



**Seas, Oceans & Public
Health in Europe**

Balancing future trends and local ambitions for Seas, Oceans and Human Health

A report on local stakeholder discussions regarding future trends, impacts and research gaps for four European Sea Basins

Authors

Marit de Vries, Susanne Wuijts, Judith Hin, Liesbet Dirven-van Breemen, Fabio Serafim, Henk Hilderink

Organisation

National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands

Reviewers

Theo van Alphen (RIVM)
Anouk Blauw (Deltares)

Contact

susanne.wuijts@rivm.nl

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Abstract

Balancing future trends and local ambitions for Seas, Oceans and Human Health

Future trends, like climate change, increasing migration, an ageing population, growing pollution and advancing technology, will have a great impact on societies in Europe. So far, the impacts of these trends have been studied at a continental or national level and policy development is often based on these high-level studies. The implications of global trends on a local level, are still barely understood. However, local authorities need to take action now to anticipate the impacts of future trends to keep their citizens healthy and safe.

The Horizon 2020 project Seas, Oceans and Public Health in Europe (SOPHIE) explores the complex interplay between the human health and the marine environment. Research targeting this link between ocean and human health is in a relatively early stage of development. The relevance of this link, however, is important and is expected to increase in the coming decades, due to different aspects future trends impacting both ocean and human health. The increase of coastal populations, growing tourism, an ageing population and impacts of climate change are examples of future developments that will influence the interplay between ocean and human health. The SOPHIE project aims to develop a European research agenda and a research community in which the different environmental and health communities can meet. To have a better understanding of current and missing knowledge on this link from a local perspective, is the objective of this study within the H2020 SOPHIE project.

One of the activities in the SOPHIE project is to identify and analyse relevant case studies and future scenarios in order to demonstrate potential risks and benefits from interactions between the marine environment and human health. Four case studies (sea basins) have been selected to identify relevant trends, potential impacts and research gaps from a local perspective. The selected sea basins include the Eastern Scheldt (North Sea), the Baltic Sea, Atlantic Ocean and the Mediterranean Sea.

For all four case studies, an interactive, participatory approach has been developed to identify current and future challenges at a local level arising from global trends. In separate interactive workshops for the different basins, a broad variety of local stakeholders discussed the impacts of relevant trends and its interactions in the local environment. Different stakeholder perspectives were exchanged resulting in suggestions on how to deal with these trends and clarify research gaps that need to be addressed. The joint discussion on different trends enabled the identification of cross-sectoral issues, impacts and research gaps and the potential to create co-benefits with other sectors. Examples are the importance of the sea on health and wellbeing, education and the inclusion of elderly in education activities, strengthening a sense of place and pride and dealing with social inequalities. The outcomes of the workshops have been used as input for the SOPHIE strategic research agenda.

This interactive approach stimulating the exchange of general and local knowledge and ideas on ocean and human health might lead to new collaborations between people who work in the health, economic or ecological sector. Our approach has already contributed to the development of a community of experts and stakeholders in the field of Oceans and Human Health.

1. Introduction

The Horizon2020 project Seas, Oceans and Public Health in Europe (SOPHIE) explores the complex interplay between the health of the marine environment and of humans. Research targeting this link is in a relatively early stage of development. The term human health is used in this context in a broad way and includes physical health, mental health and well-being as well as aspects of food related human health. The concept of 'ocean health' in this project is used in a similar way as 'human health', but leaves room for interpretation as well. An analogy for this concept can be found in the definition of a river's 'health' (Norris and Thoms 1999). Here, we define a 'healthy ocean' as an ocean in which the ecosystem is in such a state that optimal conditions for biodiversity are met, a broad diversity of species can thrive and a good ecological status in general can be achieved.

The relevance of the link between ocean and human health is already considered important and might gain even more relevance in the coming decades due to different future trends impacting both ocean and human health. For example, the increase of coastal populations, growing tourism, and an ageing population and the impacts of climate change are some important future developments that will influence the interplay between ocean and human health. In this perspective a better understanding of current and lacking knowledge on this link is one of the main objectives of the H2020 project Seas, Oceans and Public Health in Europe (SOPHIE)¹. The SOPHIE project aims to develop a European research agenda and a research community in which the different environmental and health communities can meet. The research agenda will serve as input for future planning of the EC research programme in this field.

One of the main activities in the SOPHIE project is to identify and analyse relevant issues and future trends demonstrating potential risks and benefits in the interactions between the marine environment and human health from a local perspective. Four case study areas, each in different European sea basins have been selected to identify relevant trends, potential impacts and research gaps from a local perspective. The selected sea basins include the North Sea (Eastern Scheldt), the Baltic Sea (Helsinki area), Atlantic Ocean (San Sebastian Donostia) and the Mediterranean Sea (Málaga area).

For all four case study areas, workshops have been organised with a diverse representation of researchers and practitioners from the marine, maritime, medical and public health communities. The results of the workshops directly feed into the SOPHIE Strategic Research Agenda and the participants are invited to join a network of relevant experts and stakeholders in the field of Oceans and Human Health.

The outcomes of these workshops will be analysed and compared in order to identify the role of the local context regarding ocean and human health. Central questions for this analysis are:

- What are relevant trends for ocean and human health for the different sea basins in Europe?
- What are knowledge gaps regarding these relevant trends?
- What are norms, values in ocean and human health policy in Europe?
- What is the role of the local context?

Since the workshops offered more results than could be processed in the Research Agenda, this report aims to describe the outcomes of the individual workshops and a synthesis of the joint results. The report builds on and complements progress in other relevant projects (e.g. Horizon 2020 BlueHealth, INHERIT and SeaChange Projects).

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Uncertainty about future developments and trends is inherently a part of future outlook studies. In the case of the Sophie project, therefore we have not included any consequences of the current situation that Europe and the rest of the world are facing with regards to the spread of the new coronavirus. Any possible consequence of the societal impact of the Covid-19 outbreak for future (local) policy making is not taken into account in this study. All local workshops and policy document analyses were carried out before January 2020.

Structure of the report

This report describes the applied scenario methodology regarding the development of future scenarios (Chapter 2). In the following chapters (Chapter 3-6), the case studies for the four sea basins are described (North Sea - Eastern Scheldt, Atlantic Ocean - San Sebastian, Baltic Sea - Helsinki area and Mediterranean Sea – Malaga area). Chapter 7 reflects on similarities and differences between the different basin areas with regard to relevant trends, issues and possible research gaps. Chapter 8 describes conclusions and recommendations based on the results of this study.

2. Methodology

2.1 Introduction

Ocean health and human health communities have their different perspectives and interests concerning which research gaps should be addressed in the field of ocean and human health. The SOPHIE project takes an international and innovative interdisciplinary and cross-sectoral approach to explore future developments in Europe's important water basins. It examines how these basins can be used to promote health and well-being and the research questions that need to be addressed to realise this. This chapter describes the methodology applied for the development of SOPHIE Future Outlooks.

Future outlook studies are able to provide insight into trends at global, regional or local level. Where global studies describe trends applicable to large regions, regional or local studies cover trends in more detail and of specific concern to those areas (see e.g. (Dammers, Ludwig et al. 2017)). The impacts on different geographical scales are interrelated. Global trends, such as climate change, have an impact at the local scale as well, while the interventions at the local scale in turn may influence the impacts at a national and global level, both in terms of climate change and policy development. The methodology developed for this project builds on the work in the H2020 project BlueHealth (Wuijts, De Vries et al. 2019).

2.2 Approach developed for this study

In general, six iterative steps can be identified in the scoping of future outlook studies (e.g. (Schwartz 1998, Shell 2008, Alcamo 2011)): framing of the issue (which questions need to be answered with the future outlook studies), development of a conceptual model, relevant scales to consider, scenario logics, scenario types and the use of tools and instruments. These steps have also been the backbone of our approach. Therefore, elements of scenario-building are used together with stakeholder engagement processes to identify issues, relevant trends, impacts and research gaps in order to address the research question for this study.

Table 2.1 summarizes the scope selected for this study in all six iterative steps, the design of the interactive approach and the interaction with local actors within these steps. The approach builds on the methodology developed for the H2020 project BlueHealth (Wuijts, De Vries et al. 2019), although there are differences in scope and objectives that have resulted in an approach tailored for the SOPHIE Future Outlooks.

Table 2.1 Scoping of this study.

#	Step	Scope of this study	Justification
1	Framing the issue	Central questions: <ul style="list-style-type: none"> What are relevant trends for ocean and human health? What are knowledge gaps regarding these relevant trends? What are norms, values in oceans-health policy in Europe? 	Central questions formulated by project team. Focal point for stakeholder workshops
2	Conceptual framework of the scenario	Connects trends, local conditions, impacts to drivers of health and well-being, ecology and social-economic aspects, ambitions and possible research gaps (Figure 3.1).	Structures discussion on local impacts of global, European or national trends during stakeholder workshops
3	Scale of time and space	<u>Time:</u> <ul style="list-style-type: none"> Trends should be meaningful for an EU research agenda: Research Agenda towards 2030, impact 2030-2050 Trends have different time horizons (e.g. climate vs. technology) 2040 is the horizon selected, with a view further in time for climate change <u>Space:</u> <ul style="list-style-type: none"> Local scale within the context of a sea basin 	Basis for trend analysis
4	Scenario logics	Both cognitive and normative uncertainties included in the scenarios	Cognitive and normative uncertainties are collected and discussed during stakeholder workshops
5	Scenario type	Descriptive trend scenario based on outcomes workshop	Review by workshop participants
6	Tools, instruments	Combination of literature and input from local experts and stakeholders	Input from workshop participants and publicly available studies

2.3 Conceptual framework

The conceptual framework developed for this study connects: (1) driving forces and their related trends, (2) local situation and issues, (3) the impact of drivers on health and well-being, ecology and social-economical aspects, and (4) possible research gaps (see Figure 2.1). It is used as a working procedure to identify relevant trends, their local impacts within a sea basin and formulate relevant research gaps. All steps are being discussed during stakeholder workshops on their local relevancy. Outcomes are reviewed by workshop participants and other relevant local actors.

The conceptual framework used in this study, is based on the frameworks DPSIR (Driver Force, Pressure, State, Impact, Response) (EEA 1999), DPSEEA (Driving Force, Pressure, State, Exposure, Effect, Action) (Corvalán, Briggs et al. 1996), and eDPSEEA (Morris, Beck et al. 2006, Reis, Morris et al. 2013). These frameworks are closely linked. The eDPSEEA framework is a further development of the DPSEEA framework, which takes the environment and the ecosystem services into account. These frameworks all provide tools to understand and influence the interactions between local environments and health (and other endpoints in the case of DPSIR).

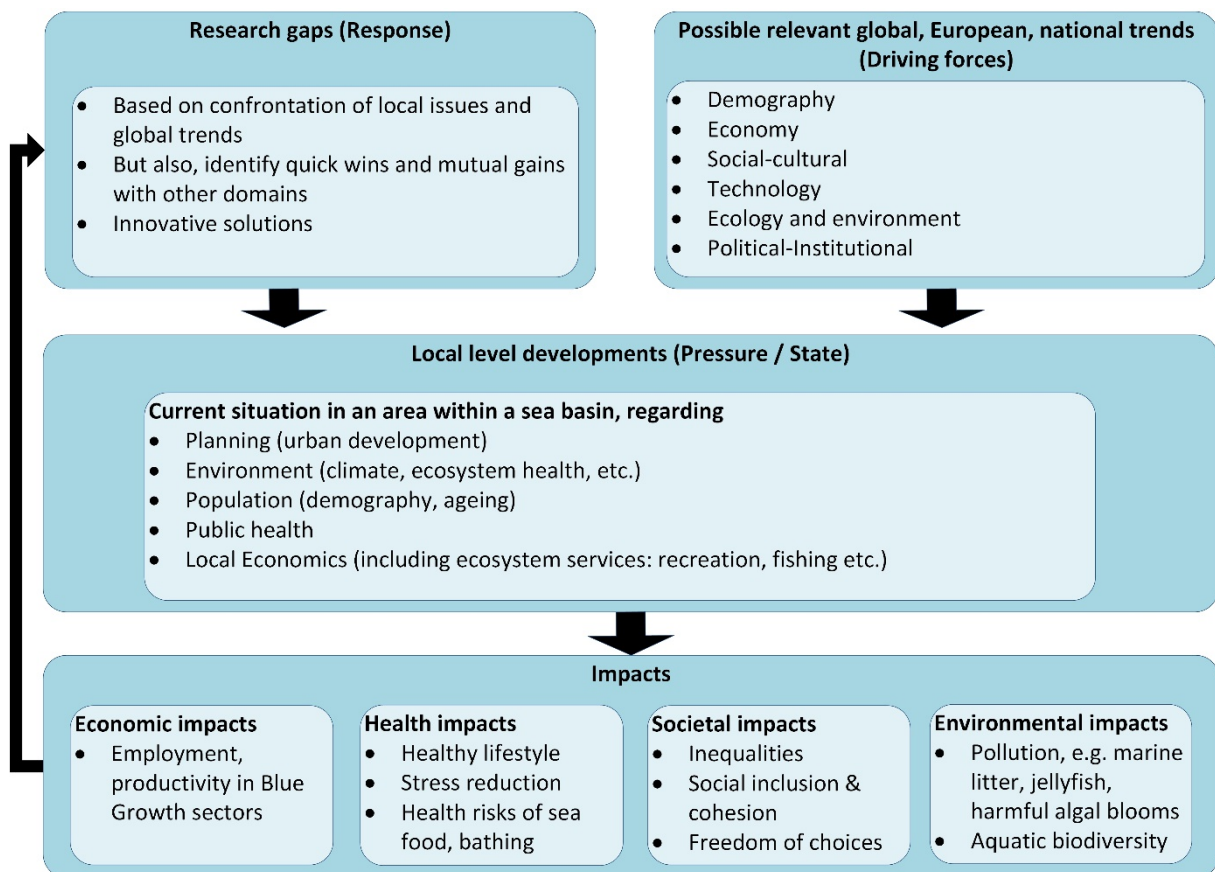


Figure 2.1 *Conceptual Framework to analyse local impacts of high level trends within the scope of ocean and human health structured by the DPSIR-framework (Driving forces, Pressures, State, Impacts, Response) (elaborated on (EEA 1999)).*

2.3.1 Possible relevant global, European, national trends (Driving forces)

The first element of the conceptual framework concerns the identification of driving forces and trends, for which the **DESTEP**-categorisation (Demography, Economy, Social-cultural, Technology, Ecology and Political-institutional) was used to systematically identify and structure the driving forces and trends. Working with the DESTEP categories ensured the selection of a broad range of trends that drive changes in the domains of water and health and well-being. The trend analysis from the H2020 BlueHealth project (Wuijts, De Vries et al. 2019) were used as a starting point and tailored to the domain of ocean and human health with experts from the Sophie team. The result was a broad identification of global trends that drive changes in the fields of ocean and human health and well-being (also referred to as 'health' in the remainder of this report), divided in the six DESTEP categories. This set of global trends functions as the starting point for the development of local discussions with local stakeholders. An overview of these trends can be found in Appendix I.

2.3.2 Local level developments (Pressure/State)

In order to understand the relevance and impact of global trends at the local level, workshops with local stakeholders and experts were organised to identify locally relevant trends and understand the impacts of these trends on water and health related issues in the local context. This approach implies that not the complete sea basin has been studied, but only the interaction of the local situation with the impact of global trends.

2.3.3 Economic, health, societal and environmental impacts (Impact)

Trends may have impacts on economic development, health, society, and the (natural and built) environment and affect the intricate relationship between ocean and human health. For each of the

trends identified as relevant, workshop participants discussed the possible impacts on the local scale. The results of these discussions were taken as the starting point for this report.

2.3.4 Research gaps (Response)

Based upon the analysis of current issues, relevant trends and their impact on the local situation, research gaps and relevant questions have been identified. This was part of the interactive discussions with stakeholders during the workshops.

2.4 Case study selection

Based on the conceptual framework a standardised procedure was set up to develop future outlooks and identify research gaps for each of the sea basins. The consecutive steps that have been undertaken are explained in Table 2.2. The case studies described in this report relate to the Baltic Sea, the North Sea, the Mediterranean Sea and the Atlantic Ocean. They are all situated in Europe, and are need to meet the same European ambitions while having to deal with similar European trends. However the extent and impact of these trends are highly dependent on geographical and societal factors. The sea basins have been selected to give a diversity in climate zones, ecological and societal issues in order to provide a variety in the results worthwhile for the development of the European Research Agenda on Ocean and Human Health.

2.5 Stakeholder engagement

According to relevant scientific literature, stakeholder engagement leads to better informed, more democratic and more effective decisions (Orr, Adamowski et al. 2015). To realise this, the engagement of stakeholders needs to be carefully designed and based on clear objectives that need to be achieved (Newig, Gaube et al. 2008).

To identify the relevancy of global trends on local level, a thorough understanding of the local situation and input from local stakeholders is indispensable. Since relevant trends may cover a wide variety of disciplines and their interaction, the representation of different stakeholders in terms of backgrounds and roles is an important aspect in the preparation of the stakeholder workshops. Furthermore, different stakeholders have different values/ambitions for the future. This stresses the need to engage stakeholders with different roles and responsibilities and from different organisations. For all workshops, participants were invited with local knowledge related to all DESTEP fields of expertise as well as the domains of ocean and human health.

Table 2.2 *Working procedure for building Sophie Future Outlooks.*

Step	Description	Method	Actors involved
1	Identification of possible relevant trends	<p>DESTEP-methodology used to identify trends:</p> <ul style="list-style-type: none"> • Identification and elaboration by project team • Input and feedback from WP partner Deltares • Input and feedback from experts and local stakeholders in workshops organised for each of the basins 	<p>Project team</p> <p>Local experts and stakeholders in workshops</p>
2	Identification of issues and perspectives	<p>Different actors hold different perspectives on the current situation and on the future. Since the objective is to identify local issues, relevant trends relate to these issues and research gaps. The identification of issues and perspectives is a topic for brainstorm and discussion at each of the local stakeholder workshops. Participants were asked to exchange views in pairs about the sea basin at stake and health. Results were discussed plenary.</p>	<p>Local experts and stakeholders in workshops</p>
	Prioritisation of trends	<p>What are the most relevant trends and what are the trends with the highest uncertainty?</p> <p>These two questions are to be answered by the participants of the local stakeholder workshops (standardised materials developed). The values of participants regarding ocean and human health may influence this assessment. Therefore it is important to have a fair representation at the workshops with participants from different backgrounds and stakeholder groups.</p>	<p>Local experts and stakeholders in workshops</p>
	Local situation	<p>Description of the current local situation:</p> <ul style="list-style-type: none"> • Data used: city specific data, data from European data sources (Eurostat), • Data validated and possibly refined with data from local actors (prior or during the stakeholder workshop) 	<p>Preparation by project team</p> <p>Refinement by local actors</p>
3	Impacts (economy, health, society, environment)	<p>What could be the impact of the most relevant trends at the local scale? What could be research gaps related to the impact of these trends?</p> <p>These questions are addressed first at the local stakeholder workshops. A standardised template is used for the discussion. Elaboration of workshop results and relevant trends into local Sophie Future Outlooks.</p>	<p>Initial discussion at stakeholder workshop</p> <p>Elaboration by project team</p> <p>Validation of drafts by stakeholders</p>
4	Research gaps	<p>Based upon the impacts of trends, research gaps are identified and discussed, taking mutual gains into account with other policy domains. Output from the stakeholder workshop is elaborated and reflected on and serves as input for the Strategic Research Agenda on Ocean and Human Health.</p>	<p>Initial discussion at stakeholder workshop</p> <p>Elaboration by project team</p> <p>Validation of drafts by stakeholders</p>
5	Stepwise and cyclic approach	<p>Validation of outcomes with the participants of the stakeholder workshops who have indicated to be interested to stay involved.</p>	<p>Project team</p> <p>Stakeholders involved</p> <p>Other interested parties</p>

3. North Sea (Eastern Scheldt)

3.1 Introduction

The Eastern Scheldt basin (an estuary of the North Sea) is a highly valued, attractive (nature preservation) area where multiple activities take place, from recreation, shipping, ecology, flood protection, fishery & aquaculture to energy supply. All these diverse activities highlight the importance of the Eastern Scheldt to the community. It is this same diversity of activities that sometimes causes conflict as they are all dependent on the same source. Therefore, a long term vision on how to balance these functions and preserve its ecosystem services and resulting health effects is needed. Another important challenge for the province of Zeeland, which the Eastern Scheldt is part of, is its variation in population composition. While the local population shows a trend towards shrinking, the population strongly increases during the summer due to tourism. This puts pressure on various facilities in the area. See also Figure 3.1 for more information regarding the Eastern Scheldt case study area.

On March, 7th 2019 in Middelburg (Netherlands) an interactive workshop was organised to gather input and explore relationships between human health and the North sea, with a special focus on Eastern Scheldt, in order to collect input for the Strategic Research Agenda the Sophie project has to deliver. The experts and stakeholders participated provided a great diversity of expertise ranging from water management, spatial planning, bathing water, governance, education, recreation, nature preservation, public health and health care and community engagement.

The workshop was structured with the following questions:

- What is the current situation?
- What are the most economic, societal, and environmental relevant trends to consider when it comes to the relation between public health and the sea?
- What questions related to this topic should be studied?

The answers focussed on various themes ranging from food quality and pollution of the basin, tourism and coastal living of the North Sea to the risks they impose on ecosystems and biodiversity (e.g. microplastics and other pollution). Aquaculture is an important sector in the estuary, but also a source of pollution e.g. ropes and feces. A lack of attention for salinization of farmland in the region was observed as well. A summary of these issues has been presented in Table 3.1.

Table 3.1 Workshop participants views on current issues related to ‘Ocean and human health’ for the North Sea with a specific focus on the Eastern Scheldt case study area.

	North Sea
Food	<p>Opportunities for seaweed as food and medication (cure for diabetes or Alzheimer’s)</p> <ul style="list-style-type: none"> • Food quality (shellfish, toxins) • Aquaculture is important, but also source of pollution (ropes, tin, feces) • Cultivation of shellfish is very limited • Lack of attention for salinization of farmland
Pollution	<ul style="list-style-type: none"> • Risks of micro plastics for animals and ecosystems • Regional waters with toxic algae influence quality Eastern Scheldt • Focus on individual substances, necessary to have more system based approach • There is little attention for ‘new’ substances (like drug residues or plastics)
Tourism and coastal living	<ul style="list-style-type: none"> • Chances for sea air (salt) as cure for disease • Risks of sea air for health (particles in the air); necessity of a healthy ecosystem (Grevelingen Lake mentioned as a negative example) • Risks of pollution due to shipping • Mass tourism is damaging for ecosystems • Too little attention for a healthy water system and public health • Future vision is lacking, how to combine functions in a right and sustainable way? What is prioritized? More attention for recreation, water quality and public health necessary. • Climate change is not taken into account regarding tourism • Are safety risks (diseases / flooding / sea level rise) taken into account sufficiently? E.g. Japanese oister is used for bank reinforcement, safety issue for swimmers; sand banks and movement creates unpredictable currents. • <i>Vibrio alginolyticus</i> can cause wound infections, to what extent a problem in Eastern Scheldt? • Attractive area for recreation: Lots of people and too little space (depending on the season, sea level), many different forms of water recreation (who, what, how much, where?). ‘Varen doe je samen’ is a partnership to create more safety on the water • Risks for bathing water quality are well known, important for recreation in Zeeland. What are the health benefits of different types of water recreation? • Create testing grounds: Free zones in the Eastern Scheldt, more space for innovation
Biodiversity	<ul style="list-style-type: none"> • Risks of micro plastics for animals and ecosystems • World beneath the water is unknown (‘unknown makes unloved’ (Dutch expression)) • What will temperature rise do to sea life? E.g. due to more concentrated discharges. • Clean water (a cook from Zeeland cooks with water from the Eastern Scheldt)
Other	<ul style="list-style-type: none"> • Lack of knowledge on interconnectedness ocean and human health • Important to connect climate, socio-economic and demographic developments: forecasting, planning (!) and execution • Municipalities: shrinking population should be reversed to growth: Mobility (faster connection) to Randstad via dams / dikes or water • Risks for water quality and shellfish (viruses and bacteria) • Pressure on (care) services as a consequence of ageing and shrinking population. At the same time a duplication of the population in the summer months due to tourism • Removal of barriers to improve water quality and health

North Sea, profile Eastern Scheldt



Figure 3.1 Background material on the North Sea/Eastern Scheldt case study area using the DESTEP-categorization to identify relevant information.

3.2 Identification of relevant or uncertain trends for ocean and human health

From the North Sea with its current issues (see Table 3.1), the Eastern Scheldt area was taken as the starting point for the identification of trends that could be relevant or uncertain for the region regarding ocean and human health. From a collection of 35 possible relevant trends, workshop participants selected their five most relevant trends and consequently their five most uncertain trends. The most relevant and the most uncertain trends do not necessarily coincide. The results have been presented in Tables 3.2 and 3.3.

The most relevant trends identified were climate change (1), higher rate of renewable Energy/ transition to more sustainable energy production (2), technological developments in industry (3), an increasing proportion of people who are either overweight or obese (4) and development of aquaculture (5).

The trend climate change relates to the effects of anthropogenic activities, whereas technological developments in industry and aquaculture aims to use technology to its benefits in order to reduce the impact on local environment. The Eastern Scheldt basin is a highly valued, attractive (nature preservation) area with multiple functions (recreation, shipping, ecology, flood protection, fishery & aquaculture, energy supply) that sometimes conflict. Currently, a long term vision on how to balance these functions and preserve its ecosystem services and resulting health effects, is lacking.

From the 35 possible relevant trends, five trends were then identified as most uncertain with a potential high impact. The most uncertain trends identified were climate change (1), technological developments in industry (2) and the increase of protected areas (3). This implies that climate change and technological developments in industry were regarded as both relevant and uncertain, meaning that the impact maybe high yet with many unknowns. One of the participants observed that ‘the effects of climate change manifest themselves at an unprecedented rate’.

In addition, the workshop participants came forward with several other potential relevant trends. The relationship between water and health was identified (e.g. micropollutants, mental health and wellbeing, bathing water quality, safety issues where conflicting functions are present (e.g. swimming and shipping)), but not yet fully understood. An important challenge for the province of Zeeland, from which the Eastern Scheldt is a part, is its variation in population composition. While the local population shows a trend towards shrinking, the population strongly increases in summer due to tourism. This sets pressure on various facilities. Technology and especially the digitization of environmental health monitoring was seen as an opportunity to deal with this pressure.

Table 3.2 Trends identified during the workshop as most relevant for the North Sea with a specific focus on the Eastern Scheldt case study area.

Trend	Description
Climate change	Climate change will further lead to more weather extremes (storms), higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water. Further loss of biodiversity.
Higher rate of renewable Energy/ Transition to more sustainable energy production	Energy consumption of households will decrease; the rate of renewable electricity consumption (hydropower and solar and wind power) will continue to grow.
Technological developments in industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. Furthermore, emission reduction technology as well as new substances being used.
Overweight/obesity	An increasing proportion of people who are either overweight or obese.
Development of aquaculture	More utilization of coastal areas; more activities and businesses catering to the increased demand.

Table 3.3 *Trends identified during the workshop as most uncertain for the North Sea with a specific focus on the Eastern Scheldt case study area.*

Trend	Description
Climate change	Climate change will further lead to more weather extremes (storms), higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water.
Technology in industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. Furthermore, emission reduction technology as well as new substances being used.
Protected areas	The increase of protected areas, Policies regarding the protection of certain areas are Increasing in both size and amount.

3.3 Impact of trends

Workshop participants discussed the potential impact of four of the trends that were identified as relevant for ocean and human health. The impact of climate change for the Eastern Scheldt area is exemplified by the Sea level rise of the North Sea which leads to more frequent closure of the Eastern Scheldt storm surge barrier. Another effect is the salinization of the farmland, which impacts the process of food production and requires adapting agricultural practices. In addition, the projected lack of space will lead to competition on the use of available land for aquaculture as well as safeguarding the protected areas. Tourism is a big source of income for the Eastern Scheldt region, it provides many seasonal jobs. However, due to the decrease in seasonal employees, it is important to invest in a sustainable labour population. See for more relevant identified trends and impacts Table 3.4.

Table 3.4 *Impacts and research gaps for the most relevant trends identified during the workshop for the North Sea with a specific focus on the Eastern Scheldt case study area.*

Trend	Impact	Research gaps
Climate change	<ul style="list-style-type: none"> • Sea level rise. Increased closure of Eastern Scheldt storm surge barrier, reduction of water inflow, impacts water quality, and other water functions. Current water quality in Eastern Scheldt very good (used for Michelin star cooking), multiple functions. • Salinization of farmland. Agriculture is dependent on rainfall, timing is now already 'off', fresh water shortages. • Impact climate change is uncertain, what remains of the beaches, aquaculture. • Decrease of livability and consequently impacts on health (worries on safety, related stress). • Temperature rise influences bacteria, algae growth • Increased heat related mortality. • Velocity of change is unprecedentedly high. 	<ul style="list-style-type: none"> • Direction of impacts is very unsure, many questions (increase of invasive species, what will happen to the landscape). • Temperature effects on health at the sea: buffer zone of climate change (microclimate) • Changes in water quality (algae, bacteria) due to climate change and health effects. • How do you adapt to climate change? • How can you realise adaptation that serves both safety, ecosystem preservation and health? • Salination: salt resilient crops: effects on health unknown if they are increasingly consumed in a daily diet.
Protected areas & Aquaculture	<ul style="list-style-type: none"> • Chances for new species because of climate change. Changes in production of cultivation and nature. • Conflict over space → important to keep on consulting and talking. Necessity for an Eastern Scheldt governance structure. When functions cannot exist next to each other (anymore) it is necessary to make choices (not realised in current 'Eastern Scheldt Vision'). • Designation of protected areas has a positive effect on the habitat and number of species. Currently Eastern Scheldt is breeding ground for many species and in that sense essential for food safety and food availability. • Find the balance between nature and recreation (development large scale recreation homes) in protected areas: awareness and education for both citizens and tourists. Shared usage for recreation (under restrictions). 	<ul style="list-style-type: none"> • How to combine different functions? In space and in time. Knowledge supporting a long term vision in spatial planning (capacity to say no or yes under specified conditions). • Not only focus on current uses and functions, but also new possibilities. • What is the capacity of the system? • What will be the consequences for local entrepreneurs? What will be the impact on local communities? • Nature friendly recreation development: how to realise that (including holiday homes). • Development of education/awareness programs on how the sea contributes to health. • Further research on the relation between fish from farms and intestinal cancer. • Better insight in the full food chain from the sea regarding food safety and food availability: what are strengths and weaknesses, unknowns.
Recreation and tourism	<ul style="list-style-type: none"> • Climate change will lead to more warm days and thus chances for tourism and recreation. E.g. longer season. Also more extreme rainfall and water quality issues. • Lack of (seasonal) employees is a problem, important to invest in sustainable labor population. 	<ul style="list-style-type: none"> • What will the impact of temperature rise be on water quality? • How does (sea)water contribute to human health? • What will be the consequences for local entrepreneurs? What will be the impact on local communities?

Trend	Impact	Research gaps
Obesity	<ul style="list-style-type: none"> • Obesity may lead to diabetes, cancer, cardiovascular diseases. It is a myth that this can be resolved solely by improving diet and exercise. The cause is often very complex. • The number of overweight people increases, especially children. In Zeeland, the number is lower than in the rest of the Netherlands. • 'Health' tourism may be a new industry (IVM initiative to combine nature walks for obese people). • Inequality is closely linked to obesity. 	<ul style="list-style-type: none"> • How do you invite people to exercise more? (input from Dutch Health Prevention Agreement).

3.4 Research gaps

For the trends identified as relevant, workshop participants discussed the potential impact and research gaps on ocean and human health. The impacts identified for the relevant trends presented in Table 3.4 are accompanied by a high level of uncertainty. Some of these uncertainties may be addressed by research. Table 3.4 presents the research gaps identified for the relevant trends and their impacts.

Research gaps for instance, were identified for:

- How to realise an adaptation that serves both safety, ecosystem preservation and health? For instance the risks of drowning when adapting the coastline through climate adaptive measures (moving channels and undercurrents).
- Changes in water quality (algae, bacteria) due to climate change and health effects are largely unknown. Further research is necessary on the relationship between fish from farms (aquacultures) and health, e.g. the relationship with intestinal cancer.
- Development of education/awareness programmes on how the sea contributes to health: How do you invite people to exercise more in the outdoors?
- Better insight in the complete sea food chain regarding food safety and food availability: what are strengths and weaknesses, unknowns (e.g. the health impact of cultivated sea weeds and effects of sea water temperature rise).

3.5 Summary of research gaps and quotes

During the workshops, participants identified research gaps that have been used as input for the Sophie Strategic Research Agenda. Textbox 3.1 shows summaries of the results of these discussions on the theme 'Food from the ocean' focusing on the North Sea. Textbox 3.2 and 3.3 show summaries for the research gaps identified for 'Blue spaces, tourism and well-being' and 'Marine biotechnology and medicine' respectively.

Textbox 3.1 Summary of results of the discussion with local experts and stakeholders on 'Ocean and human health' for the North Sea (Eastern Scheldt). Some noted relevant research gaps about 'Food from the ocean'.

Research gaps

- ✚ Research on the relation between the sea water temperature rise, culturing shellfish and food safety.
- ✚ Better insight in the complete sea food chain regarding food safety and food availability: what are strengths and weaknesses, unknowns (e.g. the health impact of cultivated sea weeds).
- ✚ Further research on the relation between fish from farms (aquacultures) and health, e.g. the relationship with intestinal cancer.

Textbox 3.2 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the North Sea (Eastern Scheldt). Some noted relevant research gaps and quotes about ‘Blue spaces, tourism and well-being’.*

Research gaps

- ✚ While the local population shows a trend towards shrinking, the population strongly increases in summer due to tourism. This sets pressure on various facilities.
- ✚ Changes in water quality (algae, bacteria) due to climate change and health effects.
- ✚ Development of education/awareness programs on how the sea contributes to health.
- ✚ The relationship on water and health was identified (e.g. micropollutants, mental health and wellbeing, bathing water quality, safety issues where conflicting functions are present (e.g. swimming and shipping)), but not yet fully understood.
- ✚ More knowledge is necessary on how one can realise adaptation that serves both safety, ecosystem preservation and health and knowledge supporting a long term vision in spatial planning (capacity to say yes or no under specified conditions).
- ✚ How do you invite people to exercise more outdoors?
- ✚ Better insight into physical safety such as drowning when adapting the coastline through climate adaptive measures (moving channels and undercurrents).
- ✚ The Eastern Scheldt basin is a highly valued, attractive (nature preservation) area where multiple functions take place (recreation, shipping, ecology, flood protection, fishery & aquaculture, energy supply) that sometimes conflict. A long term vision on how to balance these functions and preserve its ecosystem services and resulting health effects, is lacking.
- ✚ Temperature change effects on health of the sea: can the coastal area be a bufferzone of climate change (microclimate).

Quotes

- ✚ “In Zeeland you sleep better because of the sea air”
- ✚ “It is impossible to balance the growth of all the activities that take place in the Eastern Scheldt, we have to make choices. But until now we have not been able to do so”

Textbox 3.3 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the North Sea (Eastern Scheldt). Some noted relevant research gaps and quotes about ‘Marine biotechnology and medicine’.*

Research gaps

- ✚ Climate change, technological developments in industry and the increase of protected areas are the most uncertain trends for the case study area.

Quotes

- ✚ “Zeeuws DNA”
- ✚ “Appreciate the added qualities that seas bring to us”
- ✚ “I am very interested to learn more about the benefits of the sea for health and wellbeing”

4. Atlantic Ocean (Donostia/San Sebastián)

4.1 Introduction

The Donostia/San Sebastián region at the Atlantic coast can be characterised by relative high economic growth, where tourism plays an important role. The region welcomes visitors but aims to avoid the development of mass tourism. The fishing sector is declining and the development of aquaculture is limited, due to waves and currents. The population is slightly growing and progressively ageing. Further information regarding the characteristics of the Donostia/San Sebastián region at the Atlantic coast can be found in Figure 4.1.

The interactive workshop was held on June 6th, 2019 at the Sea Aquarium in San Sebastián (Spain) during the AZTI Summer School. Participants discussed what they consider relevant issues when it comes to ocean and human health. The answers focussed on various forms of pollution (from marine litter, to anti-biotic resistant bacteria, to plastic waste on the shore, to harmful algae blooms and oil spills), but also it was stated that this sea basin is clean compared to the Mediterranean Sea. The theme of tourism/coastal living was considered by the participants as a big asset, but concerns exist on the unawareness of the health risks of swimming and surfing among people, the access of the coast for all (rich and poor) and changing currents in San Sebastián. Only few participants mentioned the theme of food related items, such as aquaculture and the connection between seafood and litter. Finally, some noted that there is a lack of communication between countries sharing an ocean (e.g. USA and Europe) and there is a lack of knowledge on the link between oceans and human health. Also, relevant education is missing, but integrated planning is underway. A summary of these issues is presented in Table 4.1.

Table 4.1 *Workshop participants views on current issues related to ‘Ocean and human health’ for the Atlantic Ocean with a specific focus on the Donostia/San Sebastián case study area.*

	Atlantic Ocean
Food	<ul style="list-style-type: none"> • Litter: seafood • Fishing source • Aquaculture closest link to human health
Pollution	<ul style="list-style-type: none"> • Marine litter • River: high discharge • Coastal infrastructure under threat from extreme events • Metal pollution of water by industry • Big difference between countries & estuaries in terms of water quality • Clean environment compared to Mediterranean • Antibiotic resistant bacteria • Plastic washes up on shore • Worries about pollution, overflow, litter • Harmful algal blooms • Quite clean, not really a focus on human health, only animal health - more information on effects of pollution on health is missing • Oil spills (no information on human health impacts)
Tourism and coastal living	<ul style="list-style-type: none"> • Social benefits • Sea food, oil industry, cruise ships (tourism generally) • Tourism (small) • Exposed shore, no foam, but plastic (some plastic coming from Canada) • People swim no matter the circumstances. Discourage this behavior through awareness about the health risks • Ocean: big asset for tourism (coastal paths) • Alert system for surfers on water quality, access not for all • Not everybody has access to the beach even if close to it. Big difference between rich-poor in rural area • Warnings: make warnings inclusive for different groups and empower people on what they can do in terms of safe behavior. • Growth in triathlon popularity raises health concerns (water quality) • Ocean visits as medication (social prescribing) • Quality control seawater beaches (tourism) • Changing currents endangers safe bathing (San Sebastián) • Individual point of view neglected
Other	<ul style="list-style-type: none"> • No link between ocean and human health, need to share knowledge, do more for human health • Changing currents (San Sebastián), climate change • Lack of communication between countries sharing ‘some ocean’ (e.g. US & Europe) • Missing: education • We see the sea every day, integrated planning underway • Incentives, action also for health animals not only human

Atlantic Ocean, profile Donostia/San Sebastián



Figure 4.1 Background material on the Donostia/San Sebastián case study area using the DESTEP-categorization to identify relevant information.

4.2 Identification of relevant or uncertain trends for ocean and human health

The Donostia/San Sebastián area with its current issues was taken as the starting point for the identification of relevant and uncertain trends for this region regarding ocean and human health. From a collection of 35 possible relevant trends (see Appendix I), workshop participants individually selected their five most relevant trends and consequently their five most uncertain trends. The aggregated results have been summarized in Table 4.2 and 4.3.

Among the highest ranked trends were a further loss of biodiversity and other ecological impacts (1), the development of a circular economy (2), transitions in healthcare and energy supply (3) and an increasing use of blue spaces for recreation (4).

A further loss of biodiversity and other ecological impacts and the development of a circular economy both relate to the effects of pollution, whereas the development of a circular economy might be a driving force for water quality improvement. Transitions in healthcare and the increasing use of blue spaces for recreation relate to the dimension of human health and well-being, although these trends could affect water quality as well.

Changes in consumer food preferences (1), changing institutional and governance structures (2) and further loss of biodiversity and other ecological impacts (3) came forward as most uncertain trends with a potentially high impact.

During the discussion, food preferences were identified as part of the cultural heritage. The discussion highlighted that preferences may be perceived and appreciated very differently throughout different basins. For the Donostia/San Sebastián area the availability of sea food is very important.

In addition, the workshop participants came forward with several other potential relevant trends:

- The increase of invasive (different) species related to climate change;
- The current change in Atlantic Ocean, a temperature rise of 2 °C, a major consequence of climate change;
- Local sea level rise;
- Enforcement of rules and regulations: how good/easy is it with multiple countries/continents at the table?

Table 4.2 Trends identified during the workshop as most relevant for the Atlantic Ocean with a specific focus on the Donostia/San Sebastián case study area.

Trend	Description
Further loss of biodiversity and other ecological impacts	The ecological impacts due to human activities (loss of biodiversity, pollution, depletion of natural resources) will increase. <i>Plastics, oil, chemical substances</i>
Towards a circular economy	Strong development towards a circular economy, with less use of fossil fuels and replacement by renewables. <i>The development of newer, less-harmful chemicals and substances</i>
Healthcare transition	Increasing costs and cost-management of healthcare, as well as alternative methods of financing & management systems.
Energy transition	Development of new energy sources: tidal, wave, blue, solar & wind energy generation
More recreational use of blue spaces	Recreational use of blue spaces will increase, under influence of tourism and popularity of water-related activities in coastal areas.
Changes in income distribution	Income inequality is expected to rise further. <i>Income inequalities can cause health and social problems</i>

Table 4.3 Trends identified during the workshop as *most uncertain* for the Atlantic Ocean with a specific focus on the Donostia/San Sebastián case study area.

Trend	Description
Consumer food preference	Changes in the preferences of consumers for alternative sources of food, such as seaweed, algae, jellyfish, insects and initiatives like Food from Food
Changing institutional and governance structures	Decision-making is moving from government to multi-actor governance, including involvement of citizens. This trend differs from country to country
Further loss of biodiversity and other ecological impacts	The ecological impacts due to human activities (loss of biodiversity, pollution, depletion of natural resources) will increase. <i>Plastics, oil, chemical substances</i>
Migration	Continued growth around international migration into European countries, driven by conflicts, climate change and/or economic motivation.
Technology in Industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. Furthermore, emission reduction technology as well as new substances being used.

4.3 Impacts of trends

For the trends identified as relevant, workshop participants discussed the potential impact of five of these trends on ocean and human health. The *increase of recreational use of blue spaces* for instance, may contribute to an improved mental and physical health for all, but also requires management of litter, pollution (noise, air, water), has impacts on local infrastructure and may be a threat to benthic communities and biodiversity. The trend *towards a circular economy* may have a positive effect on water quality due to renewable energy, less waste and the increased lifetime of goods but it needs bigger projects to realise change. It takes time to change current systems and habits and awareness for unintended impacts is needed (e.g. effects of substitutes for plastics).

The changing governance structures may lead to a situation where the public is setting the policy agenda more and more: money for funding may follow public hypes, politicians 'jumping' to media opinions and scientists having little incentives to do dissemination. *An increasingly aging population* is expected to result in an increase in medicine usage and thus an increase in the medicine load of sea basins. This will affect water quality, ecosystem and seafood.

The introduction of *more healthy living in national policies and strategies* may lead to an increased use of blue spaces for recreation, potentially impacting biodiversity if not well managed. Balancing economic interests that strongly depend on tourism and the capacity of the ecosystem to deal with tourism sustainably requires active adaptive management of such plans.

An overview of the discussion has been presented in Table 4.4.

Table 4.4 *Impacts and research gaps for the most relevant trends identified during the workshop for the Atlantic Ocean with a specific focus on the Donostia/San Sebastián case study area.*

Trend	Impacts	Research gaps
More recreational use of blue space	<p><i>Health impact:</i> If conditions for access and water quality have been met, improved mental and physical health;</p> <p><i>Pressure on biodiversity:</i> Impact on benthic communities;</p> <p><i>Pollution:</i> Increase of noise; air pollution;</p> <p><i>Economy:</i> More jobs.</p>	<p><i>Behavior/education:</i> Research on behavior in recreational areas, on behavior change ('cleaner' habits), education for people not living by the sea; awareness of recreational use, perception of associated risks;</p> <p><i>Management:</i> How to implement approaches with multiple objectives; integrative and sustainable use of blue spaces (e.g. for all ages, restore and preserve biodiversity); include recreation in marine spatial planning;</p> <p><i>Capacity:</i> Assessment of sustainable recreation capacity;</p> <p><i>Relationships:</i> Research on negative relationship between recreation and environment; how risk threats will impact humans; how increase use will impact ecosystems; link human health and recreation; recovery of degraded systems and recreation recovery.</p>
Towards a circular economy	<p><i>Economy:</i> Market uncertainty, loss of jobs; cost of life might increase (inequalities)</p> <p><i>Inclusion:</i> All people (also ageing, sick, disabled, refugees); making knowledge about circularity more accessible for people living in the area (opportunities, threats of waste);</p> <p><i>Improvement:</i> Bigger projects are necessary; renewable energy, less waste; increase the life of goods (reduce impacts);</p> <p><i>Change:</i> New methods/technologies are needed; time it takes to change the current system/habits; unintended impacts; is it possible to replace all plastic uses.</p>	<p><i>Relationships:</i> Research on new impacts from circular economy; does it work (not clear what it is); effect on social inequalities (associated with full-cost accounting); unknown impacts from renewable energy infrastructures (e.g. windmills); what is the impact of changes in infrastructure/circular economy on people and environment;</p> <p><i>Implementation:</i> Research on implementation methods; implementation, motivation and incentives; how can you raise acceptance and support for circular economy; integrate economists, business related to the sea, marine scientists to work together in the design of the circular economy.</p>
Changing governance structures	<p><i>Public driving the agenda:</i> Money for funding following public hype; politicians 'jumping'; scientists not incentivised to do dissemination (except some EU grants)</p>	<p><i>Behaviour/education:</i> Raising awareness for all (not only children); ocean literacy (telling the 'right' story – interpretation, negotiation); engagement; how to make actions happen.</p>
Increasingly aging population	<p>Increase in medicine usage = increase in load in sea basins: affects water quality and seafood etc.</p>	<p><i>Behaviour/education:</i> Information; communication;</p> <p><i>Relationships:</i> Cumulative effects: what makes seafood more healthy and sustainable.</p>
More healthy living in national policies and strategies	<p><i>Biodiversity:</i> risk of pressure on biodiversity</p> <p><i>Economy:</i> e.g. overcrowding due to tourism (vulnerability of economies depending too much on tourism only, especially since it is mostly seasonal labour/younger people)</p>	<p><i>Implementation:</i> Multi-topic platforms; real time monitoring; need for blue growth agenda;</p> <p><i>Relationships:</i> Cumulative effects of different policies.</p>

4.4 Research gaps

The impacts identified for the relevant trends presented in Table 4.4 encompass a high level of uncertainty. Some of these uncertainties may be addressed by research. Table 4.4 presents the research gaps identified for the relevant trends and their impacts.

Research gaps for instance, were identified for:

- *Behavioural change*: how to achieve ‘cleaner’ habits with less litter, more awareness of risks and adequate (safe) behaviour, especially for people who do not live by the sea. Current examples regarding awareness raising are Surfers against Sewage (UK) (<https://www.sas.org.uk/>), Plogging (Sweden) (<https://www.euronews.com/living/2019/03/04/plogging-sweden-s-new-eco-sport>), Ellen McArthur Foundation (<https://www.ellenmacarthurfoundation.org/our-work/activities/new-plastics-economy>).
- *Integrative implementation strategies*: the development and management of blue spaces may have co-benefits for multiple sectors, e.g. climate resilience, economic development (tourism), health, food production. A research gap was identified regarding the development and use of cross-sectoral implementation strategies. Examples for instance, can be found at: Jan Gehl Institute (<https://gehlpeople.com/>), BlueHealth infrastructures (<https://bluehealth2020.eu/projects/beat/>).
- *Inclusiveness in the use of blue spaces*: blue spaces should be attractive for all ages, gender and social-cultural backgrounds. Research on what drives people to use blue spaces and what do they need (information, design of a space, facilities, accessibility etc.) could provide valuable information to achieve this. Results from recent surveys in both the H2020 BlueHealth project (<https://bluehealth2020.eu/projects/bluehealth-survey/>) and the Sophie project (<https://sophie2020.eu/activities/sophie-survey/>), could be used to explore these needs.
- *Assessment of the sustainable recreation capacity*: as ecosystems have a limited capacity to deal with people, this capacity should be assessed in order to develop an indicator for sustainable recreation. This would support local policy makers in their pursuit of a sustainable management of their coasts and sea. In another part of the H2020 project, building blocks have been collected for this (<https://sophie2020.eu/resources/tourism-training/>).

4.5 Summary of research gaps and quotes

During the workshops, participants identified research gaps that have been used as input for the Sophie Strategic Research Agenda. Textbox 4.1 shows summaries of the results of these discussions on the theme ‘Food from the ocean’ focusing on the Atlantic Ocean. Textbox 4.2 and 4.3 show summaries for the research gaps identified for ‘Blue spaces, tourism and well-being’ and ‘Marine biotechnology and medicine’ respectively.

Textbox 4.1 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Atlantic Ocean** (San Sebastián - Donostia case study area). Some noted relevant research gaps and quotes about ‘**Food from the ocean**’.*

Research gaps

- ✚ Cumulative effects research: what makes seafood more healthy and sustainable.
- ✚ Research on negative relationship between recreation and environment; how risk threats will impact humans; how increase use will impact ecosystems; link human health and recreation; recovery of degraded systems and recreation recovery.
- ✚ Behavior/education: raising awareness for all (not only children); ocean literacy (telling the ‘right’ story – interpretation, negotiation); engagement; how to make actions happen.
- ✚ Overcrowding due to tourism, pressure on biodiversity: implementation: multi-topic platforms, real-time monitoring, cumulative effects.

Quotes

- ✚ “Ocean food is part of our cultural heritage”

Textbox 4.2 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Atlantic Ocean** (San Sebastián - Donostia case study area). Some noted relevant research gaps and quotes about ‘**Blue spaces, tourism and well-being**’.*

Research gaps

- ✚ Research on behavior in recreational areas, on behavior change (‘cleaner’ habits), education for people not living by the sea; awareness of recreational use, perception of associated risks.
- ✚ Management: How to implement integrative use of blue spaces (e.g. for all ages); include recreation in marine spatial planning.
- ✚ Capacity: assessment of sustainable recreation capacity.
- ✚ Relationships: research on negative relationship between recreation and environment; how risk threats will impact humans; how increase use will impact ecosystems; link human health and recreation; recovery of degraded systems and recreation recovery.

Quotes

- ✚ “Only things that can be measured get focus now”

Textbox 4.3 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Atlantic Ocean** (San Sebastián – Donostia case study area). Some noted relevant research gaps and quotes about ‘**Marine biotechnology and medicine**’.*

Research gaps

- ✚ Research on new impacts from circular economy; does it work (not clear what it is); effect on social inequalities (associated with full-cost accounting); unknown impacts from renewable energy infrastructures (e.g. windmills); what is the impact of changes in infrastructure/circular economy on people and environment.
- ✚ Research on implementation methods; implementation, motivation and incentives; how can you raise acceptance and support for circular economy; integrate economists, business related to the sea, marine scientists to work together in the design of the circular economy.

5. Baltic Sea (Helsinki)

5.1 Introduction

The connection with the sea is visible everywhere in Helsinki. Ferries depart from the harbour; cruise ships arrive bursting with tourists; fishing boats land and sell their catch; all restaurants serve fish and, even on grey and cold days, people swim in the harbour pool. The peninsula nature of the coastline creates an extensive recreational space alongside the water and many people have a second house near the sea.

The Helsinki region situated adjacent to the Baltic Sea can be characterised by a strong connection to the sea. It has a growing population with a relatively high GDP earned mainly in the services sector. The digital connectivity in economy and society is high and focus on technological developments to improve sustainability is apparent (e.g. Smart City, Climate-proof city). The society can be further characterised by a high level of social cohesion and relatively equal income distribution. Employment in the fishing sector is declining and the development of off shore fish farming is challenging due to severe winter conditions with sea-ice and formation of high waves during melting. Further information regarding the characteristics of the Helsinki region at the Baltic Sea can be found in Figure 5.1.

Through cooperation between the Dutch National Institute of Health and the Environment (RIVM), the Finnish Environmental Institute (SYKE) and experts from the Bonus project on Blue Health and Wealth from the Baltic sea, a diverse group of stakeholders representing various disciplines: geology, marine ecology, life science, law, environmental economics, ecosystem services and marine biogeology explored the relationship between the sea and public health in the Baltic Sea on 9th of October 2019 in Helsinki (Finland).

From the perspective of these stakeholders, the Baltic Sea area provides:

- an important place for recreation,
- inhabitants who are well-informed about the water quality,
- with increasing information on health benefits of marine aerosols,
- a more positive situation regarding eutrophication, dioxins and climate change than is believed by most people.

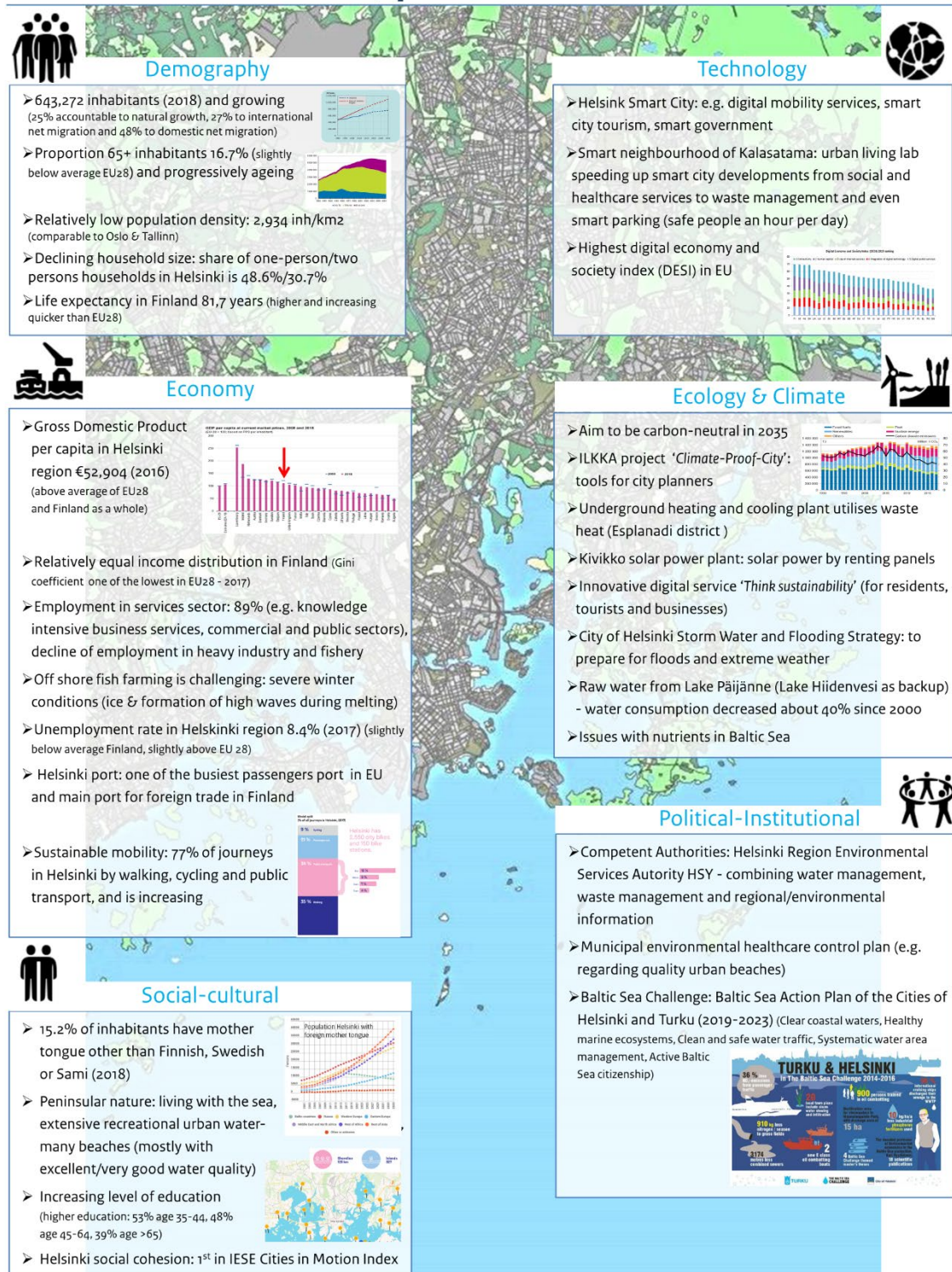
But stakeholders also have concerns about water quality as a combined risk from pharmaceuticals in wastewater, wastewater effluent discharges, agricultural runoff and pollution from intensive ship traffic in the Baltic Sea. For example chemicals like dioxins can end up in fish; nutrient levels and coastal eutrophication are increasing and toxic algae blooms prevent people from swimming in summer.

In addition, there is some concern over governments lacking focus on negative environmental health and well-being effects on the Baltic Sea and the lack of legal means to act on cross-border and cross-sectoral issues. It was also noted that more knowledge is needed on values and culture and their relationship with health and well-being, e.g. with regard to the effects of sea-ice decrease. The Finnish situation is not fully representative of the Baltic Sea, as governments of countries around this sea basin have a very different attitude and approach towards ocean and human health. A summary of these issues is presented in Table 5.1.

Table 5.1 *Workshop participants views on current issues related to ‘Ocean and human health’ for the Baltic Sea with a specific focus on the Helsinki case study area.*

	Baltic Sea
Food	<ul style="list-style-type: none"> • A lot of people go fishing. Previously there were worries about dioxins etc. in the fish before eating them, but not anymore.
Pollution	<ul style="list-style-type: none"> • Mismatch spatial planning and regional legal framework • Chemicals in fish • Interaction of various drugs in waste water • Pollution, algal blooms affecting health • Wastewater treatment, microbial study • Wastewater system, agricultural runoff
Tourism and coastal living	<ul style="list-style-type: none"> • Sea is important for recreation (many second homes by the sea), but people don’t swim during algae toxic blooms and are concerned about flooding and intensive traffic (e.g. cruise ships) causing oil and waste pollution • Limitations of the EU Bathing Water Directive (2006/7/EC)
Water composition	<ul style="list-style-type: none"> • No space for additional aquacultures, because of present nutrient level • (Coastal) Eutrophication • Eutrophication, dioxygen, climate change – not perfect, but better than what people believe

Baltic Sea, profile Helsinki



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Judith Hilt, Marië de Vries, Liesbeth Dirven, Fabio Maurits Gueth, Henk Hilderink & Susanne Wuijts

Seas, Oceans & Public
Health in Europe

European Centre for Public Health
and the Environment
Institute of Health, Environment & Society

Figure 5.1 Background material on the Helsinki case study area using the DESTEP-categorization to identify relevant information.

5.2 Identification of relevant or uncertain trends for ocean and human health

The current issues identified for ocean and human health and well-being in the Baltic Sea region were used as starting point to identify the most relevant and most uncertain trends in Helsinki regarding ocean and human health. From a compilation of 35 possible trends in the categories of demography, economy, social-cultural, technology, ecology-climate, and political-institutional (see Appendix I) the individual stakeholders in the workshop prioritized the five most relevant and the five most uncertain trends. The overlap between both lists of most relevant and most uncertain trends was limited, implying that future research should cover a broad range of subjects. The aggregated results have been summarized in Table 5.2 and 5.3.

Climate change (1) was identified by an overwhelming majority of the stakeholders as most relevant trend affecting human health and well-being. Its diverse impact on ecology was a major concern, but also its effect on governance and economy of in the Baltic Sea region and with changes it might trigger regarding social-cultural factors.

Other relevant trends regarding Baltic Sea and human health, were energy transition (2); and changing institutional and governance structures; technology in industry and further loss of biodiversity and other ecological impacts (shared 3). Although perceived relevant, there was less unanimity on these issues.

Migration (1); consumer food preference (2); more global agenda setting (3); and digitalisation of society (4) came forward as most uncertain trends with a potentially high impact.

Especially the identification of digitalisation of society as an uncertain trend was questioned, given the fact that society is increasingly digitalised. Participants explained that not the extent to which society is digitalised is uncertain, but the consequences of digitalisation are far from fully understood and therefore create an uncertain trend for the future regarding blue health. The consumer food preference was identified as uncertain because the deterioration of water quality in the Baltic Sea threatens the traditional sea food diet of the population in Helsinki, to which they are very attached.

Table 5.2 Trends identified during the workshop as most relevant for Baltic Sea with a specific focus on the Helsinki case study area.

Trend	Description
Climate change	Climate change will further lead to more weather extremes (storms), higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water.
Energy transition	Development of new energy sources: tidal, wave, blue, solar & wind energy generation
Changing institutional and governance structures	Decision-making is moving from government to multi-actor governance, including involvement of citizens. This trend differs from country to country
Technology in Industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. Furthermore, emission reduction technology as well as new substances being used.
Further loss of biodiversity and other ecological impacts	The ecological impacts due to human activities (loss of biodiversity, pollution, depletion of natural resources) will increase. <i>Plastics, oil, chemical substances</i>

Table 5.3 Trends identified during the workshop as *most uncertain* for the Baltic Sea with a specific focus on the Helsinki case study area.

Trend	Description
Migration	Continued growth around international migration into European countries, driven by conflicts, climate change and/or economic motivation.
Consumer food preference	Changes in the preferences of consumers for alternative sources of food, such as seaweed, algae, jellyfish, insects and initiatives like Food from Food
More global agenda setting	Global governance and agenda setting are becoming wider-more spread phenomena integrating multiple policy domains, e.g. UN SDGs.
Digitalisation of society	Emergence of big data and new technologies, such as artificial intelligence, internet-of-things (IoT), autonomous vehicles, 3D printing, and nanotechnology.

5.3 Impacts of trends

The stakeholders discussed on the potential impact of the top five relevant trends for ocean and human health.

The stakeholders discussed the impact of *climate change* mainly related to ecology. Climate change could lead to increased storminess and precipitation, in turn accelerating erosion and nutrient transport from land; to rising sea temperatures, reducing biomass of fish and changes in species diversity; to increases in marine toxins and blue algae; and to higher risk of flooding, broadly altering ecosystem functioning.

Governance issues resulting from climate change focused on the response to the rapid and unpredictable increases in both sea level and flooding, as well as the paralyzing ‘lost cause’ effect of negative ecological outcomes. Concern was also raised about the different attitudes towards environmental change in countries surrounding the Baltic Sea, and how this might complicate a coordinated and consistent response – particularly as some countries do not have a history of stable, peaceful societies.

Rising sea levels raised economic concerns related to climate change, this time due to the salinization of groundwater and having an impact on food and drinking water production. The effect of algae blooms and an increasing push for marine renewables were also noted as economic pressures to prepare for.

The social, cultural and health impacts of climate change raised discussions on the potential for harmful algae in making beaches unsafe, and how the loss of homes and land may cause significant psychological trauma. Research gaps were also identified, as well as the need for more interdisciplinary approaches that cover the complexity associated with global warming.

The *energy transition* was seen as having both positive and negative ecological effects. While new infrastructures will reduce greenhouse gas production and better air quality, at the same time it may disturb marine and terrestrial wildlife, like migrant fish being unable to swim up the rivers due to water power plants. Furthermore, energy transition might lead to competition and potential conflicts over the use of space, e.g. with windfarms at sea taking space from shipping and fishing. But it might also result in more jobs and energy security.

New industrial technology may lead to reduced emissions and improve (cleaner) fish production, but there is concern about the unknown impacts from nanotechnology producing nanofibers and utilization of mineral aggregates of ferromanganese concretions (sea floor mining) for high tech metals such as cobalt, gallium and lanthanum.

Loss in biodiversity might lead to changes in the ecosystem functioning, loss of species which could result in gaps taken over by invasive species.

An overview of the discussion has been presented in Table 5.4.

Table 5.4 Impacts and research gaps for the most relevant trends identified during the workshop for the Baltic Sea with a specific focus on the Helsinki case study area.

Trend	Impact	Research gaps
Climate change, incl. loss of biodiversity	<p><i>Ecological:</i> threat to biodiversity with local extinctions due to propagation of non-indigenous species, range shift, cyanobacteria causing marine toxins, increased sea temperature leading to higher primary production, reduced biomass of fish and seafloor oxygen deficiency, increase storminess and precipitation leading to erosion and eutrophication; acidification, change in hydrological cycle, loss of sea ice leading to change in timing algae spring bloom, salinity change.</p> <p><i>Governance:</i> higher stress/uncertainty and demand on water resources, such a higher run off, for cooling and other uses; prolonged and high summer heats in countries; paralyzing effect 'lost cause'; sea level rise leading to flooding incidents</p> <p><i>Social-cultural:</i> diet/food system impacts on humans and animals; filamentous algae leading to bad beaches; rising seas leading to loss of home/land causing depression and social disruption</p> <p><i>Economic:</i> push for marine renewables; algae blooms affecting across industries and sectors; rising sea levels leading to water infiltration of seawater into groundwater impacting food/drinking water production</p>	<p><i>Ecosystem:</i> Understanding the multiple drivers (associated with climate change) affect ecosystem functioning; research on species resilience, species mitigation and predictive modelling of alien species invasion (and effectiveness and costs of preventive measures); research on changes in ocean streams: effects of salt water streams from the Atlantic; research on specific groundwater-seawater interaction in the Baltic Sea</p> <p><i>Interdisciplinary approaches:</i> ecosystems-sociological, water quality-human health, plant/animal health-human health, invasive species-health, human activities-biodiversity-health</p> <p><i>Governance:</i> novelties in food web structure, reconciliation of climate change mitigation with other policies, research on potential changes of water demand, sea resources and ecosystem services due to climate change; coastal city protection against hazardous weather events and sea level rise; knowledge development on how to govern anticipated rapid and unpredictable changes in countries used to stable, peaceful societal systems together with countries that are less used to stable peaceful societal systems</p> <p><i>Health:</i> research on loss of microbiological biodiversity on the immune system; research on impact of biodiversity on physical health of people</p>
Energy transition	<p><i>Ecological:</i> infrastructure at sea with effect on marine and terrestrial wildlife, e.g. migrant fish unable to swim up the rivers due to water power, wind mills affecting animals</p> <p><i>Economic:</i> more 'competition' and potential conflicts: e.g. windfarms will take space from shipping and fishing; recreation values versus coastal windmills; increased energy security; changing job market</p> <p><i>Society:</i> changes in landscape (values), political unrest, rural-urban inequality</p>	<p><i>Society:</i> research on impacts of new technologies on humans; research on trade-off between ecosystem services, incl. culture and health</p> <p><i>Ecology:</i> research on impact of windfarms on local ecosystems (e.g. currents); research on effects of shift from air to sea transportation</p> <p><i>Governance:</i> need for cross-sectoral policy instruments linking global & local levels; development of legal framework for multi-use including uncertain ecological impacts;</p>

Trend	Impact	Research gaps
Technology in industry	<p><i>Ecological:</i> impact of new chemicals, nano-technology; utilization of sea floor mining for high tech metals; cleaner oceans due to reduced emissions, cleaner fish production, improved waste technology</p> <p>Health: resource savings leading to more resources to benefit health</p>	<p><i>Ecological:</i> research on emissions and impact of nano-technology (e.g. bioaccumulation?); research on ecological impact of sea mining (e.g. effect on ecosystem services like carbon capture)</p> <p><i>Society:</i> research on changing job market; implementing legislation on sea floor mining; research on governance of new technology as acceptance procedures are slow and careful, while socio-ecosystem change rapidly</p>

5.4 Research gaps

The impacts identified for the relevant trends encompass opportunities and threats, which can be further clarified and weighed by additional research. Table 5.4 also presents the research gaps in regard to these relevant trends.








Research gaps, for instance, were identified for:

- *The use of interdisciplinary approaches* as multiple drivers associated with climate change affect ecosystem functioning, but less is known about the way they interrelate, how they impact health and well-being and what could be societal consequences or co-benefits; e.g. changes in sea temperature causing invasive species; sea level rise affecting coastal groundwater reserves; impact from increasing salt streams from the Atlantic Ocean with change in ocean streams. A current example of such interdisciplinary research is the Bonus Rosemarie participatory systematic review for smart decisions on blue health and wealth from the Baltic Sea (<https://www.era-learn.eu/network-information/networks/bonus-169/bonus-call-2017-synthesis/blue-health-and-wealth-from-the-baltic-sea-2013-a-participatory-systematic-review-for-smart-decisions>).
- *How to realise effective cooperation between states with different historical backgrounds and political systems* to anticipate together on the rapid and unpredictable effects of climate change in the Baltic Sea. Not all Baltic all states are used to stable peaceful societal systems and, therefore, have a different valuation of top-down or bottom-up approaches and implementation strategies. Examples of projects aiming at possible win-win scenarios for states around a sea basin are the Baltic State Challenge, for a clean, productive and shared Baltic Sea (<http://www.itamerihaaste.net/en>) and the Baltic Sea Action Plan for reaching good environmental status for the Baltic Sea (<https://helcom.fi/baltic-sea-action-plan/>).
- *Impact of new technologies* on ocean and human health in the Baltic Sea. This is especially relevant as formal procedures to implement new technologies are slow and careful, while social-economic systems and technology develop rapidly. More research is needed, for instance, on the emissions of new uses of nano-technology and possible bioaccumulation it might cause and on the impact of mining for aggregates on the biodiversity but also on how to govern and balance long term preservation goals and short term economic and technological developments.


5.5 Summary of research gaps and quotes

During the workshops, participants identified research gaps that have been used as input for the Sophie Strategic Research Agenda. Textbox 5.1 shows summaries of the results of these discussions on the theme 'food from the ocean'. Textbox 5.2 and 5.3 show summaries for the research gaps identified for 'Blue spaces, tourism and well-being' and 'Marine biotechnology and medicine' respectively.

Textbox 5.1 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Baltic Sea** (Helsinki case study area). Some noted relevant research gaps and quotes about ‘Food from the ocean’.*






-  Biodiversity loss:
 - Predictive modelling of how human activities causes biodiversity loss and how that feeds back to human activeness (and health) and of alien species invasion and effectiveness and costs of the preventive measures,
 - Possible health impact of invasive species,
 - Novelty in food web structure,
 - Impact on biodiversity from seafloor mining for aggregates and its impact on the ecosystem services provided? (like carbon capture).
-  Development of interdisciplinary, system based, approaches (ecosystems-sociological, water quality-human health, plant/animal health-human health, invasive species-health) to preserve ocean and human health in the Baltic Sea.
-  Changes due to climate change: ocean streams (effect of salt water streams from the Atlantic), impact of sea level rise on the quality of coastal groundwater reserves (interaction groundwater-seawater in the Baltic Sea).
-  Cross-sectoral policy development: How to reconcile climate change mitigation and adaptation with other policies; how to set legal requirements for uncertain ecological impacts; how to use/divide the space?
-  How to govern anticipated rapid & unpredictable changes in countries used to stable, peaceful societal systems together with countries that are less used to stable peaceful societal systems (Baltic states and Russia).
-  Energy transition: impacts on local ecosystems/human health and the evaluation of trade-offs of qualitative ecosystem services (e.g. air quality versus cultural services); effects and legal requirements for combining different species in windmill building (e.g. mussels for mitigation of water quality); impact of shift from air to sea transportation.
-  New uses of nano-technologies: what new emissions & potential impacts do they have? Bioaccumulation? Where does it go?

Quotes


-  “Governments of countries around the Baltic Sea have a very different attitude and approach towards oceans and human health”.

Textbox 5.2 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Baltic Sea** (Helsinki case study area). Some noted relevant research gaps and quotes about ‘Blue spaces, tourism and well-being’.*

Research gaps



-  Health effect of increase of temperature and connection to the sea
-  Impacts of climate change at local scales.
-  Coastal city protection against hazardous weather events and sea level rise
-  Impacts of new technologies on humans, communities.
-  Formal acceptance procedures to new technologies are slow and careful. At the same time, socio-eco systems change rapidly, making predictions on future impacts even more difficult. Impacts on permitting new technologies?

Quotes

-  “Many second homes by the sea, recreation is important”.

*Textbox 5.3 Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Baltic Sea** (Helsinki case study area). Some noted relevant research gaps about ‘**Marine biotechnology and medicine**’.*

Research gaps

-  Loss of microbiological biodiversity in people? What is the impact on the immune system functioning: several diseases?
-  How does biodiversity impact the physical health of people?

6. Mediterranean Sea (Málaga)

6.1 Introduction

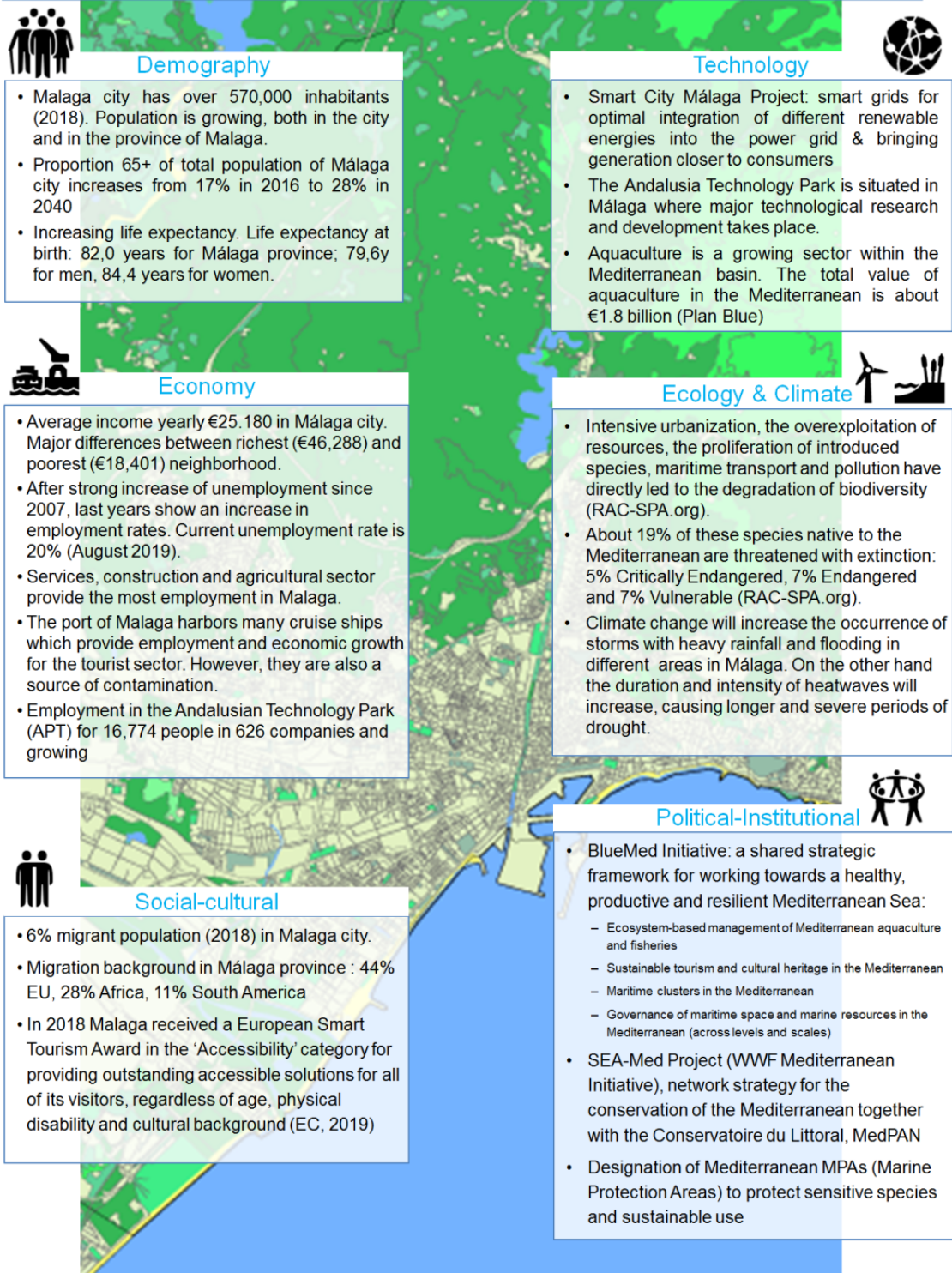
The Málaga area situated on the western part of the Mediterranean Sea is renowned for its tourism. In 2018, Málaga received the European Smart Tourism Award in the ‘accessibility’ category for its outstanding accessible solutions for all of its visitors regardless of age, physical ability and cultural background. With the tourism sector being a driving force of the economy, the port of Málaga provides not only an entry point for tourism but also other goods to the region as well as being a source of employment. Other aspects influencing the livelihood in Málaga are the aging population, the intensive urbanization, the overexploitation of natural resources, the proliferation of introduced species, maritime transport and pollution. Further information regarding these characteristics of the Málaga region at the Mediterranean Sea can be found in Figure 6.1.

During a side event at the PANACeA conference regarding “Ecosystem-Based Adaptation: A pulse for transformative changes in the Mediterranean Sea” on October 14th 2019 in Málaga (Spain), an interactive workshop was organised to gather input and explore the relationship between human health and the sea in the Mediterranean sea basin, with special focus on the Málaga case study area. This workshop aimed to collect input for the Strategic Research Agenda for the SOPHIE project. A group of twelve stakeholders concerning the Mediterranean Sea participated in the workshop, representing various countries and disciplines (marine ecology, economy, environmental policy and management, coastal management and planning and marine biology). During the workshop the participants discussed the what they considered relevant issues related to ocean and human health in the Mediterranean. Concerning the Mediterranean Sea, the answers focussed on various themes from food & pollution of the basin (illegal fishery, sustainable use of resources, contamination of sea life), to maritime spatial planning and the social-economic imbalance of the countries around the Mediterranean. A summary of these issues has been presented in Table 6.1.

Table 6.1 *Workshop participants' views on current issues related to Ocean and human health for the Mediterranean Sea with a specific focus on Málaga case study area.*

	Mediterranean Sea
Food	<ul style="list-style-type: none"> • Marine pollution by pesticides • Missing information: How are marine organisms affected by pharmacology? • Illegal fisheries in Montenegro • Maritime spatial planning: to take into account a sustainable way of using resources. Balance between the consumption and needs
Pollution	<ul style="list-style-type: none"> • Marine pollution by untreated waste water from sewage • Biodiversity loss • Known cases of toxification of marine species • Increased knowledge on entanglements of marine mammals and turtles as a consequence of plastic pollution • Effect of pollutants on algae and biodiversity in fresh water and marine ecosystems including pesticides (nutrients) and litter, especially plastics • Global threats and local threats create a dark future (climate change—> marine species?, overexploitation, pollution, plastics) • Marine litter project in Libya: Climate change & single use plastics • Israel: at the moment there are few projects trying to reduce marine litter (clean beach measurement) that gives an incentive to municipalities (municipalities or citizens?!) to act • South of Spain and South Italy don't care much about a healthy water system, but it is improving (e.g. marine litter is seeable, people are starting to care. Issue with what is not seen, e.g. chemicals) • In France marine litter and pollution are viewed as two of the main problems of the Mediterranean Sea • Is there a direct link between marine litter and human health? • Ecotoxicological studies on marine litter impacts on biodiversity, including humans are needed
Tourism and coastal living	<ul style="list-style-type: none"> • Overexploitation of coastal waters • Lot of pressure on space at the coast line • South of Spain and South Italy don't care much about a healthy water system, but it is improving. E.g. marine litter is seeable, people are starting to care. Issue is with what is not seen, e.g. chemicals • The public not informed about risks and consequences of poor water quality • Biodiversity is degrading due to increase of economic development and tourism, especially at local level • Bad management of waste water, unadjusted infrastructure in peak season • Energy production
Other	<ul style="list-style-type: none"> • Geopolitical crisis in part of the Mediterranean basin • Socio-economic unbalance within the region • In France migration is viewed as one of the main problems of the Med Sea • Lack of awareness of the link between marine health and human health • Governance: Lack of land-sea coordinated management • Imbalance between OSPAR HELCOM and Mediterranean (Barcelona convention) regarding the presence of EU countries • Considering EU countries: Water Framework Directive implementation —> good situation BUT need to focus on new contaminants (e.g. PFAS) • Climate change and increase of temperature • Knowledge: We should identify families of problems: national (EU) and regional

Mediterranean Sea, profile Malaga



27-09-2019 SOPHIE
Judith Hin, Marië de Vries, Liesbeth Dirven, Fabio Maurits Guelth, Henk Hilderink & Susanne Wuijts

Seas, Oceans & Public
Health in Europe

National Institute for Public Health
and the Environment
Rijksinstituut voor Volksgezondheid
en Milieu (RIVM)

Figure 6.2 Background material on the Málaga case study area using the DESTEP-categorization to identify relevant information.

6.2 Identification of relevant or uncertain trends for ocean and human health

From the Mediterranean Sea with its current issues, the Málaga area was taken as the starting point for the identification of trends that could be relevant or uncertain for the region regarding ocean and human health. From a collection of 35 possible relevant trends, workshop participants selected their five most relevant trends and consequently their five most uncertain trends. The most relevant and the most uncertain trends do not necessarily coincide. The results have been presented in Tables 6.2 and 6.3.

The most relevant trends identified were climate change (1), loss of biodiversity (2), increase of aquaculture (3) and an increase in individualisation (4). The climate change and loss of biodiversity both relate to the anthropogenic effect, whereas increasing aquaculture aims to use technology to its benefits and improve and reduce the impact on local environment. As for the increasing individualisation, the increasing social inequalities may hinder the access to blue spaces for recreation which in turn could lead to adverse health effects.

In contrast, the most uncertain trends identified were urbanization (1), migration (2), consumer food preference (3), and the unstable political situation creating difficulties for cooperation within the sea basin (4).

The trend regarding the unstable political situation create difficulties for cooperation within the sea basin and has been identified as uncertain due to the location of the Mediterranean Sea as it borders different continents. The participants highlighted the lack of governance harmonization, exemplified by the European Water Framework Directive (2000/60/EC). Non-European countries are not bound to this and other European directives.

Table 6.2 Trends identified during the workshop as most relevant for the Mediterranean Sea with a specific focus on the Málaga case study area.

Trend	Description
Climate change	Climate change will further lead to more weather extremes (storms), higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water.
Loss of biodiversity	The ecological impacts due to human activities (loss of biodiversity, pollution, depletion of natural resources) will increase. <i>Plastics, oil, chemical substances</i>
Aquaculture	Aquaculture technology (materials used) improved and reduces impact on the local environment.
Increasing individualization	Growing individualism and increasing social inequalities, may lead to more polarization and segregation (security), and possibly affect social safety.
More recreational use of blue spaces	Recreational use of blue spaces will increase, under influence of tourism and popularity of water-related activities in coastal areas.
Towards healthy living	Increase in life expectancy; increasing importance of living healthy.

Table 6.3 Trends identified during the workshop as most uncertain for the Mediterranean Sea with a specific focus on the Málaga case study area.

Trend	Description
Urbanization	Challenge of desirable and wealthy coastal areas vs. deprived areas.
Migration	Increased migration from overseas due to war/climate change/economic factors etc. resulting in increased risk of drowning; overcrowding of coastal areas.
Consumer food preference	Changes in the preferences of consumers for alternative sources of food, such as seaweed, algae, jellyfish, insects and initiatives like Food from Food
Unstable political situation create difficulties for cooperation within the sea basin	Decision-making is moving from government to multi-actor governance, including involvement of citizens. This trend differs from country to country. However, this involvement of multiple levels/actors can result in time delays as it is often difficult to find time suitable for everyone.

6.3 Impact of trends

The workshop participants discussed the trends identified as most relevant for ocean and human health on their potential impact and research gaps. Table 6.4 presents the research gaps identified for the relevant trends and their impacts.

Climate change may contribute to ecological disruption of ecosystem structures and its dynamics. In addition, an increase of floods and erosion at coastal areas and rising temperatures enable the settlement of invasive species and the severe change in biodiversity attributing to the ecological effects of climate change. Despite policy interventions (e.g. WFD), the lack of harmonization of interventions may yield different outcomes across the basin area. The social-cultural issues related to climate change focused on the aspect of how climate change will affect the future generations in their livelihoods as well as cultural preferences for specific seafood from the region.

The *loss of biodiversity* may lead to the loss of food availability and fish production due to invasive species, pollution and overfishing which in turn will not only have an ecological effect, but an economic effect as well due to scarcity.

The *increase of tourism and recreational use of blue spaces* may generate a negative ecological impact. The destruction of coastal ecosystems to the benefit of touristic establishments along the shorelines has a detrimental effect on the marine coastal environments. Moreover, the increased use of blue spaces may also lead to an increase of waste flowing into the water and polluting the ocean.

Table 6.4 Impacts and research gaps for the most relevant trends identified during the workshop for the Mediterranean Sea with a specific focus on the Málaga case study area.

Trend	Impact	Research gaps
Climate change	<p><i>Ecological:</i> disruption of ecosystem structures, dynamics of ecosystems are changing, eventually leading to regime changes that cannot be turned around anymore; increased flood and erosion risks at coastal areas; acidification; serious changes in marine biodiversity; rising temperatures will make it possible for invasive species to settle; water level will rise; loss of species and habitats</p> <p><i>Governance:</i> impacts are not the same across the basin area</p> <p><i>Social-cultural:</i> climate change will affect livelihoods of future generations</p> <p><i>Economical:</i> the rise of sea level can create corrosion of infrastructure</p>	<p><i>Ecological:</i></p> <ul style="list-style-type: none"> • Increase of mass mortalities/diseases as well as blooms of organisms • Answers for mitigation, restoration of ecosystems, adaptive management • Data on thresholds of our ecosystems. What are points of no return? • Standardized monitoring for a better understanding of the phenomenon • Present knowledge on impacts of climate change is not equal across the basin and different regions need different knowledge <p><i>Interdisciplinary approaches:</i></p> <ul style="list-style-type: none"> • Climate change and the issue of multiple stressors: how do stressors exacerbate/influence each other (a more integral way of looking) <p><i>Governance:</i></p> <ul style="list-style-type: none"> • A global pressure needs a global solution • Including the consideration of climate change into policies (we are now planning the present without considering the future), e.g. in existing frameworks
Loss of biodiversity	<p><i>Ecological:</i> loss of ecosystem services and ecological functions (e.g. impact on food availability and fish production, coastal protection, carbon sinks, socio-economic impacts); mass mortalities; regime shifts; invasive species; overfishing; pollution; loss of biodiversity and other ecological impacts are not the same for the Med sea basin; strong changes in ecology of the marine environment</p> <p><i>Economical:</i> Food availability</p>	<p><i>Ecological:</i></p> <ul style="list-style-type: none"> • What are the thresholds to take into account? • Knowledge on impacts differs across the basin, e.g. on alien species <p><i>Governance:</i></p> <ul style="list-style-type: none"> • Main key ecosystems depend on many State Planning Policies (SPP) status • Answers through transboundary approaches • Restoration and protection • Ecosystem based management
More tourism and recreational use of blue spaces	<p><i>Ecological:</i> destruction of coastal ecosystems, including key ones for natural resources renovation; negative impacts on marine coastal environments</p>	<p><i>Governance:</i></p> <ul style="list-style-type: none"> • Mitigation measures needed • Blue Growth as an opportunity, but also big risk (considering role of multiple stressors). Often too much focus on economic benefits and not enough on the negative ecological impacts. Green Growth as an example takes natural impacts more into consideration. • Marine spatial planning should clearly focus on the protection of marine environments. Include conservation targets; meaning a change of the policy focus in MPA framework.

6.4 Research gaps

The impacts of the relevant trends identified show a high level of uncertainty (Table 6.4). Some of these uncertainties may be addressed by research. Table 6.4 presents the research gaps identified for the relevant trends and their impacts.

Research gaps for instance, were identified for:

- *Climate change and the issue of multiple stressors*: currently there is a knowledge gap in the understanding of how different stressors relate to each other and their impact on the Mediterranean Sea. Current examples regarding multiple stressors affecting the Mediterranean can be found in the upcoming 2020 Mediterranean Assessment Report from the Mediterranean Experts on Climate and Environmental Change (MedEC): <https://www.medecc.org/our-work/>
- *Maritime spatial planning*: As the impact of climate change is not the same across the basin it is important to adopt an approach that benefits all areas of the basin. Therefore a coherent approach on maritime spatial planning for EU and non-EU countries has been identified as a research gap. Currently projects exploring this issue are the Supporting Maritime Spatial Planning in the Eastern Mediterranean (SUPREME) <http://www.msp-supreme.eu/results> and West Mediterranean <http://www.mspglobal2030.org/msp-global/pilot-project-west-mediterranean/>
- *Blue Growth*: The current EC Blue Growth Strategy aims to support sustainable growth in the marine and maritime sectors. However, research gaps have been identified on the balance between economy and the environmental health of the marine ecosystem. The PHAROS4MPAs – Blue Economy and Marine Conservation: Safeguarding Mediterranean Marine Protected Areas in order to achieve Good Environmental Status project has provided several policy briefings as well as recommendations on how the environmental impacts of seven sectors can be prevented or minimized. <https://www.msp-platform.eu/projects/pharos4mpas-blue-economy-and-marine-conservation-safeguarding-mediterranean-mpas>. In addition, the PHAROS4MPAs project also developed a Decision Support Tool to support the operationalization of the recommendations as well as translating the knowledge acquired from best practices and case studies. <https://pharos4mpas.tools4msp.eu/>

6.5 Summary of research gaps and quotes

During the workshops, participants identified research gaps that have been used as input for the Sophie Strategic Research Agenda. Textbox 4.1 shows summaries of the results of these discussions on the theme ‘Climate change & biodiversity’ focusing on the Atlantic Ocean. Textbox 4.2 and 4.3 show summaries for the research gaps identified for ‘Blue spaces, tourism and well-being’ and ‘Blue spaces and governance’ respectively.

*Textbox 6.1 Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Mediterranean** (Málaga case study area). Some noted relevant research gaps about ‘Climate change and biodiversity’.*

Research gaps

- ✚ Multiple stressors; it’s easy to predict the effect a single stressor, but it is difficult to forecast the impact the single stressors have on one another.
- ✚ What is the impact of climate change across the different parts of the basin.
- ✚ Research on the increasing flood and erosion risks at coastal areas.
- ✚ Research on the changes in marine biodiversity and its impact on the intrusion/introduction of invasive species.
- ✚ More data to unravel at what point we reach the threshold point of no return regarding damage to the ecosystem.

Textbox 6.2 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Mediterranean** (Málaga case study area). Some noted relevant research gaps and quotes about ‘Blue spaces, tourism & well-being’.*

Research gaps

- ✚ Research on negative relationship between recreation and environment; how risk threats will impact humans; how increase use will impact ecosystems; link human health and recreation; recovery of degraded systems and recreation recovery.
- ✚ Behavior/education: raising awareness for all (not only children) on preventing littering impact of overcrowding due to tourism.
- ✚ Best practices at local level on informing the public about (possible) health risks while recreating in closed of beaches.

Quotes

- ✚ “It is important to explain to the people about the risks of why they can’t swim or recreate when the beaches/recreational area is closed”

Textbox 6.3 *Summary of results of the discussion with local experts and stakeholders on ‘Ocean and human health’ for the **Mediterranean** (Málaga case study area). Some noted relevant research gaps and quotes about ‘Blue spaces, tourism & governance’.*

Research gaps

- ✚ Research for a harmonized approach to mitigate and adapt to the effects of climate change across the basin.
- ✚ Overview of best practices of adaptation strategies across the basin.
- ✚ More research on Maritime Spatial Planning is needed to improve the protection of marine ecosystem.
- ✚ Research on negative relationship between recreation and environment; how risk threats will impact humans; how increase use will impact ecosystems; link human health and recreation; recovery of degraded systems and recreation recovery.

Quotes

- ✚ “A more inclusive approach to the EU Water Framework Directive on the Mediterranean is needed as the Mediterranean Sea borders three continents.”

7. Synthesis and discussion

7.1 Introduction

The seas and oceans in Europe all have their own characteristics and issues to cope with. People living at coastlines have their particular views on what is at stake and what should be improved or protected. Furthermore, global trends like climate change and the increase of (mass) tourism, may have different impacts on local communities. In order to understand these local impacts arising from global trends, understanding of local perceptions on European oceans and their relation to ocean and human health is needed. To gather this type of information, a participatory approach has been developed within the H2020 SOPHIE project.

During interactive workshops for the North Sea, the Baltic Sea, the Atlantic Ocean and the Mediterranean Sea, various groups of local stakeholders discussed (1) current priority issues, (2) the relevance and impact of global trends for their area, and (3) the research gaps that need to be addressed in order to gain a better understanding on what is needed to anticipate or adapt on these trends. The results of the workshops have been used as input for a European strategic research agenda on ocean and human health.

In this chapter, the outcomes of these workshops will be analysed and compared in order to identify the role of the local context regarding ocean and human health. Central questions for this analysis are:

- What are relevant trends for ocean and human health for the different sea basins in Europe?
- What are knowledge gaps regarding these relevant trends?
- What are norms, values in ocean and human health policy in Europe?
- What is the role of the local context?

7.2 Issues at stake

We have found that there are both similarities and differences concerning the relevant issues for each of the European sea basins involved in this study with regards to ocean and human health. For instance, both positive and negative views exist regarding the role of tourism, with tourism as important economic contributor versus pollution by tourism. Other differences exist concerning economic dependencies on the sea, the possibilities of aquaculture, sources of pollution and more specific aspects related to the cultural heritage of the region such as food from the sea. Issues regarding ageing of the population, with different demands for recreation at sea, increasing use of medicines and the impact on the environment, and concerns about the protection of vulnerable ecosystems, all came forward in a similar way during the workshops. Table 7.1 summarizes the current issues that were identified during the four stakeholder workshops. These issues have been described in more detail in the previous Chapters 3 to 6.

Table 7.1 *Current situation and issues identified in the four stakeholder workshops.*

Themes*	Atlantic Ocean (San Sebastián)	Baltic Sea (Helsinki)	Mediterranean Sea (Malaga)	North Sea (Eastern Scheldt)
Demography	Population slightly growing, increasing ageing	Population slightly growing, increasing ageing	Ageing population and increasing life expectancy	Local population is shrinking, strong increase in summer due to tourism. This sets pressure on various facilities.
Economy	Relatively high economic growth	High GDP, mainly services sector, fishing declining, High digital connectivity, smart city, living lab	BlueMed Initiative: for a healthy, productive and resilient Mediterranean Sea, High unemployment figures since the 2007 economic crisis	Highly valued area with multiple - sometimes conflicting - functions: recreation, shipping, ecology, flood protection, fishery & aquaculture, energy supply.
Fishery and aquaculture	Fishing sector declining, Aquaculture limited due to waves and currents	Living with the sea (peninsular nature), Eating much seafood as part of cultural heritage, No offshore fish farming (severe winters)	Importance of seafood for cultural identity	Strong fishing sector (mussels)
Tourism	Welcome to visitors but avoid mass tourism	Busy harbour for passengers and trade	Cruise ship sector provides employment and economic growth but is also an important source of contamination.	Tourism: beaches nature; water recreation
Ecology		Issues with nutrients in the Baltic Sea		Concerns on increased use of pharmaceuticals
Climate change	Increase of flooding and development of storms and currents	Storm water and flooding strategy needed	Increase of storms with heavy rainfall and flooding, heatwaves and severe droughts	Unprecedented rate of climate change. Increase of flooding and droughts
Ocean and human health interactions				The relationship on water and health is identified, but not yet fully understood.
Policy development		Baltic Sea Action Plan	MPAs (Marine Protection Areas) to protect sensitive species and sustainable use	A long-term vision connecting ocean and human health, is lacking.

*Not all categories came forward explicitly during each of the stakeholder workshops.

7.3 Relevant trends

Based on their expertise and knowledge of the local situation, the participants in the stakeholder workshops identified from a wide array of global trends, the trends they consider relevant for their sea basin (see Table 6.2). The energy transition, further loss of biodiversity and climate change came forward as relevant for (almost) all sea basins. Other trends only proved relevant for one or two of the sea basins. This could reflect substantial differences in relevant issues between regional sea basins. Alternatively, the results could be influenced by the backgrounds of the stakeholders participating in the workshops. Different stakeholder groups may therefore identify other relevant trends. Nevertheless, these results give a first indication of trends of concern in the different areas.

Table 7.2 Overview of most relevant trends for ocean and human health for different sea basins from the four stakeholder workshops.

Most relevant trends	Short description	Atlantic Ocean (San Sebastián)	Baltic Sea (Helsinki)	Mediterranean Sea (Málaga)	North Sea (Eastern Scheldt)
Towards a circular economy	Strong development towards a circular economy, with less use of fossil fuels and replacement by renewables. <i>The development of newer, less-harmful chemicals and substances.</i>	X	X		
Energy transition	Development of new energy sources: tidal, wave, blue, solar & wind energy generation	X	X		X
Aquaculture	More utilization of coastal areas for aquaculture; more activities and businesses catering to the increased demand.				X
Healthcare transition	Increasing costs and cost-management of healthcare, as well as alternative methods of financing & management systems.	X			
Changes in income distribution	Income inequality is expected to rise further. <i>Income inequalities can cause health and social problems.</i>	X			
Increasing overweight/obesity	An increasing proportion of people who are either overweight or obese.				X
More recreational use of blue spaces	Recreational use of blue spaces will increase, under influence of tourism and popularity of water-related activities in coastal areas.	X		X	
Technology development in industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. <i>Furthermore, emission reduction technology as well as new substances being used.</i>		X		X
Further loss of biodiversity	The ecological impacts due to human activities (loss of biodiversity, pollution (plastics, oil, chemical substances), depletion of natural resources) will increase.	X	X	X	X
Climate change	Climate change will further lead to more weather extremes (storms), higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water.		X	X	X
Changing institutional and governance structures	Decision-making is moving from government to multi-actor governance, including involvement of citizens. This trend differs from country to country.		X		

7.4 Local impacts of relevant trends

The joint discussion on different trends enabled the identification of cross-sectoral issues, impacts and research gaps and the potential to create co-benefits between sectors, e.g. regarding social inequalities, health and wellbeing, education and the inclusion of elderly in education activities to emphasize the importance of the sea. Ocean fronts in cities can also create a sense of place and pride to citizens.

Some highlights from these discussions on cross-sectoral issues, impacts and co-benefits are:

- The recreational use of blue spaces may lead to improved mental and physical health for all, but also requires management (litter, pollution (noise, air, water), impacts on local infrastructure), awareness of risks, the importance of the local heritage for different groups, and the protection of biodiversity (benthic communities) (*Atlantic Ocean, San Sebastián*).
- The impacts of climate change are highly uncertain, yet in some cases changes take place at an unprecedented rate (*North Sea, Eastern Scheldt*).
- The push for marine renewables (energy transition) may have negative impacts on ecology. This further loss of biodiversity might add to the current policy discussions for the Baltic Sea

as a 'lost cause' but also serve as an incentive to create co-benefits for ecology. Further loss of biodiversity may result in local extinctions of species, an increase of invasive species, an increase of blue algae and the weak adaptation of fish etc. may add to a changing ecosystem and have impact on food webs (*Baltic Sea, Helsinki*).

- Increased flooding and erosion risks at coastal areas may arise due to climate change. The effects this may have on the ecosystem may lead to regime changes that we cannot turn around anymore. Loss of biodiversity and other ecological impacts are not the same for the whole Mediterranean Sea basin (*Mediterranean Sea, Málaga*).

7.5 Research gaps

7.5.1 Strategic Research Agenda OHH

The research gaps identified in the stakeholder workshops fed into the Strategic Research Agenda (SRA) of the H2020 Sophie project (<https://sophie2020.eu/strategic-research-agenda/> (last accessed April 2020)). This agenda presents the research on Ocean and Human Health that is needed for fundamental questions to be answered, evidence to be provided to policymakers and Ocean and Human Health literacy to be increased in Europe and beyond. The SRA identifies research needs in three areas:

- Sustainable seafood and healthy people,
- Blue spaces, tourism and well-being,
- Marine biodiversity, medicine and biotechnology.

In addition, the SRA offers several overall recommendations regarding means of collaboration between researchers from different OHH fields (platform, guidance documents), the necessity of systematic reviews and longitudinal studies, training and education, policy advice and stakeholder engagement.

7.5.2 Local context and research gaps

The local stakeholder workshops have provided input for the SRA. The diversity of relevant issues and trends in and around different sea basins in Europe shows that research gaps at a local level may have different accents or specifications than research needs at a European level. Improved understanding of the local context also supports questions regarding transferability of cases from one location to another and input for policy plans.

Some research gaps identified during the workshops are relevant for multiple sea basins, such as the introduction of cross-sectoral planning and implementation strategies across institutional levels and geographical scales for ocean and human health and the need for awareness raising and behavioral change ('cleaner habits', perceptions of risks). Other research gaps have a specific local focus, e.g. the local impact of climate change and pollution on bathing water quality, biodiversity and the marine food web and the sustainable recreation capacity of an area.

Questions regarding future planning especially require inclusion of the local context in the research design. What are the risks and benefits for local coastal areas regarding human health and well-being? How can these risks and benefits be balanced well and serve health promotion? How to realise climate adaptation that serves both safety, ecosystem preservation and human health?

The role of the local context should therefore be included in future research and policy planning on both local and European scale on how to realise benefits for ocean and human health.

7.6 Reflections on the methodology used

In this study we used local (policy) documents on current issues and future plans, a wide array of possible relevant trends and input from local stakeholders and experts to identify local challenges and potential research gaps. In this approach the input from workshop participants plays a major role. To facilitate interdisciplinary and transdisciplinary discussions on the cross-cutting topic of ocean and human health, stakeholders have been invited from a wide range of backgrounds, like water management, spatial planning, bathing water, governance, education, recreation, nature preservation, public health and health care and community engagement all with a focus on the local situation. Next to the domains of ocean and human health, the aim was to have all of the fields of expertise in the DESTEP-categorization, present at the workshops.

In practice, it was difficult to get all these different fields of expertise represented. Stakeholders were approached beyond usual networks and were not always willing to invest time in such a workshop. This could imply that the sense of urgency for those not directly involved is not as high. For instance, economists were missed in most of the workshops and the health sector was limitedly represented. This implies that the outcomes of the workshops can be biased to a certain extent.

The actual participants however appreciated the interdisciplinary focus of the workshop and the discussion with professionals from other backgrounds and new to them, on a joint objective: identifying current issues, relevant future trends, possible impacts and research needs. The methodology applied during the workshop adequately supported this objective. The observed differences between local contexts, justify the organisation of the local workshops where experts and stakeholders from different backgrounds can identify joint challenges and research needs to follow up on.

For this purpose, a more systematic approach to involve stakeholders is needed to promote active participation of all crucial stakeholders. This can be achieved through the following steps:

- A stakeholders analysis that identifies the crucial stakeholders on local level, their knowledge, roles and responsibilities;
- A clear description of the contribution needed from each stakeholder and tailor made invitations and follow up requests to maximize compliance;
- A combination of different sources of information (quantitative, qualitative and citizens' science) in order to achieve an integral view on the local situation and its critical issues;
- The use of participative workshop methods that focus on sharing information with stakeholders from various backgrounds. It means investing in understanding each other's socio-cultural background in order to first develop a common language before concentrating on the issues at stake. Enough time for evaluation and feedback with all stakeholders in order to strengthen and sometimes redefine their position for future local cooperation on the issues that were prioritized during discussions.

The value of these outcomes could be improved by further exploration and elaboration in a wider community, refining the conceptual framework for individual basins (see Figure 2.1) based on these outcomes and follow up discussions on how to embed the results in policy planning and interventions. In this respect it is important to acknowledge that a coherent public health framework for future action should consist of three components: prevention, promotion and intersectoral collaboration:

- Prevention of substances that are harmful for individual and public health;
- Promotion of healthier lifestyles in an environment that support it;
- Intersectoral collaboration as a key to health in all policies.

8. Conclusions and recommendations

In this report, local case studies from different European sea basins have been described. In these case studies, current local issues, potential relevant trends, their impact and attributed research gaps were identified using an interactive, interdisciplinary approach with local stakeholders and experts. From this analysis several overarching conclusions came forward:

- *Local context and communities shape opportunities for OHH:*
Although many trends act at global scales, the impacts, values and ambitions may differ between regions. Therefore, solutions need to be developed based on the interests of local stakeholders and communities. Involvement of local communities can accelerate the enhancement of ocean and human health.
- *Health aspects need to be included in coastal and marine policy plans:*
Coastal authorities responsible for planning are often limitedly aware of the potential health benefits they can realise with integrated planning. Workshop participants from this study indicated the differences between European States (not all are part of the European Community and not bound to the legislative framework), within basins regarding their institutional and legal setting and thus the options to realise this. To this end more scientific evidence is required on the impact of design, ecological status and use of marine areas on public health, both on global and local scales as well as practical guidance on how this can be achieved in reality.
- *The role of the sea in health policy plans is missing now and should be included:*
During the organisation of the workshops, it was challenging to get the actors from the different fields of expertise to the table. Once present, the interdisciplinary discussion was much appreciated. Identification of the role of these different actors in policy plans could support this development towards interdisciplinarity.
- *To realise the benefits from OHH interactions, an intersectoral and interdisciplinary approach is needed:*
Policy making for healthy humans and oceans involves a wide range of policy issues, from demographic changes to public health, water governance, biodiversity, social inequalities and economic development.

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Appendix I Overview of possible relevant trends

To facilitate the workshops and overview of trends possibly relevant to ocean and human health, has been collected. This overview builds on the work carried out in the H2020 project BlueHealth (Grant Agreement No 666773). During an interdisciplinary expert session all trends identified by (Wuijts, De Vries et al. 2019) have been evaluated, updated and complemented to meet the research question of this study.

I.1 Demographic trends

The demographic characteristics of EU countries might show a particular variation, but most of them have many similarities regarding future demographic trends. Birth rates have been below replacement level for several decades already, resulting in population decline in the longer term and in a changing age structure of the population, with a growing proportion of elderly. The ageing of the EU population is further reinforced by increasing life expectancies, resulting from improved socioeconomic conditions and healthcare. Migration, as a third component of demographic change, shows some more annual fluctuations since it depends on geopolitical situations, economic growth and labour market developments. Finally, there is a general trend towards increasing urbanisation and, as result of a decrease in household size, a growing number of households.

Table I.1 Summary of possible relevant trends for the Demographic pillar.

Driver	Trend	Description
Demography	Changing population composition	The population is ageing and the population size slowly increases, mainly driven by migration. In cities population growth is driven by a net influx of young people.
	Changing household size	The average household size is decreasing, resulting in an increase in the number of households.
	Urbanisation	The number of people living in coastal areas in Europe slowly increases, although there are large differences between EU cities. <i>Particularly capital cities will face ongoing growth of the urban population. Shrinking population size occurs in rural areas and in some cities.</i>
	Migration	Continued growth around international migration into European countries, driven by conflicts, climate change and/or economic motivation.
	Increasing life expectancy	The number of years people are expected to live will continue to increase. In addition to life expectancy, health and wellbeing are of importance

I.2 Economic trends

Changes in the economy are expected to have a large influence on the quality of lives of the European population. There has been a tremendous growth in wealth in Europe since the end of the Second World War and a major shift from primarily secondary sector manufacturing-based economies towards tertiary sector high-knowledge service economies. Agriculture still remains strong, but the rural workforce makes up just 5% of the total workforce because of further industrialization and automatization (Eurostat 2017). Economies are strongly influenced by decisions made at the political level, ranging from EU to (sub)-national level. Even though the EU has economic policies aimed at reducing disparity, inequalities remain at the national level. Sectoral changes and technological development have changed the type of jobs and this change is expected to continue. How climate and other environmental change will impact sectoral changes remains a question.

Table I.2 Summary possible relevant trends for the Economic pillar.

Driver	Trend	Description
Economy	Growth of the gross domestic product (GDP)	Overall EU-28 GDP growth is expected to be moderate and stable, but with large differences between EU Member States.
	Labour market changes	The number of service jobs is expected to increase as well as the number of part-time jobs.
	Changes in income distribution	Income inequality is expected to rise further. <i>Income inequalities can cause health and social problems.</i>
	Changes in labour conditions	Work weeks are expected to be shortened, but with large variation between EU-countries.
	Increased waterway-transport	Growth of transport on water due to maritime freight transport and recreation industry (cruise ships).
	Expansion of artificial barriers and harbours	Expansion of artificial barriers and harbours to deal with increased transport
	Towards a circular economy	Strong development towards a circular economy, with less use of fossil fuels and replacement by renewables. <i>The development of newer, less-harmful chemicals and substances.</i>
	Healthcare	Increasing costs and cost-management of healthcare, as well as alternative methods of financing & management systems
	Aquaculture	More utilization of coastal areas; more activities and businesses catering to the increased demand
	Energy transition	Development of new energy sources: tidal, wave, blue, solar & wind energy generation

The number of service jobs is expected to increase further, so is the number of people working part-time or in freelance jobs (OECD 2017). This does however not necessarily imply that people will have shorter workweeks. They may have several jobs, and the resultant increased insecurity may lead to adverse psycho-social effects (e.g. stress). Certain EU member states (notably Finland) are starting to implement a universal income (a basic income for all) on a trial basis. Others, including Sweden, are testing a shortening of the working week in order to create more quality jobs and improve quality of life.

A specific water related sector is transportation on water, of both goods and passengers. Maritime transportation provides significant gain for society, but is also associated with a variety of pollution and potential accidents. The current trends suggest that transportation on Europe's seas will continue to increase.

More generally, the trend towards a bio-based and circular economy and the trend towards energy transition underline the positive trend towards senior-knowledge technology service based economies. A radical shift from linear end-of-pipe to closed looped production and consumption systems is required, but still faces many hurdles. The commitments made under the Paris Climate agreement (UNFCCC 2016) and the 2030 Agenda for Sustainable Development point in the right direction for 2040. The positive growth of this trend is surrounded with limited uncertainty. This trend will be most importantly be increased by private and public sector efforts, which may both speed up or hamper the trend's growth. In the ocean domain this transition (wind and solar parks) may impact available space and interactions with the ecosystem are largely unknown.

I.3 Societal and cultural trends

The social and cultural characteristics of European countries are quite diverse, although some general trends are applicable to most of the societies within the EU. A multitude of social and cultural aspects shape societies. Here we focus on five developments that seem especially important for the ways in which European societies are developing. A first development is the way in which water and the coastline is increasingly regarded and used as a source for recreational activities within Europe. This development is strongly linked to a trend in recent decades within urban planning that

focuses on the redevelopment of urban waterfronts into attractive spaces for public and private use. A third important development is the increasing ethnic and socio-cultural diversity of European societies as a consequence of increased migration. Increasing individualisation is another trend that shapes European societies; it can lead to more freedom of choice and possibilities for people, but can also cause social isolation of some groups in society. The final potential relevant trend is the increasing levels of education of people in EU-countries. Higher levels of education may increase ocean and health literacy and thus lead to healthier oceans and humans.

Table 1.3 Summary of possible relevant trends for the Society and Culture pillar.

Driver	Trend	Description
Society and culture	More recreational use of blue spaces	Recreational use of blue spaces will increase, under influence of tourism and popularity of water-related activities in coastal areas.
	More waterfront development for urban regeneration	Waterfronts in European cities are increasingly redeveloped into attractive blue spaces for citizens, tourist and employees, emphasizing the connection of the city with the water and natural space. Depending on the course of urban developments and decisions made by governments, waterfront regeneration can be more or less inclusive.
	Growing ethnic diversity	Ethnic diversity within societies will increase under influence of migration. This introduces new opportunities and challenges for European societies with regard to health and water related issues (e.g. types of recreation, increased risks of drowning).
	Increasing individualisation	Social cohesion will be increasingly under pressure due to growing individualism and social inequalities, leading to more polarisation and segregation.
	Increasing education levels	A growing number of people that complete tertiary education
	Consumer food preference	Changes in the preferences of consumers for alternative sources of food, such as seaweed, algae, jellyfish, insects and initiatives like Food from Food
	Overweight/obesity	An increasing proportion of people whom are either overweight or obese

I.4 Technological trends

Looking back at the technological developments of the last decades, changes in technology are easily understood. However, it is difficult to imagine how technology will influence our lives in 2040. Current identified technological trends may be only applicable for the next five to ten years. Nevertheless, they form the basis for further developments ahead of that period.

Presently several technological trends have been identified in Europe, although some are still in an initial phases. Our societies are expected to digitalise substantially further, with developments such as artificial intelligence (using Big Data), automation, 3D printing, and nanotechnology. The Internet of Things (IoT) is an underlying current increasing digital connectivity. It will be easier to transmit and find data for all kinds of purposes, including data for monitoring health and environmental quality and make smart interdisciplinary analysis using big datasets.

New technologies for smarter urban water systems are expected to be developed (Eurostat 2017), leading to unprecedented possibilities for large-scale environmental surveillance. On the household level, technological systems tailored towards more efficient domestic water management are expected to be introduced on larger scales. Next to emission reduction technology new (substitute) substances may be used.

Increased digital connectivity may result in intra-European community building around water, health and well-being. This could potentially lead to increased advocacy and generally, to more inclusiveness. Individuals and organisations will have easier access to data, partly stimulated by a growing health economy, although access to and use of big data might also lead to new societal divisions (McCarthy 2016). Increased public-private partnerships will boost the investment in health

and water technology for smart and resilient living environments that are able to promote healthy long living and well-being. Examples are technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc.

Table I.4 Summary of possible relevant trends for the Technological pillar.

Driver	Trend	Description
Technology	Digitalisation of society	Emergence of big data and new technologies, such as artificial intelligence, internet-of-things (IoT), autonomous vehicles, 3D printing, and nanotechnology.
	Towards healthy living	Increased investments in smart urban water management systems on drinking water, wastewater management, and coastal water. Reduction of sewage overflows.
	Technology in industry	Technological improvements in food production systems, fishery technology, waste collection, processing, shipping etc. Furthermore, emission reduction technology as well as new substances being used.

I.5 Ecological and environmental trends

Since the publication of the first report for the Club of Rome in 1972 (Meadows, Meadows et al.), awareness of the anthropogenic impact on the local and global environment has increased. The world has been able to overcome major environmental problems, such as tackling the gap in the ozone layer and acid precipitation. Nowadays, the global community is being confronted with new major problems, with climate change being one of the most persistent ones, both in terms of the cause (economies build on fossil fuels) and in terms of effects. Climate change is a global phenomenon and thus also affects Europe, although in different ways and intensity throughout the European climate zones. Climate change results in a cascade of other ecological and environmental effects, such as increased risks of flooding, sea level rise, changing currents and sea waves, acidification, drought and heat waves and warmer sea water.

These effects could lead to water scarcity but also changes in behaviour of humans in terms of interactions with the natural environment. Also, the prevalence of waterborne and vector-borne pathogens might change and new infectious agents might emerge (EEA 2017). All these effects have societal and economic impact.

Almost all countries in the Paris agreement on climate change (UNFCCC 2016) have committed themselves to accelerate their mitigation efforts around climate change to prevent the increase of the global temperature above 2 °C maximum. Thus, all countries will have to increase their implementation rate of renewable energy. Together with the need for additional resources for growing populations and growing consumption patterns this could lead to an increase of the pressure on the natural system. This could, however, also result in an increased valorisation of ecosystem services.

Table I.5 Summary of possible relevant trends for the Ecological and Environmental pillar.

Driver	Trend	Description
Ecology and environment	Climate change	Climate change will further lead to more weather extremes, higher temperatures, more droughts, more floods and sea-level rise. Coastal erosion. Acidification. Warmer sea water.
	Increased valorisation of ecosystem services	Increasing societal and economic valorisation of ecosystem services in public decision making.
	Further loss of biodiversity and other ecological impacts	The ecological impacts due to human activities (loss of biodiversity, pollution, depletion of natural resources) will increase. <i>Plastics, oil, chemical substances</i>
	Higher rate of renewable energy	Energy consumption of households will decrease; the rate of renewable electricity consumption (hydropower and solar and wind power) will continue to grow.
	Use for drinking water and irrigation water	Increased use of desalinated sea water for drinking water and irrigation, process water for industry, cooling water for power plants and heat-cold storage due to climate change.

I.6 Political and Institutional trends

In European water policy, a shift from government to governance can be identified in the last decades (EC 2001). Governance approaches, with the involvement of multiple actors at multiple levels, and particularly bottom-up approaches, are often regarded as more effective in dealing with complex urban water issues, compared to conventional legal frameworks with top-down central steering mechanisms (Lee 2009, Howarth 2017). In 2016, the European Commission and the High Representative of the Union for Foreign Affairs and Security Policy launched an agenda for international ocean governance (JOIN 2016) and is part of the EU's response to the UN SDGs, in particular SDG 14 'to conserve and sustainably use the oceans, seas and marine resources'.

The agenda aims to strengthen international ocean governance in order to manage and use the world's oceans and their resources in ways that keep our oceans healthy, productive, safe, secure and resilient. The agenda calls for a cross-sectoral, rules-based international approach. Although some (indirect) linkages to health risks can be found in agenda, the potential benefits of oceans to human health and well-being are lacking.

To date, ocean and human health does not have an explicit place in European policy making (Borja, White et al. 2020). The EU maritime policy and legislative framework is designed to regulate human activities in order to protect the marine environment (Boyes and Elliott 2014). Only a small number of EU maritime instruments take specific account of human health aspects (e.g. the Bathing Water Directive (2006/7/EC), the Shellfish Waters Directive (EU, 2006/113/EC) and the Water Framework Directive (2000/60/EC)), and the EU Maritime Security Strategy (2014) (https://ec.europa.eu/maritimeaffairs/policy/maritime-security_en (last accessed April 2020)). These directives aim to deal with health risks (e.g. due to chemical pollution or waterborne pathogens) rather than health promotion. Most of the EU's maritime legislative instruments do not account for the connections between ocean and human health, including flagship policy instruments such as the Marine Strategy Framework Directive (2008/56/EC), the Maritime Spatial Planning Directive (2014/89/EC) and the Blue Growth Strategy (EC 2012).

EU health policy aims to protect and improve health of EU citizens and complements national policy since the Member States are primary responsible for their own health services and medical care.

However, cross-border health threats may be subject to a European approach. So far, there seems to be little focus on health benefits at the EU level. The EU Third Health Programme (2014-2020) (EC 2014) addresses the critical link between environment and health, but does not refer to the particular benefits of coastal or blue environments or how these could be realised.

Table I.6 Summary of possible relevant trends for the Political and Institutional pillar.

Driver	Trend	Description
Policy and institutions	Changing institutional and governance structures	Decision-making is moving from government to multi-actor governance, including involvement of citizens. This trend differs from country to country
	More healthy urban living in EU policies and strategies	The importance of healthy urban environments is increasingly recognised in EU policies and strategies.
	More healthy urban living in national policies and strategies	The importance of healthy urban environments is increasingly recognised in national policies and strategies, e.g., national climate adaptation strategies and increased spatial planning.
	More global agenda setting	Global governance and agenda setting is becoming a more wide-spread phenomenon integrating multiple policy domains, e.g. UN SDGs.
	Growing public private partnerships	A growing number of contracts between private parties and government entities.
	Protected areas	Policies regarding the protection of certain areas are increasing in both size and amount.

