations decreased over time. This trend made governments believe that a stable supply of commodities can only be secured by themselves.

At the same time, COVID-19 made people more aware of global long-term challenges and about the effects of climate change. The struggling with the global COVID-19 crisis made people aware that the looming climate and biodiversity crisis is a concern as well. Therefore, it is believed that climate change mitigation measures must be implemented to ensure economic growth in the future.

People believe that the protection of biodiversity is the number one goal; to them, it does not make much sense to have more goods if you have less biodiversity. In order to enlarge their market shares, economic activities focus more on sustainability. Although producers do their best they can to reduce environmental pressures as much as possible to meet this consumers' demand for sustainable production, innovation is hampered because of money constrains. Therefore, a significant part of the demand is still supplied with traditional technologies.

Due to a lack of breakthroughs in innovation, people realised the only way to reduce environmental pressure, is by consuming less. Therefore, compared to the Big Blue Economy, a minimalistic lifestyle is a more significant contributor to the decrease in environmental pressures.

Furthermore, because the supply side is unable to meet the required sustainability goals by improving its productivity, the demand side is mainly responsible for lowering the environmental pressures. Therefore, compared to the movement towards a circular economy, a minimalistic lifestyle is a more significant contributor to the decrease of environmental pressures. People believe that less is better because most commodities are 'just' stuff. The marginal utility of most commodities has decreased over the past years, because society believes that biodiversity is more important. Furthermore, people want to have a better overview of the sustainability of the commodities they consume and believe the best way to do this is by focussing on local economies.

To what extent an economic activity decreases, relies on the kind of commodities it uses and produces. For example, the demand for luxury goods has seen a more significant decrease than commodities that are considered to be more essential for the minimalistic lifestyle of citizens. To conclude, the environmental pressures were affected because of two major aspects: the lack of innovation and the movement towards a minimalistic lifestyle. On average, this resulted in a moderate decrease of environmental pressures.

The general attitude in Small Blue Economies can be summarized as follows:

> *"I want to protect the environment because if I am being honest, most stuff is just stuff and money is only money. I try to buy local and only if it's absolutely necessary"*

OSPAR
Conservation plays a significant role in the allocation of economic activities in the OSPAR region. Furthermore, the exploration and exploitation of new sites for resources hampered, especially in international waters. Biodiversity is mainly protected due to non-technological fixes. For example, in the North East Atlantic Ocean, economic activities expanded at the cost of old sites in order to protect biodiversity. Moreover, people adapted to sustainable ways of consumption, such as vegetarian diets, consuming less and consuming local products.

Due to limited budgets in the various countries, there is no financial room for ambitious environmental targets at OSPAR level. However, the ecological status did not decrease due to a combination of a reduction in international trade, a shift towards more environmentally friendly ways of recreation, and a serious increase in the number and size of Marine Protected Areas.

There is a strong believe that local activities are the most appropriate production and consumption way in order to develop a more sustainable world

Picture 7. Retrieved from LINK
Picture 8. Retrieved from LINK

6.5 Economies of individuals: Low economic growth and low environmental awareness

It's the year 2030. COVID-19 had a big impact on society. The low economic growth decreased the ability of society to innovate and stimulate productivity for many years. People are less willing to adopt to new ways of living as social learning has decreased.

It is harder to convince people that innovation is worth adopting through empirical evidence. People became more suspicious towards strangers and science because the distinction between fake news and empirical evidence has become more blurred. Today, the dominant believe of society is to buy goods and consume services as fast as possible to fulfil individual needs. Compared to 2020, there is a higher level of rivalry between people (and countries) because it is believed that most commodities cannot be consumed twice. The last attempt to stimulate the circular economy (a hot topic in 2020) stranded in 2025 due to the fact that it was not possible to make it profitable.

Furthermore, most people try to prevent someone else from using resources because they believe most natural resources are private.

People prefer goods that are cheap, and are more or less indifferent about the sustainability of commodities because they have a short term perspective on what needs to be done. It's harder to fulfil societal needs because the economy still has to recover from the recession. Within the limited money constrains, resources are extracted and exploited as fast as possible through technologies that are already in place.

Collaboration between nations is limited and the feeling of belonging to a bigger society is less than even before. There are more trade tensions and international knowledge exchange hardly takes place anymore. The primary aim of governments, economic sectors and other organizations is to increase production levels as fast as possible, with hardly any attention to environmental protection. Since both total production and productivity decreased, most environmental pressures increased moderately over the past years.

The general attitude in Economies of individuals of be summarized as follows:

> *"My biggest aim is to support myself, my friends and family, no matter the costs. Others just want to benefit from my effort and expenses; I won't let them"*

OSPAR
The primary focus of OSPAR countries is to increase economic activity and to make profit as fast as possible. Innovation has slowed and environmental awareness decreased. Nations mainly accuse each other of free rider behaviour. Therefore, also within OSPAR, the diffusion of knowledge and technologies has slowed, since countries in the North East Atlantic mainly focus on how they can increase their individual benefits. The objectives of the North East Atlantic Environmental Strategy, signed in 2021, have not been reached, not even half way.

International collaboration is low and there is low trust in society, governments and science.

Picture 9. Retrieved from LINK
Picture 10. Retrieved from LINK

7 Results

Based on the future images presented in the storylines, certain sectoral developments may become more or less likely. This chapter describes for each of the 9 economic sectors what the most important drivers and their level of uncertainty. This chapter tries to discuss the sectoral developments in a structured way through the four scenarios. It aims to capture the most important sectoral drivers of change and assess their level of uncertainty.

Based on the information retrieved from literature, interviews and the workshop 'Exploring the Future Together', it is tried to capture the possibility range of sectoral outcomes (the sectoral bandwidth) through this scenario analysis as best as possible.

Before the workshop started, participants received, among other things, a poster that listed sector specific drivers of change that were found in scientific literature or/and addressed during interviews beforehand. By taking into account these sectoral factors, it can be better understood what influences these economic sectors. Thereby, it is easier to imagine how they would respond the assumptions made in the scenarios[14].

First, the most important sectoral factors of change are listed that were found during literature research and interviewing. Next, the results of the workshop are taken into account in the discussing about how each of the nine sectors would respond to each of the four scenarios. Thereafter, the most important uncertainties of each economic sector is discussed. Finally, a bandwidth is presented that tries to cover the level of uncertainty about the sector's economic growth, total environmental pressures and environmental pressure per unit of production in 2030.

7.1.1 *Agriculture*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews.

Less or more global food value chains

- Developing countries become a more important player for the global food market which might result in less food production in and around OSPAR region.
- Harmful global trade policy interventions in food sector which could result to more food production in and around the OSPAR region. The food price crisis in 2007/2008 has led to a shift towards more protectionist trade policies in an attempt to protect domestic consumption from volatility of the international food price. In the medium-long term, many countries have maintained more defensive trade policies towards international markets. For instance, by creating higher standard requirements for food import.
- Protecting domestic food consumption, could again lead to more food production in and around the OSPAR region.
- Consumer preferences shift towards local food markets possibly resulting in more food production in and around the OSPAR region.

14 The workshop participants were urged to make their own interpretation of the scenarios. The scenarios were mainly used as reference point for the discussion about the future developments of a certain sector. Participants used a virtual poster wall made in the virtual poster building app Mural to share their images of the future in accordance with the scenarios.

- Lower trust in a complex food sector might lead to more local food consumption and thereby, to more food production in and around the OSPAR region. For instance, a decline in trust in the food and beverage industry has reinforced the trend to buy local. Food fraud and food safety incidents have revealed the complexity of the food supply chain while challenging consumers' trust in the food industry.

Economic growth

Wealth is proven to be an underlying driver of changing diets. However, especially due to the current COVID-19 circumstances, economic growth is uncertain. Therefore, it is uncertain if the trend towards healthy, convenient and sustainable food will continue.

Diet shifts

- The upcoming trend of online labelling made customers make increasingly informed decisions about what they eat and drink. This might result in more sustainable food production.
- Demand for healthy convenience food is growing. This might lead to more high-quality food products.

Consumer food preferences

Overall, price remains the most important factor determining food choice. However, the wealthier a person is, the more consumer behaviour is affected by factors related to health (allergies & intolerances, living a healthy life style, food safety), social responsibility (local products, animal welfare) and convenience (short preparation time) (Santeramo & Lamonaca, 2020). In particular, the demand for healthy convenience food is growing. This has been one of the main drivers of change in the food sector in the last five years. With the lifestyle of consumers becoming increasingly mobile and faster paced, availability of convenient products, such as full meals 'on-the-go', have become a key need (Santeramo & Lamonaca, 2020). Overall, consumers pay increasing to the sustainability of the products they consume, often considering the consequences of their consumption habits notably with regard to climate change, biodiversity and animal welfare. The European organic market experienced steady growth in the past decade. The It is expected that there is sufficient market demand to increase organic farming worldwide. However, assessing the underlying drivers, this excessive prospected demand is based on the assumption that the average global income would rise in the coming years. However, due to COVID-19, the trend towards high quality products because of continuously higher average incomes is uncertain.

Innovation

- For past few decades, the concept of innovation has been aligned to technological progress and commercialization rather than considering the wider context > environmental pressures of society increased.
- Innovation in the food industry is focusing on packaging and marketing. Most innovations are incremental. For instance, the total value added within the food chain is largely and increasingly concentrated in the processing and retail stages, whereas the agricultural sector's share has not increased to the same extent.
- Customers are playing a crucial role in product and process development through demand-led innovation.

Trust in science

Most of the time, policies are developed in line with scientific knowledge about environmental pressures related to agricultural practices. However, a low level of trust in science might decrease the willingness of stakeholders involved in the agricultural sector to follow the advice of science. This might lead to less collaboration between governments, science and stakeholders. This would make it more difficult to reach policy targets.

Sectoral response to scenarios

The following paragraphs describe how the agriculture sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, the agricultural sector had been moving steadily to the world of Consuming Economy?

Imaging agriculture in the Consuming Economy

In Consuming Economy, the tendency to produce abundant and cheap food has proceeded. There is a disconnection between the retail price of food and the true cost of its production. As a consequence, environmentally damaging production practices were able to deliver cheaper food than more sustainably produced alternatives.

Consumers want to buy premium quality food, but sustainability is not the most important criterium. Instead, it is all about convenience, taste and price. There are many food losses in every stage of the food production and consumption because there is a low value of food in the OSPAR region. Food is abundant and cheap.

There is a high fertilizer use in and around the land of the OSPAR region because sustainable measures are lacking. Stakeholders have a high level of resistance towards change aimed at sustainability. This slows down the change towards a more sustainable world. The environmental pressures of the agriculture sector increased rapidly in the OSPAR region. For instance, through riverine inputs of nutrients fertilizers and pesticides.

At the same time, most efficient farms had to stop in the OSPAR region and were taken over by farmers elsewhere, where (most likely) less stringent environmental restrictions apply. This meant an increase and export of environmental problems at the global level instead of reducing them.

> *"Over the past decades (ever since World War II), people have become money rich but time poor: people are working hard to earn money, but lack time to cook. Therefore there has been an ever growing demand for processed food. Processed food is often linked to higher environmental pressures."* - Participants of Exploring the Future Workshop, 28th of January

Imaging agriculture in the Big Blue Economy

In Big Blue Economy, the transition towards large scale intensive but environmental friendly farming practices has been growing over the past few years in order to produce abundant, sustainable and cheap food. In this scenario, the environmental impacts of producing cheap food were increasingly internalised in the cost of food commodities and products. Therefore, sustainable products became cheaper and more convenient to consumers, whilst unsustainable ones became more expensive.

The demand for sustainable food became more dominant. There was a significant change in the type of food, towards food which causes less environmental pressure. The trend towards consumption of less meat is has growing steadily of the past ten years. Instead of meat, people shifted to more artificial meat and insects. Developments stimulated the circular economy. This reduced environmental pressures significantly. For instance, all parts of all agricultural products are used because a value system for waste products is created. Agricultural production became very efficient, with lower emissions per kilogram product compared to 2020. The technologies produced in the OSPAR region are spread across the globe.

Furthermore, there is more coherence between policies that influence agricultural practices (e.g. the CAP, trade policy, environmental policies, etc.) and the EU's international commitments (e.g. UNDP SDGs, Paris Agreement, etc.) A lot of the environmentally harmful subsidies are removed.

> *"In recent years we have seen a climate debate (e.g. Fridays for future). This made the wider public more aware of environmental problems. Also of those caused by agriculture. Therefore, society demands environmental protection. There will be a change towards food which causes less environmental pressure. At the European level, everything is in place for recovery after the pandemic, economic growth is expected to increase later on. Environmental awareness is expected to remain high, due to consumers behaviour and regulation." - Participants of Exploring the Future Together Workshop, 28th of January*

Imaging agriculture in the Small Blue Economies

In Small Blue Economies, many small producers of local produce have developed. At the same time, price policies for agricultural products were implemented to guarantee a higher level of certainty for supply. More environmental friendly - technology based - production methods were not implemented by farmers because they lacked the money to invest in more sophisticated technologies. Export of food has decreased. Thereby, local consumers became a more important part of the consumer market.

In this scenario, short food supply chains and local food systems increasingly provided a fair price for farmers and fresh and seasonal produce for consumers, reduced environmental pressures and created greater social cohesion at the local level. EU policies established the necessary prerequisites and conditions for the local systems and stimulate their development.

There is a significant change in the type of food, towards food which causes less environmental pressure and is more healthy. For instance, there is a sugar tax implemented in the OSPAR region. Environmental awareness has stimulated a trend towards consumption of less meat. In Small Blue Economies meat became more often replaced by fish. Within this scenario the market for regional premium quality produce increased most.

> *"Part of society is nowadays in Consuming Economy, whereas some others are in the Small Blue Economies, either by choice (people who want to enjoy quality of life; good environmental friendly produced food and/or value time more than money), or because of [necessity] (people who lost their job; lack the money to buy processed food)."* - Participants of Exploring the Future Workshop, 28th of January

Imaging agriculture in the Economies of Individuals

In economies of individuals, the tendency to produce abundant and cheap food has proceeded. However, in contrast to the world of Consuming Economy, the production takes place on a more regional level. The answer to the question 'what does sustainable food production mean', became increasingly blurred for consumers. Consumers do not trust they would buy sustainable food when the producers claimed it to be. For instance, sustainable food certificates do not represent universal views. As a consequence, producers and consumers gradually stopped trying to map out the sustainability of food products. It became unprofitable to produce sustainable food products because there was no plain level playing field. Thereby, the attempt of niche producers to upscale their sustainable food production has stopped. There are many (old) small scale farmers that farm in a traditional way, with significant environmental pressures. Small scale farmers are not interested in more environmental friendly production methods but they also do not have the means to invest in these methods. In the world of Economies of Individuals, sustainable food production is very low in the OSPAR region.

Conclusion

To conclude, there are two major factors of uncertainty for the environmental pressures asserted by the agricultural sector. One, there is uncertainty about the extend there will be less or more global food value chains in the future. Second, there is uncertainty about the evolvement of consumer's food preferences in the future.

Today, on both the production and consumption sides, there is less need for most of the population across the OSPAR contracting countries to live near where food is produced. With the lifestyle of consumers becoming increasingly mobile and faster paced, availability of convenient products, such as full meals 'on-the-go', have become a key need (Santeramo & Lamonaca, 2020). However, as the scenarios show, this might change in the future. For example, in Consuming Economy, there is a tendency to shift agricultural production towards countries outside the OSPAR region because of cheaper production costs, while in Small Blue Economies, the consumer demands agricultural activities to be more local; the activities have to move closer to the consumer market and therefore, the agricultural activities outside the OSPAR region are shifted towards the OSPAR region.

In addition, in Big Blue Economy, most innovations are focussed on efficient land use and sustainable packaging of agricultural products. For example, they focus on creating global food hubs and improving the way agricultural products can be containerized. In Small Scale Economies, however, the room for innovation is smaller due to low economic growth. People are mainly focussed on supporting local ways of agricultural production and rely more on solutions that already existed in 2020 to make the agricultural sector more sustainable. For example, people increasingly believe they can reach sustainability goals by shifting to more sustainable diets. For instance, by consuming food according to the seasons, eating local, vegetarian or vegan and eating less. In Small Scale Economies, there is a minor increase in environmental pressures because new consumption practices cannot offset the increase in production totally, as technological innovation is lacking. In the Economies of Individuals scenario, the environmental pressures due to agriculture increases more because countries are more inclined to secure their own food supply through domestic farming while resources are exploited as fast as possible by using conventional farming methods.

The environmental pressures for the Big Blue Economy scenario decreases rapidly because they can rely on more technologies while at the same time production in the OSPAR countries decreases. In Big Blue economy, the globalization of agriculture increased the efficiency of land use. Besides socio-economic differences such as the availability of productive space and labour cost, matters of sustainability is one of the most important criteria to determine what land is suited for agricultural production. Productivity gains in agriculture and displacing production from marginal to high potential regions saves land for nature. Due to efficient land management and major technological innovations in agriculture, global shortage of productive land is prevented. In Consuming Economy, the interconnectedness of the world, caused more cropland expansion outside the OSPAR region. It caused land use change in remote location because the high interconnectivity between places made it profitable to produce agricultural products there.

For past few decades, the concept of innovation has been aligned to technological progress and commercialization rather than considering the wider context. Thereby, the environmental pressures caused by agricultural practices increased. For example, innovation in the food industry has mainly been focusing on packaging and marketing. However, as these scenarios show, the environmental pressures associated with the aim to keep global agricultural products ready for consumption might decrease in time.

For example, in the scenario of Small Blue Economies, most people cannot afford or want to buy processed food. Therefore, the environmental pressures of the agricultural sector were mainly reduced by switching towards more sustainable products. This resulted from the increased demand for a vegetarian or vegan diet. Therefore, there is an increase in total production, but the total environmental pressures decreased mainly due to decreasing meat and milk production. For example, the cows that are grazing in the fields had been substituted by corn. The environmental pressures per unit of production (for example, one kilo of potatoes) stayed more or less the same because technological innovation was minor. In Big Blue Economy however, the environmental

pressures were mainly declined due to rapid technological innovation such as sustainable food packaging or new types of artificial meat.

It is interesting how the participants explicitly mentioned their worry about offsetting environmental pressures to non-OSPAR parts of the world. For instance:

> "In various countries in Europe, agricultural production is very efficient, with relatively low emissions per kilogram product. However, due to environmental restrictions that apply at the national level, those efficient farms have to stop. Production is taken over by farmers elsewhere, where (most likely) less stringent environmental restrictions apply. This means an increase and export of environmental problems (at the global level) instead of reducing them."

Thus, relocation of agricultural production towards countries outside the OSPAR region, might lead to less nutrients in the North East Atlantic Ocean, but more environmental pressures on a global level. Therefore, the interconnectedness of the world, may cause more land use change in locations outside the OSPAR region because the high interconnectivity between places made it more profitable to produce agricultural products there instead of within the OSPAR region.

The shift in OSPAR countries towards eating less meat is however likely not to result in a reduction in environmental pressure by agriculture if more and stringent regulation will not develop. Most food products of the OSPAR region are exported. Given that the world population keeps growing, there will be a growing demand for food (and meat), which will offset the reduced consumption within the OSPAR countries. In line with this argumentation, it could be argued that the trend towards eating less meat will not proportional result in less meat production practices in the OSPAR region.

However, in Small Blue Economies the export of food products are very low in comparison to the year of 2020. Thus, you could argue that any shifts in diets in contracting parties of OSPAR would have a bigger impact on the OSPAR region. Big Blue Economy, it is more likely there would be a smaller change in type of food production in the OSPAR countries. In order to make sure agricultural production is kept within environmental limits, more and stringent regulation of fertilizers is needed.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[15]	Bandwidth size of prospective total production quantity[16]	The prospective total environmental pressures[17]	Bandwidth size of prospective total environmental pressures[18]	The prospective environmental pressures per unit of production[19]

15 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

16 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth.

17 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

18 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures.

19 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

Agriculture	Diet shifts Global food chains Regulation	80-120	40	70-130	60	Moderate decrease – moderate increase

7.1.2 *Aquaculture*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews.

Globalization
Aquaculture has developed into a highly globalized trade-dependent industry. At the beginning of aquacultural developments, corporate interests were the dominant driver of development. For instance, the interest of profit and market share were the primary aim. At that time, aquaculture producers was seldom constrained by local resource inputs; operating on a global scale, producers were enabled to exploit resources of varying locations across the globe. However, aquacultural practices are shifting towards more sustainable forms. This includes a local production chain and supervising the environmental quality of the ecosystems that produce resources for local aquacultural practices.

Various reports expect that the sector of aquaculture would show a major increase as it is seen as an important activity to ensure food security in the future. They assume that technologies and the state of knowledge would evolve rapidly in the future. Improved logistics is seen as one on the most important technological innovations for the coming decade.

COVID-19

- The current circumstances of COVID-19 makes the major increase of aquaculture production in and around the OSPAR region less likely.
- Higher-value food exports, which are generally more dependent on sales to restaurants and the tourism sector than to households, dropped significantly due to COVID-19.
- The collapse in air passenger traffic, diminished air freight capacity and raised costs for the export of high-value food.
- A part of the growth of aquaculture in the OSPAR region is expected to come from higher value food products; the market share would increase by focussing on organic status production, such as in the Irish salmon industry. Because the recovery period of the tourism and catering business on the long-term is uncertain, the demand for aquaculture products produced in the OSPAR region might grow slower than was prospected pre-COVID-19 times.

International trading

- Trade tensions in the global food market which might result in less aquacultural food exports and thereby to less aquaculture growth in the OSPAR region.
- A significant part of the future consumer market of aquacultural OSPAR products is in Asia. Therefore, difficulties in accessing international markets for foreign food products might decrease the growth of aquaculture production in the OSPAR region.
- In the OSPAR region, a part of the aquacultural production and consumption is depended on global value chains. If the world economy becomes less liberalized, aquacultural production is likely to decrease.

Global environmental policies
Policies and practices of agencies and governmental organizations, such as liberal investment

policies, subsidies and development aid, might encourage development and implementation of environmental friendly practices. Depending on the global environmental policies, the mining of marine resources may or may not increase due to aquacultural developments.

Diet shifts
The upcoming trend of online labelling made customers make increasingly informed decisions about what they eat and drink. This might result in more sustainable aquacultural production.

Sustainability
Various reports, for example the Blue Economy report, perceive aquaculture to play an important role to stimulate sustainable economic growth. However, there is discussion about to what extent aquaculture is a (more) sustainable farming practice. For example, there is a dominant believe that aquaculture can sustainably ease pressure on threatened wild stocks. However, aquacultural practices cause environmental pressures of their own. Therefore, it is uncertain to what extent society with a high level of environmental awareness will prefer to eat aquacultural fish over other types of food. This is depended on the extent the aquacultural sector becomes more sustainable in the future. For instance, the development of integrated multi-trophic aquaculture, multi-use platforms and emerging biotech. Furthermore the traceability of seafood could make aquacultural products more sustainable.

Most important sectoral drivers of change according to the workshops participants

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Demographic evolution + consumer behaviour + increasing purchasing power	Societal drivers (environmental awareness, international cooperation, populism)
Driver 2	Technological development	Demand
Driver 3	Overfishing: solution needed	Geography
Driver 4	Space on land (race of for space) and using ocean potential	Production technology & innovation
Driver 5	Regulatory framework (access to space, standards etc.) without overregulation (visibility issue: under water is not visible)	Regulation

Sectoral response to scenarios

The following paragraphs describe how the aquacultural sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, the aquacultural sector had been moving steadily to the world of Consuming Economy?

Imagining aquaculture in the Consuming Economy

In the world of Consuming Economy, increased globalization and technological innovation has led to the fact that OSPAR's seafood became accessible to the rest of the world. The progress made in the aquacultural sector in order to develop more sustainable production practices has ended in 2022. In this year, governments agreed that economic goals were more important than environmental ones in order compete with the price charged for aquaculture products from overseas. For instance, the

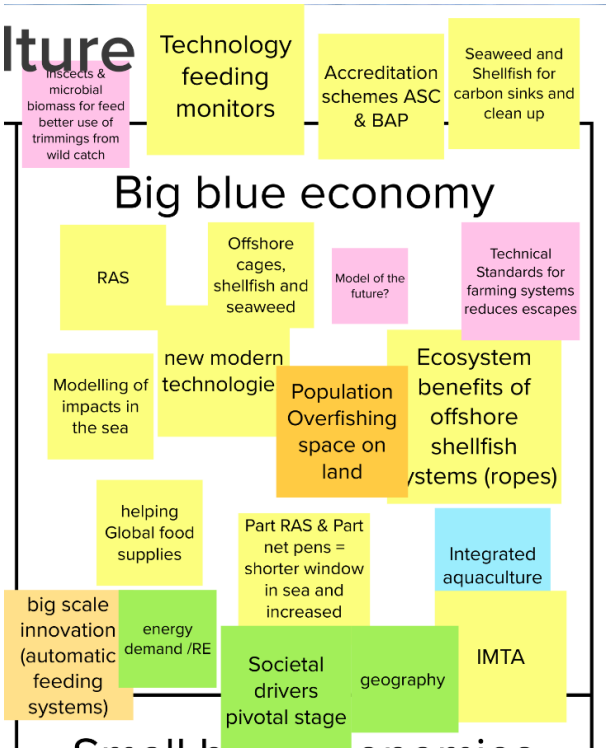
interest of profit and market share was the aquacultural sector's primary aim. Investment policies, subsidies and development aid encouraged development of the industry between 2020 and 2030.

In 2030, they succeeded to reach these targets as Asia and South America became an important consumer market for the North East Atlantic's aquacultural seafood. Technological advances were focused on reducing costs. For instance, automatic feeding systems from land-based control units developed.

Aquacultural production and consumption practices have become more globalized due to e-commerce, improved logistics and better information and transport systems. This made transportation costs very low. The resources for aquacultural stem from all over the globe. For instance, the aquacultural system of OSPAR is able to switch rapidly between marine areas for fishmeal supply. This system lacks to foresee environmental constrains; in Consuming Economy, aquacultural practices are not constrained by local resources. For instance, the location for fishmeal harvesting is determined by economic advantages. In this scenario, the sector's incentives to respond to changes in the capacity of ecosystems are undermined; there is lack of feedback between economic performance and environmental pressures on marine ecosystem services. For instance, producers have a limited concern to protect local fish population and ecosystems. Therefore, in Consuming Economy, aquaculture practices in the OSPAR region have expanded rapidly at the costs of the North East Atlantic´s environment. Eutrophication of OSPAR waters became is increasingly becoming an bigger environmental problem; it is intensifying and spread into new OSPAR areas.

Imagining aquaculture in the Big Blue Economy

It is the year 2030 and the high ambition that has been set in the previous decade to reduce environmental pressures of aquacultural practices - towards limits defined by the index of Good Environmental Status (GES) of ecosystems - has succeeded. An universal view on sustainable aquacultural practices has been developed and seafood became traceable to the origin. For instance, in time, the wide range of different aquaculture certification schemes (around forty in 2020) started to develop into a single one. Global environmental policies for aquacultural practices established.



Picture of the virtual poster wall made during the aquaculture workshop

In this world, the trajectory of developments is mainly aimed to reduce environmental pressures of aquaculture through social and technical innovations. Driven by economic growth together with limited space at sea, integrated multi-trophic aquaculture, multi-use platforms and other creative ways of combining aquaculture practices on sea developed.

Aquacultural organisms are produced in large off-shore recirculation systems and ease pressure on threatened wild fish stocks. The world collaborated in order to encourage the sector to increasingly update and apply the best environmental practices. Microbiological solutions established and eutrophication is tackled through seaweed productions and bivalves. Through modelling approaches, the environmental pressures of aquacultural practices are reduced right on time in order for local ecosystems to recover. Automatic feeding systems are in place. Standards developed for farming methods in order to reduce the escape of fish from aquaculture cultivation practices.

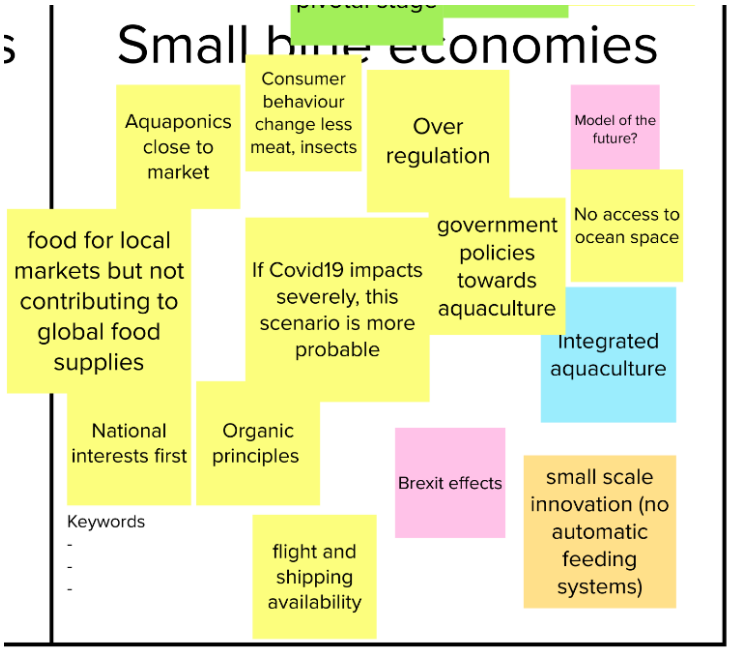
Imagining aquaculture in the Economies of individuals

In this scenario, aquaculture is driven by local economic and political issues. From 2020 onwards, the distinction between fake news and science became more blurred as the mistrust in science and governments increased. Policies are driven by populist norms. They believe global food chains are

not suited to secure the primary needs of their nations, such as food. The attempts of the sector to innovate their practices towards more environmental friendly ways, halted in 2023. Looking backwards from 2030 to 2020, the hope that aquaculture products would become one of the most sustainable type of food was too optimistic. For instance, new aquacultural places were slower developed than was expected back in 2020. Due to low economic growth and a low level of environmental awareness, the sector of aquaculture has a low innovation rate and aquacultural products are harvested as fast as possible. The increased harvest of aquacultural products was mainly due to intensification of the aquacultural sites that were already in place in 2020. Therefore, the environmental pressures, such us increased pollution by nutrients, led to a more intense level of eutrophication near OSPAR's aquacultural practices.

Imagining aquaculture in the Small Blue Economies

Due to health issues associated with aquaculture, COVID-19 accelerated the trajectory towards more local aquacultural products, as it made many people more cautious about possible health effects of consumption in an global interconnected world economy. The aquaponics consumer market is near the place of production since OSPAR's aquacultural sector is producing food for local markets but not for global food supplies. The development towards big-offshore aquacultural activities has slowed.



Picture of the virtual poster wall made during the aquaculture workshop

People believe slower economic growth is needed for management of the environment. The aquacultural growth as was expected in 2020, was downsized by choice (aiming for slow economic growth) but also by default (economic growth slowed down due to a recession). The sector is driven by local regulation that determines the quantity of production and what the best environmental friendly practice is. The system is based on organic principles.

There is small level of innovation and environmental pressures decreased mainly due to changing consumer behaviour. For instance, automatic feeding systems did not develop, but people demand their food the be organic and local. Small Blue Economy is driven by more critical users of products and services. In this world, the access to ocean space is very low because a lot of Marine Protected Areas developed in order to protect the environment.

Conclusion

Many reports expect that the sector of aquaculture will increase. For instance: "To have enough fish to satisfy future demand, world aquaculture production would need to increase threefold during the 2010-2030 period, a truly daunting task" (*Ireland's National Strategic Plan for Sustainable Aquaculture Development*, 2015). Aquaculture is perceived as a relatively new form of food production that will ensure food security in the future. Overall, it is expected that technologies and the state of knowledge will evolve rapidly in the future. However, as the scenarios shows, a rapid increase of large offshore aquaculture sites in the OSPAR region is uncertain. For example, its underlying assumptions (e.g. about the prospected level of globalization, innovation and perceived sustainability of aquaculture by consumers) are uncertain due to the large range of important socio-economic underlying drivers.

For instance, most growth of aquaculture is correlated with the assumption that there will be a more a more interconnected world economy in the future since most prospective growth of the consumer market for aquacultural products is in Asia.

Over the past few years, aquaculture made some big steps towards more environmental friendly practices. For example towards new type of species, such as sea trout. In addition, the sector is focussing on socio-technical developments towards a more circular systems. Norway has developed big-offshore aquacultural activities that are part of recirculation systems in the OSPAR region.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[20]	Bandwidth size of prospective total production quantity[21]	The prospective total environmental pressures[22]	Bandwidth size of prospective total environmental pressures[23]	The prospective environmental pressures per unit of production[24]
Aquaculture	Innovation Investments International trading	115-150	35	100-155	55	Major decrease – minor increase

Sectoral response to the scenarios

7.1.3 *Fishery*

Political stability

The division of the fish quota might become less stable if more parties are involved in the negotiations. For example, for years the division of fish shares was steady and divided among the EU and Norway. However, in the future the UK will be another party around the negotiation table. If there is more political instability in and around the EU, for instance due to the election of anti-EU political parties, there will be more parties participating in the negotiations.

Trust in research

According to research, a lot of important decisions are based that impact the fishing sector. For example, on a yearly basis, the size of fish stocks are measured and according to this research, fish quota are divided among parties. However, a low level of trust in science might decrease the willingness of stakeholders involved in the fishing sector to follow the advice of science.

Scepticism

Fisheries may become more sceptic towards governments. At first fisherman were not monitored and controlled, but for the past few years, there has been a large increase of measures of sustainability. These policies all have an impact on the ways fishers can conduct the way they are used to fish. In turn, this decreases the level of trust towards governments. For instance, fishers

20 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

21 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth.

22 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

23 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures.

24 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

have the feeling that they must pay the price for sustainable policies: Due to the enormous increase in scale of wind at sea and the associated space claims from nature organizations, a lot of fishing ground will be lost. Thereby, it is likely that the polarisation between fisheries and governments might increase in the future. This might lead to less collaboration between governments, science and stakeholders. This would make it more difficult to reach policy targets.

Fishing culture

Cultural shifts in how fishing operations are conducted, such as the way used fishing nets are disposed, might increase or decrease environmental pressures. More environmental awareness might lead to more sustainable practices. However, the willingness to change fishing habits seems to be decreasing.

International collaboration

If there is a low level of trust towards international collaboration, nations might want to keep international vessels outside their part of the North East Atlantic Ocean. Consequently, due to different capacity limits of national fish fleet, some fish surrounding certain national waters may be underfished, while other parts of the OSPAR region maybe overfished. Therefore, if there is a low-level trust towards international collaborations, nations will be less willing to share their fishing waters and thus fish will be overharvested in some places and underharvested in others.

Trade wars

The export of fish will decrease due to trade wars. It is expected that the tensions within the political arena will have big impact on the fishing activities in the OSPAR region. Currently, the doors of OSPAR seas are very much open, if access to the seas would be more limited in the future, you would get a totally different fishing sector.

Economic growth

- The fishing industry is highly dependent on economic growth. Low economic growth may result in a high level of environmental pressures; "the feeling that your firm will lose in time, gives you less time to think about extra's. Such as sustainability."
- Furthermore, the fish sector is for a large extent dependent on the price of oil and gas. If the price of oil and gas is high, vessel would not go that far to fish and the global market becomes smaller. Is there is a large economic growth, vessels go further, and capacity is reached more easily.
- Foreign demand for fish, shellfish and crustacean products of the OSPAR region has been growing for years. A fall in fish prices does not seem unlikely due to a possible oversupply of fish products in store. COVID-19 has a negative impact on employment (and therefore incomes), tourism and exchange rates. Therefore, it is expected that spending on fish products may decline temporarily. Furthermore, COVID-19 disrupted the global production chains of the fishing industry. For example, the reduced shrimp peeling capacity in Morocco forced the fishing industry to severely limit the supply.

Innovations

Monitoring is seen as an important measure to make fisheries more sustainable in the future. For instance, to address control and enforcement of the landing obligation. Currently the at-sea monitoring is low. High environmental awareness might increase monitoring.

<u>Most important sectoral drivers of change according to the workshops participants</u>

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Climate change	Everlasting demand for fish and fish products. With population growth

		and more wealth -> growing market
Driver 2	Pandemic follow up	Limitation of fishing grounds due to MPA's and other upcoming activities
Driver 3	Globalisation	Innovations towards multiple use (e.g. marine aquaculture and windfarms)
Driver 4	Social inequality	Shifting markets, like seaweed and ore proteins form insects.
Driver 5	Competition for space	-

Sectoral response to scenarios

The following paragraphs describe how the fishing sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, the fishing sector had been moving steadily to the world of Consuming Economy?

Imagining fishery in the Consuming Economy
In this scenario, the fishing sector has developed deep sea fishing techniques to harvest new species. For instance, pelagic fisheries have developed. Fisheries try to develop economies of scale as fast as possible in order to have competitive advantages. In time, fewer but larger fishing companies developed. The question about the sustainability of these fishing practices was no priority because there was a stronger focus on protecting and stimulating the interest of fisheries to make profit. As a consequence, the knowledge about what the sustainable stock sizes of new fishing species lacked behind; no reliable data sets were developed as the traceability of seafood towards individual fishing boats was not a priority. The pace of development towards more thoroughly monitoring is slowed down because consumers preferred to buy cheap seafood; the guarantee they would buy sustainable seafood became less important to them. International protocols and standards about environmental friendly seafood did not develop.

In Consuming Economy, many fishermen and governments have responded to the fact that fish became harder to catch with investments in equipment and technology to fish longer, harder, and farther away from their home ports. These efforts have resulted in what is essentially an 'arms race' within the marine fishing industry. Radio and satellite navigation allows fishermen to better locate fishing grounds, while new fish-aggregating devices intensify the harvests. These changes put more pressure on fish stocks and leave fewer regions out of reach so that fish can reproduce unmolested, thus exacerbating the effects of over-harvesting. Consumer tasters in the global world has largely contributed to over-harvesting. There was an increasing demand for top predators, such as swordfish or tuna due to high economic growth and low environmental awareness.

In this scenario, the bycatch of non-target species is not regulated. This lead to further marine mammal populations extinction. In this scenario, the environmental pressures related to overfishing increased rapidly; fishing practices fished down the food chain. Furthermore, fishing nets are still disposed in the OSPAR region.

Imagining fishery in the Big Blue Economy
In this scenario sustainable fishing has developed. For instance, it became increasingly easier for fisheries to adapt to the state of the fish populations and ecosystems. Based on monitoring, species are harvested in line with environmental boundaries, such as the reproduction rate of fishing species. There is close cooperation between countries to ensure the Good Environmental Status (GES) is not surpassed. Monitoring developed due to international protocols and standards. The handling of endangered and protected species is tracked in order to ensure a comprehensive dataset on fishing behaviour. Society demanded this level of transparency. In this scenario, every fishery is certain that every other fishery is complying with exactly the same regulations. There is a more universal view on what sustainable fishing is about because there is international consensus on the definition of discards. As a consequence, the disposal of fishing nets in the OSPAR region decreased rapidly.

Fisheries have a more universal view on what the acceptable loss of the targeted catch is. This improved the selectivity of fish and reduced the bycatch. The loss of targeted catch is offset through some compensatory increases in the value of catch or other measures such as additional days at sea allocated.

In Big Blue Economy, remote electronic monitoring has been developed. There is a high level of transparency to ensure a comprehensive dataset on fishing behaviour. For example, the consumption of seafood is traceable to individual fishing boats and the certificates of sustainability have a high level of credibility. This has resulted from the consumer's need to be ensured that they buy sustainable seafood. The fishers are proud to point out they are part of one of the most sustainable and most accountable fisheries in the world. They have a high trust collaboration with the government to achieve their shared sustainability goals. Most regulations are focussed on protecting the average size of fish caught in order to allow fish species to reach reproductive age and size before being removed from the population.

Imagining fishery in the Economies of individuals

In Economies of Individuals the development towards a general international management plan about fishing practices in the OSPAR region was halted. For instance, there is lack of control and enforcement about fish disposal. There is limited interest of consumers to get informed about state of fishing stocks/species. In time, the level of credibility of certificates of sustainability became very low because it became more blurred what sustainable fishing is about. Regional fishing practices, such as traditional bottom trawling and otter trawl fishing increased. In this scenario, fisheries are fishing down the food chain and fishing practices in order to catch fish meal is increased. Fisheries became more sceptic towards the policies because they were fed up with how the policies impacted their ways of fishing. The polarisation between fisheries and policy makers increased.

Throughout the years, the division of fish shares (fish quotas) between relevant parties became more difficult as the trust towards international collaboration became very low. Due to political instability and capacity limits of national fleets, some parts in the OSPAR region became underfished while others were overfished.

Due to low economic growth, low level of trust and high competition between fisheries, fisheries increasingly felt that their firm would lose in time. Thereby, they had less time to think about 'extra's', such as sustainability. Because the price of oil and gas is increased in time, vessel were unable to go far to fish and the global market became smaller. As such, it was harder for fisheries to reach the minimum fish catch capacity required to make profit.

Due to the election of anti-EU political parties, more parties participated in the negotiations about the division of fish shares. In this scenario, nations are less willing to share their fishing waters. Thereby, fish is overharvested in some places and underharvested in others. While the doors of the OSPAR seas were relatively very much open in 2020, the access to the OSPAR region in 2030 is very limited. Furthermore, the export of fish is decreased due to trade wars.

Imagining fishery in the Small Blue Economies

In this scenario, more small scale fisheries have developed because there is less international collaboration. The local distribution of fish harvested in the OSPAR region is enhanced. There is a strong focus on achieving the most sustainable yield on a local scale. A lot of fisheries relocated to their national waters.

Picture of the virtual poster wall made during the fishery workshop

Conclusion

Matters related to technological innovation, international collaboration, trust, globalization, economic growth and environmental awareness all influence the transition towards more sustainable fishing.

Innovations in monitoring is seen as an important measure in order to make fisheries more sustainable in the future. Currently the at-sea monitoring is low. Sea monitoring tracks the handling of endangered and protected species, such as turtles shares and skates. Developments in at sea monitoring could lead to a high level of transparency to ensure a comprehensive dataset on fishing behaviour. Electric monitoring (EM) increases the accountability of fish caught and thereby, could disapprove untruthful claims of overfishing. Furthermore, every fisher could be more certain that every other fisher is complying with exactly the same regulations and thus removing the attitude of "well if he's doing it, why shouldn't I". Accurate data on discards, the proportion of the catch that fishers do not retain, is necessary to achieve socioeconomically and ecologically sustainable fisheries (Suuronen, 2020).

The pace of development towards more thoroughly monitoring is uncertain for various reasons. First, strong international protocols and standards should be developed. Second, the consumers would find it necessary to be guaranteed that they buy sustainable seafood. Third, the certificates of sustainability should have a high level of credibility and people should have a more universal view on what sustainable fishing is about. For instance, many countries have somewhat different definitions of discards in their legislation (Suuronen, 2020). There is no international consensus on the definition of discards. Furthermore, even the MSC certification does not represent such an universal view; boats who do not have this certificate may be sustainable as well (fishing interview). Therefore, today we cannot solely depend on MSC certificates to determine the level of sustainable fishing practices. Fourth, for the past few years there has been a large increase of measures of sustainability and monitoring if these measures are executed. For example, at first fisherman were not monitored and controlled. Also, fishers have the feeling that they have to pay the price for sustainable policies. For example, due to the enormous increase in scale of wind at sea and the associated space claims from nature organizations, a lot of fishing ground will be lost (LINK). These policies all have an impact on the ways fishers can conduct the way they are used to fish. In turn, this decreases the level of trust towards governments. Thereby, it is very much possible that the polarisation between fisheries and governments might increase in the future.

Furthermore, if there is a low level trust towards international collaborations, nations will be less willing to share their fishing waters and thus fish will be overharvested in some places and underharvested in others.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[25]	Bandwidth size of prospective total production quantity[26]	The prospective total environmental pressures[27]	Bandwidth size of prospective total environmental pressures[28]	The prospective environmental pressures per unit of production[29]
Fishery	Consumer's demand Fishing culture International collaboration	90-105	15	80-100	20	Moderate decrease – minor decrease

7.1.4 *Mineral extraction*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews.

Societal perception on mineral extraction

In general, it is assumed that mineral extraction is a necessity for future life on earth and therefore, extraction of these resources should be ensured. However, this might change as a result of environmental awareness and technological innovation.

Environmental awareness

Environmental awareness effects the demand for minerals in the OSPAR region in the future.

- A high level of environmental awareness might decrease the demand for traditional extraction practices because more sustainable construction materials are demanded.
- It is uncertain to what extent increased willingness of society to consume locally will impact mineral extraction in the OSPAR region.

Technological advances

- Recycling might decrease the demand for mineral extraction.
- Increased efficiency of raw material use decreases the demand for mineral extraction.
- Further research and knowledge might stimulate deep sea mining in the OSPAR region and thereby, increase mineral extraction in the OSPAR region.

Economic growth

Marine mining and deep-sea mining were part of the 2012 EU's Blue Growth strategy. At that time, up to 10% of global production of minerals such as cobalt, copper and zinc was expected to come

25 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

26 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth.

27 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

28 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures.

29 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

from the ocean floor by 2030, providing a global turnover of up to Euro 10 billion. However, the impact of COVID-19 makes this development more uncertain.

Service economy

The increased shift towards the service economy in and around the OSPAR region might decrease the demand for mineral extraction in the OSPAR region.

Level of globalization

- Oil and gas prices might change the amount of mineral extraction in the OSPAR region.
- A low level of international collaboration may cause delays in the supply chain of minerals and thereby decreases the exports.
- In a high globalized market, increased demand does not necessarily lead to increased mineral extraction in the OSPAR region because it can be extracted outside the OSPAR region. However, OSPAR region might become a more important supplier of minerals for the global market in the future. This might increase export and mineral extraction in the OSPAR region.

Deep sea mining

- The value of a new extraction site mut be greater than the investment and production costs. For instance, the richness of the deposit or the transport distance. However, more research is needed to determine the profit of extraction sites in the OSPAR region.
- The technologies in use might decrease costs and would make deep sea mining profitable. Therefore, high economic growth might lead to more sophisticated production and thereby, increase the mineral extraction in the OSPAR region.
- Deep sea mining becomes more likely in a world with a high level of globalization. For instance, commercial interest for ocean minerals picked up after the global financial crisis when commodity prices soared as a consequence of Chinese double-digit growth.

Political instability

In a world with increased political instability, large investments might decrease and thereby lead to a decrease in extraction of new sites. This would decrease mineral extraction.

Most important sectoral drivers of change according to the workshops participants

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Security of supply / prices	COVID-19 and ability to cross borders
Driver 2	Regulatory framework	Consumer preferences
Driver 3	Increased technology in society	Economic growth
Driver 4	Environmental Policies (adaptation and mitigation)	Technology and political will to support development
Driver 5	Societal perception	Demographics

Sectoral response to the scenarios

The following paragraphs describe how mineral extraction in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, mineral extraction had been moving steadily to the world of Consuming Economy?

Imagining mineral extraction in Consuming Economy

In this scenario, deep sea mining developed rapidly. Society believes mineral extraction from the ocean is a necessity. The exponential and insatiable demand for minerals has led to an overall decline of the quality of terrestrial ore that remains available. With decreasing ore quality, economic and societal pressure on these mining activities grows exponentially. Consequently, alternatives appear – new mining resources were fully explored in the OSPAR region.

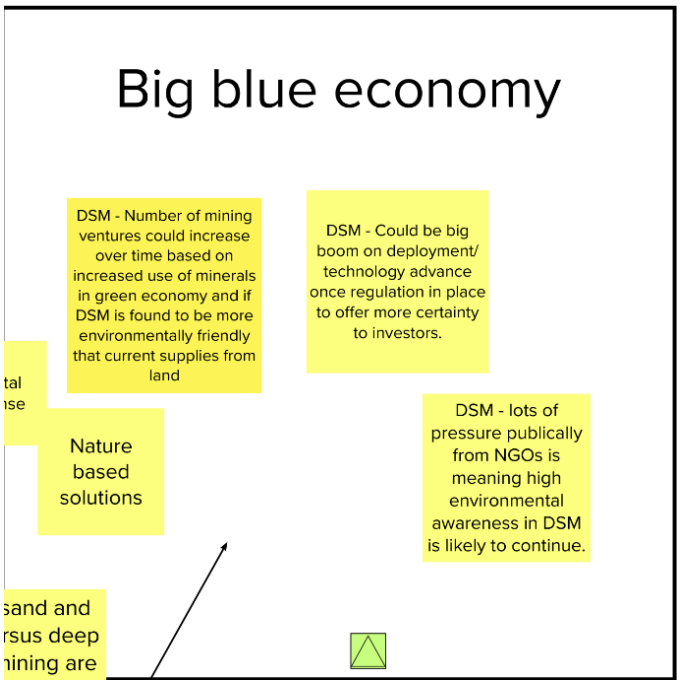
As easily mineral ore deposits were quickly declining, more complex mining activities gained further attention. Deep sea mining is seen as the most suitable solution: new resources will be found in the deep subsurface or in other remote locations: although mining these deposits will consume large amounts of energy.

Moreover, it is believed the increasing importance of recycling and the circular economy was overestimated in 2020; even a hypothetical (and impossible) 100 per cent recycling will not be sufficient to satisfy the exponential increase in demand. Therefore, primary sources of metals remain imperative. In this scenario, the price of minerals decreased over time.

In time, society invested a lot of money to develop the required techniques to exploit the primary ores in the OSPAR region. One of the main partners was China in order to secure minerals supply. Environmental research did not keep up with the exponential demand for mineral resources. There was a lack of time because the demand for mineral resources was prioritized over environmental protection. For instance, UNCLOS was initiated that forced a two year deadline on regulation development. It was perceived to be too difficult to form sufficient environmental regulation on time.

Imagining mineral extraction in the Big Blue Economy

In Big Blue Economy, society demands that construction activities use sustainable resources. They became aware about their ecological mining footprint; about how their homes, streets and offices how depend on exploitation of resources located in nature.



Picture of the virtual poster wall made during the mineral extraction workshop

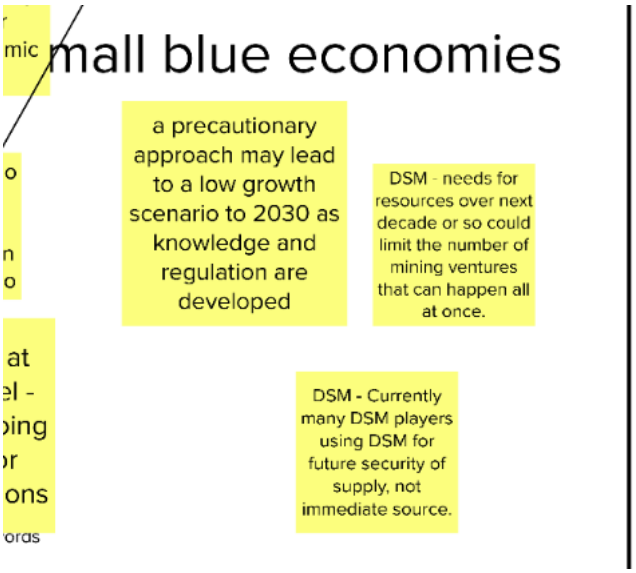
There was a lot of political will to support the development of sustainable deep sea mining. Society invested a lot of money to develop a sufficient regulation framework in order to guarantee sustainable exploitation of OSPAR's minerals. Research concluded that deep sea mining is more environmental friendly than terrestrial supplies. The price of minerals increased over time. The number of mining ventures in the OSPAR region increased over time, driven by the demand for sustainable minerals. Nature based solutions developed to protect local ecosystems. A lot of companies are focusing on recycling minerals as best as possible. Due to high environmental awareness, recycled minerals have very high values; almost 90% is recycled. Up to 20% of global production of minerals such as cobalt, copper and zinc comes from the ocean floor of the OSPAR region.

Imagining mineral extraction in the Economies of individuals

Countries want to safeguard national supplies of minerals. For national reasons, countries are trying to explore and exploit mining activities themselves as fast as possible. Minerals are very expensive.

Imagining mineral extraction in the Small Blue Economies

Society concluded that there was too much uncertainty about possible environmental damage done by deep sea mining activities in the OSPAR region. For several reasons, society lacked the resources to invest the time and money necessary for research to find out to what extent deep sea mining causes environmental pressures. Therefore, a precautionary approach was adopted up to 2030 to make sure environmental knowledge and regulation have enough time to develop. The number of mining ventures were very limited. Deep sea mining is seen as an activity that could secure the supply of minerals for future generations; securing the mineral stocks today in order to safeguard access tomorrow is done by leaving the minerals in the ocean floor.



Picture of the virtual poster wall made during the mineral extraction workshop

Conclusion

In general, it is assumed that mineral extraction is a necessity for future life on earth and therefore, extraction of these resources in the OSPAR region should be guaranteed. However, this might change as a result of environmental awareness. Furthermore, technological innovation might decrease the demand for primary ores by developing more efficient recycling processes.

At the moment, there is the perception that deep sea mining is greener than the exploitation of terrestrial minerals. The knowledge of environmental research on deep sea mining is limited. Thereby, it is difficult to form sound environmental regulation by 2030 if no more research is done. Participants perceived that developments in line with the scenario of Consuming Economy are likely to happen for deep sea mining.

It seems that the current uncertainties are too big to envision sustainable deep sea mining. In the scenario of Big Blue Economy it is simply assumed deep sea mining is more sustainable due to a lot of innovation. Therefore, a lot of research need to be done in order to guarantee a higher level of sustainability of deep sea mining activities. At the moment, most stakeholders believe that deep sea mining would not fit in a scenario of Big Blue Economy because its current development is not linked to local ecosystems. The main interest to support deep sea mining is profit; "*In contrast to land mines, there are no human on the seafloor to object*". There is no universal view if large investments in deep sea mining would be the best way forward. Some argue it would be better to allocate more time and money in order to guarantee the future supply of resources.

Furthermore, it seems difficult to envision what kind of materials could lead to less exploitation of primary resources.

A participant pointed out that it is important to take into account coastal defence in future policy making: "*coastal defence is a big concern but most of the times out of the scope during normal concessions. It is almost not covered by current permits.*"

Future trends in the extraction of aggregates will be influenced by a variety of factors. Including the rate of economic growth and its effect on construction demand, the availability of other sources of aggregates, including recycled material as well as land-based sources, available reserves of marine aggregates and the need for coastal defence works.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[30]	Bandwidth size of prospective total production quantity[31]	The prospective total environmental pressures[32]	Bandwidth size of prospective total environmental pressures[33]	The prospective environmental pressures per unit of production[34]
Mineral extraction	- Consumer demand - Deep sea mining technology - Regulatory framework - Environmental awareness	105-150	45	100-165	65	Minor decrease – major increase

7.1.5 *Oil and Gas production*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews.

Oil supply runs out

- A long-term risk for oil and gas companies is a dwindling natural supply.
- Oil is finite, estimates vary but many people believe that we have nearly reached maximum production (peak oil) and over the coming decades we will see a decrease in supply. As supply decreases countries will be forced to look for alternatives.
- Many countries like the UK are seeing their own supplies of oil run out. This has turned the UK from a net exporter to a net importer. Because of this the UK is looking for alternative sources of energy.
- As the supply of oil runs out, energy companies and countries are investing in alternatives. With the knowledge that oil will run out, many want to become market leaders.

Price of oil

- As the price of oil increases the cost of alternatives become much more attractive.
- As world oil supplies run out, companies are having to extract oil from deeper underground and in more inhospitable places. These increased extraction costs will ultimately increase the cost of oil, making it less attractive.

30 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

31 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

32 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

33 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

34 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

Demand for oil
As the world's population exceeds 7 billion people and as countries become richer, the demand for oil (and the price) will steadily increase. Increased demand will be particularly pronounced from emerging markets like China.

Political stability

- If your country depends on imports of oil, it is very important that you maintain good relations. However, this is not always possible. Therefore, countries increasingly seek to become energy independent. This may decrease oil export in the future.
- Many countries that are rich in oil are politically unstable. Political instability can affect supplies and cause price increases. Again, this may decrease oil exports in the future.

International collaboration

- International agreements like Kyoto are setting greenhouse gas emission quotas. Individual regions like the EU and the UK are also setting targets. With targets to meet more countries are looking to invest in alternatives (renewable energy that pollutes less).
- Carbon tax: If carbon taxes are introduced it will greatly increase the value of oil products, making alternatives relatively cheaper and more attractive.

Environmental awareness

- NGO pressure: NGOs are becoming increasingly vocal in their fight against fossil fuels and promotion of greener alternatives. As more consumers listen to NGOs, governments and energy companies are likely to find alternatives.
- Public Image: Because of rising prices at the pump (garages), the link to global warming and oil spills are all giving the oil industry a bad image. Because of this countries and energy companies are looking for alternatives.
- Oil spills: When large quantities of oil are transported by sea or pipeline, there is always the risk of accidents.
- Greenhouse effect and global warming: Fossil fuels are all major contributors to the greenhouse effect. To try and reduce the effects of global warming, many countries are trying to reduce their dependency on oil.

Public health
Oil used in vehicles, planes and industry all contribute to air pollution, which can have a negative effect on the health of people - especially asthma. Increased awareness about this might decrease demand for oil in the future.

Globalization

- Degree of oil and gas export by the OSPAR region. For instance, in order to supply China's demand for energy. However, it seems likely that China will not import large numbers of oil and gas because of their aim to become a sustainable market leader.
- Import of energy to satisfy demand for energy in the OSPAR region.

Environmental awareness
Natural gas seems trapped between O&G companies' decarbonization strategy of focusing on low-carbon fuels and the broader impetus to replace gas with renewables for electricity generation. Therefore, it is uncertain to what extent environmental awareness would lead to a major decrease of natural gas.

Economic growth

It is uncertain to what extent the economic impact of COVID-19 results in less oil and gas production in the OSPAR region.

Due to COVID-19, grid operators, sought the cheapest (and cleanest) supply source to balance the lower demand. Therefore, weaker electricity demand increased the share of renewables in the system while sending the more polluting and costly carbon fuels to the back of the queue. This effect happened even at a time of historically low fossil fuel prices. But the longer-term effect of the crisis is yet to be seen, as softer lockdown measures have shown a recovery of demand.

The lockdown provides a real sense of opportunity for the energy sector. It brings plenty of lessons about clean energy policy, changes in demand patterns and knowhow for a greener grid without compromising the security of supply. It also opens further opportunities for investment and innovation. However, at the same time, a lot of COVID-19 policies supported carbon-intensive industries without demanding carbon reductions. For instance, support to airlines.

Most important sectoral drivers of change according to the workshops participants

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Economic growth (rate of recovery)	Societal perceptions/expectations (supply and demand)
Driver 2	Climate/energy policy (influencing both supply and demand)	Globalisation
Driver 3	Consumer behaviour/prefrences	Business adaptability (to changes in supply and demand; to developing alt products)
Driver 4	Technology innovation	Technological innovation and funding
Driver 5	Global politics (EU positioning, security, USA politics)	Total energy demand (and infrastructure)

Sectoral response to the scenarios[35]

The following paragraphs describe how mineral extraction in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, oil and gas production had been moving steadily to the world of Consuming Economy?

Sectoral response to scenarios

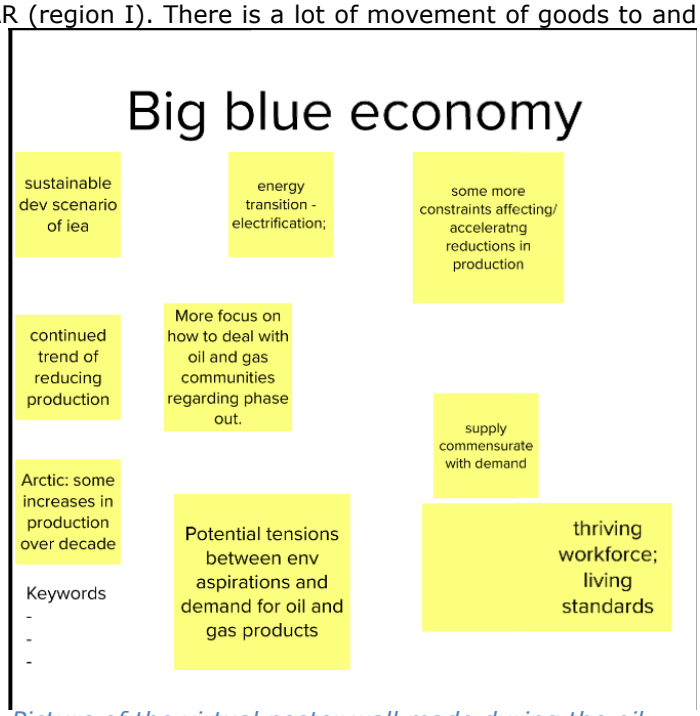
Imagining oil and gas production in the Consuming Economy

[35] It was decided to focus on other - more uncertain sectoral - developments because of limited time. Therefore, this section is understudied. Most uncertainty of this sector stems from environmental drivers. For instance when the oil ang gas in the Artic becomes available due to the melting of ice.

In this scenario, the total demand for oil and gas increased. Large investments are made to extract oil and gas from the Artic Waters of OSPAR (region I). There is a lot of movement of goods to and from the Artic Waters. According to the workshop participants, this scenario is a projection of the current oil and gas sector.

Imagining oil and gas production in the Big Blue Economy

In this scenario, the EU followed their desire to become a global leader in sustainable energy supplies. There are innovative consumption patterns such as sharing use. A lot of investments were made to improve battery and carbon capture storage technologies, efficiency of extraction. This was driven by reducing the footprint of existing activities. This scenario is driven by net zero ambitions. The trend of reducing oil and gas production continued rapidly.



Picture of the virtual poster wall made during the oil and gas production workshop

Imagining oil and gas production in the Economies of individuals

In this scenario, no additional constrains are imposed on the industry. Due to geopolitical tensions, funding was limited to support innovation.

Imagining oil and gas production in the Small Blue Economies

In this scenario, there is low demand for oil and gas.

Conclusion

Although this sector seems to have relatively less uncertain developments, it is important to be aware that the possible exploitation of oil and gas in the Artic is likely to increase environmental pressures.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[36]	Bandwidth size of prospective total production quantity[37]	The prospective total environmental pressures[38]	Bandwidth size of prospective total environmental pressures[39]	The prospective environmental pressures per unit of production[40]
Oil and Gas production	Oil supply runs out Demand and price for oil	80 – 115	35	75 - 115	40	Minor decrease – minor increase

36 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

37 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

38 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

39 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

40 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

	Renewable energy Political stability Environmental awareness Regulatory framework					

7.1.6 *Plastic production*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews before the workshop started.

Environmental awareness

Because of its short-life function, packaging waste comprises the largest proportion of post-consumer plastic waste. It is argued that a cultural change towards the use of plastics is going on and that society is changing its habits on plastic. For example, increased public disgust at the sight of choked animals and soiled coastlines, the packaging industry was forced to respond. A high level of environmental awareness among society might decrease the demand for plastics.

Development of international standards

The development of international standards, such as a timescale for the degradation of biodegradable plastics, might increase sustainable plastic production.

Technological innovation

- Technical advances might increase the recyclability of plastic products.
- The development of new materials that satisfy the purposes for which plastics are used might result in less plastic production. Most innovations focus on increasing the recyclability of plastics and the development of bioplastics or biodegradable plastics. In Europe, the share of bio-based plastics is small – between 0.5% and 1.0% in 2016. Many bio-based plastics substitute for conventional plastics. Critics argue bioplastics are not the sustainable because most of them need high temperature industrial composting facilities to break them down. With few local authorities able to handle them, the result is most must go to landfills where they are likely to release methane, an important GHG emission.

Local production and consumption

While most reports assume the demand for plastics will increase rapidly in the future, some circumstances could decrease the demand. For instance, local production and consumption of goods may decrease the demand for plastics.

Oil and gas price

Since 2010 the petrochemical industry has invested about $200bn, and with $100bn more planned to be spent, plastic production is expected to grow 40% by 2030. The production and disposal of plastic now uses nearly 14% of all the world's oil and gas. Some people argue that plastic could be driving half of all oil demand growth in the future because plastic is the oil's great hope for expansion. A low level of environmental awareness among society is likely to limit the trajectory towards oil and gas free plastics.

Most important sectoral drivers of change according to the workshops participants

Working groups →	Working group 1	Working group 2

Most important drivers ↓		
Driver 1	Cultural change (less plastic society/slower consumption of (single use) plastics)	COVID-19 (a lot of (new) online consumption of SUP/packaging)
Driver 2	Environmental awareness (1 and 2 are interrelated; = consumer side)	Environmental awareness
Driver 3	Circular Economic growth (linked to technological innovation)	Market alternatives (also innovations) pushed back (because of COVID-19)
Driver 4	Technological innovation	Promotion of reuse/recycling … to reduce production need
Driver 5	Plastics regulations pushing Circular Economy	Existing (EU) plastics regulation should be implemented and enforced

Sectoral response to scenarios

The following paragraphs describe how mineral extraction in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, plastic production had been moving steadily to the world of Consuming Economy?

Imagining plastic production in the Consuming Economy

In this scenario, single use plastics has increased because people demand fast and convenient consumption of goods. The trends towards cheap and non-environmental friendly products continued. For instance, there is a lot of take-away and online shopping which causes increased demand for packaging. Thereby, a lot of plastic is discharged to the ocean. The need for packaging is higher than ever before and therefore the use of plastics. International environmental agreements are mandatory and not binding. There is strong lobbyism to keep using plastics.

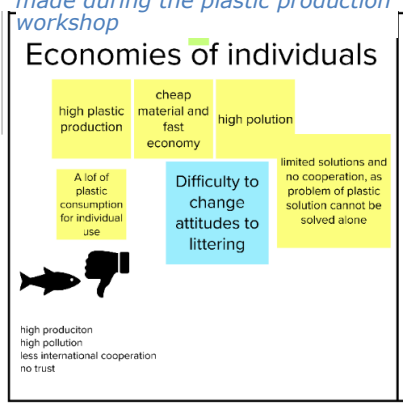
Imagining plastic production in the Big Blue Economy

In the Big Blue Economy, plastic production is high. People are aware of their relationship with marine litter in the ocean. There is high recycling rate of plastic since it was increasingly imposed by environmental laws and EU regulation. In time, plastic became a high value material. Sustainable bioplastics became the dominant material for food packaging. Furthermore, most litter is removed through innovative cleaning technologies. The biggest driver for this scenario is the goal to substitute plastics as much as possible. Therefore, a lot of investments are made in order to stimulate innovation of more environmental material. Over the years, plastics were substituted by other materials due to innovation.

Imagining plastic production in the Economies of individuals

In this scenario, there is a high level of plastic production, especially for individual use. The environmental pressures increased rapidly because there was almost no cooperation between different stakeholders. Very limited solution were achieved to continuously deliver cheap and convenient plastic based products. The attitude towards single use plastics did not change and litter is a major environmental problem. The costs to deal with waste increased because

Picture of the virtual poster wall made during the plastic production workshop



there was simply too much waste to handle on a global scale. Countries decided that waste found within their geographic boundary would be incinerated as fast as possible.

Imagining plastic production in the Small Blue Economies

In this scenario, plastic production decreased. A lot of local initiatives established to decrease the need for plastics. Plastics are seen as unnecessary for local production-consumption chains. Convenient fast consumption is not the biggest driver anymore. For instance, people increasingly want to take their time to prepare dinner. Plastic use became too costly. Due to increased environmental awareness there was more urgency to process waste environmental friendly. For instance, more policies are implemented to reduce the environmental pressures related to plastic production and consumption. Thereby, in order to avoid costs of waste, it became cheaper to consume less plastics.

Conclusion

It seems unlikely that demand for plastic would decrease towards 2030. Existing (EU) plastics regulation should be implemented and enforced.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[41]	Bandwidth size of prospective total production quantity[42]	The prospective total environmental pressures[43]	Bandwidth size of prospective total environmental pressures[44]	The prospective environmental pressures per unit of production[45]
Plastic production	Demand for convenient products Global vs. local value chains Technological innovation International standards	95 - 200	105	90 – 170	80	major decrease – minor decrease

7.1.7 *Shipping*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews before the workshop started.

Location consumer market and place of production

Important drivers for the expected growth of the shipping industry are the locations of harbours, ports, industrial areas and consumer markets. These locations determine the most efficient trading routes. For example, Europe currently has a dominant consumer market. In addition, what kind of

41 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

42 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

43 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

44 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

45 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

goods countries surrounding the OSPAR region will produce and consume in the future is an important driver. Furthermore, it is expected that self-sufficiency would decrease the demand for shipping rapidly.

Limited space
Scarcity in space due to other activities is perceived to be a small driver in the OSPAR region. It is argued that ships would only have to change their trading route. In contrast, Maritime Protecting Areas (MPA) would have a big impact on shipping activity. Most important factors of change for shipping lines are economic drivers. The shipping routes are developed when they are most profitable. This does not necessarily result in the shortest distance between shore-to-shore. Efficient fuel use due to navigational restrictions (factors related to the sea state such as wind and currents) is more important as well.

China
China is increasingly focusing on their own market. Therefore, China may become an important global consumer market in the future. There is a small chance this would lead to an increase of shipping activity in the OSPAR region. It is expected that China would develop towards an economy that produces more and imports less because it increasingly wants to become self-sufficient. For instance, they want to import less end-of-the-chain products. Thereby, the prospected developments of China would lead to a decrease of shipping activity in and the OSPAR region. China would still have to import raw materials (which are most often transported through shipping activities).

Fuel change
The transition towards alternative fuels, such as bio fuels, synthetic fuels or e-fuels, are seen as an important measure in order to reduce GHG emissions of the shipping sector. The supply of these fuels is limiting this transition. In general, LNG is seen as an important transition fuel for deep sea shipping although it is thought of as unsustainable. The level of environmental awareness could change the perception on what type of fuel ships should run on.

Alliances
There is a trend towards alliances between shipping companies in order to fill the large volume of the vessels and achieve economies of scale. Thereby, the costs per container unit decrease which is one of the most important driver for shipping activities. There is also a believe that the demand for bigger ships for deep sea shipping might decrease in the future for several reasons, such as a decline of maritime cargo volume, the development towards circular economy and the re or near shoring of production. These drivers would increase the demand for short sea shipping. Furthermore, the level of trust towards (international) collaboration might decrease the trend for deep sea shipping in the future.

COVID-19
The impact of COVID-19 on global trade done by the shipping sector is uncertain. As long as there is a pandemic, viruses have a big impact on the shipping sector. However, it is expected that the long-term impact of COVID-19 is minor.

Disconnecting global supply chains
It is uncertain to what extent local markets will play a more significant role in society's daily consumption. However, it is likely that the transition towards a circular economy would lead to a more dominant local market.

Environmental awareness
It is uncertain to what extent environmental awareness goes hand in hand with less shipping. For instance there is discussion about if circular economy would decrease the demand for shipping. This relationship is considered to be uncertain because it depends on a lot of different factors that influence the transport costs and profits of shipping. For instance the location of recycling plots or consumer markets and if recycling economies of scale would develop.

- In the future society may perceive international circular economy as an important measure to achieve sustainable consumption. Thus implying and re-use of scarce raw materials or

semi-products. Shipping might facilitate the transition towards a circular economy, for instance by facilitating the recycling flows through short sea shipping.

- It is expected that the transition towards a circular economy will impact trading routes in and around the OSPAR region. Economic activities extract less resources because within a circular economy, they aim to recycle the resources that are already out there. This would decrease demand for shipping.
- Circular economy does not necessarily mean that transport would decrease. That depends on the location of recycling plots, the location of the consumer market and the location of economic activities.
- If these are close, less shipping is needed, but if they are dispersed, circular economy would increase the need for shipping. Therefore, it is uncertain if scenarios with high environmental awareness would lead to less shipping of commodities.
- High environmental awareness might also lead to less demand for goods in general. This would decrease demand for shipping.

Most important sectoral drivers of change according to the workshops participants

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Consumer demand for goods and transport	Demand for products and services (societal fast from anywhere, tourism, transport, job travel)
Driver 2	World trade (trade routes, market development, production location, circular economy, independence)	Climate change (innovations & sustainability)
Driver 3	Energy transition (renewable fuels, electricity etc.)	Economic security (political, international trade & demand, predictability, security in delivery of goods)
Driver 4	Innovation propulsion systems and fuels (industry pioneers leads)	Policy (on Climate Change and environment, pandemic response)
Driver 5	Policy and regulations (rules incentivise the strategies)	Innovation and technology (emission reduction, autonomous, bigger ships)

Sectoral response to scenarios

The following paragraphs describe how the shipping sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, the shipping sector had been moving steadily to the world of Consuming Economy?

Imagining shipping in the Consuming Economy

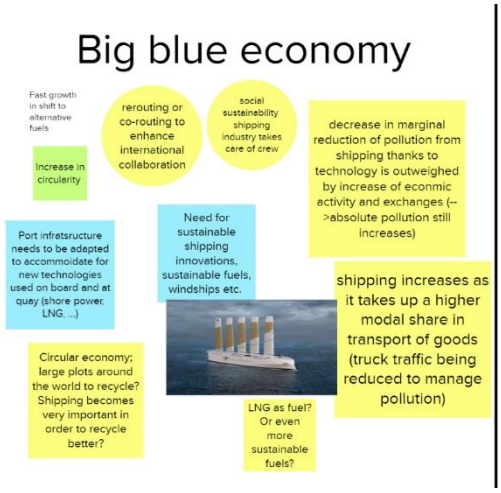
In the Consuming Economy, shipping practices are continued in the existing networks of 2020. Infrastructure that was already in place in 2020 are used most of the times in the same way as was the case in 2020. For instance, during their entire life time, ships were used without any updates for

the sake of less environmental pressures. The updates were only aimed at reducing costs. For instance, the costs per container unit decreased rapidly.

In the time period of 2020-2030, the continuously aim to make profit, resulted in more profitable trading routes and larger ships. This was supported by better and more globally used Network Information Systems (NIS). The distribution of shipping activity was driven by the need to build bigger ports. As a result, the larger ports increased their market share. The existing technology was kept running and oil and gas are still the dominant fuels used for shipping practices. Niche technology developments for the sake of the environment were not fruitful because there was no level playing field. There were no major changes to reduce environmental pressures and a major increase of international maritime transport.

Imagining shipping in the Big Blue Economy

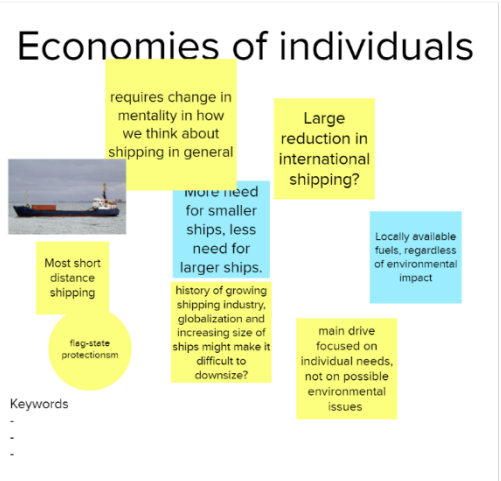
Similar as in Consuming Economy, the growing international collaboration between countries demanded that the shipping sector rerouted to enhance international collaboration. Increased international collaboration was primary aimed at protecting the global environment while supporting the further development of a global economy. In Big Blue Economy, the sector responded to the growing awareness among society. In this world, shipping plays an important role in the development of a circular economy. Large vessels ship goods from large recycling plots to industrial areas anywhere in the world. The shipping alliances made sure the volume of the recycling flows filled the minimum capacity to maintain profitable trading routes. Furthermore, the investment of large ports and large shipping corporations in more sustainable fuels before the period of 2025 invested paid off; most of ships shifted towards less carbon intensive fuels, such as LNG. After 2025, the supply of sustainable fuels developed rapidly. For instance, ships active in short sea shipping trade within the OSPAR region are partially propelled by wind energy through innovative aerodynamic designs. Shipping increased rapidly in and around the OSPAR region to facilitate the circular economy flows. However, innovation focused environmental friendly technology could not outweigh the increase of shipping activity. Therefore, absolute pollution still increased, but the relative pollution decreased.



Picture of the virtual poster wall made during the shipping workshop

Imagining shipping in the Economies of Individuals

In this world, there is a large reduction in international shipping. Furthermore, policies is more focussed on flag state protectionism. Therefore, it is expected that this worlds decreases shipping activity in the OSPAR region. In Economies of Individuals, there is a growing need for smaller ships. Nations use locally available fuels, regardless of their environmental impact. The main drive for shipping is supplying individual needs by shipping domestic resources, products and people. Environmental pressures are given almost no attention. Therefore, environmental pressures increased, such as noise, pollution and GHG emissions. The rapid decrease of shipping activity resulted in a decrease of environmental pressures in absolute terms. The environmental pressures per unit of production, however, increased rapidly due to less production. For instance, because environmental pressures per container unit. The shipping sector would had a hard time to adopt towards a world of Economies of Individuals. The



Picture of the virtual poster wall made during the shipping workshop

history of growing shipping industry, globalization and increasing size of ships made it difficult to downsize.

Imagining shipping in Small Blue Economies
In Small Blue economies, there is a high decrease in shipping in general because most societies invested in local production to limit the need for maritime transportation. Thereby, the amount of NECA (nitrogen emission control areas) and MPA (marine protected areas) zones increased rapidly in the OSPAR region. The remaining maritime transport of goods is done by ships that are running on low pollution fuels, such as LNG. Because society finds fast delivery less important, the ever growing demand for fast delivery became less pronounced as was expected. In Small Blue Economies, ships decreased their speed rapidly. As a consequence, there were less environmental pressures such as noise and GHG emissions per shipping activity compared to 2020. Furthermore, due to the minimalistic lifestyle of people, there was a strong decrease of cruising activity. In this scenario, the market share for ports (mainly big ports) declined, some even went out of business and are in need for reconversion.

Conclusion

The environmental awareness in the shipping sector is increasing and there is a strong believe this would guide the developments in the shipping sector most. Therefore, the shipping sector developments are assumed to be less likely to develop in accordance with drivers related to the Consuming Economy or Economies of Individuals. Furthermore, it is believed that COVID-19 will have a big impact on the shipping sector. Therefore, the developments of the shipping sectors are perceived to be most in accordance towards the world of Small Blue Economy (low economic growth and high level of environmental awareness).

However, the expectation to transform the shipping sector in line with a high degree of environmental awareness might be to be too optimistic. Some stakeholders argued that it is likely that there will be no profound improvements in the shipping sector to reduce environmental pressures until 2030. The world of Consuming Economy has the most parallels with the state of the things today in the shipping sector.

Important drivers for the expected growth of the shipping industry are the locations of harbours, plots and consumer markets. These locations determine the most efficient trading routes. For example, Europe has a dominant consumer market. However, as the scenarios show, how the consumer market of the OSPAR region will develop towards 2030 is uncertain.

For the time period 2020-2030 it seems that a minor or moderate increase of the shipping sector is considered to be more likely than a major increase. The expected growth is downsized for a couple of reasons.

- First, due to COVID-19 it is expected that the growth of economies will decrease because they first must recover.
- Second, it is expected that supply chains will be disconnected. For example, China is expected to export less goods because more products will be consumed by their own consumer market. In addition, trade wars could lead to less import and export.
- Third, consumers in Europe are getting more and more aware about the environmental impact of their consumption. For example, they want to consume more local goods. This decreases the transport of goods.
- It is likely that the shipping sector will not show a large increase in economic growth.

There are other factors that make double digit growth less likely.

Next to consumer markets, another important driver for the OSPAR region is what types of goods will be produced by the contracting parties. For example, America does not export much products by sea because they deliver a lot of high tech knowledge and services. Germany on the other hand, is

an important exporter for industrial goods. Food is exported a lot by the OSPAR region. More goods are becoming suitable to transport via containers. For example fruit. The demand for container transport has grown over time. However, other drivers may alter this development. For instance, the demand for local goods or trade wars.

Overall it is argued that the transport of goods will show minor or moderate economic growth. However, the economic growth has a significant level of uncertainty.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[46]	Bandwidth size of prospective total production quantity[47]	The prospective total environmental pressures[48]	Bandwidth size of prospective total environmental pressures[49]	The prospective environmental pressures per unit of production[50]
Shipping	- Global vs. local value chains - Location of recycling plots - Oil and gas price - Innovation	80-105	35	70 - 110	35	moderate decrease – minor increase

7.1.8 *Renewable energy*

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews before the workshop started.

Limited space

Land use issues: Marine renewables can interfere with other uses of the sea or marine conservation objectives – causing hazards to shipping and the servicing of the offshore industry, and displacing fishing activities and recreational boating. These conflicts might decrease renewable energy production in the OSPAR region.

Disturbance

Some people may object to how wind turbines look on the horizon and to how they sound. This might decrease wind production.

46 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

47 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

48 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

49 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

50 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

Technological advancements

- Engineers are working on solutions to make wind energy safer for flying wildlife.
- Continuous innovation led to renewable energy to become the cheapest source of energy. The price of wind energy is still declining. This makes it a more valuable resource and thereby, increases wind production.

Technical limitations

- For wind turbine, speed should not increase beyond 25 m/s; otherwise, turbine will be damaged. Also, low speed of wind, that is, <3 m/s, will not be sufficient for the generation of electric power.
- Energy storage
- Energy efficiency

Preferred investment

Renewable energy has become investors' preferred choice for new power plants.

Environmental awareness

Cities, states, and federal governments around the world are instituting policies aimed at increasing renewable energy.

There is a strong consensus that renewable energy is environment friendly.

Securing energy supply

- Nations aim to become energy self-sufficient. This might increase renewable energy production because it is almost everywhere available (sun, wind).
- The seasonal change of renewables might decease renewable energy production if seasonal change is dominating the discussion about the ability of renewable energy can secure a 24 hours energy supply. For instance, just as with peak electricity demand conditions, a drastic lower demand with a higher and unexpected percentage of variable renewable energy can stress the grid system's operation. The state of the network and grid infrastructure matters, as a more flexible, efficient and smarter grid allows for more interconnected plants and fewer bottlenecks. However, this depends on the pace of innovation and investments.

COVID-19

It is uncertain to what extent the economic impact of COVID-19 results in less oil and gas production in the OSPAR region.

Due to COVID-19, grid operators, sought the cheapest (and cleanest) supply source to balance the lower demand. Therefore, weaker electricity demand increased the share of renewables in the system while sending the more polluting and costly carbon fuels to the back of the queue. This effect happened even at a time of historically low fossil fuel prices. But the longer-term effect of the crisis is yet to be seen, as softer lockdown measures have shown a recovery of demand.

The lockdown provides a real sense of opportunity for the energy sector. It brings plenty of lessons about clean energy policy, changes in demand patterns and knowhow for a greener grid without compromising the security of supply. It also opens further opportunities for investment and innovation. However, at the same time, a lot of COVID-19 policies supported carbon-intensive industries without demanding carbon reductions. For instance, support to airlines.

Land use issues

- It is uncertain to what extent the limited space can be utilised to achieve the governments' renewable energy targets.

Technological advancements

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	Energy demand	Climate change / energy policy
Driver 2	Technology + innovation driven	Consumer behaviour / demand for renewable energy
Driver 3	Climate change	Economic growth
Driver 4	Emotion driven vs. knowledge driven	Technology/innovation (availability of renewable energy)
Driver 5	International collaboration vs. populism	Availability of non-renewable energy and political interests

- Innovation is necessary to make renewable energy more efficient, easier to store and more secure.
- It is uncertain to what extent innovation towards 2030 will be aimed to reduce environmental pressures of renewable energy.

Most important sectoral drivers of change according to the workshops participants

Sectoral response to scenarios

The following paragraphs describe how the shipping sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies). Thus, starting with Consuming Economy: What if, up to 2030, renewable energy production had been moving steadily to the world of Consuming Economy?

Imagining renewable energy in the Consuming Economy

In this scenario, there are no mitigation measures in place to avoid environmental pressures of renewable energy production. For example, the collision of birds with wind farms on sea. The location of wind farms is based on economic targets (for example, they are developed on the cheapest places). Innovation in renewable energy were mainly aimed to make them more efficient, the energy easier to store and the provision secure. Therefore, there is an moderate increase of windfarms and it is very likely that environmental pressures have increased in this world due to renewable energy practices on sea.

Imagining renewable energy in the Big Blue Economy

In the Big Blue Economy large scale windfarms have developed. The innovations are cooperation driven. The incentives for new-renewables have been removed as best as possible through policies. Technical limitations, such as speed level, energy storage, energy efficiency, are not a problem anymore. Renewable energy became investors' preferred choice for new power plants. Investments were made in order to develop a more flexible, efficient and smarter grid.

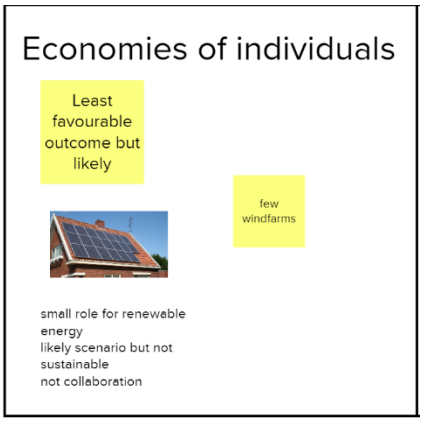
Continuous innovation led to renewable energy of the North East Atlantic Ocean to become the cheapest source of energy by far. This made wind energy a very valuable resource. There is high international collaboration and renewable energy produced by the North East Atlantic is bought all over the world through green energy certificates. The objective of the EU commission to grow to 60 GW of offshore wind and 1 GW of ocean energy by 2030 was already met in 2027. Today, the North East Atlantic Ocean provides society with around 120 GW of renewable energy.

Imagining renewable energy in the Economies of individuals

In economies of individuals, a few windfarms have been developed because there were limited incentives to make society depended on renewable energy. There was almost no collaboration. Seasonal change of renewables dominated the discussion; eventually nations decided that renewables were not able to provide a stable supply of energy. It was believed that the grid system's operation would become too stressed.

Imagining renewable energy in the Small Blue Economies

There was high ambition but due to a lack of funding, the increase of renewable energy production was limited. Only a few windfarms developed.



Picture of the virtual poster wall made during the renewable energy production workshop

Conclusion

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[51]	Bandwidth size of prospective total production quantity[52]	The prospective total environmental pressures[53]	Bandwidth size of prospective total environmental pressures[54]	The prospective environmental pressures per unit of production[55]
Renewable energy production	Limited space Technological advancements Preferred investment Environmental awareness Securing energy supply	200-300	100	160 – 340	80	major decrease – major increase

51 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

52 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

53 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

54 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

55 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

7.1.9 *Tourism*

Sector specific drivers of change

This paragraph describes the most important sector specific drivers of change that were found in scientific literature or/and addressed during interviews before the workshop started.

Changes in demand patterns through time

More frequent but shorter trips throughout the year. This might effect the environmental pressures associated with tourism and recreation, such as fuel use. This trend affected the coastal and maritime sector through a decline in total expenditure per visit.

An ageing society and evolutions in spending capacity

Between 1994-2014, individuals over 60 doubled globally and this trend is expected to continue till 2030; and this population group will remain important till 2050. This will require new services but also reduce seasonality (elderly often go to coastal regions in winter season). This might change the tourism and recreational practices.

An increase in environmental awareness

Growing interest in 'authentic experiences'; interest in experiencing local cultural, social and environmental characteristics while avoiding negative externalities. Environmental friendly tourist practices might increase in the future which has a high level of environmental awareness.

Geopolitical threats raising safety concerns

Geopolitical tensions and south-north inequalities in coastal/island destinations in the Mediterranean (e.g. high number of refugees in Greece) and safety concerns in other parts of the world (e.g. zika virus in South Amerika) could have positive effects on other, 'safer' destinations within the EU. This might increase tourist activities in and around the OSPAR region.

COVID-19

The EU expects that the impact on coastal tourism will be very large in size, strong in initial impact and very lagged in its recovery path. This might decrease the growth of the tourist sector in the future.

Most important sectoral drivers of change according to the workshops participants

Working groups → Most important drivers ↓	Working group 1	Working group 2
Driver 1	COVID-19	COVID-19 and ability to cross borders
Driver 2	Economic development	Consumer preferences
Driver 3	Population demographics	Economic growth
Driver 4	Environmental policies	Technology and political will to support development
Driver 5	Globalization	Demographics

Sectoral response to the scenarios

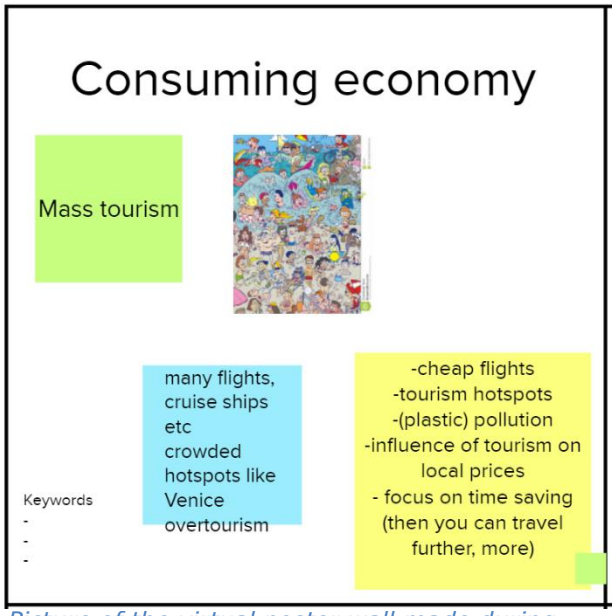
The following paragraphs describe how the tourism and recreation sector in the OSPAR region would have developed if the trajectory was in accordance with a certain scenario (either Consuming Economy, Big Blue Economy, Economies of Individuals or Small Blue Economies).

Thus, starting with Consuming Economy: What if, up to 2030, the tourism and recreation sector had been moving steadily to the world of Consuming Economy?

Imagining tourism and recreation in the Consuming Economy

In Consuming Economy, the demand for holidays and recreation have increased rapidly, especially the demand for short trips. International tourism flows increased but also short trip destinations. Tourist sectors are driven by mass tourism. For instance, there are cheap flights for families.

Consumers want to gain memorable experiences as fast as possible. They focus on saving time during their travels since this helps them to travel further and more often. Cheap flights are offered and cruises increased rapidly. The majority of society finds it important to visit hotspots like Venice. Tourists have a big influence on these hotspots. For instance, a lot of coast cities are increasingly producing goods and services specialized to satisfy the needs of (international) tourists. Sometimes this is at the expense of local needs.



Picture of the virtual poster wall made during the tourism and recreation workshop

Technical innovations were mainly aimed at making goods and services available for a bigger part of society. More people possess holiday homes and recreational products, such as boats.

Imagining tourism and recreation in the Big Blue Economy

The demand for green recreation activities increased. There is less negative impact on the environment through technological solutions. Environmental taxes are paid by tourists or other stakeholders of the sector. Decisions about holiday destinations are guided by the Good Environmental Status index of environments. Technical innovations were mainly aimed at reducing environmental pressures. For instance, supplying activities with green energy or making holiday accommodations more sustainable. Small distance flights decreased and train traffic increased.

Imagining tourism and recreation in the Economies of Individuals

In economies of individuals, the possibilities to travel is limited due to money constrains and stricter cross-border policies. The sector has a higher dependence on income from tourism for coastal sides because their market share is mainly based on local tourism (local tourists prefer to go to the beach).

Imagining tourism and recreation in the Small Blue Economies

In this world, local tourism became important. People want to have holidays at home or near home. The demand for slow tourism dominates the sector. There are less flights and more environmental activities. People want to enjoy nature. The long distance travels decreased. A new trend emerged: staycation. Home vacations increased. People prefer to spend more time on recreation instead of consumption.

Conclusion

The possible mid/long-term impacts of COVID 19 are one of the most important drivers of change. Higher environmental awareness creates opportunities for tourism and recreation in the OSPAR region. Economic development determines the tourism demand; money is especially an important constrain for the domestic population's decision on where to go. Globalization and the level of international tourism flows are another driver of change. These all determine the competitive advantage of OSPAR region compared to elsewhere. This sector is highly influenced by population demographics because older people have relatively more time for recreation. The sector is dependent on what tourist want to see from the OSPAR environment. For example, the status of the sandbank or fish stocks is less important to tourists compared to aesthetics landscapes. Good Environmental Status (GES) creates an opportunity for recreation. Examples of eco-tourism are special bird

watching or cruises to watch seals. An environmental tax paid by the tourist sector or tourists themselves might develop. It might become more common to decide your holiday destination based on the state of the environment. For instance, tourist could base their decisions on targets of GES of environments.

Open boarders policies are an important driver of change as well. They enable society to travel inside or outside the OSPAR region. The short-term policies are dominated by the circumstances of COVID-19. Technologies may improve how tourists travel. For instance, by investing in railway systems in the OSPAR region, more sustainable ways of travelling will develop. If price and travel time dominates the choice of transport, travel by train would need to speed up. In the future, policies might be implemented to provide cheaper prices for train tickets. However, this is highly dependent on the political will to implement cross border cooperation. The technology is out there but still has to be integrated with the infrastructure which would need large investments.

Consumer preferences are important. For instance, a small part of society feels ashamed when they choose to travel by plain. The preference to travel environmental friendly might dominate the choice of travel in the future. In low economic growth scenarios, people would have less money to spend on holidays. As a results of COVID-19, people are more often looking for holiday homes in the country/coast.

The following table translates the qualitative storylines about sectoral developments into quantitative indicators, such as the prospective total production quantity.

	Main Drivers	The prospective total production quantity[56]	Bandwidth size of prospective total production quantity[57]	The prospective total environmental pressures[58]	Bandwidth size of prospective total environmental pressures[59]	The prospective environmental pressures per unit of production[60]
TRE	Changes in demand patterns through time Type of tourists Environmental awareness Geopolitical threats raising safety concerns COVID-19 An ageing society and evolutions in spending capacity	90-130	40	60 - 150	90	Major decrease – major increase

56 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

57 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

58 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

59 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

60 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

7.2 Summary of results

The table below presents a schematic overview of sectoral developments per scenario, based on the information presented in the previous sections.

Table 2 Prospective development of economic sectors (Source: author)

	Main Drivers[61]	The prospective total production quantity[62]	Bandwidth size of prospective total production quantity[63]	The prospective total environmental pressures[64]	Bandwidth size of prospective total environmental pressures[65]	The prospective environmental pressures per unit of production[66]
AGR	- Diet shifts - Global food chains - Regulation	80-120	40	70-130	60	Moderate decrease – moderate increase
AQU	- Innovation -Investments - International trading	115-150	35	100-155	55	Major decrease – minor increase
FIS	- Political stability - Fishing culture - International collaboration	90-105	15	80-100	20	Moderate decrease – minor decrease
MEX	- Consumer demand - Deep sea mining technology - Regulation	105-150	45	100-165	65	Minor decrease – major increase
OGP	- Oil supply runs out - Demand and price for oil - Renewable energy - Political stability	80 – 115	35	75 - 115	40	Minor decrease – minor increase
PLP	- Demand for convenient products	95 - 200	105	90 – 170	80	major decrease – minor decrease

61 A more comprehensive list of drivers for each sector is given in chapter seven 'Results'.

62 These numbers represent expected economic growth or decline by 2030 in percentage relative to 2020 (which is the '100' reference point).

63 Since this number is produced by subtracting minimum prospective total production quantity from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future growth. For example, in agriculture, the maximum is 120 and minimum is 80. Thereby, the bandwidth of uncertainty is 40 (120-80=40).

64 These numbers represent expected growth or decline in total sectoral environmental pressures by 2030 in percentage relative to 2020 (which is the '100' reference point).

65 Since this number is produced by subtracting minimum prospective total environmental pressures from the maximum for each sector, it represents the degree of uncertainty in predicting a sector's future environmental pressures. For example, in agriculture, the maximum is 130 and minimum is 70. Thereby, the bandwidth of uncertainty is 60 (130-70=60).

66 These qualitative variables (minor, moderate or major; either increase or decrease) represent the degree to which each sector's production manages to reduce their environmental pressures per unit produced from 2020 to 2030. This differs from total environmental pressures since it implies a sector's actual efficiency in reducing environmental pressures. Even though their high production levels might result in higher total environmental pressures.

	- Global vs. local value chains -Innovation -Regulation					
SHI	- Global vs. local value chains - Location of recycling plots - Oil and gas price - Innovation	80-105	35	70 - 110	35	moderate decrease – minor increase
TRE	- Type of tourists - Geopolitical threats raising safety concerns - COVID-19	90-130	40	60 - 150	90	Major decrease – major increase
REP	- Limited space - Innovation - Preferred investment - Securing energy supply	200-300	100	160 – 340	80	major decrease – major increase

8 Discussion, conclusion and recommendations

This chapter discusses the limitations of this research. Furthermore, the most important and uncertain developments and their potential implications for policymaking are presented. Finally, it is explained how this assessment is linked with the other assessments and projects of OSPAR. For example, the Joint Assessment & Monitoring Programme (JAMP B14 project), the Quality Status Report 2023 (QSR 2023) and the North-East Atlantic Environment Strategy (NEAES).

Discussion

It is important to stress that it is not possible to include and describe all possible drivers of change, but this research tried to identify and structure the most important ones as best as possible. First of all, because not all drivers are socio-economic variables. Natural drivers of change, such as the spread of diseases among species in the OSPAR region, are excluded from this analysis. Also the impacts of climate change have been excluded in this study because of the scope in this report (see Chapter two for more details). Secondly, not all socio-economic drivers can be taken into account, such as micro-economic changes. Thirdly, as explained earlier in chapter four ´Managing Uncertainty´, the so called systemic shocks or game changing events are also excluded from this analysis. The uncertainty about the long-term impact of the current COVID-19 pandemic is however included in the scenarios.

Next to the fact that the scenarios presented in this study are (just as any other scenario study) unable to include all drivers of change, the cause and effect mechanisms are a simplification of the real world. The alternative future developments described relate mainly to economic production and environmental pressures adjusting automatically to macro-changes. By focussing attention on the most important and uncertain drivers of change, and thereby simplifying the real world, the scenarios are easier to understand and can be used to explore the future together with a group of stakeholders. However, often, cause and effect mechanisms are much more complex in real life than assumed in scenarios. For instance, it is not necessarily true that low economic growth goes hand in hand with local economies.

Furthermore, the environmental pressures described in these scenarios are far from covering all potential pressures. Next to reasons associated with a high level of complexity, a sectoral perspective may cause a too limited scope on environmental pressures in the OSPAR region. It is less obvious to take the entire life-cycle of products into account if you focus on sectors. For instance, you are more tended to skip certain life cycle stages of products and services. Often, the way goods are consumed by citizens receive less attention from a sectoral perspective.

Conclusion

Compared to other activities, aquaculture, mineral extraction, plastic production and renewable energy production have relatively the highest potential economic growth. However, the level of uncertainty about economic growth varies between this group of activities since the level of renewable energy production and plastic production falls within a much larger bandwidth compared to aquacultural and mineral extraction.

It is expected that the same level of economic growth of aquaculture would result in less environmental pressures compared to the growth of mineral extraction. This is because it is expected that the aquacultural sector would have a more rapid pace of innovation aimed to protect the environment compared to the mineral extraction sector. The environmental pressures of mineral extraction have a relative high level of uncertainty because the field of environmental pressures related to deep sea mining (an important driver for the expected sectoral growth) is understudied.

The environmental pressures per unit of plastic production is very likely to decrease while the same is less certain for renewable energy production: this could vary between a moderate decrease and moderate increase. This uncertainty is mainly due to the additional environmental pressures caused by sustainable energy production: while this industry does reduce greenhouse gasses, it can also

negatively affect biodiversity and natural habits. Since this aspect is still understudied, uncertainty is relatively high.

While exploring to the future, it seems that the OSPAR area is likely to become more industrialized; the density of activities will grow. However, the environmental pressures of this growth have a higher level of uncertainty since environmental research about these future activities is currently in an early stage of development. Therefore, it is important to allocate enough time and resources to this type of research. For instance, precautionary principles could be put in place in order to hamper the development towards a future similar to the scenario of Consuming Economy is limited. During interviews and the workshop, people often perceived sectoral developments to be driven by the scenario of Consuming Economy. To them, the drivers of Consuming Economy had the most parallels with current trends affecting the economic activities in and around the OSPAR region.

The scenarios presented in this study should be considered as four alternative possible states of the world, but not as a comprehensive list of alternatives. These scenarios mainly aim to make a *more* comprehensive list of drivers, to show how uncertain the future is, and to make a best estimated guess of how these drivers may cause economic activities and environmental pressures to grow or not.

This document could be used to assess the uncertainty about the extent environmental pressures of sectors may increase or decrease in the future. Based on this knowledge, it is easier to determine whether additional measures should be implemented to protect the marine environment in the OSPAR area in the future. It would be best when measures are taken that are robust and flexible enough to protect the environment in as many alternative scenarios as possible.

The results of this research provide an overview of possible drivers of change that can be used for other analyses about the OSPAR region. For instance, they provide input for the DAPSIR model. Furthermore, sometimes trends lack an in depth explanation about drivers of change and their level of uncertainty. The findings of this report could assist in providing in depth information about trends. Next, it could make individuals more conscious of the assumptions behind trends and why those trends may not turn out as expected by 2030.

<u>Recommendations</u>
The results of this research provide a framework for future examinations of possible socio-economic drivers for economic activities by painting dots on the horizon. The scenarios and their sectoral responses can be improved by a more collaborative process that takes into account the necessary expertise across discipline. For instance, by engaging more stakeholders, the findings of this research can be discussed and refined. In order for future research on this topic to be comprehensive, it would be advisable to employ a team of researchers; the level of detail necessary to produce operational scenarios is simply too great. This course of action is supported by experts in the field of scenario writing[67].

Scenarios have different purposes. The four scenarios could contribute to answering important questions about the management of the OSPAR region by using them in a different way. Thereby, the four scenarios could be used as a reference point the help guide other important difficult discussions OSPAR is facing today.

First, the four scenarios could be used to explore to what extent the OSPAR objectives[68] will be met in the future. For example, it could be explored to what extent activities/pressures are too high in certain scenarios to meet the conservation targets while in other scenarios the targets could easily be met.

67 Such as Gerbert Romijn from the department CPB Netherlands Bureau for Economic Policy Analysis.

68 In addition, participants of the workshop found it interesting if the scenarios would be used to consider the objectives of EU-Biodiversity Strategy, UN SDGs, MSFD, Habitats Directive.

Second, this scenario analysis aimed to explore drivers and environmental pressures of economic activities. During the workshop, many participants gave voice to the social outcomes of sectoral developments towards 2030. Therefore, it might be interesting to adjust these scenarios to further explore the social impact of these economic activities in 2030 (such as labour force, labour conditions etc.).

Third, in another research, it would be interesting to focus on what role OSPAR might play in the future. The scenarios could help to structure the discussion about how OSPAR could prepare for the future. Instead of focusing on the economic sectors, it could be explored how OSPAR would respond to each of the four scenarios. In chapter five 'Constructed scenarios', a brief first response of OSPAR to the four scenarios is written. These could be discussed and elaborated more in further research.

And finally, these scenarios can function as anticipatory scenarios. These are also known as prescriptive or normative scenarios and help to structure the discussion about how organizations could guide the way forward in order to achieve their goals. In this case, you start with a prescribed vision of the future and then work backwards in time to visualize how this future could emerge. During the workshop, it became clear that participants started to discuss what kind of future they would want to live in. Most of the times it was Big Blue Economy and sometimes Small Blue Economy. This was no surprise since OSPAR has a clear focus on sustainable development of the North East Atlantic region, and participants assumed this would be most easily achieved in this scenario. By choosing Big Blue Economy as the prescriptive vision, stakeholders could start discussing about how OSPAR could help to arrive in such a future state.

> *People want to do the right thing. So, what we need to do is to create environmental awareness, by presenting an easy and appealing message: We want to leave the world in a better state than we found it*
>
> Participants of Exploring the Future Workshop, 28th of January

> *One thing the Corona pandemic has shown, is that technological development and implementation can happen fast. Before the pandemic online workshops were unthinkable, but within a year it is widely used and functioning well. Due to technological development, physical location does not limit productivity anymore. Technological development can and will be used to realise sustainable agriculture.*
>
> Participants of Exploring the Future Workshop, 28th of January

> *I am incredibly impressed by the workshop. It would have been most beautiful if we would have been able to have this meeting in physical form, but it is beautiful to have this type of exchange of views. Exchanging views is important since we are all OSPAR countries and share the same sea. This type of horizon scanning workshops are really important and useful for all types of work, and also for the new North East Atlantic Strategy.*
>
> Participants of Exploring the Future Workshop, 28th of January

9 Bibliography

HELCOM (2018): Economic and social analyses in the Baltic Sea region – HELCOM Thematic assessment 2011–2016. Baltic Sea Environment Proceedings No. 160." Available at: http://www.helcom.fi/baltic-sea-trends/ holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/

Alcamo, J. (2001). *Scenarios as tools for international environmental assessments*. Off. for Off. Publ. of the Europ. Communities.

Alcamo, J. (2008). Chapter Six The SAS Approach: Combining Qualitative and Quantitative Knowledge in Environmental Scenarios. In J. Alcamo (Ed.), *Developments in Integrated Environmental Assessment* (Vol. 2, pp. 123–150). Elsevier. https://doi.org/10.1016/S1574-101X(08)00406-7

Allen, B., Bas-Defossez, F., & Weigelt, J. (n.d.). *Feeding Europe: Agriculture and sustainable food systems*. 22.

Álvarez-Fernández, I., Fernández, N., Sánchez-Carnero, N., & Freire, J. (2017). The management performance of marine protected areas in the North-east Atlantic Ocean. *Marine Policy*, *76*, 159–168. https://doi.org/10.1016/j.marpol.2016.11.031

An, C.-B., & Jeon, S.-H. (2006). Demographic change and economic growth: An inverted-U shape relationship. *Economics Letters*, *92*(3), 447–454. https://doi.org/10.1016/j.econlet.2006.03.030

Andrew, R. (2014). *Socio-Economic Drivers of Change in the Arctic* (No. 9). Arctic Monitoring and Assessment Programme (AMAP). https://www.amap.no/documents/doc/socio-economic-drivers-of-change-in-the-arctic/1115

Bhadola, A., Patel, V., Potdar, S., & Mallick, S. (2020). *Technology Scouting—Carbon Capture: From Today's to Novel Technologies*. Concawe.

Bottero, M., & Ferretti, V. (2010). Integrating the analytic network process (ANP) and the driving force-pressure-state-impact- responses (DPSIR) model for the sustainability assessment of territorial transformations. *Management of Environmental Quality: An International Journal*, *21*(5), 618–644. https://doi.org/10.1108/14777831011067926

Cambray, J. A. (2003). Impact on indigenous species biodiversity caused by the globalisation of alien recreational freshwater fisheries. *Hydrobiologia*, *500*(1), 217–230. https://doi.org/10.1023/A:1024648719995

Coccia, M. (2014). Driving forces of technological change: The relation between population growth and technological innovation: Analysis of the optimal interaction across countries. *Technological Forecasting and Social Change*, *82*, 52–65. https://doi.org/10.1016/j.techfore.2013.06.001

Delgado, C. L., Wada, N., Rosegrant, M. W., Meijer, S., & Ahmed, M. (n.d.). *The Future of Fish: Issues and Trends to 2020*. 6.

Deutsch, L., Gräslund, S., Folke, C., Troell, M., Huitric, M., Kautsky, N., & Lebel, L. (2007). Feeding aquaculture growth through globalization: Exploitation of marine ecosystems for fishmeal. *Global Environmental Change*, *17*(2), 238–249. https://doi.org/10.1016/j.gloenvcha.2006.08.004

Dogan, M., & Yaprak, A. (2017). Self-Construal and Willingness to Purchase Foreign Products: The Mediating Roles of Consumer Cosmopolitanism and Ethnocentrism. In M. Stieler (Ed.), *Creating Marketing Magic and Innovative Future Marketing Trends* (pp. 1499–1511). Springer International Publishing. https://doi.org/10.1007/978-3-319-45596-9_277

Ehrenfeld, D. (2003). Globalisation: Effects on Biodiversity, Environment and Society. *Conservation and Society*, *1*(1), 99–111.

Elliott, M., Burdon, D., Atkins, J. P., Borja, A., Cormier, R., de Jonge, V. N., & Turner, R. K. (2017). "And DPSIR begat DAPSI(W)R(M)!"—A unifying framework for marine environmental management. *Marine Pollution Bulletin*, *118*(1–2), 27–40. https://doi.org/10.1016/j.marpolbul.2017.03.049

Erokhin, V., & Gao, T. (2020). Impacts of COVID-19 on Trade and Economic Aspects of Food Security: Evidence from 45 Developing Countries. *International Journal of Environmental Research and Public Health*, *17*(16), 5775. https://doi.org/10.3390/ijerph17165775

European Union. (2016). *The competitive position of the European food and drink industry*. ECORYS. doi:10.2826/039661

European Union (Ed.). (2017). *Globalisation patterns in EU trade and investment: 2017 edition* (Manuscript completed in October 2017). Publications Office of the European Union.

Groeneveld, R. A., Bosello, F., Butenschön, M., Elliott, M., Peck, M. A., & Pinnegar, J. K. (2018). Defining scenarios of future vectors of change in marine life and associated economic sectors. *Estuarine, Coastal and Shelf Science*, *201*, 164–171. https://doi.org/10.1016/j.ecss.2015.10.020

Ilić, M., & Nikolić, M. (2016). Drivers for development of circular economy – A case study of Serbia. *Habitat International*, *56*, 191–200. https://doi.org/10.1016/j.habitatint.2016.06.003

Ireland's National Strategic Plan for Sustainable Aquaculture Development. (2015). European commission.
https://www.agriculture.gov.ie/media/migration/seafood/marineagenciesandprogrammes/nspa/NationalStrategicPlanSusAquaDevel181215.pdf

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(48), 19127–19129. https://doi.org/10.1073/pnas.1116914108

Manzanedo, R. D., & Manning, P. (2020). COVID-19: Lessons for the climate change emergency. *Science of The Total Environment*, *742*, 140563. https://doi.org/10.1016/j.scitotenv.2020.140563

Munir, K., & Ameer, A. (2018). Effect of economic growth, trade openness, urbanization, and technology on environment of Asian emerging economies. *Management of Environmental Quality: An International Journal*, *29*(6), 1123–1134. https://doi.org/10.1108/MEQ-05-2018-0087

Palamenghi, L., Barello, S., Boccia, S., & Graffigna, G. (2020). Mistrust in biomedical research and vaccine hesitancy: The forefront challenge in the battle against COVID-19 in Italy. *European Journal of Epidemiology*. https://doi.org/10.1007/s10654-020-00675-8

Pringle, T., Barwood, M., & Rahimifard, S. (2016). The Challenges in Achieving a Circular Economy within Leather Recycling. *Procedia CIRP*, *48*, 544–549. https://doi.org/10.1016/j.procir.2016.04.112

Quina, M. J., Soares, M. A. R., & Quinta-Ferreira, R. (2017). Applications of industrial eggshell as a valuable anthropogenic resource. *Resources, Conservation and Recycling*, *123*, 176–186. https://doi.org/10.1016/j.resconrec.2016.09.027

Renes, G., & Romijn, G. (2015). *Bijsluiter bij de WLO-scenario's* (No. 1771). Planbureau voor de Leefomgeving (PBL) and Centraal Planbureau (CPB).

Santeramo, F., & Lamonaca, E. (2020). *The Role of Non-tariff Measures in the Agri-Food Sector: Positive or Negative Instruments for Trade?* 35–59. https://doi.org/10.1007/978-3-030-25662-3_3

Shahbaz, M., Shahzad, S. J. H., Mahalik, M. K., & Sadorsky, P. (2018). How strong is the causal relationship between globalization and energy consumption in developed economies? A country-specific time-series and panel analysis. *Applied Economics*, *50*(13), 1479–1494. https://doi.org/10.1080/00036846.2017.1366640

Slater, M. J., Mgaya, Y. D., Mill, A. C., Rushton, S. P., & Stead, S. M. (2013). Effect of social and economic drivers on choosing aquaculture as a coastal livelihood. *Ocean & Coastal Management*, *73*, 22–30. https://doi.org/10.1016/j.ocecoaman.2012.12.002

Snellen, D., Hamers, D., & Tennekes, J. (2019). *Scenario's voor stedelijke ontwikkeling, infrastructuur en mobiliteit. Verdieping bij Oefenen met de toekomst. Ruimtelijke Verkenning 2019* (No. 3381). (Planbureau voor de Leefomgeving.

Suuronen, P. (2020). Monitoring and managing fisheries discards_ New technologies and approaches. *Marine Policy*, 9.

Van Den Toren, J. P., & Cloosterman, E. (2020, October 8). Gevolgen en herstel van economische schok verschillen sterk per regio. *ESB*, *Empirische Analyse*(105), 4.

Vos, R., Martin, W., & Laborde, D. (2018). Implications of the global growth slowdown for rural poverty. *Agricultural Economics*, *49*(3), 325–338. https://doi.org/10.1111/agec.12419

Pirrone, N., Trombino, G., Cinnirella, S., Algieri, A., Bendoricchio, G., & Palmeri, L. (2005). The Driver-Pressure-State-Impact-Response (DPSIR) approach for integrated catchment-coastal zone management: preliminary application to the Po catchment-Adriatic Sea coastal zone system. *Regional Environmental Change*, *5*(2-3), 111-137.

Schulz, M., Neumann, D., Fleet, D. M., & Matthies, M. (2013). A multi-criteria evaluation system for marine litter pollution based on statistical analyses of OSPAR beach litter monitoring time series. *Marine environmental research*, *92*, 61-70.

Strietman, W.J., K.G. Hamon, A. Mol, 2019. De economische effecten van twee toekomstscenario's voor de Noordzee; Een economische verkenning van de effecten van twee ruimtelijke scenario's voor de Noordzee, opgesteld door het Planbureau voor de Leefomgeving, op de Noordzee gebruiksfuncties tot en met 2050. Wageningen, Wageningen Economic Research, Rapport 2019-080.

European Commission (2020). The EU Blue Economy Report. 2020.

Publications Office of the European Union. Luxembourg.

Claussen, U., Zevenboom, W., Brockmann, U., Topcu, D., & Bot, P. (2009). Assessment of the eutrophication status of transitional, coastal and marine waters within OSPAR. In *Eutrophication in Coastal Ecosystems* (pp. 49-58). Springer, Dordrecht.

de Grunt, L. S., Ng, K., & Calado, H. (2018). Towards sustainable implementation of maritime spatial planning in Europe: A peek into the potential of the Regional Sea Conventions playing a stronger role. *Marine Policy*, *95*, 102-110.

Rustomjee, C. (2017). Operationalizing the Blue Economy in Small States: Lessons from the Early Movers.

Ban, N. C., Alidina, H. M., & Ardron, J. A. (2010). Cumulative impact mapping: Advances, relevance and limitations to marine management and conservation, using Canada's Pacific waters as a case study. *Marine Policy*, *34*(5), 876-886.

Xu, Y., Xu, X., & Tang, Q. (2016). Human activity intensity of land surface: Concept, methods and application in China. *Journal of Geographical Sciences*, *26*(9), 1349-1361.

Kristensen, P., 2004. The DPSIR Framework.

United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).

Matthijsen, J. et al. (2018), De toekomst van de Noordzee. De Noordzee in 2030 en

2050: een scenariostudie, Den Haag: PBL.

Morrissey, K. (2014). Using secondary data to examine economic trends in a subset of sectors in the English marine economy: 2003–2011. *Marine Policy*, *50*, 135-141.

Stebbings, E., Papathanasopoulou, E., Hooper, T., Austen, M. C., & Yan, X. (2020). The marine economy of the United Kingdom. *Marine Policy*, *116*, 103905.

Vogel, C., Ripken, M., & Klenke, T. (2018). Linking marine ecosystem services to the North Sea's energy fields in transnational marine spatial planning. *Environments*, *5*(6), 67.

Beckert, J. (2013). Imagined futures: fictional expectations in the economy. *Theory and society*, *42*(3), 219-240.

O. Langmead, A. McQuatters-Gollop and L.D. Mee (Eds.). 2007. European Lifestyles and Marine Ecosystems: Exploring challenges for managing Europe's seas. 43pp. University of Plymouth Marine Institute, Plymouth, UK.

10 Appendix

10.1 Classification of linkages human activity – environment

In order to provide information on how the various economic sectors can be linked to the environment of the OSPAR region, this section explains how these economic sectors depend on the ocean's natural capital. This natural capital consists of the natural assets of the ocean that human activities depend on. The relationship between human activity and the marine environment can be established based on four linkages. First of all, how the natural capital may function as input for human activity (minerals, fish etc.). Secondly, how the marine environment takes care of output (waste disposal). Thirdly, the marine natural capital may provide amenity services. Fourthly, it provides basic life-support functions (Perman, 2019). Figure (…) gives and overview of these linkages.

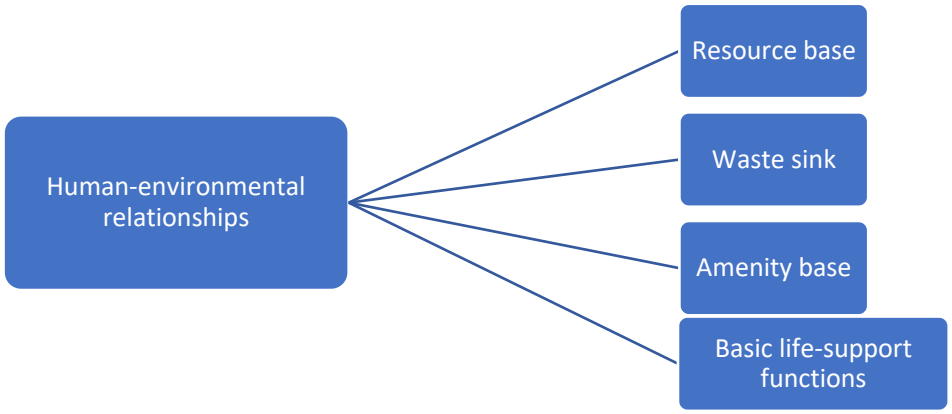


Figure (…) *A classification of the functions that the environment provides for humans*

First of all, the North East Atlantic Ocean is a resource base for many human activities. The natural resources can be distinguished by stock or flow resources. They differ in whether the lever of current use affects future availability. While flow resources have no link between current and future use (for example, solar, wave and wind energy), stock resources can be distinguished by the nature of this link. If stock resources are dependent on the flora and fauna of a maritime environment, they are renewable resources because it has the potential to grow by means of natural reproduction. For example, if fish harvest is equal to the natural growth of the fish population (also known as sustainable yield), the resource can be used infinitely. However, non-renewable resources such as minerals and fossil fuels have no natural reproduction, except on a geological timescale. Consequently, more use now necessarily implies less future use. It is important to distinguish the class of non-renewables between fossil fuels and other minerals because fossil fuel combustion is an irreversible process while other minerals can be recycled. Moreover, fossil fuel combustion is a major source of greenhouse gas emissions, for example carbon dioxide (CO_2). The harvest of resources may cause disruption of the ecosystem, for example through overexploitation, soil degradation and noise pollution.

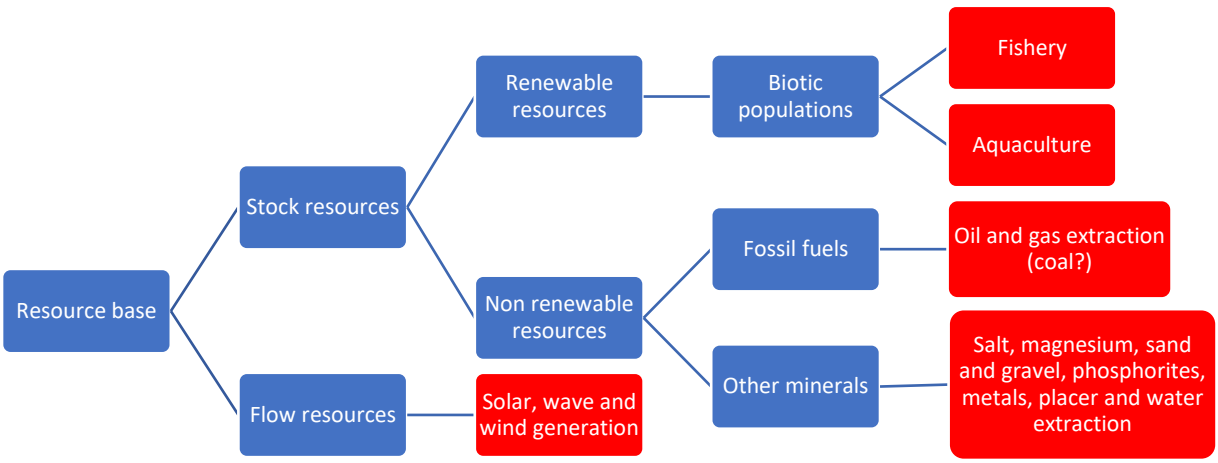
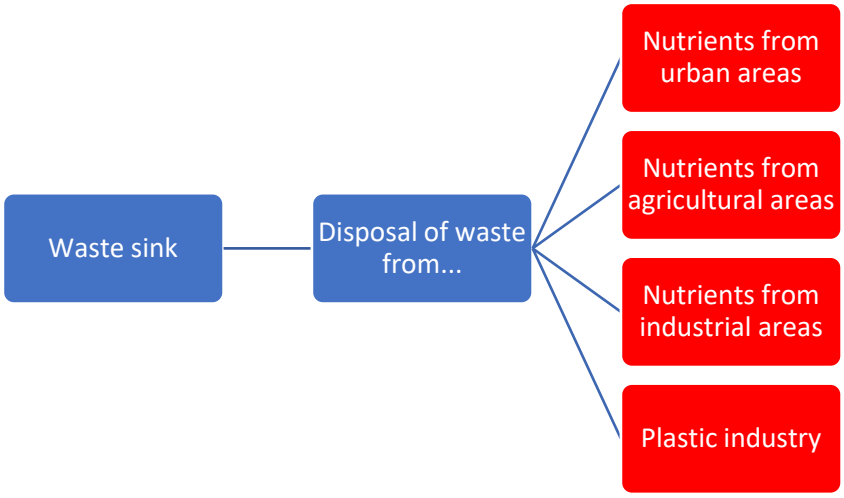


Figure (…)Economic sectors related to the resource base function of the North East Atlantic Ocean

Secondly, the marine environment can be seen as a waste sink for land-based human activities. Activities involved in production and consumption give rise to waste products that are discharged into the natural environment. Consequences of these discharges are most of the time related to pollution. For example, the excess amounts of nitrogen and phosphorus applied in agriculture may lead to



eutrophication.

Figure (…)Economic activities/sectors related to the waste sink function of the North East Atlantic Ocean

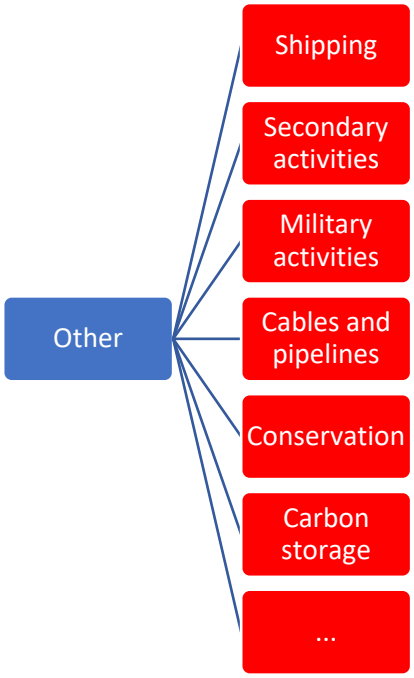
Thirdly, the North East Atlantic Ocean provides amenities for individuals that can be directly obtained. The water provides recreational facilities and other sources of pleasure, such as swimming, boating, diving and sunbathing. These activities are important for the tourism sector. Excessive use of a beach area can lead to changes in its character, as with the erosion of sand dunes following vegetation loss caused by human visitation.

The fourth environmental function of the North East Atlantic Ocean is more ambiguous. The biosphere currently provides the basic life-support functions for humans. For example, humans can tolerate a certain range of temperatures and have requirements in terms of breathable air and drinkable water. For example, solar radiation could be a serious problem for marine systems, where the base of the food chain consists of very small organisms living in the surface layers of the ocean, which solar radiation reaches (Perman, 2019). Ozone in the stratosphere performs a life-support function by absorbing solar radiation. Furthermore, the OSPAR region functions as a breeding ground for marine species.

From an environmental economics perspective, it is difficult to classify human activities because most activities rely on a broad range of different types of natural assets of the ocean. Therefore, in order to provide more structure in the wide range of human activities, the main type of natural assets is considered. However, some human activities have a more ambiguous link to the dimensions of resource base, amenity base or waste sink. Therefore, `Other´ is added as an additional

class. The activities that this class consist of are shipping, secondary activities, military activities, cables and pipelines, carbon storage and conservation. The secondary activities do not directly use the resources of oceans but support activities that do. Secondary market activities are for instance ship building and reparation. One option is left open (see the orange box '…') because only the main relationships between the environment of the OSPAR region and humanity are taken into account in this figure. Moreover, it is assumed that the list of (future) relationships between the maritime environment and humanity cannot be comprehensive because of the complexity of the relationships. Therefore, this figure mainly functions to provide some clarity on these relationships but cannot be perceived as final.

Figure (…) Other economic sectors of the North East Atlantic Ocean



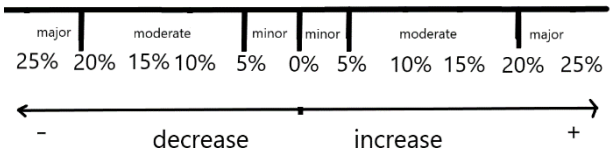
10.2 First draft of sectoral responses analysis

The blue squires represent changes in total production of the various economic sectors. The white squires represent changes in total environmental pressures.

	Big Blue economy	*Consuming economy*	*Small Blue economies*	*Economies of individuals*
Agriculture	Minor decrease of production	Moderate decrease of production	Moderate increase of production	Moderate increase of production
	Moderate decrease of environmental pressures	Minor increase of environmental pressures	Minor increase of environmental pressures	Major increase of environmental pressures
Aquaculture	Major increase of production	Minor increase of production	Moderate increase of production	Minor increase of production
	Minor increase of environmental pressures	Minor increase of environmental pressures	Minor decrease of environmental pressures	Minor increase of environmental pressures

Fishery	Moderate decrease of production	Moderate increase of production	Moderate decrease of production	Minor increase of production
	Major decrease of environmental pressures	Moderate increase of environmental pressures	Moderate decrease of environmental pressures	Minor increase of environmental pressures
Mineral extraction	Minor increase of production	Major increase of production	Moderate decrease of production	Moderate increase of production
	Minor decrease of environmental pressures	Major increase of environmental pressures	Minor decrease of environmental pressures	Moderate increase of environmental pressures
Oil and gas production	Moderate decrease of production	Major increase of production	Moderate decrease of production	Moderate increase of production
	Major decrease of environmental pressures	Major increase of environmental pressures	Minor decrease of environmental pressures	Major increase of environmental pressures
Plastic industry	Minor increase of production	Rapid increase of production	Minor decrease of production	Moderate increase of production
	Major decrease of environmental pressures	Major increase of environmental pressures	Minor decrease of environmental pressures	Moderate increase of environmental pressures
Shipping	Minor increase of production Inter-continental shipping increases more than intra-continental shipping	Moderate increase of production Inter-continental shipping increases more than intra-continental shipping	Moderate decrease of production Inter-continental shipping decreases more than intra-continental	Major decrease of production Inter-continental shipping decreases more than intra-continental.
	Minor increase of environmental pressures	Major increase of environmental pressures	Moderate decrease of environmental pressures	Moderate decrease of environmental pressures
Tourism and recreation	Moderate increase of production	Major increase of production	Moderate decrease of production	Moderate decrease of production
	Minor decrease of environmental pressures	Major increase of environmental pressures	Minor decrease of environmental pressures	Minor decrease of environmental pressures
Renewable energy	Major increase of production	Moderate increase of production	Moderate increase of production	Minor increase of production
	Minor increase of environmental pressures	Major increase of environmental pressures	Minor decrease of environmental pressures	Major increase of environmental pressures

The results are based on the variables represented in the figure below.



Major change (+++ or ---) represents change larger than twenty percent. Moderate change (++ or --) represents change between five and twenty percent and minor change (+ or -) represents change less than five percent.