Seafood in Europe

A food system approach for sustainability

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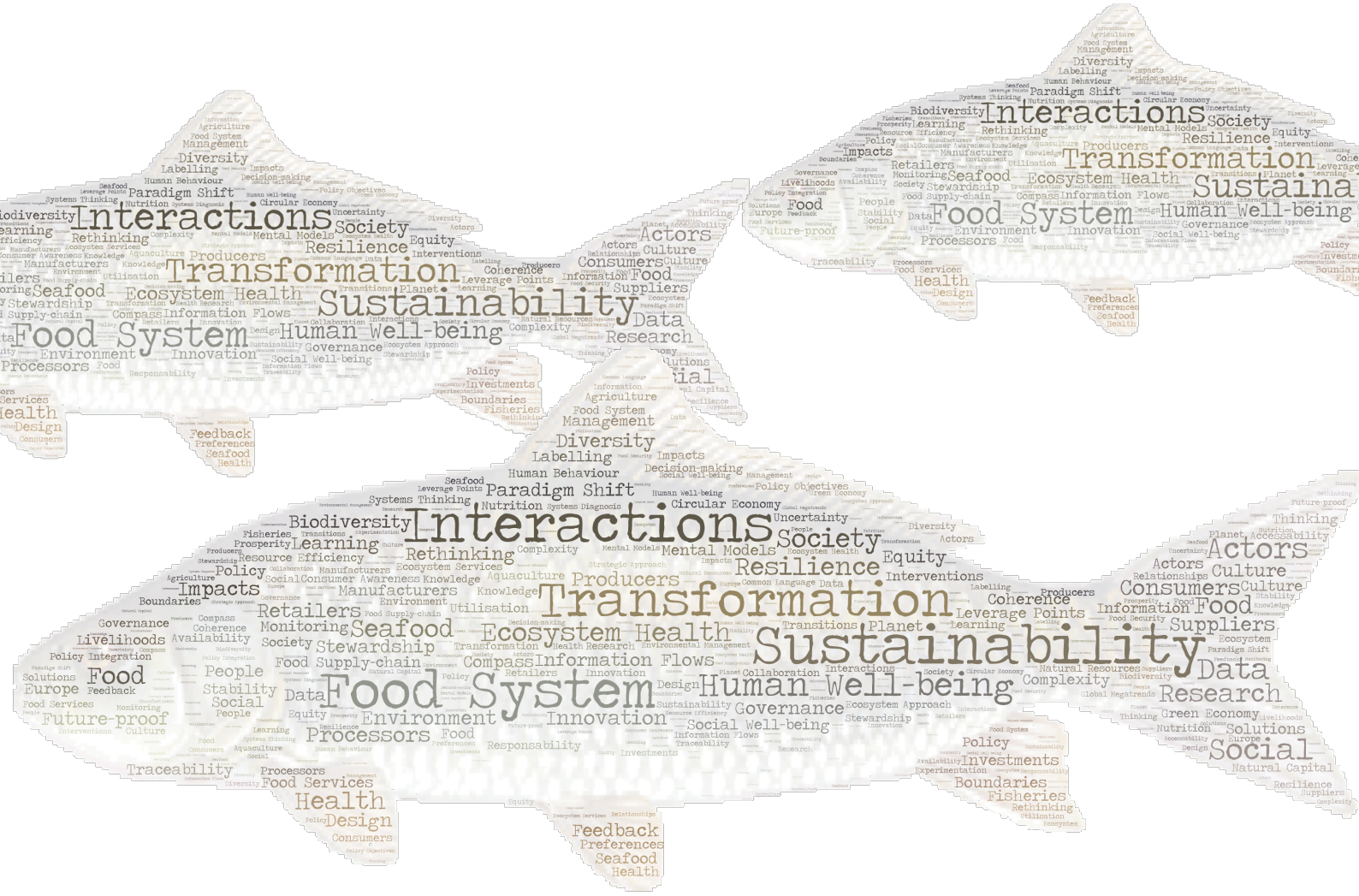

European Environment Agency

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Executive summary

Towards sustainability in the food system

By 2050, the world's population is projected to grow to 9.6 billion and demand for food will increase accordingly. The resulting rise in food production and consumption will arguably originate from a position of vulnerability: today, the global food system is responsible for 60 % of terrestrial biodiversity loss, around 24 % of greenhouse gas emissions, 33 % of degraded soils, full exploitation or overexploitation of around 90 % of commercial fish stocks, and overexploitation of 20 % of the world's aquifers. Worldwide, a number of striking effects on people's health and well-being can also be observed, associated with some modern diets that are rich in fat, sugar, salt and meat. Nearly 800 million people are hungry and over 2 billion suffer from micronutrient deficiencies, which affect their growth and development. On the other hand, almost 2 billion people are overweight and over 600 million of those are obese.

The challenges raised by our food pose major questions for our societies. How can we feed the world in an equitable and nutritious way, while sustaining the natural capacity of land and marine ecosystems to provide food, among other equally important primary services? And how can Europe adapt and transform its food system to support such objectives?

This European Environment Agency report, *Seafood in Europe*, is a first contribution to the collective endeavour of rethinking Europe's food system for sustainability goals, as recently articulated globally in the Sustainable Development Goals (aimed at 'Transforming our world') and in Europe with the implementation of the 7th Environment Action Programme (aimed at 'Living well, within the limits of our planet'). The report's intended readership includes policy actors, practitioners and researchers who are thinking about sustainability in food, and who are in a position to act strategically. It is also aimed at professionals in the fields of food security and marine environmental sustainability.

With a focus on seafood, the analysis builds on a food system approach from which it explores the knowledge base on food systems and on the seafood that the EU produces, trades and consumes. It then further assesses the implications of such a food system analysis for EU policy and knowledge development, by identifying three complementary pathways in the current EU policy framework related to food, seafood and healthy seas, and its knowledge base, which can help support a more functional system.

Sustainability in food requires a policy framework that embraces a food system approach, and that allows a shared understanding of the food system to be built

The EU has developed, in an implicit way, a broad policy framework for food — including policies related to environmental protection, agriculture, fisheries and aquaculture, research and innovation, trade and development — which is now embedded in long-term sustainability objectives (Figure ES.1). These policies influence how activities and actors in the food supply-chain interact with each other and use natural resources from land and sea. However, this EU policy framework is not currently implemented according to a food system approach. Such an approach recognises the food system as a complex, adaptive system, comprised by multiple interacting actors with diverse interests and values.

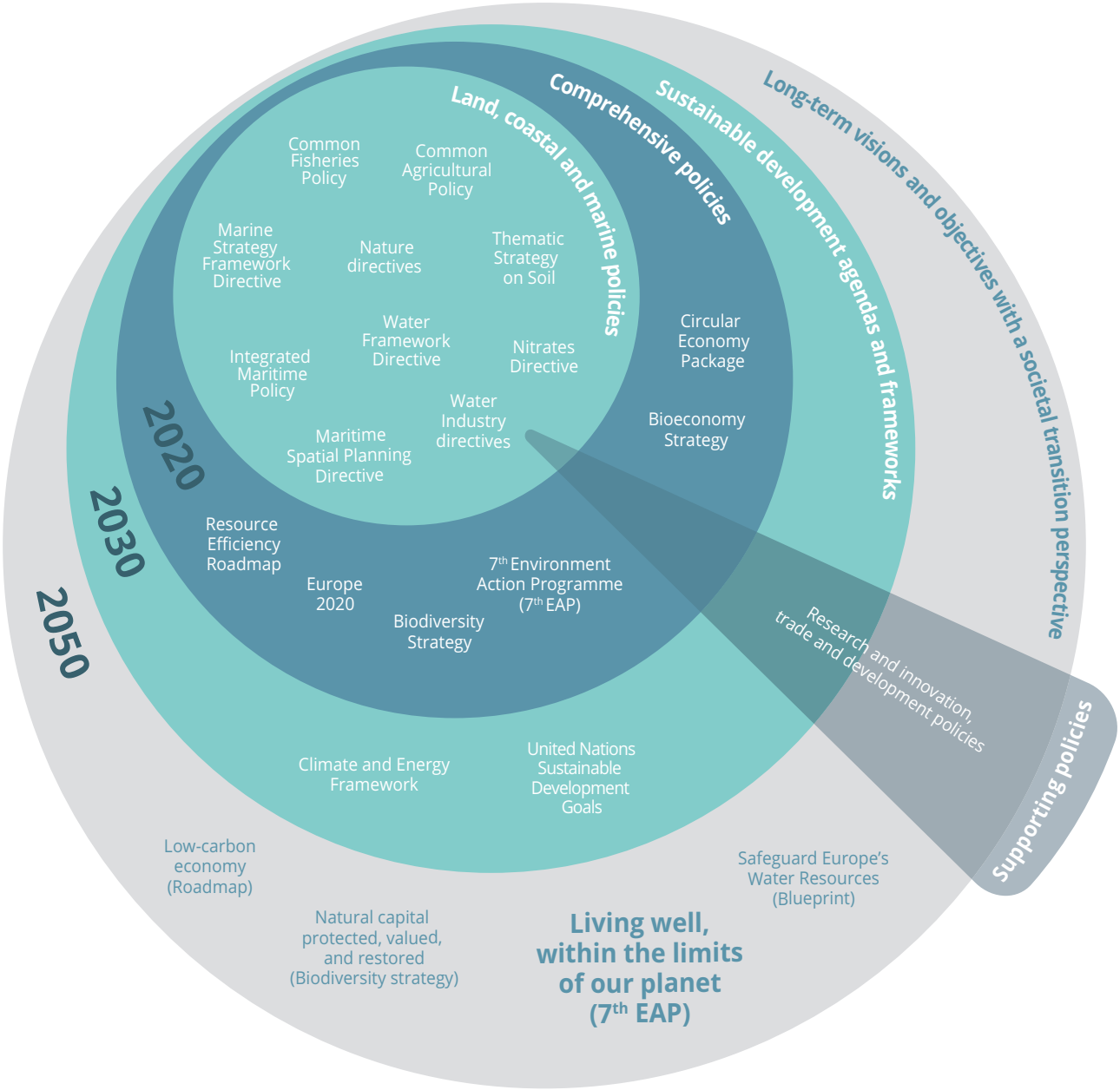
Policies help shape the food system. They establish a common framework for governance and action, define incentives, and direct research and innovation. Adopting a food system approach to EU policy would allow for complexity to be better embraced, and policy coherence and coordination to be strenghtened. It would also provide opportunities to build a shared understanding of the food system among policymakers and other actors in Europe's food system, such as producers, businesses in the food industry and civil society groups.

Adopting a food system approach requires a shift in the thinking about the food system and its outcomes. Initiatives at the EU level are already underway and have the potential to support such a shift in thinking and build a shared understanding of the food system among food system actors. These include a first EU Research and Innovation Agenda for Food and Nutrition Security and cross-policy foresight studies by the European Commission related to the implementation of several

of the EU policies related to food (such as agriculture, fisheries, the bioeconomy and the sustainable development goals). These initiatives could provide an important stepping-stone to design governance processes and research initiatives that could bring together EU institutions, Member States, food system actors, experts from a multidisciplinary background and other stakeholders to build a deeper and shared understanding of why and how food is produced, obtained and consumed. The design of such governance mechanisms could allow these stakeholders to open up to a wider array of solutions.

Solutions for sustainability in the food system will also require a deeper understanding of the interactions between ecosystem functioning and the ways in which food is produced. Mapping and assessing ecosystem services is key to understanding how natural capital is generated, and how people benefit from it. In this respect, the EU has begun a process under the Biodiversity Strategy to 2020 to apply a common ecosystem services approach that can lead to a common language at the EU level that will define and assess interactions between ecosystems and people. Although it is still early days for this process, especially

Figure ES.1 An illustration of relevant EU policies for food and sustainability until 2050



Source: EEA.

for marine ecosystems, such a common language across the EU can be instrumental in building a shared understanding of the food system outcomes on ecosystem health, and how best to manage them.

Finally, adopting a food system approach requires a policy implementation process that departs from the classical problem-solving and planning paradigm. Instead it will increasingly need to build on systems learning and experimentation via iterative, adaptive and participatory processes, and embrace human factors that influence decision-making and behaviour more fully. A great wealth of information is already available on how to complement policy implementation with behavioural insights. Working with human behaviour is especially important in the context of food, since food is related to many other interweaving aspects of our lives such as education and culture.

There is a need to improve the knowledge base related to seafood in order to better understand interactions in Europe's food system and beyond

Data and information flows related to food system activities and their environmental and socio-economic interactions and outcomes allow us to monitor change and assess it against EU sustainability objectives, namely by monitoring aspects related to food security, ecosystem health and social well-being. This information acts as feedback that can validate how we think about the food system, or signal the need to revise it. Additionally, this feedback from the food system allows us to make sense of change and forms the basis for action, such as policy interventions.

The assessment of the knowledge base that underpins the production, trade, distribution and consumption of seafood for the EU indicates that these different activities are still mostly monitored in isolation, and miss out important interactions on the journey of fish to fork. Currently, assessments tend to focus on the environmental impact of fisheries and aquaculture on Europe's marine ecosystems, or the economic performance of the sectors, both of which are critical knowledge for ensuring the long-term availability of seafood. However, information that allows for an understanding of what is happening at sea — both in Europe and from where Europe sources seafood — by connecting it to what and who is driving the production of seafood is scarcer.

In this context, although more than half (55 %) of the seafood consumed by EU citizens comes from outside EU borders, there is little information available beyond market data that enables the outcomes of the EU's need for seafood to be traced. International trade allows for sourcing across the world but it does not carry with it ecosystem signals, such as the state of fish stocks, that reflect local conditions and could act as a sustainable production boundary. Data that provide a better place-based understanding of the outcomes of the food system are limited. The contribution of fisheries and aquaculture to outcomes such as community integrity, food security and ecosystem stewardship are not visible in highly aggregated global, EU or national level statistics. These statistics were not designed to capture local dynamics but they may carry more weight when it comes to influencing decision-making in policy. Other interactions remain under-investigated, such as those in the aquaculture production of marine fed-species. The production of species such as salmon and shrimp have broader marine and land interactions — such as dependencies on wild fish stocks or land-based crops for the production of aquaculture feed — but the current information flows on seafood provides limited capacity to understand such interactions.

An integrated assessment of the production and consumption of seafood for Europe is therefore currently hindered by a lack of information that facilitates understanding of the means by which the different activities of the supply-chain shape the demand and supply of seafood and its outcomes over local-to-global scales. The new types of knowledge required for a switch to a sustainable food system do not necessarily imply more data and information. The wealth of existing data and information from EU policy implementation processes — such as those from the new Common Fisheries Policy, which deals with both the production of fisheries and aquaculture and the organisation of the common market for seafood — could be further explored to better capture the multiple interactions of the food system.

Implementing an ecosystem approach to Europe's seas — a key principle in several EU policies — is critical to securing the long-term availability of seafood, but further efforts are needed to support its operationalisation

The ecosystem approach to management — also known as ecosystem based management (EBM) — is a central principle in EU marine and maritime policy for ensuring the sustainable use of Europe's seas and the long term provision of ecosystem services, including the provision of seafood. Essentially, EBM is a policy-driven process that aims to strike a balance between ecological and social 'wants and needs' for the use of ecosystem services and natural resources.

The implementation of EBM in Europe and elsewhere, however, has been slow.

A major barrier to EBM implementation is the reconciliation of the often incompatible environmental, social and economic objectives of different actors and policies related to the use of marine ecosystems. Even with a unifying policy such as the Common Fisheries Policy (CFP), conflicting objectives and values, such as those related to securing short-term social and economic benefits from fisheries or optimising fisheries for broader social and environmental benefits in the long-term, hamper the effective implementation of core EBM measures for fisheries. This is illustrated by the difficulty faced in fishing at maximum sustainable yield in Europe's seas and the influence of political processes that go beyond the capacity of science to set this boundary for sustainability in fisheries management.

Another key impediment to successful EBM is the complex European marine governance system currently in place. A plethora of governance forums, including those stemming from the CFP, the Marine Strategy Framework Directive (MSFD) and the recently adopted Maritime Spatial Planning Directive (part of the Integrated Maritime Policy), are discussing parts of the problem and parts of the solutions concerning the sustainable use and conservation of Europe's seas. However, the different policies involved bring different actors together in different processes that do not necessarily encourage broader reflection and joint action. As such, a broader strategic approach to implementing EBM in Europe's seas is in order.

Finally, EBM is a learning and adaptive process that can take time to deliver tangible effects in ecosystem health. A resilient food system requires the stable production of food in the long-term. As such, measures to protect, restore and conserve the natural capital that underpins the very existence of a food system are essential for its sustainability. A key measure in the EBM tool box for Europe's seas and the availability of seafood is the development of an adequate network of marine protected areas (MPAs). Implementing coherent and representative MPA networks is a no-regret option for the safeguarding of biodiversity and the services that marine ecosystems provide, such as seafood. The ecosystem approach introduced by the MSFD and the CFP provides an opportunity to employ a holistic approach to designing, managing and evaluating MPA networks in Europe's seas. MPAs are also essential tools for ensuring the long-term viability of fisheries and the availability of resources on which the whole food supply-chain depends, ending with the 505 million citizens of Europe who want to be able to eat fish today and in the future.

1 Introduction

1.1 Food connects people, the planet and prosperity

Having food to eat is a daily requirement for all of the 7.2 billion people currently on the planet. It is expected that by 2050 there will be at least 2 billion more people to feed. Ensuring food is produced, distributed and consumed in a way that is socially, economically and environmentally sustainable is one of the main challenges of this century (World Bank, 2008; FAO, 2009; UN, 2015).

> “When we think about threats to the environment, we tend to picture cars and smokestacks, not dinner. But the truth is, our need for food poses one of the biggest dangers to the planet.”
>
> Richardson (2014)

The way we eat has contributed to the development of a complex global food system, connected by diverse networks of producers, business actors in the food industry, governments and consumers. The evolution of this highly interconnected system has brought both intended and unintended consequences for the planet and for people. Natural resources and ecosystems are under pressure. Globally, the food system is responsible for 60 % of terrestrial biodiversity loss, around 24 % of greenhouse gas emissions, 33 % of degraded soils, full exploitation or overexploitation of around 90 % of commercial fish stocks, and overexploitation of 20 % of the world's aquifers (FAO, 2016; UNEP, 2016). A number of striking effects on people's health and well-being worldwide can also be observed, associated with some modern diets that are rich in fat, sugar, salt and meat. Nearly 800 million people are hungry and over 2 billion suffer from micronutrient deficiencies, which affect their growth and development. On the other hand almost 2 billion people are overweight and over 600 million of those are obese, with worldwide obesity having more than doubled since 1980 (WHO, 2016).

Rethinking sustainability in food

The state of play in the global food landscape clearly shows that today's food system is dysfunctional. In addition, a variety of global megatrends — large-scale, high-impact and often interdependent social, economic, political, environmental or technological changes — are unfolding within Europe and across the world (EEA, 2015a). Such changes, related to population growth, rising incomes, economic growth patterns, loss of biodiversity and the intensification of climate change, will alter future food production and consumption patterns, and influence both societies and the environment (GO-Science, 2011). Thus, a transformation of the food system is increasingly being called for to ensure a system that is resilient to global change and capable of providing healthy and sustainable food for current and future generations.

Food is now at the top of policy agendas worldwide, through the recently adopted 2030 Agenda for Sustainable Development (UN, 2015). A set of 17 Sustainable Development Goals (SDGs) is intended to stimulate action between now and 2030 to shift the world onto a sustainable and resilient path. Two SDGs relate directly to food, but essentially food connects all of the goals ([1]). Consequently, it is considered that, without eliminating hunger, achieving food security and improving the health and nutrition of the world's population, the 2030 Agenda for Sustainable Development cannot be implemented effectively (UNEP, 2016). Obtaining sufficient and nutritious food by 2050 is a challenge that affects all countries, but it is one that will unfold differently in each one of them. The world's main food security challenge in the future seems to be to secure regular access to adequate food for the majority, while addressing the persistent food insecurity of a fraction of the population (Maggio et al., 2015).

([1]) The SDGs that relate directly to food are SDG 2, 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture', and SDG 14, 'conserve and sustainably use the oceans, seas and marine resources for sustainable development', but approaches are being developed showing how food connects all of the SDGs; see http://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html.

Food and the choices about what we eat are tied to many interweaving aspects of life, including cultural norms and values that influence individual preferences, and to the economic, social and political mechanisms governing when, where and how food can be accessed. If food is increasingly seen as an essential connecting thread between people, prosperity and the planet (UNEP, 2016), how to transform our food system in today's hyper connected world is still far from evident. Solutions for ensuring healthier food for a growing population, while reducing its environmental impacts will require a deeper understanding of the natural and human interactions in the food system. This understanding requires us to stop looking in isolation at what is happening at the production, processing, distribution and consumption steps of food. As such, a systems analysis of the many factors governing food security and its outcomes is key to guiding decisions for sustainability in a strategic and holistic manner (Ingram, 2011; UNEP, 2016).

Transforming Europe's food system

What is happening on the global food landscape matters for Europe's food security and its societies' broader well-being. Europe is embedded in a dynamic global web of producers, processers and markets that obtains and sells goods and services related to food. In 2014, the European Union (EU) had an 18 % market share of global exports and a 14 % share of global imports of agricultural commodities such as meat, dairy, cereals and drink products (Food Drink Europe, 2016). When it comes to seafood, the EU is the largest importer of seafood and fish products in the world, with a market share of 20 % of total global imports between 2013 and 2015, and was responsible for about 6 % of total global exports in the same period (FAO, 2016).

The time is ripe for rethinking the sustainability of Europe's food system. The EU has framed an engaging vision of the future until 2050, where we will be 'living well within the limits of our planet' (Box 1.1). This vision sets the context for exploring pathways for a transition towards the sustainability of Europe's food system, alongside the other systems of production and consumption that meet its needs for mobility, housing and energy (EEA, 2015b). The European Commission (EC) is further discussing a 'European brand' for a sustainable society, in which economic growth is compatible with planetary boundaries and its benefits are fairly distributed (EPSC, 2016). In the context of food, the EU is also actively engaging with stakeholders to develop a new EU food research area by 2020 in order to future-proof Europe's food system to achieve food and nutrition security for all, in a global context (EC, 2015a).

Nevertheless, the current landscape of EU policies and initiatives related to food — such as those on environmental protection, agriculture, fisheries and aquaculture, research and innovation, trade and development — is fragmented and thus not suited to the complexity of the food system. To transform Europe's food system and make it sustainable in the 21st century requires the knowledge base on its actors, activities, relationships and outcomes for both people and the planet to be strengthened and the implications of this knowledge for policy and governance explored.

1.2 About this report

This report aims to contribute knowledge to the collective endavour of rethinking Europe's food system for sustainabillity. With a focus on seafood, the analysis builds on a complexity framework — a food system approach — from which it explores the knowledge base on food systems and on the seafood

Box 1.1 The EU 2050 sustainability vision from its 7th Environment Action Programme

"In 2050 we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. Our low-carbon growth has long been decoupled from resource use, setting the pace for a safe and sustainable global society."

Living well, within the limits of our planet

7th Environment Action Programme

that the EU produces, trades and eats. It then further assesses the implications of such food system analysis for EU policy and knowledge development. The report's intended readership includes policy actors, practitioners and researchers who are thinking about sustainability in marine and land-based food, and who are in a position to act strategically. It is also aimed at professionals in the fields of food security and marine environmental sustainability.

This report brings a sustainability perspective to the food system, exploring the environmental, social, economic and governance dimensions around food and seafood in particular. It therefore departs from assessing the environmental impact of fisheries and aquaculture on Europe's marine ecosystems, which is assessed elsewhere (EEA, 2015c). Moreover, the report does not focus on natural resource use in the food system and how to address its environmental impacts, which have recently been assessed on a global level (UNEP, 2016). A systems approach that explores interactions and outcomes of the 'fish to fork' activities in which Europe is embedded remains under-investigated at EU level. This report aims to address this gap.

A food system approach allows the activities and actors in the food supply chain — from production and manufacturing to supply, retail and consumption — as well as the various social, economic and environmental outcomes of these activities, to be connected and examined (Ericksen, 2007; Ingram, 2011). Such system analysis further helps to distinguish the relationships that shape production and consumption patterns, which can support the identification of leverage points for accelerating the transformation of the food system towards sustainability (Meadows, 1999; Abson et al., 2016).

This report is structured around three main chapters. Chapter 2 sets the scene for the assessment. It describes the sustainability challenges related to food and to seafood in particular, both globally and in Europe, and defines the food system. It then explains the conceptual approach of the assessment. Chapter 3 takes us on a 'fish to fork' journey via a food system approach, by exploring the relationships and outcomes that are intrinsic to Europe's demand for seafood. In doing so, it aims to illustrate the need for a systems approach to understand the factors that are governing the long-term availability, access and use of seafood for the EU. Chapter 4 builds on systems thinking to identify three complimentary pathways for sustainability in Europe's food system. It does so by considering opportunities that are available or emerging in the current EU policy framework related to food, seafood and healthy seas, and its knowledge base. Finally, Chapter 5 looks ahead and provides food for thought on aspects relevant for a transformation towards sustainability in Europe and its food system.

2 Sustainability in the food system

2.1 The global and European seafood landscape

The role of fish as a source of food, income and livelihood ([2])

The combination of population growth, urbanisation and rising incomes is projected to increase global food demand compared with current needs by an estimated 50 % by 2030 and by 80–100 % by 2050 (Maggio et al., 2015). Although projections vary, the world needs to close the gap between the amount of food available today and the amount required in 2050. Part of this new demand for food will be met with fish. Caught or farmed fish is already an important source of food and provides an essential contribution to human health given its high protein content but also a wide range of essential micronutrients, including various vitamins, minerals, and polyunsaturated omega-3 fatty acids. In 2013, fish accounted for about 17 % of the global population's intake of animal protein (11.7 % in developed countries and 20 % in developing countries) and 6.7 % of all protein consumed (FAO, 2016).

World fish consumption has been on the rise in recent decades, having almost doubled in the last 55 years (from an average of 9.9 kg per capita in 1960 to 19.7 kg in 2013) (FAO, 2016). More recently, this aggregated value has been mostly influenced by fish consumption in Asia, Africa and South America, where the per capita fish consumption increased by 9 %, 5 % and 15 % respectively, between 2007 and 2011 (EUMOFA, 2015). The total global fish production that was used for direct human consumption grew by 20 % (from 67 to 87 %) between 1960 and 2014, supported by significant enhancements in efficiency, lower costs, wider choice, and safer and improved products (FAO, 2016). In 2014, around 13 % of global fish production was destined for non-food use, 76 % of which was transformed to fishmeal and fish oil and used for a number of purposes including for direct feed in aquaculture (FAO, 2016).

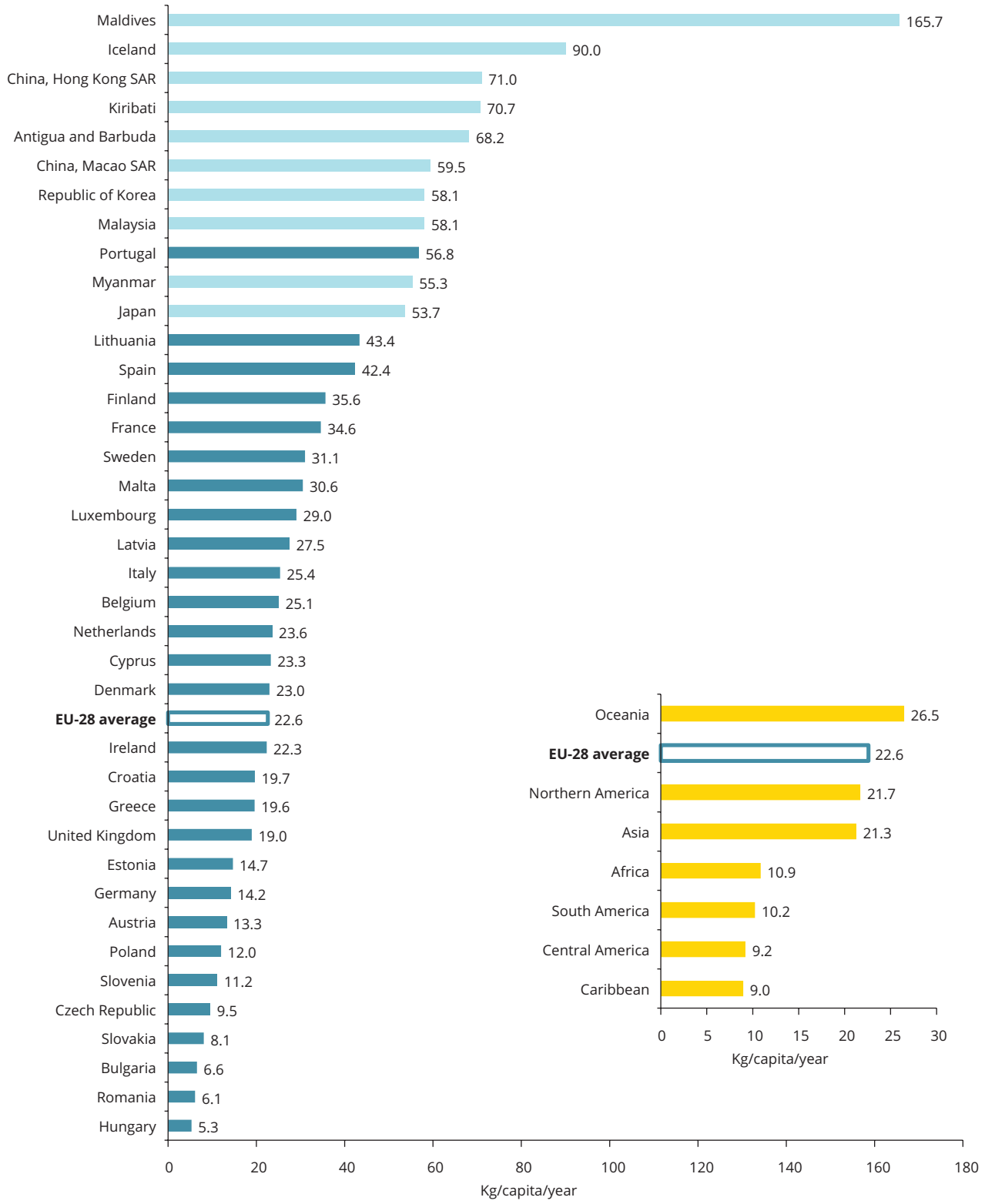
Seafood is also an important source of nutritious food for the EU. The average apparent fish consumption per capita in the EU is the second highest in the world (at around 22 kg/capita/year), and some individual EU Member States have among the highest rates in the world (Figure 2.1). Europeans favour wild fish. In 2014, around 75 % of fisheries and aquaculture products consumed in the EU ([3]) came from marine capture fisheries, which remains consistent with trends over the last decade (EUMOFA, 2015).

In addition to providing a valuable supply of food, fisheries and aquaculture provide income and support livelihoods for many people around the world. An estimated 56.6 million people were engaged in capture fisheries and aquaculture in 2014, the vast majority (87 %) being in Asia (FAO, 2016). The small-scale fisheries sector is estimated to employ around 90 % of the world's fishers, producing almost half of the world's fish and supplying most of the fish consumed in the developing world (FAO, 2016). Since 1990, the number of people employed in capture fisheries has decreased by 16 % (from 83 % in 1990 to 67 % in 2014), while at the same time employment in aquaculture increased by 16 % (from 17 to 33 %) (FAO, 2016).

In the EU, fishing provided about 129 000 jobs in 2014 (STECF, 2015) while aquaculture accounted for about 80 000 jobs in 2012 (STECF, 2014a). Producing and processing fish as food in the EU is still largely dependent on small and medium sized businesses; most of the EU fishing fleet is considered small-scale (74 % of active vessels in 2013); the majority of aquaculture enterprises employ fewer than10 people (90 % in 2012 and with significant part-time employment) and fish processing enterprises fewer than 50 (85 % in 2012) (STECF, 2014a, b and 2015). In several EU regions the fishing sector plays a crucial role for employment and economic activity — in some European coastal communities, as many as half the local jobs are in the fishing sector (Natale et al., 2013).

([2]) The global and European statistics related to fish consumption and trade, by definition, include freshwater fish. Therefore, in this section, 'fish' includes both freshwater and marine fish. 'Seafood' is used when referring to marine fish only.
([3]) Based on own calculations from European Market Observatory for Fisheries and Aquaculture (EUMOFA) data. Includes freshwater species.

Figure 2.1 **The apparent consumption of fish in the EU compared with the rest of the world (food supply quantity as kg/capita/year), 2011**



Note: The FAO item 'fish, seafood', which also includes freshwater fish, was used to create this figure.

Source: FAO, 2016, FAO Food Balance Sheets: Food Supply Quantity.

Seafood is also the most globally traded of all agricultural and food commodities; around 37 % of all fisheries and aquaculture production enter international markets, with developing countries representing a growing portion of this trade (FAO, 2016). The EU plays an important role in this global trade dynamic. It is the largest importer of seafood and fish products in the world, with a market share of 20 % of total global imports between 2013 and 2015, and was responsible for about 6 % of total global exports in the same period (FAO, 2016). Whereas the EU is a net exporter of meat, especially processed products, it is a net importer of fishery and aquaculture products (EUMOFA, 2015). The EU's self-sufficiency in fish and aquaculture products — that is, the capacity of the EU to meet the demand for fish from its own waters — has been around 45 % since 2008 (EUMOFA, 2015).

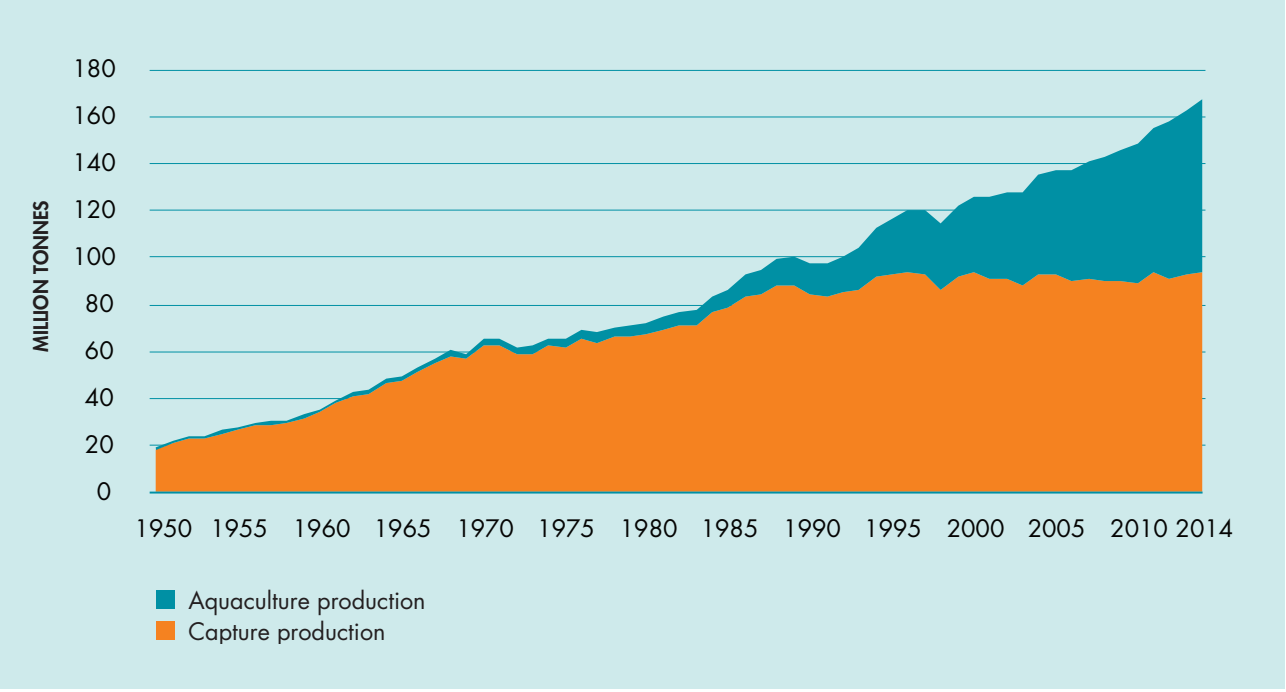
Trends in the production of fish

Since the 1990s, the increase in fish supply has derived from aquaculture ([4]) (inland and marine), which increased from 7 % of global fish supply in 1974 to 44 % in 2014 (FAO, 2016) (Figure 2.2). The year 2014 also marks an important milestone for the world's food supply. For the first time ever, aquaculture provided more fish for human consumption than capture fisheries. China has played a major role in achieving such shift in food supply and currently represents over 60 % of world aquaculture production (FAO, 2016). In contrast, the production of EU aquaculture has been decreasing significantly over time in terms of both volume and value (STECF, 2014a).

By 2030 it has been projected that over 60 % of fish for human consumption will be supplied by aquaculture (World Bank, 2013). However, it is foreseen that productivity gains in aquaculture will be affected by the availability of and accessibility to land and marine spaces, financial resources, improvements in technology and accessibility to feed (OECD/FAO, 2015).

Global capture fisheries reached their peak production of 86.4 million tonnes in 1996 and have generally stabilised since then (Figure 2.2). Today, most fish stocks are being used at or above their sustainable levels (see Figure 2.3). Global numbers since 1974 depict an increasing trend towards overfishing (FAO, 2016). In 2013, around 89 % of the world's fisheries were either fully fished (58 %) or overfished (31 %), leaving only around 10.5 % underfished (FAO, 2016).

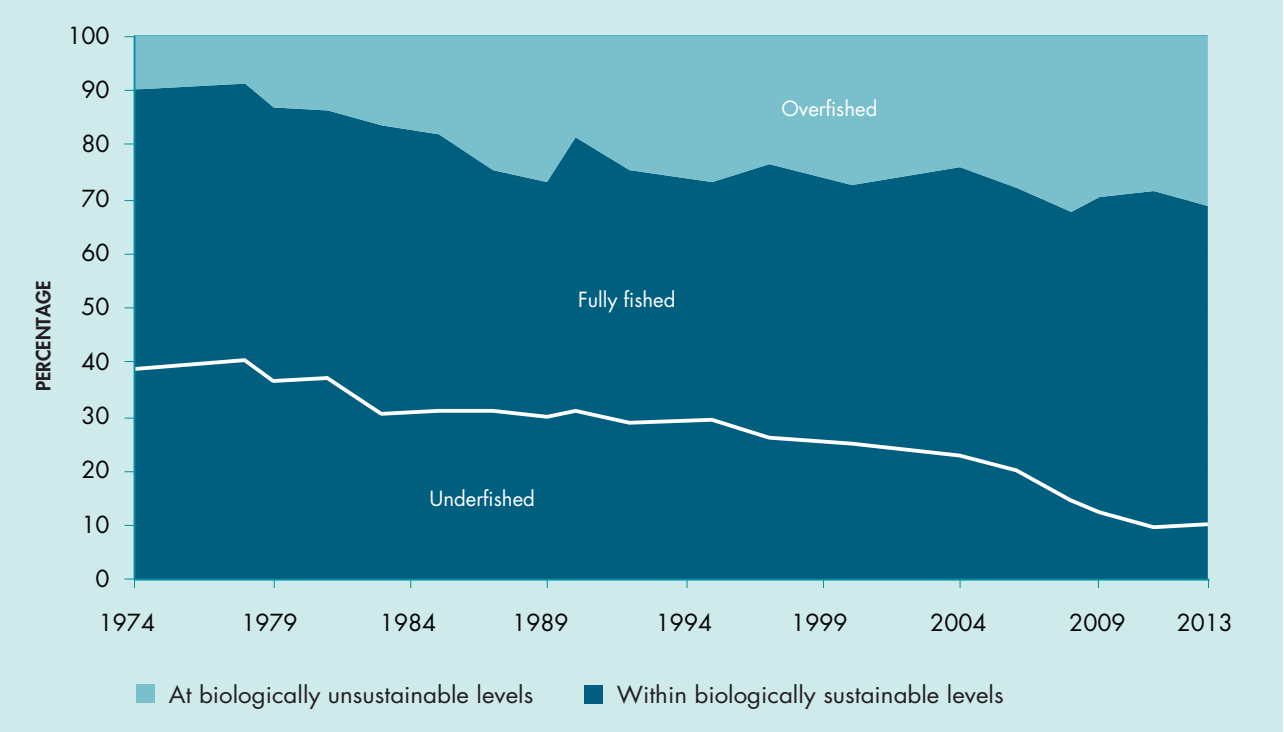
Figure 2.2 World capture fisheries and aquaculture production



Source: FAO, 2016.

([4]) Freshwater aquaculture is also seen to have an increasing role in food security, but its analysis is beyond the scope of this report.

Figure 2.3 Global trends in the state of world marine fish stocks

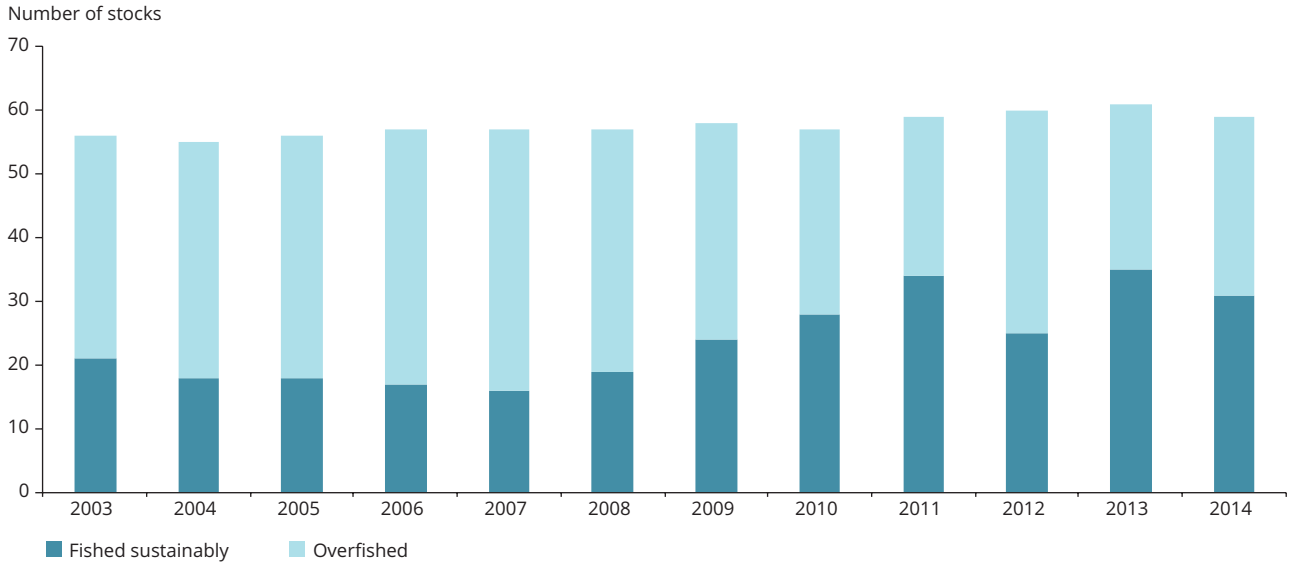


Note: Dark shading = within biologically sustainable levels; light shading = at biologically unsustainable levels.
The light line divides the stocks within biologically sustainable levels into two subcategories: fully fished (above the line) and underfished (below the line).

Source: FAO, 2016.

In Europe's seas, overfishing levels (defined as fishing above maximum sustainable yield) remain high overall: 50 % in the EU's north-east Atlantic Ocean and Baltic waters, and over 90 % in the Mediterranean and Black Seas in 2014 (STECF, 2016a). Many stocks have been recovering since 2003, largely as a result of better management and significant progress towards fishing at maximum sustainable yield in the EU's north-east Atlantic Ocean and Baltic waters (Cardinale et al., 2013; STECF, 2016a) (see Figure 2.4).

Figure 2.4 Trends in the state of European fish stocks in the north-east Atlantic Ocean and Baltic waters



Note: The figure shows number of assessed stocks in the north-east Atlantic Ocean, North Sea and Baltic Sea in EU waters and contiguous shared stocks, showing numbers of stocks fished sustainably (current fishing mortality is at or below maximum sustainable yield (MSY) or overfished (current fishing mortality is above MSY).

Source: Based on STECF, 2016b.

The broader horizon for seafood provision and access

The state of coastal and marine ecosystems is of concern globally. Despite this, increasing, multiple uses of the global ocean continue to create further pressure on already vulnerable ecosystems (EEA, 2015c; UN, 2016).

Economic ambitions for new or increased use of marine spaces (e.g. offshore wind farms, mining and biotechnology) are growing, and oceans are often looked at as a means to help meet growing global demand, not just for food, but also for energy, raw materials and, ultimately, income and jobs (OECD, 2016). In the EU, this is demonstrated by the Blue Growth strategy, which is the long-term strategy to support sustainable growth in the marine and maritime sectors (EC, 2012). This growing interest in the oceans, both globally and in the EU, is likely to bring further constraints on fish production by increasing competition for the same areas and, in some cases, resources. It will be necessary to coordinate various activities taking place in a particular region, to recognise their cumulative impacts and to harmonise sustainability goals and legal frameworks. This means increased international ocean governance will be required for coordination across sectors, and ensuring sustainability goals as well as social and economic objectives are pursued and achieved (FAO, 2016).

Climate change is bringing further uncertainty to the supply of seafood by exacerbating impacts in the marine environment, namely through warming and acidifying waters. Warming waters are causing marine species to move to colder, more northerly regions. Many of these have commercial value and are targeted by fisheries (EEA, 2015c). Recognising the growing importance of climate change for specific challenges, the United Nations' Intergovernmental Panel on Climate Change (IPCC) has determined that food security and the world's oceans are of particular importance and will be giving these areas special attention over the coming years. The IPCC has found that oceans require a more explicit focus than in the past, and so governments and policymakers need to better understand the consequences of climate change on marine ecosystems (CarbonBrief, 2016).

Finally, the increasing interconnectedness and interdependency of countries through international trade will continue to be key in shaping the patterns of production, distribution and consumption of seafood. The unbalanced global distribution of fisheries and aquaculture production causes seafood to be a highly traded commodity and thus influenced by market dynamics. In addition, global demographic and socio-economic trends such as a growing and increasingly affluent population and rising urbanisation, are shifting consumption and production patterns (GO-Science, 2011; EEA, 2015a). Already seafood consumption is on the rise in developing counties, especially in Asia, which poses new questions and potential challenges for the global provision and access to seafood (FAO, 2016).

2.2 Taking a food system approach

The increased understanding of the complex nature of our patterns of finding, processing and eating food has called for the examination of food from a much broader and integrated perspective, based on a food system approach (Ericksen, 2007; Ingram, 2011; UNEP, 2016).

A food system can be defined as 'all the elements (environment, people, inputs, processes, infrastructures, institutions etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes' (HPLE, 2014). The food system is thus defined by both the human activities that link the production to the consumption of food (i.e. along the length of the food supply chain) and the outcomes of these activities.

Food system outcomes

Food security is a core purpose of the food system (see Box 2.1 for a definition) but it has long been considered almost exclusively with respect to hunger, malnutrition and humanitarian questions (Maggio et al., 2015). This association has generated a conceptual divide between undernourished and nourished people, hiding the interplay of the problems affecting both. Food security is now increasingly seen from the perspective of access to food and of its nutritional value, whichmoves away from the previous paradigm of focusing on the production of food (Ericksen, 2007; Gustafson et al., 2016).

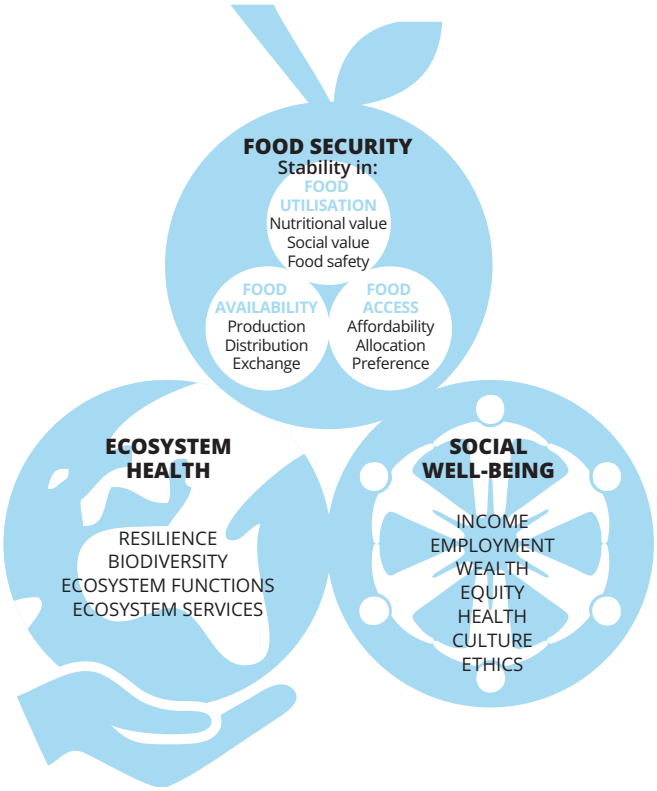
The activities involved in the food system affect a number of outcomes beyond food security, relating to ecosystem health and social well-being (see Figure 2.5). These food system outcomes all have important environmental and socio-economic feedback dynamics that influence how the food system is operating (Ingram, 2011; Maggio et al., 2015; UNEP, 2016).

Food system actors and activities

The food system is made of activities across the food supply-chain, from producing to processing, distributing and consuming food. Food system actors represent the largest group of natural resource managers in the world, and as such they are critical in both creating the problems and implementing solutions to them (UNEP, 2016). In addition to the actors that are directly involved in food chain activities, governments and civil society are also part of the food system as they set the wider policy and societal context for food chain activities. Acknowledging the roles of the actors in the food system is an important factor in identifying opportunities and pathways for enhanced food security, ecosystem health and social well-being.

The activities and actors involved in the food system can have different arrangements. Current food systems vary across the globe, from modern food systems in industrialised regions to more traditional food systems

Figure 2.5 Food system outcomes



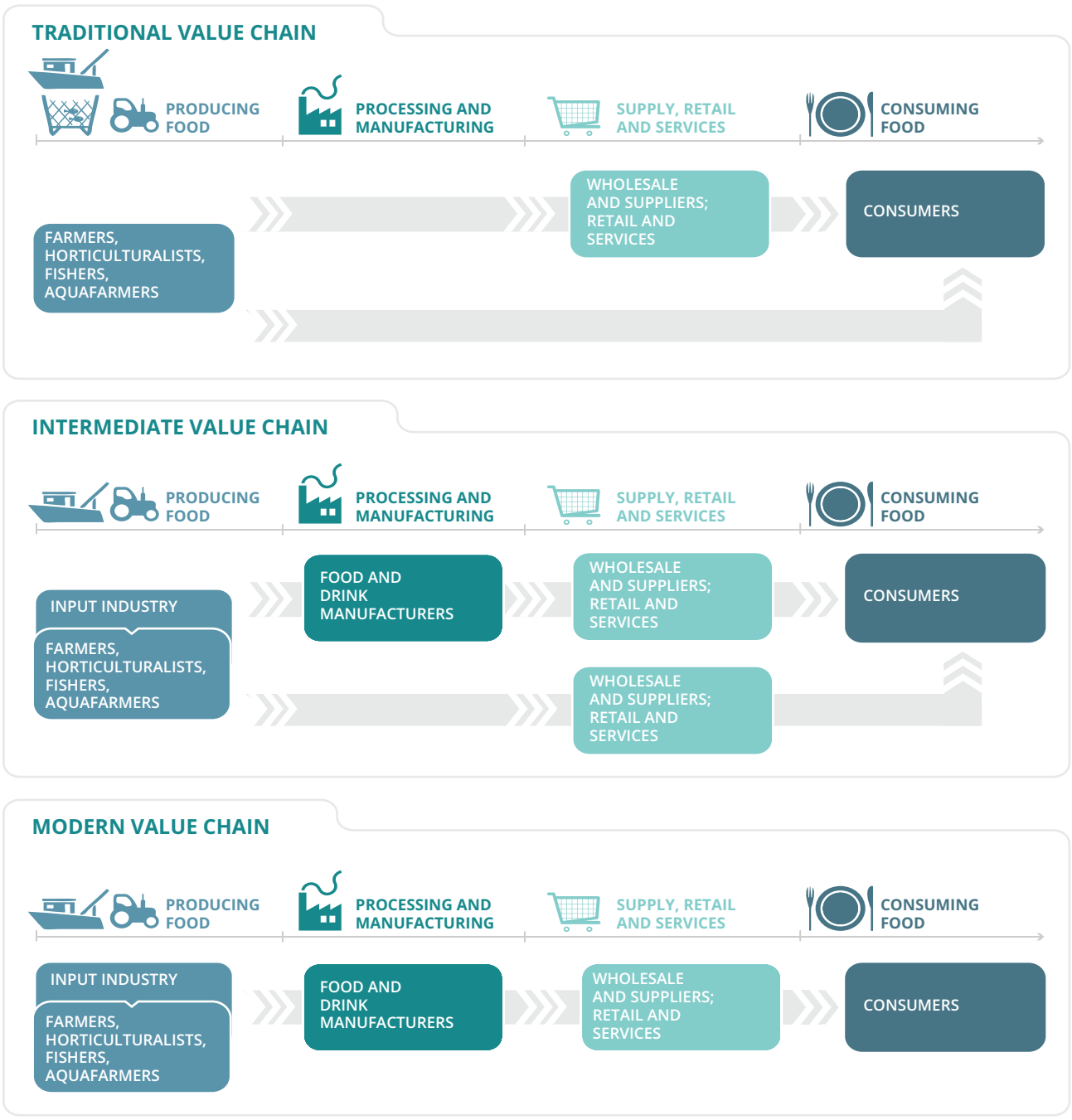
Source: EEA based on Ingram, 2011 and UNEP, 2016.

Box 2.1 Definition of food security

One of the most widely accepted definitions of food security is the conditions whereby 'all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (UNEP, 2016; after the definition of the Committee on World Food Security (CFS) — FAO, 2009).

in rural areas in developing countries (Figure 2.6). While Europe's food system mostly has a modern food chain there is also diversity, with different value chains coexisting that pursue different objectives at different scales but with multiple interactions and feedback loops. The differences between them influence the pathways to a sustainable food system and the logic of interventions, as the characteristics of the system and the drivers of change can differ. However, the main model of a modern food supply-chain sets the landscape and influences much of the policy discussion around sustainability in Europe's food system.

Figure 2.6 **Main configurations of the actors and activities of the food system**



Source: EEA based on UNEP, 2016.

2.3 Exploring sustainability in the food system

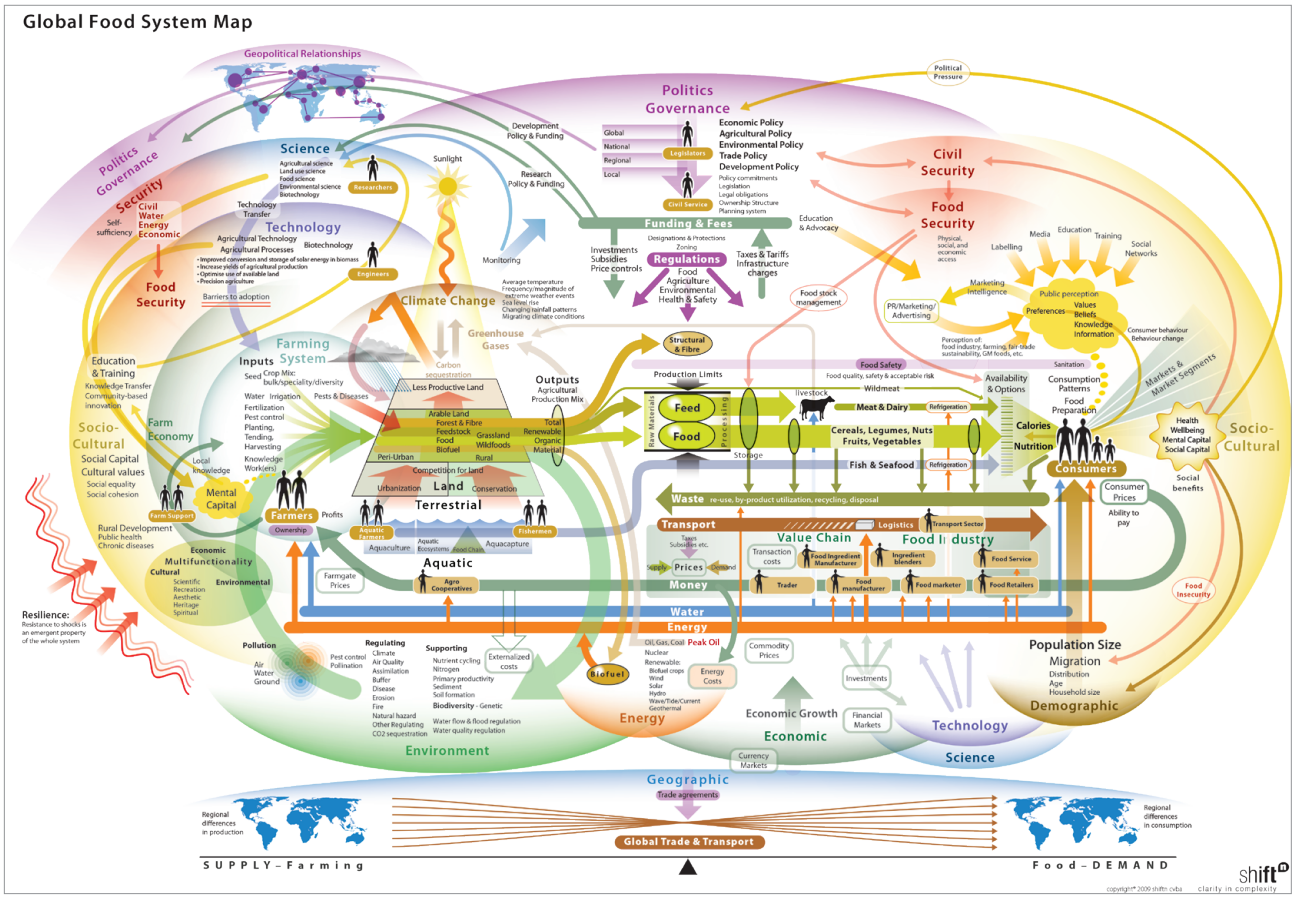
The journey of food from where it is produced until it reaches our forks can touch upon many realms, from the environment and politics to demographics and the economy. Actors in the food system are diverse and involve the private and public sphere, and their activities take place at different geographical scales. Figure 2.7 illustrates the complexity of today's food system, by pointing to the multiple two-way interactions between food-system activities and their outcomes, and the range of external drivers affecting the system. This illustration also shows that inevitably, there are many ways to look at food system problems and many potential solutions.

Whether one considers the food system to be successful, depends on the desired outcomes. From the consumer perspective, the primary function of the food system may be to supply food of the desired type, quantity, quality and price. From the perspective of the farmer or food processor, the food system's main function may be as a source of employment and income. For rural and coastal communities, the system may play a key role in social cohesion, land and marine space use and traditions. For an environmental manager, the food system might be seen as a threat to ecosystem health whose pressures on natural resources need to be minimised. It is vital to attempt to articulate what a sustainable food system is to understand where and how to act to change its outcomes.

A sustainable food system has been defined as a system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised (HLPE, 2014).

The EU and its Member States have articulated a sustainability vision 'to live well within the limits of our planet' by 2050 and to do so by transforming into a green economy, which addresses the multidimensional challenges of resource efficiency, ecosystem resilience,

Figure 2.7 An illustration of the complexity of the global food system and its multiple interactions



Source: shiftN.

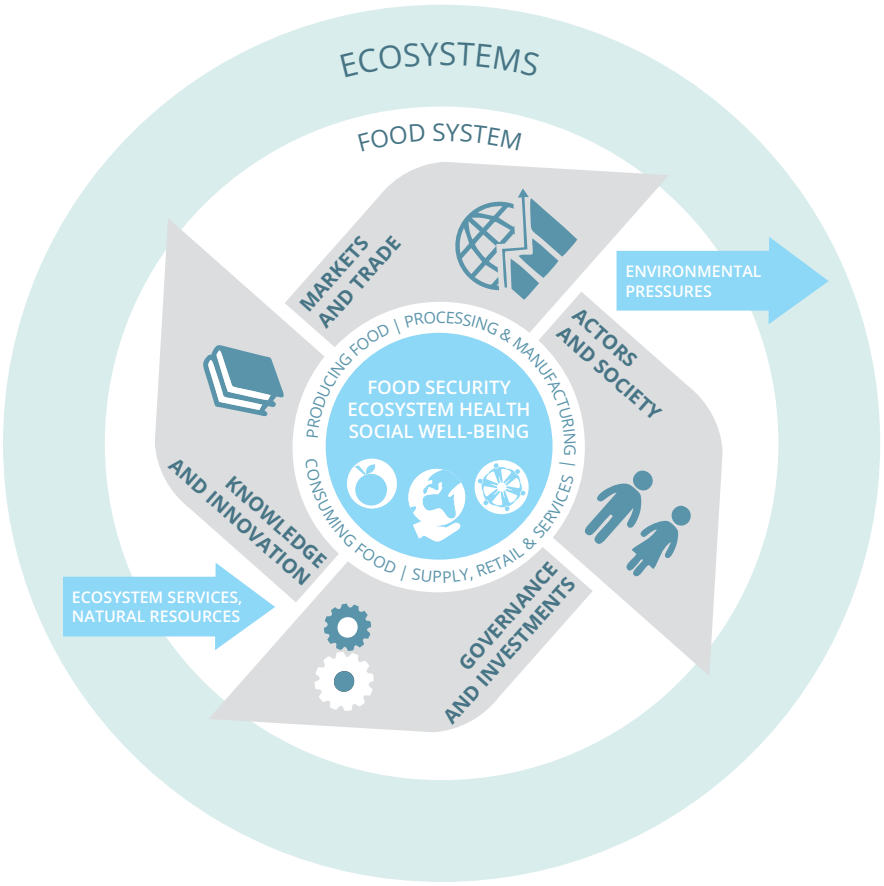
human well-being, equity and good governance (Box 2.2). Such vision and strategic direction for the EU's sustainable development entails change in current ways of producing and consuming products and services. In relation to the food system, transforming it to optimise the outcomes of food security, ecosystem health and social well-being for sustainability involves changing the way activities are undertaken (Ingram, 2011). Changing the activities in the food supply-chain entails examining values, motivations and methods across food system activities, from the production of food to its consumption, in order to identify options that support the transformation to a green economy.

Figure 2.8 provides a conceptual framework through which this report will explore sustainability in Europe's food system and its demand for seafood, and pathways for systemic change. Based on the EU's 2050 vision for sustainability and the green economy dimensions, the proposed framework identifies key

Box 2.2 Sustainability dimensions of the green economy

The concept of a green economy is seen by the EU and other international organisations as a strategic approach to the systemic challenges of global environmental degradation, natural resource security, employment and competitiveness (EEA, 2015b). Europe's 7th Environment Action Programme aims to stimulate the transition to a green economy and strives towards an absolute decoupling of economic growth and environmental degradation (EC, 2013a). The green economy approach emphasises economic development that is resource efficient, within environmental limits and equitable across society. It requires economic, environmental and social goals to be pursued simultaneously. This is a long-term, multidimensional and fundamental process of change that will necessitate profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking.

Figure 2.8 Conceptualising Europe's food system from a sustainability perspective



Source: EEA.

areas that can influence systemic change in the food system i.e. that can affect the food system activities and actors, their interactions and ultimately outcomes in terms of food security, social well-being and ecosystem health. The four areas are 'Knowledge and innovation', 'Markets and trade', 'Actors and society', and 'Governance and investments'. There are porous boundaries between these different areas for inducing systemic change and between the ways in which they influence the activities and outcomes of the food system. Hence, the proposed framework should be seen as a compass that steered and informed the analysis in Chapters 3 and 4 rather than a linear cause-effect blueprint.

3 Interactions in the journey of fish to fork

This chapter aims to show that long-term seafood security for the EU requires a fuller understanding of different factors underpinning seafood production, distribution and consumption. Its objective is not to undertake a comprehensive analysis of the food system. Instead, it examines the relationships that make seafood available to European citizens today and which are important for ensuring future access to and availability of this healthy source of food in a way that matches Europe's vision of a sustainable society. Since the EU is a net importer of seafood, the analysis brings particular focus to interactions between the EU and the rest of the world, and the multiple interactions in the global food system that enable the journey of fish to fork. The assessment also explores the influence of EU policies and initiatives related to seafood in bringing greater sustainability to its production and consumption patterns.

The sustainability aspects examined include (1) the influence of international trade in seafood production, in particular how it hides local ecosystem constraints and its unintended consequences for illicit fishing; (2) aquaculture feed as a key link between fisheries, aquaculture and land ecosystems; (3) the sustainability challenges and opportunities posed by a globalised seafood supply chain; and (4) the role of market incentives and consumer choices for sustainability in seafood.

3.1 The influence of international trade on seafood production

International trade hides local ecosystem constraints for seafood production

A large proportion of seafood is consumed far from where it was produced thanks to today's globalised economies and their sophisticated networks of trade relationships and complex supply chains. Global markets and international trade are essential components of today's food system and in particular in the supply of the world's major seafood markets such as the EU, Japan and the United States, which are largely dependent on seafood sources far beyond their domestic waters (Swartz et al., 2010). The EU imported around 55 % of its seafood in 2013 from all continents of the world (see Figure 3.1).

The role of international markets and trade in influencing the social, environmental and economic outcomes of seafood production and consumption is increasingly being recognised (Asche et al., 2015; Crona et al., 2016). Technological developments, such as in information technology and the transport systems that underpin today's global market for seafood, have made it possible to connect consumption and production systems worldwide. However, the increasing complexity of markets for seafood has led to significant information and knowledge gaps about these markets. For example, the flow of fish from where it is caught or produced to where it is consumed is still not well understood (Watson et al., 2015). Poor traceability within current global seafood supply chains has implications for ethical and sustainable production practices, as local ecologically and socially relevant feedbacks are mostly missing in the present system and cannot be inferred from trade data and economic indicators such as national supply balance (Asche et al., 2015; Béné et al., 2016).

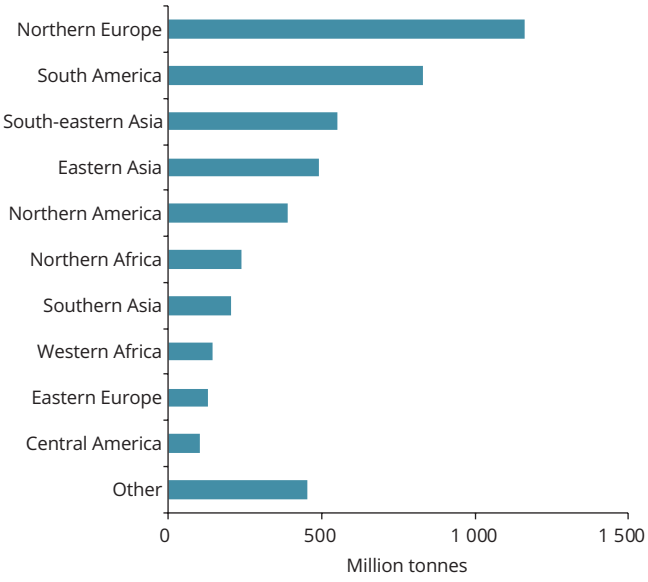
International trade enables the development of different exploitation patterns to meet the ever-growing demand for seafood, namely through substitution or the sequential exploitation of resources (Deutsch et al., 2011; Eriksson et al., 2015). Today, seafood can be harnessed from different fish stocks, species and ecosystems so that global consumers can meet their demand for preferences on a regular basis, while generally being oblivious to local environmental or social constraints (Crona et al., 2015, 2016). These dynamics of global trade are particularly harmful for fisheries, whose productivity is greatly influenced by the natural capacity of fish stocks to replenish themselves and the capability of ecosystems to withstand fishing pressure (and other human pressures) and remain in a healthy state.

Cod, one of the most consumed fish species in the EU, is one species for which the role of market and trade dynamics has been investigated. Crona at al. (2015) investigated how weak signals about the state of local cod fisheries and ecosystems are hidden by

market dynamics. The study showed how UK imports of Atlantic cod from Iceland and the Faroe Islands have helped to keep the supply of cod in the United Kingdom steady while the regional stocks in the North Sea were declining and on the brink of collapse. The research also showed this weak signal of declining stocks of North Sea cod was further enhanced by substitution with other whitefish, with only moderate effects on cod's retail price. More importantly, consumers' abilities to perceive price changes resulting from these complex market mechanisms and interpret them as a reflection of the ecological status of cod were considered limited (Crona et al., 2015).

The study on North Sea cod illustrates how the current functioning of the market and trade disconnects local ecosystems from consumers. This disconnect makes it difficult for consumers, as well as other actors in the supply chain, to make responsible choices, both environmentally and socially. The impacts of international trade on individual fisheries go beyond effects on fish stocks and affect the activities and local communities that depend on them especially in small-scale fisheries, which constitute a major element of today's food system (Crona et al., 2016). As such, there is a need to better understand the distributional impacts and benefits of the increasing globalisation of the seafood trade, namely in terms of equity (Asche et al., 2015).

Figure 3.1 Top 10 regions exporting to the EU-28 (tonnes), 2013



Note: The specified 10 regions represented around 90 % of the total exports to the EU in 2013, but the EU trades with all of the regions of the world (the imports from the remaining regions are under 'other').

Source: Based on FAO, 2016; FAO Food Balance Sheets: Food Supply Quantity.

The EU's exposure to illicit fishing through international trade

The existence of illegal, unreported and unregulated (IUU) fisheries is enabled by a lack of traceability in the supply chain and markets (Flothmann et al., 2010). An unintended consequence of the expansion of international trade is that it has created a complex environment that facilitates IUU fishing. Although difficult to quantify, IUU fishing is estimated to represent more than 15 % of world catches and its impact can be seen across the world (Agnew et al., 2009; FAO, 2016). IUU fishing is a major threat to marine ecosystems, food security and livelihoods in many countries, and undermines the efforts of legitimate fishing operators.

The EU is the world's largest seafood importer, which makes it a valuable destination market for illegal fishing operators (EJF, 2013). Around 50 % of the global seafood trade (by value) comes from developing countries, where IUU fishing is more difficult to track and control (FAO, 2016). IUU fishing is most common in the waters of developing countries that lack either the capacity or the political will to apply good governance to fish resources and put in place a robust fisheries management regime and proper control and surveillance of their waters (EJF, 2013).

Being the world's most valuable seafood market also puts the EU in a powerful position to foster sustainability and equity outside its borders. The EU has been taking an active role against IUU fishing since 2010. The EU IUU Regulation provides a framework that allows illegal fish to be seized in European ports, encourages flag states (i.e. where fishing vessels are registered) to improve their monitoring and control, and encourages the engagement of coastal states in protecting their marine resources.

In spite of difficulties in the implementation of this EU regulation, improved control measures are in place in both importing Member States and third countries that export to the EU (European Parliament, 2013). Illegal operators are also being deterred through its 'carding system' (see Box 3.1 for a testimonial from the Environmental Justice Foundation (EJF)). The IUU Regulation is considered to have placed the EU at the forefront of global efforts to address illicit fishing (European Parliament, 2013; IUUWatch, 2016). However, flag states without adequate controls over their fishing fleets, and whose vessels are engaged in IUU fishing, are continuing to export fish that can enter the EU (EJF', 2014); therefore, addressing IUU fishing requires a sustained and coordinated effort that includes governments, civil society, the seafood industry and other stakeholders.

Box 3.1 The EU IUU Regulation as a catalyst of sustainability and equity in external waters: an Environmental Justice Foundation testimonial

The EU IUU Regulation has become, in the EJF's view, the single most effective and important tool employed today in the global effort to combat IUU fishing. Among the many features of this regulation, the EU has put in place a 'carding system' that not only is proving very effective in eradicating the scourge of IUU, but is also acting as a driver for change towards the environmental, social and economic sustainability of fisheries around the world, decreasing the conduct of IUU activities and in turn the number of illegal products in the world's largest single market for seafood, the EU (EJF, 2012).

One example of the effectiveness and positive impact of the EU Regulation to combat IUU and drive better fisheries management is the case of South Korea. South Korea is one of the main long-distance fishing fleets in the world, with vessels operating in every region of the world, including West Africa. For many years, South Korean industrial vessels operated illegally and without control in the inshore exclusion zones off the coast of Liberia and Sierra Leone, depleting marine biodiversity in these rich fishing grounds and damaging food security and the livelihoods of artisanal fisher communities dependent on these resources. A key factor in the ability of the South Korean distant water fleet to operate in this way was the complete lack of any meaningful governance applied by South Korea as the flag state. Distance and disinterest on the part of political authorities in Seoul had left South Korean vessels free from restrictions on their activities.

Having been made aware of the considerable abuses taking place in West African waters and knowledgeable of the vulnerability of the region to IUU fishing, the European Commission initiated investigations into these abuses and South Korea's role as a flag state (EJF et al., 2015). A dialogue was established with the country's competent authorities, initially resulting in the imposition of a 'yellow card' by the Commission in 2013 (EC, 2013b). This yellow card is an official warning that the country may be considered as 'non-cooperating' in the fight against IUU and therefore calls for ambitious reforms of its fisheries governance and management system. The European Commission helps the country in the process of change, by jointly drafting an action plan and advising the country on how to implement it. If the yellow-carded country refuses to establish the necessary policies and legislation, the EU issues a 'red card', which carries with it several sanctions, among them a trade ban on fishery products exported to the EU and the prohibition for EU vessels to fish in the waters of the country that has been carded.

Photo: © Environmental Justice Foundation (EJF)

Box 3.1 The EU IUU Regulation as a catalyst of sustainability and equity in external waters: an Environmental Justice Foundation testimonial (cont.)

However, the key aim of this process is not punitive, but is rather for the EU to be a constructive, powerful driver for change. Hence, the 'red card' is always a last resort and used only in the most extreme circumstances. Conversely, if the carded country collaborates and implements reforms, it is delisted and supported in this process.

South Korea was willing to undertake essential changes. Within a year and a half of being yellow carded, Seoul amended its outdated fisheries law, including the aim to achieve greater control as a flag state and provisions against South Korean individuals and companies involved in IUU activities, even if flying foreign flags. The amended law also forbade long-distance fishing in countries in which control of the waters could not be properly ensured by their governments (such as Somalia). South Korea also put in place a state of the art vessel monitoring system by satellite and a fisheries monitoring centre that allowed it to monitor each of its vessels in real time, no matter where and when they were fishing. The country launched a decommissioning programme to buy back vessels operating in West Africa.

For a country for which long-distance fishing is an important economic sector and part of its history, such a fundamental change proved difficult and took time, but the political will of South Korea and the assistance of the EU eventually led to the accomplishment of the action plan, and the country was successfully delisted in April 2015 (EC, 2015b). As a result, West African waters have seen a huge reduction in South Korean pirate fishing, and the number of IUU products in the supply chains of both the South Korean and the EU markets has shrunk. A fundamental improvement of South Korean fisheries governance is now in place and the country is ready to become a new leader in a part of the world, East Asia, where many countries also play an important role in long-distance fishing, thus having the potential to create a multiplying positive effect.

Many other countries have undergone this process within the scheme of the EU IUU cards, and most of them have successfully implemented the much-needed reforms: Belize, Fiji, Ghana, Panama, Papua New Guinea, Philippines, Sri Lanka, Togo and Vanuatu and have been either yellow or red carded and eventually managed to get delisted, all with the technical assistance of the EU. In the case of developing countries, EU aid was also provided. In general, after the process, these now 'green-carded' countries are often grateful to the European Commission, as the card was the means to implement major improvements in their fisheries governance, which in many cases would not have happened otherwise. The new policies allow developing coastal countries to preserve and conserve healthy fishing grounds and to increase the revenue stemming from legal and controlled fishing in their waters. However, there is still some work to do with other countries that remain yellow or red carded at the moment; both Cambodia and Guinea are currently holding a red card, and the following countries are currently holding yellow cards: Curaçao, Kiribati, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Sierra Leone, Solomon Islands, Comoros, Taiwan, Thailand, Trinidad and Tobago and Tuvalu.

3.2 Aquaculture feed connects fisheries, aquaculture and land

Globally and within Europe, aquaculture is looked towards as an answer to meeting the growing consumer demand for fish. If aquaculture is to support the increased demand for food in a way that adds resilience to the global food system it needs to adequately capture and monitor the interactions with the marine ecosystem beyond what happens at the farm level (Troell, 2014). One such interaction is the use of feed resources in aquaculture.

Shellfish species such as mussels, oysters and clams that filter water for their nutrition do not need manufactured feed. On the other hand, farmed fish and shrimp can require significant amounts of fishmeal and fish oil in their diet (Tacon and Metian, 2015). Fishmeal and fish oil are manufactured from marine feed ingredients, which are mostly produced from wild fish (75 %), in combination with by-catch or fish trimmings (25 %) (IFFO, 2014). Therefore current aquaculture production from carnivorous fish species such as salmon, seabass, seabream and shrimp still relies significantly on already limited capture fisheries for feed input.

The dependency of aquaculture on wild fish stocks for feed has triggered changes in the sector, in particular in the production of carnivorous fish species, such as salmon and most other marine species produced in aquaculture, which require significant amounts of fishmeal and fish oil in their diet (Purchase and Dom, 2015). Forced by increasing prices and the limited availability of raw material, linked to the fast growth of aquaculture at the global level, the use of marine ingredients in aquaculture feed has been decreasing and progress in developing feed alternatives has

been made (e.g. plants, insects, microbes, algae, by-products) (Rana et al., 2009; Tacon and Metian, 2015; Ytrestøyl et al., 2015). The dependency on feed for salmon production, one of the most consumed species in the EU, is explored in Box 3.2. At the same time, the fish meal industry is working towards greater responsibility with regard to sustainable sourcing of feed ingredients, with over one third of the world production coming from 'The Marine Ingredients Organisation' (IFFO) responsible supply standard' certified factories (Jackson, 2012). The IFFO standard is an independently audited certification standard that is based on the Food and Agriculture Organization of the United Nations (FAO) Code of Responsible Fishing (Pike and Jackson, 2010).

Research and innovation are accelerating progress towards reducing fishmeal and fish oil use in aquaculture feeds, while maintaining the important human health benefits of seafood consumption. Nonetheless, aquaculture is likely to continue to rely on the inclusion of some marine ingredients, which, for the foreseeable future, will remain highly in-demand ingredients in aquaculture feed (FAO, 2016). As such, monitoring the influence of aquaculture of fed-species on wild stocks is and will remain paramount for the sustainable development of aquaculture. Our present knowledge on the interaction between aquaculture and fisheries is however limited by the lack of traceability between these activities and their management.

Traceability between the fish stocks targeted for non-food use and the fishing fleets catching them is limited at present, with data partly available through national statistics or IFFO ([5]) communications. Publically available statistics on fish for the EU (EUMOFA, 2016) and at the global level (FAO FishStat, 2016) only allow the last point of sale for imports of fish at the species level to be identified or for the fish to be categorised as non-food use. The link between the fish stocks targeted for feed, the actors processing the fish for fishmeal and fish oil, and the aquaculture companies buying the feed for their production is thus not monitored at present. This lack of traceability hinders an adequate assessment of the fishing pressure exerted on fish stocks for non-food purposes. Therefore, there is limited understanding of how much pressure fed aquaculture is putting on wild fish stocks, where the targeted stocks are — and who is responsible for their management — as well as how to balance fishing pressure according to the state of the targeted stocks for fishmeal and fish oil. This is essential knowledge for the sustainable management of fisheries and for food security.

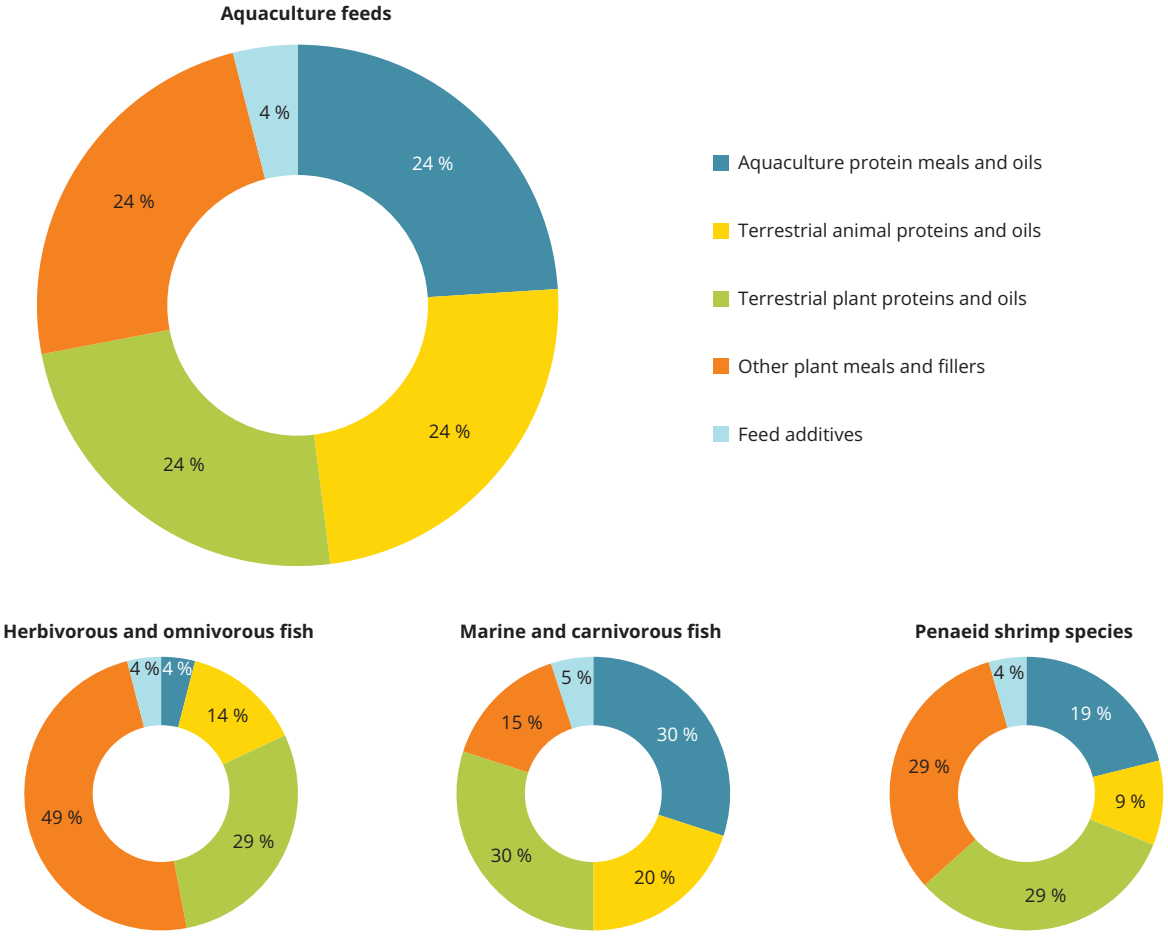
The assessment of the interactions between aquaculture feed and land ecosystems is also insufficient at present. Production innovations may be reducing reliance on wild fish caught for aquaculture feed, but this in turn will likely increase dependency on land-based ingredients. As shown in Figure 3.2, currently land-based ingredients are a big part of different types of aquaculture feed. As aquaculture production continues to grow worldwide, competition with land-based production can be expected. Already the most commonly used alternative to fishmeal is soya meal (see also Figure 3.3 in Box 3.2), which is produced in large quantities in China, as well as in North and South America. In addition, inclusion of terrestrial ingredients in aquaculture feed has implications for land and freshwater requirements, with consequential issues for biodiversity, soil erosion and deforestation, and will have other potential environmental impacts (Lane et al., 2014).

The dependency on terrestrial ingredients in aquaculture feed has led the FAO to state that 'Although the discussion on the availability and use of aquafeed ingredients often focuses on fishmeal and fish-oil resource, considering the past trends and current predictions, the sustainability of the aquaculture sector will probably be closely linked with the sustained supply of terrestrial animal and plant proteins, oils and carbohydrates for aquafeeds' (FAO, 2012). Nevertheless, the dependencies on the land required for aquaculture feed production, and how changes in the global food landscape can affect the availability and price of both marine and terrestrial ingredients used in this type of feed remain under-investigated.

In summary, given the global food landscape, the critical role of aquaculture in supplying food for Europe and beyond is undeniable. In addition, while all animals need to eat and most farmed animals need to be fed, aquaculture represents the most efficient method by which to convert feed to edible protein (Welch et al., 2010; Brummett, 2013; Waite and Kaushik, 2014). Nevertheless, the development of aquaculture needs to better capture less visible interactions with marine and land ecosystems, such as those with wild fish and terrestrial plant production, if it is to develop sustainably.

([5]) IFFO is the international 'not for profit' organisation that represents and promotes the fishmeal, fish oil and wider marine ingredients industry worldwide.

Figure 3.2 Typical levels of major categories of feed ingredients within compound aquaculture feeds



Source: Based on Tacon and Metian, 2015.

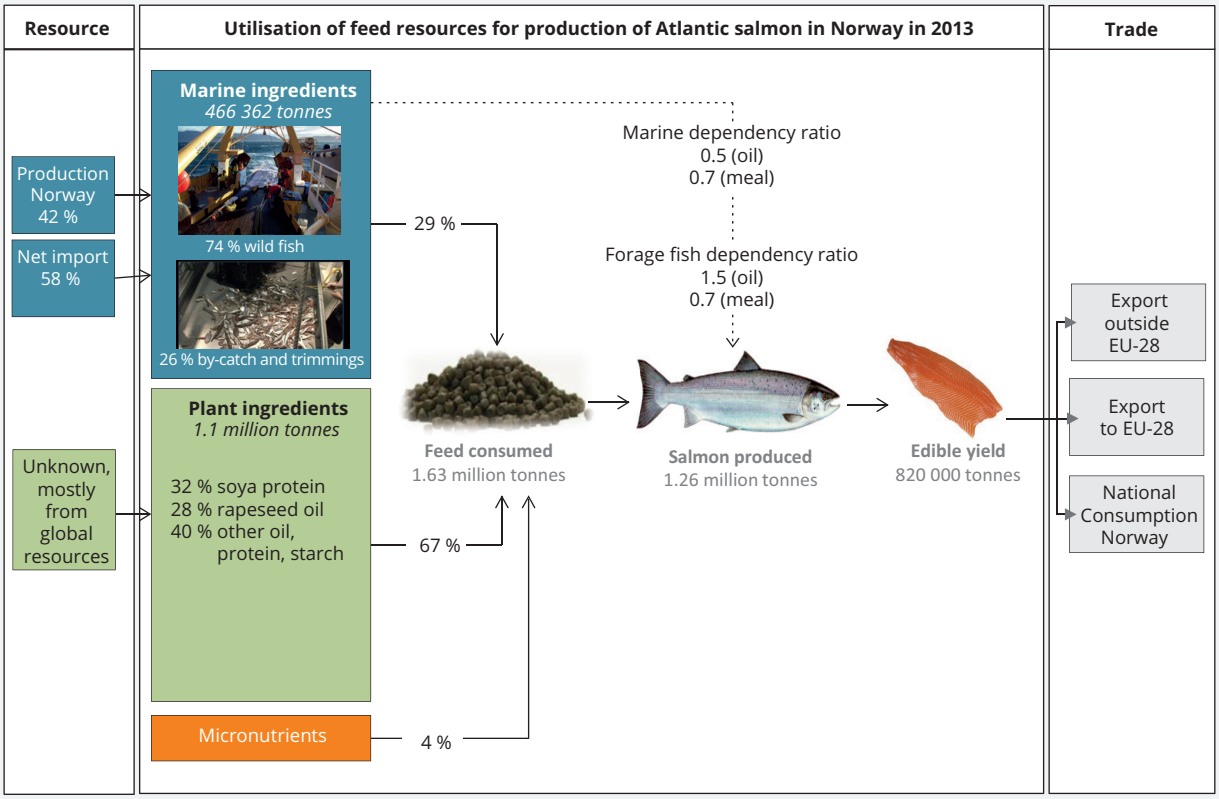
These are important considerations for the development of aquaculture in Europe, which is a strategic priority for the development of its blue economy (EC, 2012). In addition, food security is a core objective of the new EU Common Fisheries Policy (CFP). Balancing the fishing capacity of the fleets with fishing opportunities is currently a management objective of the CFP (EC, 2016a). This policy has also included the management of aquaculture since 2014, making it possible to address important 'blind spots' that exist in the relationship between fisheries and aquaculture, such as those related in this section to aquaculture feed production. However, to this day, most efforts have focused on ensuring the adequate environmental management of aquaculture operations (EC, 2016b). Although this is a critical requirement for the sustainable growth of the sector, the current policy and research debate around the sustainable development of aquaculture in Europe still lacks an integrated approach to aquaculture and fisheries.

Box 3.2 Salmon production and the demand on marine feed ingredients

With a production of 217 000 tonnes, Denmark is the largest producer of marine ingredients in the EU and is ranked seventh globally (IFFO, 2014). The majority of fishmeal and fish oil produced in Denmark is used in the region Europe (> 60 %), in particular for salmon production in Norway (> 30 %), while a fraction (> 15 %) is exported outside the boundaries of Europe (e.g. to China). Salmon consumption is high in the EU (1.97 kg/capita/year), but most salmon production takes place outside EU borders. Of the 1.4 million tonnes of Atlantic salmon produced in the region Europe in 2013, only 12 % is produced in the EU (in the United Kingdom and Ireland), with 81 % produced in Norway and 6 % in other European countries (e.g. Faroe Islands and Iceland) (FAO Fishstat, 2016). Hence, Norwegian salmonid culture puts significant pressure on the total demand for marine ingredients (Figure 3.3).

Between 2010 and 2013, Norwegian salmonid production increased by 30 %, but because of a lower inclusion of marine ingredients in the diet, the total amount of marine ingredients used for salmon feed production decreased from 544 000 to 466 000 tonnes (Ytrestøyl et al., 2015). Of the total fishmeal and fish oil used, around 60 % was imported (IFFO, 2014), which makes Norway the second largest importer of marine ingredients worldwide. In total, 74 % of marine ingredients used in salmonid culture originated from fisheries, of which 30–35 % was of North Atlantic origin (mainly capelin and sprat), whereas 37 % came from anchovy fisheries in South America (Ytrestøyl et al., 2015). The dependency on wild fish to produce salmon has decreased significantly over the last two decades and salmon aquaculture is now a net producer of marine proteins (although not yet for fish oil), measured using the Forage Fish Dependency Ratio (FFDR) for fishmeal and fish oil (FFDRmeal and FFDRoil, respectively) (FFDRmeal < 1; FFDRoil > 1; Figure 3.3).

Figure 3.3 Feed resources, aquafeed utilisation, production and trade of Atlantic salmon in Norway



Note: The FFDR is the amount of wild caught fish used in the production of fishmeal and fish oil for the production of 1 kg of salmon; the marine dependency ratio (MDR) expresses the amount of marine oil and protein required to produce 1 kg of salmon oil and protein.

Source: Based on IFFO, 2014 and Ytrestøyl et al., 2015.

3.3 A globalised seafood supply chain with emerging partnerships

The global increase in demand for seafood has supported globalisation in the industry, often reducing the number and diversity of market actors through industry consolidation of large and vertically integrated transnational corporations, connected by global networks of subsidiaries (Österblom et al., 2015). In the global seafood industry, a small number of such transnational corporations involved in all segments of seafood production dominate trade in terms of both volume and profit. Of the top 160 companies in the seafood trade, 10 account for 38 % of total revenues and a significant portion of the world's most valuable capture fisheries (Österblom et al., 2015). Overall, they handle some 208 species and operate in over 102 countries and territories, effectively linking consumers to distant producers and ecosystems.

Corporate consolidation of such transnational companies can raise equity and sustainability concerns. The concentration of economic power and control over several nodes in the food supply chain enhances the ability of such companies to define production terms and set prices, while bringing them a disproportionate ability to influence the dynamics of marine ecosystems worldwide (Österblom et al., 2015). However, the existence of globally networked and vertically integrated companies also means that the collective action by a few key entities could transform the industry substantially.

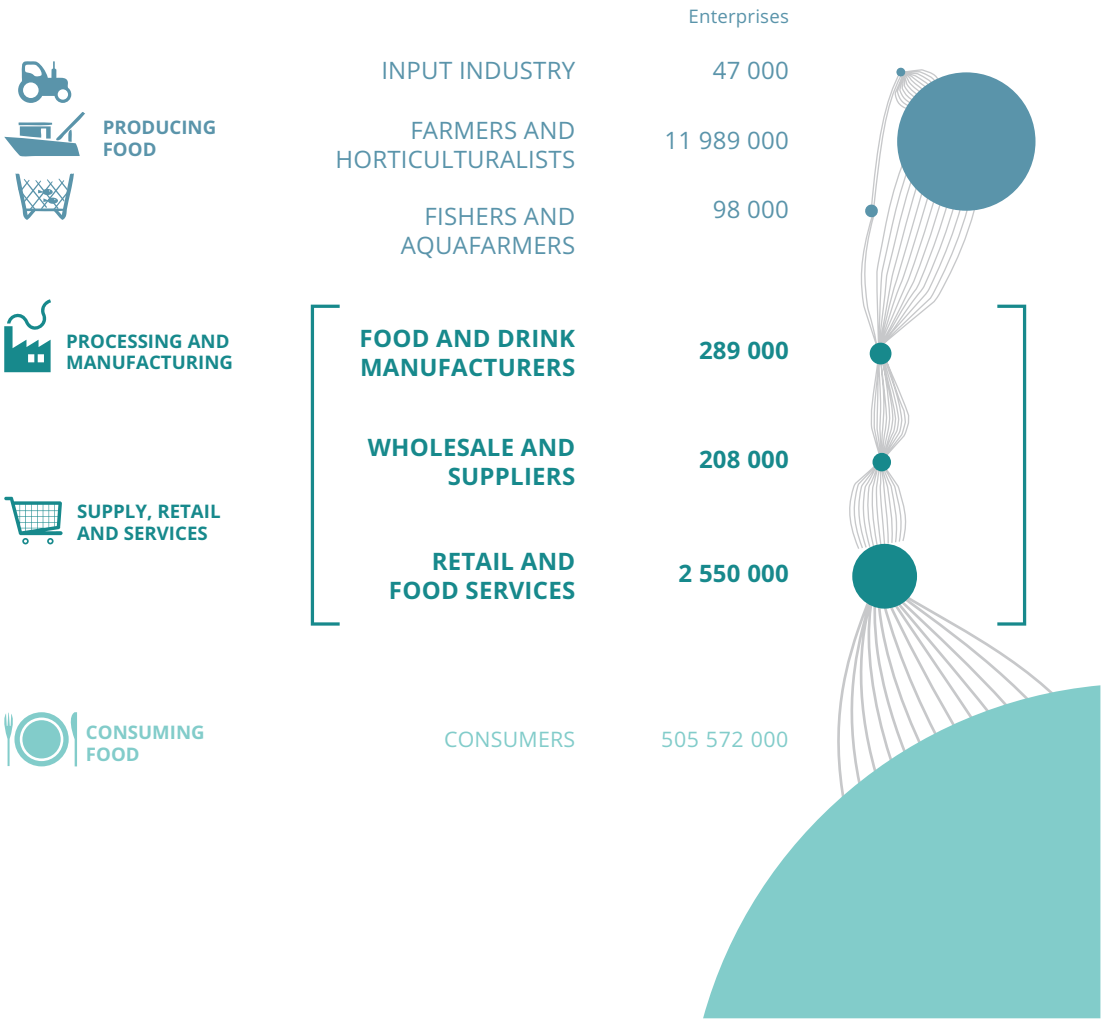
Globalised food supply chains offer opportunities for sustainability leadership and partnerships that can prove critical for food security. Recent years have seen a notable increase in partnerships between supply chain actors — including retailers, food services and restaurants, processors and distributors — and fisheries associations, non-governmental organisations and government bodies to increase the sustainability of their supply chains (Innovation Forum, 2015). The goal of partnerships is to recognise and introduce improvements into the supply chain where possible.

Traceability along the supply chain is a key factor for effective sustainable seafood sourcing partnerships (Bailey et al., 2016). However, it is still difficult to ensure full traceability along seafood supply chains because of a lack of financial and technical resources, the complexity of value chains and seafood governance, and unlawful fishing practices and inconsistencies in legislation (UNEP, 2009; Future of Fish, 2015). As such, certification schemes are a common tool that retailers and other supply chain actors use to identify the sustainability of products (UNEP, 2009). However, critics of such approaches point out a number of shortcomings. For example, certification schemes usually do not assess the sustainability of fisheries based on a systems view, and can end up certifying fisheries with unsustainable features, such as overfished stocks or practices that disadvantage the needs of local populations (Cressey, 2012; Micheli et al., 2014). The costs of certification or participation in certification schemes also make them currently more suited for production practices with high-volume, which raises questions about the suitability of such schemes for small-scale fisheries, in particular in developing countries (Blackmore et al., 2015).

Some supply chain partnerships go beyond simply increasing the number of certified products. Several initiatives exist, run by non-governmental organisations and supply chain actors, to bring retailers and other stakeholders together in fishery improvement projects (FIPs) (for examples see SFP, 2016 and WWF, 2016a). FIPs are concrete projects that are set up to realise more sustainable practices at the source of seafood supplies. Some such projects are initiated directly by retailers (UNEP, 2009). In FIPs, stakeholders in a given fishery commit to advocating better policies and management while voluntarily changing practices. This includes improving monitoring and reporting, changing harvesting techniques or equipment, encouraging dialogue among stakeholders, and sharing best practices, among other interventions.

Partnerships between retailers and producers such as in FIPs offer an opportunity to catalyse the transition to sustainable seafood systems by leveraging retailers' market power and creating market-based incentives for implementing new sustainable fishery and aquaculture practices. However, the current lack of transparency, insufficient traceability and perverse incentives that encourage unsustainable fishing practices hinder the potential of the seafood supply-chain to act with greater awareness and responsibility in order to shift the food system as a whole (Future of Fish, 2015). Given the current structure of the EU's food supply-chain and where actors concentrate (Figure 3.4), it is clear that these actors need to be involved in the design and implementation of solutions for sustainability in the food system. This involvement however requires a better understanding of practices and behaviours within food supply-chains and how they influence change in the food system.

Figure 3.4 **Europe's food supply chain by the number of enterprises in each food system activity**



Source: EEA.

3.4 Market incentives and consumer choices for sustainability

Consumers are increasingly looking to promote improvements in sustainable seafood production by aligning their buying choices with sustainability criteria. Production exists because of consumers. However, consumers come at the end of a long chain of actors across markets within the food system. Over recent decades, there has been a growing amount of information available to consumers through various types of initiative, especially labelling (TNS, 2014). Significant efforts have been made to provide consumers with more and better information (e.g. labels, certification schemes, information campaigns and buying guides) to inform them about the sustainability of their fish and seafood purchases (see Box 3.3 for examples at the EU level). However, there is insufficient evidence that these efforts have led to major gains in the overall sustainability of seafood, requiring a deeper investigation of their use (Ward and Phillips 2008; McClenachan et al., 2016; Jacquet et al., 2010).

Environmental certification schemes such as the Marine Stewardship Council (MSC) and consumer awareness programmes are designed to create market incentives for implementing fishery and aquaculture practices that are deemed sustainable. However, there are recognised limits to such initiatives. Typically, they tend to be focused on particular species and activities, and such programmes have so far triggered concerns, even if some improvements are visible (Gulbrandsen, 2009). For example, a study of 31 northern European stocks targeted by fisheries certified by the MSC as sustainable and well managed found that 11 stocks (52 %) were exploited above the maximum sustainable yield and four stocks (16 %) were outside safe biological limits. After 1 to 10 years (4 years on average), no significant

changes in fishing pressure or stock size were observed (Opitz et al., 2016).

Such schemes also come under scrutiny as operations can be certified despite degradation of marine ecosystems, loss of income among local communities and negative social impacts from the non-certified operations that overlap with certified production systems. Furthermore, the high financial costs and data requirements associated with meeting certification and recommendation-listing standards often discourage or prevent small-scale operations from participating (Ward and Phillips, 2008). Moreover, certification initiatives such as the MSC have been designed to be globally applicable. This means that place-specific attributes and regional or local considerations may not be taken into consideration when certifying fisheries, with favour given to transnational governance norms (Blackmore et al., 2015; Foley and Havice, 2016). In regard to aquaculture specifically, initiatives also tend to target species that are consumed mostly within the EU and the United States, with limited coverage of what is sold in Asia (Jonell et al., 2013). But there seems to be a rise in new fishery eco-certification initiatives that are tied to political boundaries and therefore better represent local territorial and social norms in certification and within the global framework (Foley and Havice, 2016).

New concepts for system-wide fishery and aquaculture certification programmes designed to recognise and promote change towards sustainable and resilient seafood production systems are being discussed (Micheli et al., 2014). Such programmes would consider all fishery and aquaculture activities within a system or region, as well as their possible interactions with — and cumulative impacts on — ecosystems or marine users; management actions that promote ecological, social and economic resilience; and the capacity of human communities to implement these actions and to equitably share costs and benefits. These could support the restoration and maintenance of healthy ecosystem states and of thriving human communities as a socio-ecological system (Micheli et al., 2014).

Information- and incentive-based solutions that explore consumer demand through eco-certifications and consumer awareness programmes reward producers for sustainable practices through increased prices or market access by increasing the differentiation of products on the market. They offer great promise for aligning economic and conservation objectives, because they create incentives for producing fish and seafood sustainably. However, even if consumers are properly informed regarding the sustainability of their options, this may not be enough to change their behaviour, especially at a large scale. Research on real-world consumer behaviour has clearly shown that there are limitations to the amount of information that consumers process when making choices, leading them to use mental shortcuts and rules of thumb to allow for quick decision-making, particularly in habitual behaviour such as food consumption (O'Rourke and Ringer, 2016).

Consumer choices are difficult to understand and therefore influence, because they are often embedded in deeper social and institutional contexts. Consumer selection of fish and seafood is influenced by a number of factors, including freshness, taste, personal health beliefs, traditional and cultural reasons (e.g. local customs, eating fish when on holiday, trends), and knowledge about preparing fish (Almeida, 2014). Price is often indicated as the largest factor influencing fish and seafood purchase, as it is often more expensive than meat. Other consumer barriers for the consumption of fish are the presence of bones, contamination risks, variation in quality, the perceived time-consuming character of purchasing, preparing and cooking fish, the limited product availability, and the perceived difficulty in the evaluation of its quality (Vanhonacker et al., 2013).

Technological innovations in food systems since the 1960s have enabled an increasing quantity and variety of foods to be produced, and at lower prices (Cutler et al., 2003). Ready-prepared food could be more attractive to consumers than fresh products, despite the latter usually being related to healthier food choices (Cheng et al., 2007; Hartmann et al., 2013). Overall, this suggests a trend towards convenience rather than other selection criteria such as health, sustainability or taste. This raises doubt as to how important sustainably sourced seafood may be to consumers, and whether or not such information would steer consumers' decision-making.

Consumers are important as political actors, whose voice can drive the political will to address seafood production sustainability and responsibility, particularly at system level. However, the complexity of the web of dynamic factors influencing seafood consumption choices in any particular setting suggests that an effective intervention to change consumer behaviour — be it initiated by policy, business or civil society, or an alliance of actors — will be a considerable challenge. Shifting the sustainability of production through consumer preferences will remain difficult without a better understanding of how the approaches to displaying information affect consumers, their preferences and the choices they make. Even with the right information, consumer choices are also dependent on many different factors beyond the information they receive (Umpfenbach, 2014). Human factors such as the above need to be taken into account if sustainability transformations at system level are to be achieved through consumer power.

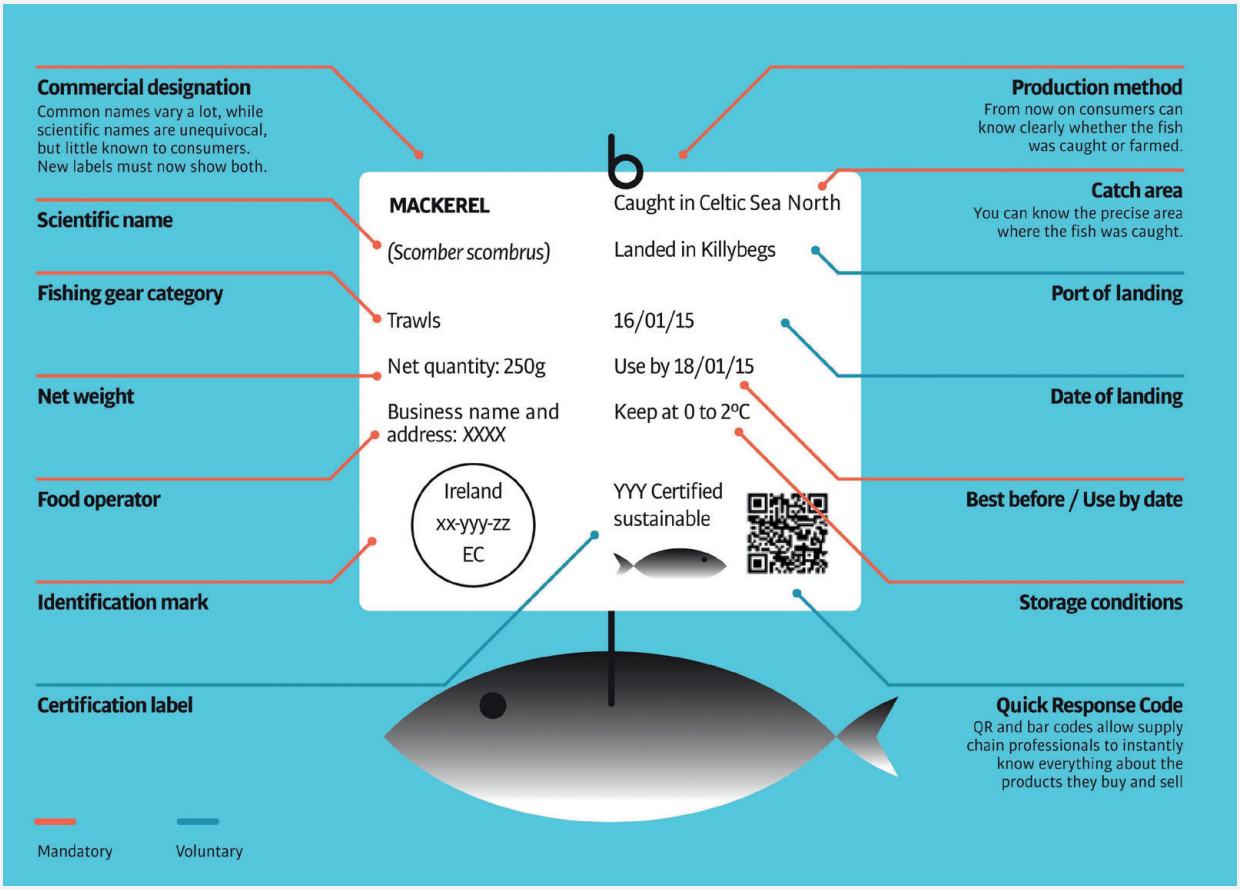
Box 3.3 Examples of EU approaches to provide better information on seafood and raise awareness

Recently the EU has run a Europe-wide information campaign — Inseparable — to promote sustainable fishing and build on the momentum of the CFP reform. The campaign is built around key areas of information: know, eat, buy, sell and find. It promotes the following overarching message to EU consumers: 'Make a difference by eating, buying, or selling sustainable seafood and help ensure future generations have the same love story we have with our fish today' (EC, 2016c).

The new EU seafood labelling rules are also key for providing consumers with detailed information about their choices. Fishery and aquaculture products sold and bought in the EU are now required to have information about the commercial and scientific name of the species, whether it was caught at sea or in freshwater or was farmed, the catch or production area and the type of fishing gear used to catch the product, and whether the product has been defrosted and the date of minimum durability (see Figure 3.5). The new rules aim to make the information to consumers more transparent, helping them understand where their seafood has come from and when it was caught or farmed. Ultimately, the request for such information improves greater transparency and traceability all along the seafood supply chain and can thus also support more informed choices by those actors as well.

Source: European Commission, Directorate-General for Maritime Affairs and Fisheries
© European Union, 2015

Figure 3.5 The new EU fish label



Source: European Commission, Directorate-General for Maritime Affairs and Fisheries © European Union, 2015.

4 Transforming Europe's food system

Solutions for addressing the sustainability issues of today, such as those exemplified by the disparities of the food system in terms of environmental and human health outcomes, are needed. Such solutions need to go beyond incremental efficiency gains, and aim to transform the core of our production and consumption systems (EEA, 2015b). The challenges we now face regarding sustainability are no longer compatible with responses solely based on the classical paradigms of science and engineering — built on industrial models of problem-solving and planning approaches (Rittel and Webber, 1973). Their complexity and scale make them different from the challenges of previous decades and call for more substantive transformations (Box 4.1). How, then, to approach change in the food system so that its outcomes reflect a sustainable society such as that envisaged by the EU?

Recognising the food system as a complex, adaptive system, which comprises multiple actors with diverse interests and values, certainly provides a richer understanding of the system and the associated sustainability challenges (Clancy, 2014; IOM and NRC, 2015). Complexity arises whenever a system — technical, social or natural — has multiple interdependent parts, whose interactions give rise to unpredictable outcomes. Complicated solutions to address complex problems are common, but evidence shows that simple rules tame complexity better than complicated solutions (Cabrera and Cabrera, 2015; Sull and Eisenhardt, 2015). Identifying the simple rules operating in the food system is challenging but using a system's approach to understand it can lead to leverage points for transformations towards sustainability. Leverage points are places to intervene in a system, in which a small shift can lead to fundamental changes in the system as a whole (Meadows, 1999; Abson et al., 2016).

With such an understanding of complexity, this chapter identifies three complementary pathways within the current EU policy framework related to food and sustainability that can help transform Europe's food system. This analysis explored, in particular, the opportunities and challenges arising from the implementation of the EU marine and maritime policy framework.

The pathways for change are (1) building a shared understanding of the food system and its outcomes at the EU level, namely by adopting a systems approach EU policies related to food and sustainability, and building on the EU efforts to develop the ecosystem services approach as a common language between ecosystems and human benefits; (2) improving the knowledge base related to seafood in order to improve sustainability assessments of seafood in Europe from a food system approach; and (3) boosting efforts to implement the ecosystem approach to Europe's seas for securing the long-term availability of seafood.

These pathways are linked to how people make sense of the world through mental models and take action. Knowledge on mental models and their influence

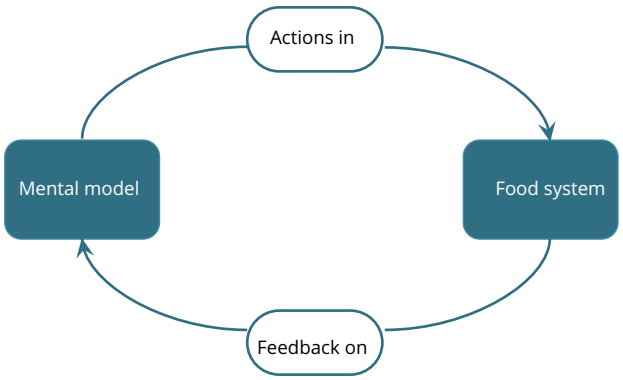
Box 4.1 Defining sustainability transformations

Within the context of climate change, O'Brien and Sygna (2013) propose that transformation can be defined as 'physical and/or qualitative changes in form, structure or meaning-making, or as the altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems). According to Patterson et al. (2015), the notion of transformation is increasingly used in the context of global sustainability to refer to 'fundamental changes in structure, function and relations within socio-technical-ecological systems, that leads to new patterns of interactions (e.g. among actors, institutions, and dynamics between human and biophysical systems) and outcomes'. The same authors add that transformation is also used to characterise aspirations to shift from current conditions into more desirable system outcomes (e.g. in terms of sustainability and equity).

on human decision-making is important because shared mental models are persistent and can exert a major influence on individual choices and aggregate social outcomes (World Bank, 2015). Figure 4.1 aims to illustrate in a simple manner the complex human process of making sense of the food system and its change. Mental models are individual or collective approximations of reality (e.g. by actors in the food system) that describe, summarise and predict the world (in this case the food system) and lead to actions therein.

Mental models are malleable to a certain extent. Through information, actors in the food system receive feedback about the consequences of their actions and can adapt their mental models accordingly, through what is necessarily a continuous learning and adaptive process (Cabrera and Cabrera, 2015). A mental model can be considered adequate if the expected outcomes of actions in the food system occur. The type of feedback (enabled by information flows) received from the food system is critical to indicate if the mental model is still valid. In addition to information, a body of work shows that context is also key for human decision-making and adapting mental models. People have several different and competing individual mental models and context will determine which one is activated (World Bank, 2015).

Figure 4.1 Making sense of the food system through mental models and feedback



Source: Based on Cabrera and Cabrera, 2015.

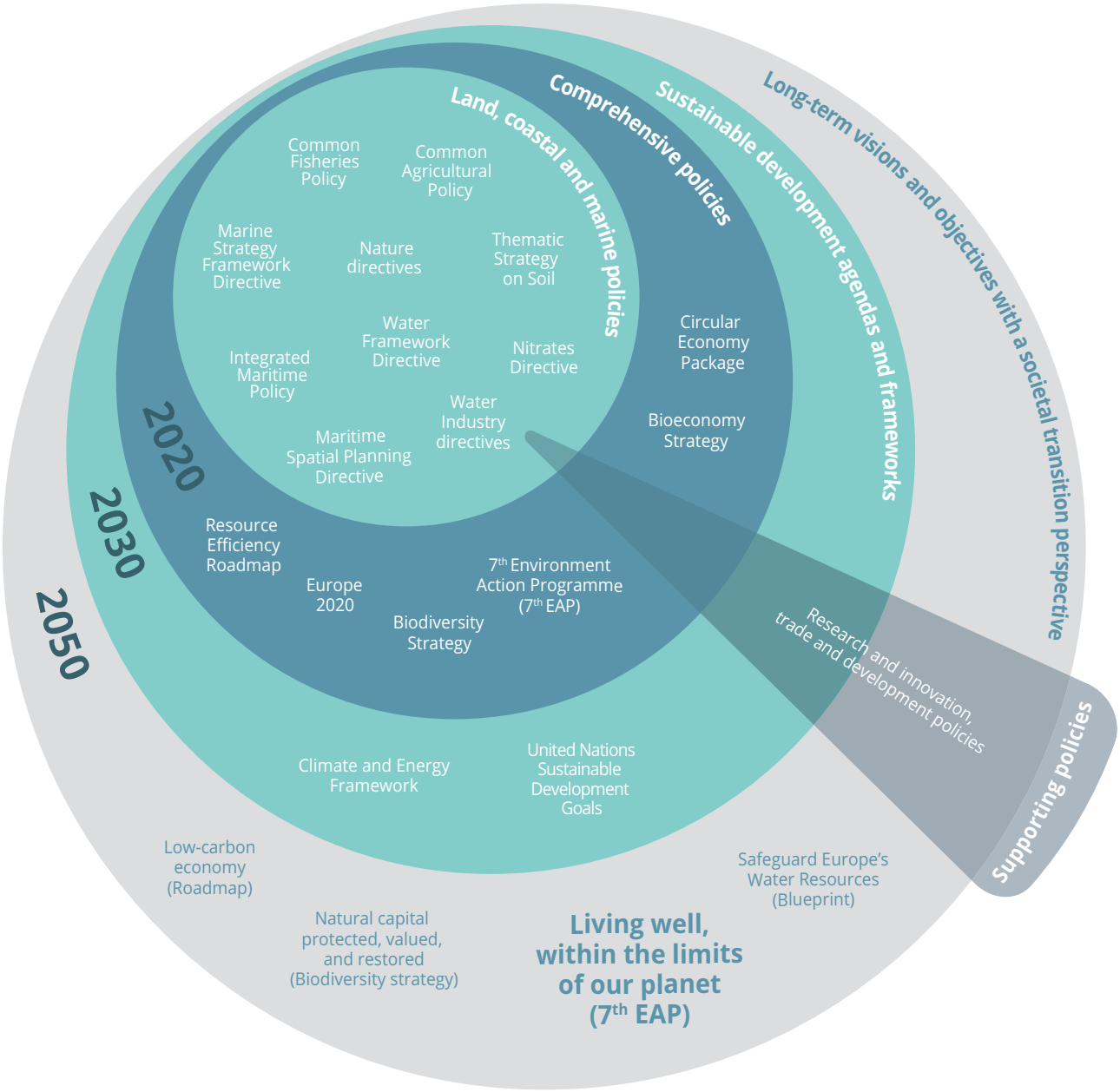
4.1 Building a shared understanding of the food system at the EU level

Adopting a food system approach to EU policies for food and sustainability

At the EU level, a variety of policy instruments relate to the production and consumption of food and seafood, as well as to the protection and sustainable use of ecosystems (for an illustration of this policy framework, see Figure 4.2). In addition, these land, marine and coastal policies related to food are increasingly embedded in longer-term comprehensive policies and agendas for sustainable development. However, the implementation of this policy framework does not currently follow a food system approach, and interactions between policies still have the potential to cause conflict or synergies. In addition, governance mechanisms associated with a specific policy are usually bound to the related policy sphere (e.g. fisheries and aquaculture is governed by the Common Fisheries Policy, agriculture by the Common Agricultural Policy, the protection of biodiversity by the Nature directives i.e. Habitats and Birds directives), and thus mostly to the motivations and knowledge of the actors in the related policy sphere.

Governments play an essential role in systemic change because of their unique capacities in, for example, defining policies with long-term societal goals, establishing a common framework for governance and action, shaping incentives and supporting research and innovation. There is growing agreement in academic literature that governments lack the required knowledge, tools and incentives to achieve effective top-down management of complex societal systems (Rotmans and Loorbach, 2010). In this context, it is widely accepted that the governance of transformations hinges on promoting experimentation and learning, via iterative, adaptive, participatory processes. For example, approaches such as 'integrated sustainability assessment' and 'transitions management' propose that actors across society be engaged in cyclical processes of problem structuring, envisaging, experimenting and learning, as a means to steer systemic change (Kemp et al., 2007; SERI, 2008).

Figure 4.2 **An illustration of relevant EU policies for food and sustainability up to 2050**



Source: EEA.

As such, the governance mechanisms underpinning the EU policy framework related to food can offer an arena for the design of implementation processes built on a food system approach, which could, in turn allow for greater experimentation and learning. These governance mechanisms could bring together EU institutions, Member States, food system actors and other stakeholders to develop processes by which these actors could become more open to a wider array of solutions, namely by building a shared mental model of the food system and agreeing on what sustainability means in the EU policy context related to food.

Some targeted actions are already underway at EU level that can promote the building of such a shared mental model of the food system and design possible pathways for sustainability transformations (Box 4.2).

Box 4.2 EU-level initiatives for building a shared understanding of the food system

The Joint Research Centre of the European Commission (JRC) recently published a foresight report entitled 'Global Food Security 2030', which highlights the need to overcome the conventional approach to food security, with much more attention paid to food availability than to food access, nutrition and sustainability (Maggio et al., 2015). This report also calls for the adoption of a food system approach to food security, which captures the variety of food systems that exist throughout the world, identifies the interactions with other human systems (e.g. energy, urban systems, etc.) and policies (e.g. trade, security, etc.), and addresses more efficiently the 'systems-oriented' issues of vulnerability, resilience and governance. Another of the report's main recommendations was to design a common food systems policy to ensure better policy coherence for food security.

More initiatives on food systems with a broader and longer term perspective are currently under way within the European Commission. The JRC and the Directorate-General for International Cooperation and Development (DG DEVCO) are starting a vision-building exercise to provide a holistic and future-proof EU position on sustainable food systems in the context of the Sustainable Development Goals. The Directorate-General for Research and Innovation (DG RTD) is increasingly using a systems-oriented approach to design research and innovation strategies for the food system. In particular, it has been steering the work of the Standing Committee on Agricultural Research (SCAR) since 2005 to promote an integrated European Research Area with a common agricultural and wider bioeconomy research agenda. The need for a strategic research agenda for fisheries and aquaculture within the agricultural and bioeconomy context mandated the establishment of a specific working group in 2012 (SCAR-Fish, 2013). SCAR's foresight work has provided the building blocks for longer-term perspectives on the development of the food system in a world of growing resource constraints and environmental limits (EC, 2011), while under competition from other emerging uses of natural resources such as the bioeconomy (EC, 2015c).

Finally, in 2015, the EU initiated a year-long dialogue with stakeholders that will result in a 'Research and Innovation Agenda for Food and Nutrition Security', which will mobilise the EU, international actors and invited funders (EC, 2015a). A key objective of this process is to understand how to best pool and organise EU Research & Innovation resources in order to future-proof European food systems to achieve food and nutrition security for all, in a global context. A 'Food Research Area', with both EU and international partners, will be created by 2020 and will focus on the four priorities of nutrition, climate, circularity, and innovation and empowerment of communities.

Understanding the interactions between ecosystems and people through the common language of ecosystems services

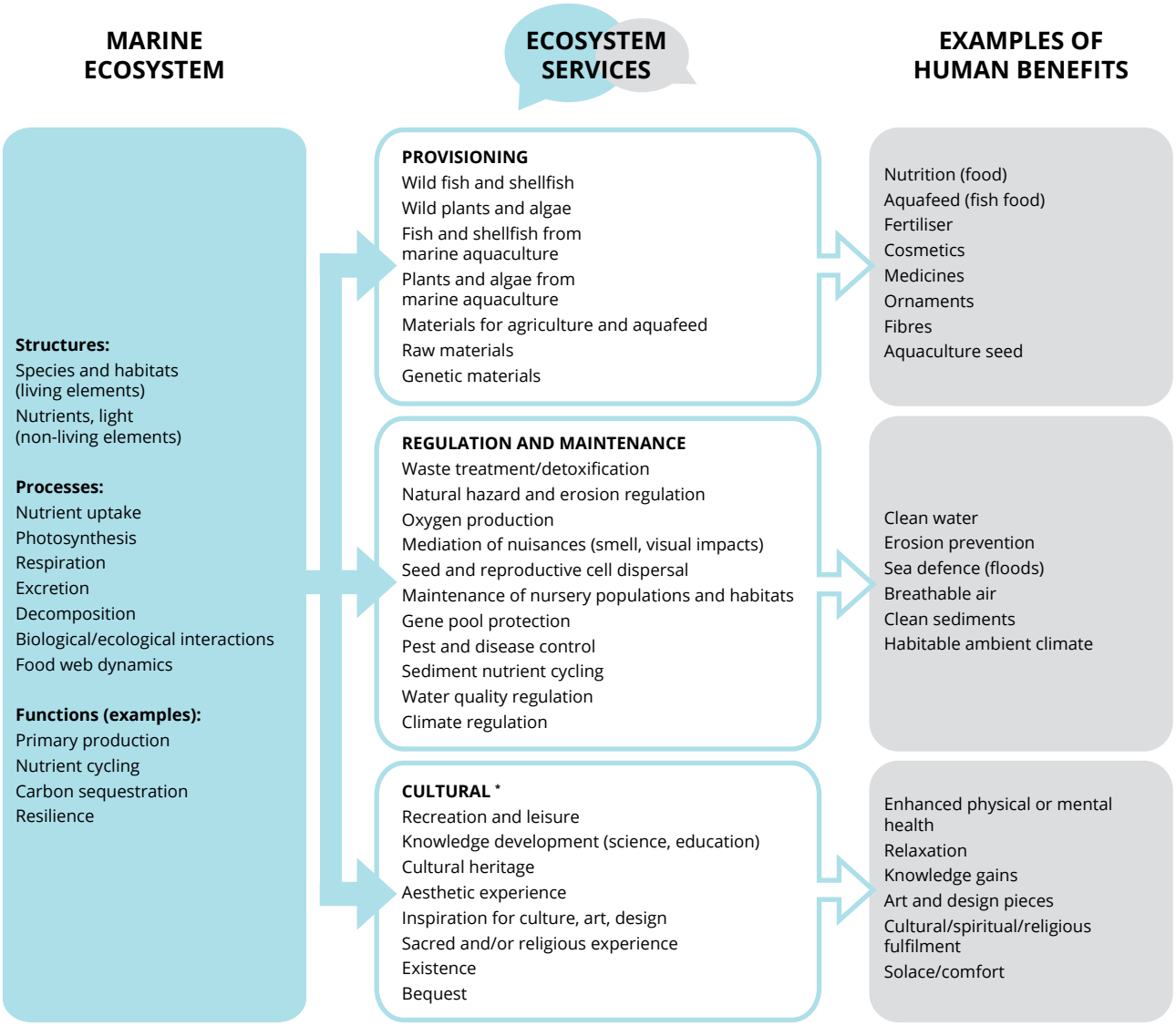
Assessing natural capital using a common language and approach between its different users and managers is also critical for building a shared understanding of the food system and its outcomes. The EU has embodied the concept of natural capital in several key policies (namely the Biodiversity Strategy to 2020 and the 7th Environment Action Programme), and has set forth a process under the Biodiversity Strategy to support the development of a common assessment approach for natural capital, based on the concept of ecosystem services (the Mapping and Assessment of Ecosystems and their Services (MAES) process). MAES aims to improve the existing knowledge of ecosystems and their services in the EU, and to make explicit the range of human goods and benefits derived from natural capital for a particular human activity (such as fisheries or agriculture) or for society at large (e.g. through cultural services, like recreation and leisure activities such as nature watching, or regulation and maintenance services such as climate regulation).

Developing a shared understanding of natural capital enables human-environment relationships to be considered in a common way. This thinking can then be used across human systems of consumption and production such as the food system. The MAES process has already provided an overarching analytical framework and the building blocks that should allow EU Member States, the science community and food system actors to map and assess ecosystems and their services in a comparable way (Maes et al., 2013). However, it is still early days in terms of assessing ecosystems as natural capital, especially in the case of marine ecosystems. Despite several national, regional and EU-level initiatives for mapping and assessing marine ecosystems and services, these analyses face several specific challenges compared with terrestrial ecosystems, where the ecosystem services concept and assessment approach originated (see EEA, 2015c for a detailed analysis of these initiatives).

The ocean is a fluid environment. Given the interconnected nature of the marine environment, marine ecosystem interactions are particularly intricate when compared with those in terrestrial ecosystems. The generation of marine ecosystem services from which human benefits such as seafood are derived is a complex process (see Figure 4.3 for an illustration of the process and EEA, 2015c for details on marine ecosystem service generation). Ecosystem services are the final outputs or products from ecosystems that are directly consumed, used (actively or passively) or enjoyed by people. They result from a range of interactions at the ecosystem level, between its structures, processes and functions. In addition, obtaining the benefits from the services requires human inputs such as labour, capital or energy investments. Often, however, there is insufficient awareness of how marine natural capital, and ecosystems services in particular, is generated among its users and managers. This hinders decision-making aimed at maintaining the resilience of ecosystems and their self-renewing capacity for providing ecosystems services in the long-term (EEA, 2015c).

Nevertheless, ecosystem services assessment is a systems methodology that allows the complexity of

Figure 4.3 **Ecosystem services as a common language to illustrate how people benefit from healthy marine ecosystems**



Note: * These are underpinned, to any degree, by marine organisms, ecosystems and/or land/seascapes.

Source: EEA based on O'Higgins, 2015 and EEA, 2015c.

environmental management decisions to be broken down so that the dependencies between human well-being and ecosystem health are considered in tandem. Having an EU-common approach for assessing interactions between ecosystems and people paves the way for food system actors and regulators to see and value not only the ecosystems services available to be harvested or captured, but also the dependencies at ecosystem level that support the delivery of services that underpin food provisioning. The ecosystem services approach should also allow for a better understanding of how the food system interacts with ecosystems and to enable us to see if they are pushing ecological boundaries.

4.2 Improving the seafood knowledge base

The feedback from data and information flows in the food system is essential for monitoring change in the system, as well as for adapting the mental models that allow us to make sense of the observed change and take action (as illustrated in Figure 4.1). Determining whether or not Europe's food system is developing in line with the EU 2050 vision of 'living well, within the limits of our planet' will require data and information that allows the EU to better track its outcomes in terms of food security, ecosystem health and social well-being and across scales — from local to global. Moreover, such feedback should also allow for an integrated assessment of the food system and its dynamics, i.e. one that makes it possible to understand how the different activities of the supply-chain shape the demand and supply of food. The assessment of the knowledge base for exploring the dynamics and outcomes of the fish to fork activities (an illustration of which is given in Chapter 3) revealed opportunities and gaps that are shared below, for enhancing future sustainability assessments of seafood in Europe from a food system approach.

Harnessing knowledge from seafood-related EU policy implementation

There is a great wealth of data and information already available from EU policy implementation processes that can be used in an integrated assessment of fish consumption and production in and for the EU. Chapter 3 of this report emerged partially from the exploration of publically available environmental and socio-economic data, which enabled aspects of fish production, processing and trade to be understood. These data come from national reporting obligations under the Common Fisheries Policy (CFP) or were mobilised under this policy, for example, through market analysis. The background analysis also used public expert assessments (and the data underpinning these assessments) related to the CFP governance mechanisms (i.e. from the Scientific, Technical and Economic Committee for Fisheries (STECF)) that analyse, on a regular basis, how fish production and processing is performing in the EU using biological and socio-economic indicators.

The STECF expert assessments aim to support the conservation and management of living marine resources — including biological, economic, environmental, social and technical considerations — that can inform, among others, the evolution of policy objectives such as those of the CFP. These assessments further provide an entry point to understanding national data in context for both national realities (e.g. conditions for economic growth) and the wider trends and outlook for the fishing, aquaculture and processing sectors (STECF, 2014a, 2014b, 2015). In addition, these expert analyses should increasingly have a broader analytical approach, rather than be a descriptive analysis of the fisheries sectors. This broader analysis includes aspects such as drivers and barriers to economic growth in the sectors. It also includes an expert assessment on possible future directions of the present assessments, on information needs such as additional variables to be included in the calls for data, and requests for specific studies and other data sources to be used. Box 4.3 provides an example of such expert requests by presenting key messages for improving the analysis of the processing sector from the latest STECF assessments of the economic performance of this sector.

The messages in Box 4.3 highlight knowledge gaps or knowledge enhancement opportunities that could support a better understanding of fish production and consumption from a food system approach. If implemented, these and other improvements would be important steps towards an integrated assessment of the consumption and production of seafood, and towards getting feedback on change from key interactions in the food system. In addition, further questions could be brought to these expert groups to enable future sustainability assessments of seafood in Europe.

Box 4.3 Key messages from expert assessments to improve a food system approach to the analysis of the EU fisheries sectors ([6])

Making the link between the fishing fleet and the processing sector

It is obvious that the performance of the fishing fleet and the behavior of fishermen influence the exploitation rate and, therefore, it makes sense to analyse the socio-economic performance of the fleet. The link from the fish processing industries to the 'sustainable exploitation of marine living resources' is less obvious. [...] STECF has several times recommended that the EC should issue a study to elaborate how the link between the activities of the fishing fleet and the processing sector can be assessed and make this link more transparent. The study shall include an elaboration of how data on raw material [e.g. the purchase of fish by species and origin] can be collected by the Member States and how this additional data can be linked to the already collected data.

(STECF, 2014b, p. 333)

Discussing drivers and trends along the whole value chain

The fish processing sector is not acting in isolation. The industry is purchasing raw material from the fisheries and aquaculture sector and on the other hand, the processed or semi-processed products go up in the value chain to supermarkets. Therefore, looking at the value chain as a whole may give a better indication of which drivers and trends are influencing on the processing industry, in contrast to just analyzing the DCF or EUMAP data [i.e. reported under the EU framework for the collection and management of fisheries data] on the status of the industry.

(STECF, 2014b, p. 334)

An important development of the fish processing industry is the outsourcing of activities. However, many of these activities are outsourced to countries outside Europe (like filleting of Cod in China) and it will be necessary to broaden the analyses and perspective looking outside of the EU. However, for this kind of analysis it is not yet clear what data is needed and what data is available for such an analysis.

(STECF, 2014b, p. 334)

Harnessing market information for greater insights

Even without the data on raw material [...] the inclusion of market information is seen as a step forward and it is very useful to get more insights and understanding on the processing industry. The market information [available from the EUMOFA website] provides knowledge on origin, species and degree of processing. The trade statistics are publicly available [...]. However, without the more detailed information on raw material the market data still only provides limited additional information on how dependent local/regional industries are on local/regional stock in the EU.

(STECF, 2014b, p. 334)

Improving food system traceability and assessment through seafood market information

The recent evolution of market traceability systems in the seafood sector offers opportunities to track the sustainability characteristics of a given fish product during its journey through the value chain (Bailey et al., 2016). Important changes in the EU fisheries policies are also increasing the traceability of fisheries products that are produced and consumed by the EU. Beyond the new rules for seafood labelling (referred to in Section 3.4), the revised Common Market Organisation under the new CFP brought with it dedicated market intelligence tools (i.e. provided by the European Market Observatory for Fisheries and Aquaculture — EUMOFA ([7])). These public tools allow for a better understanding of how the EU market functions and can support better tracking of what happens on the markets after fish is caught.

([6]) The paragraphs in this box were extracted from STECF (2014b) for illustration purposes. Text in square brackets has been added for explanatory purposes.
([7]) http://www.eumofa.eu.

EUMOFA was officially launched in 2013 as a European Commission initiative to increase market efficiency and support business decisions and policymaking. Currently, EUMOFA focuses on information on general market trends for increasing the economic viability of the market for fishery and aquaculture products. By doing so, it contributes to the promotion and presence of EU fishery products on the market (both the internal and external markets), which can translate into increased income and work opportunities in the sector.

In addition, specific requests can now be designed, as the EUMOFA market intelligence tool is fully operational. For instance, ways for this market tool to better serve the small-scale fisheries sector have already been identified, which could help fishers from this sector to better understand the market environment in which they are operating and thus generate greater economic benefits from their products (Josupeit, 2016). Other requests could also be designed for the dedicated tracking, measuring and assessment of food system outcomes of food security, ecosystem health and social well-being from an integrated perspective. For example, at present, linking production and trade data at the Member State or species level is still methodologically difficult. This more refined understanding of where, how and which fish are caught or farmed is key to empowering retailers, consumers and importers by allowing them to make informed choices.

Improving place-based understanding

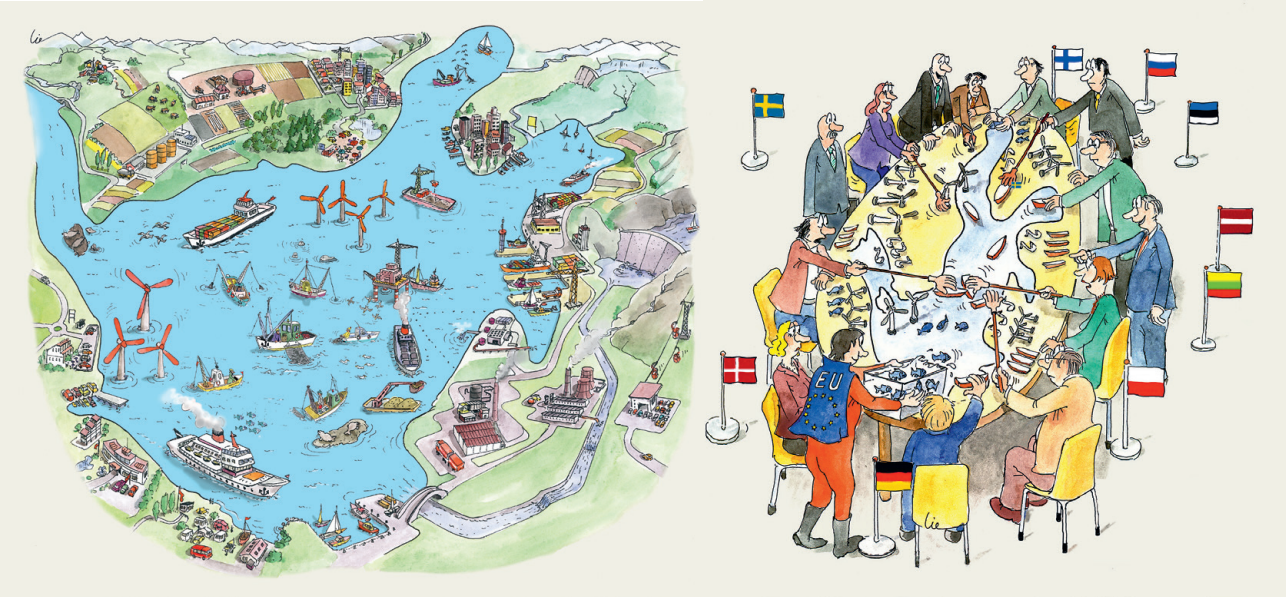
New research and methods that capture the complex and multidimensional nature of the food system and its outcomes require an adequate level of disaggregated data and/or an appropriate methodology to reach consistent and robust conclusions, in particular for informing the implementation of ecosystem-based management. For example, work is under way to develop a deeper understanding of fishery-dependent communities in EU coastal areas. A recent exploratory study was able to better estimate the contribution of fisheries to local economies across the EU, showing that this contribution was higher than previously estimated (Natale et al., 2013). Coastal fishing communities are usually supported by small-scale fisheries, but this sector is mostly unaccounted for in nationally or EU aggregated statistics in spite of its recognised importance (Guyader et al., 2013; Natale et al., 2013). By using spatial methods and by taking a geographical, rather than administrative, perspective, this study also showed the shortcomings of operating with EU or regionally aggregated statistics. Highly aggregated statistics fail to capture local dynamics and dependencies between the ecosystem and fishing communities, but also between the fishing communities and the wider economy at national or EU level.

Highly aggregated estimates such as those at global, EU or national level may carry more weight when it comes to influencing policy decision-making, but they hide socio-ecological diversity and outcomes. Such estimates do not fully capture the contribution of fisheries and aquaculture to food system outcomes such as community integrity, food security and ecosystem stewardship, which are particularly relevant at the local level (Béne et al., 2016). Understanding these dynamics and outcomes at the local level is key for balancing trade-offs and exploring synergies in the food system. Approaches already exist showing that diverse qualitative and quantitative datasets can be integrated in a robust and spatially explicit manner to describe and evaluate spatial variability in the actual interactions and outcomes associated with, for example, small-scale fisheries (Leslie et al., 2015). Assessment frameworks that enable the integration of data from diverse natural and social science disciplines are key, given that assessments based on biophysical, economic or social data may lead to quite divergent conclusions and mask inherent trade-offs.

4.3 Implementing an ecosystem approach to Europe's seas

The Ecosystem Approach (EA) to management is a holistic way of understanding the socio-ecological interplay involved in managing the resource base for the long-term availability of seafood. Also known as Ecosystem-based Management (EBM), the ecosystem approach has been incorporated as a key principle in EU marine and maritime policies for securing the sustainable use of Europe's seas i.e. the Integrated Maritime Policy and its Marine Strategy Framework Directive (MSFD), the Common Fisheries Policy (CFP) and the Maritime Spatial Planning Directive (see EEA, 2015c for a more detailed review of EBM in the EU marine policy context).

Although many definitions of EBM exist (see Long et al., 2015 for an extensive review of the literature), it is essentially a policy-driven process that aims to strike the balance between ecological and social 'wants and needs' for the use of ecosystem services and natural resources. It is a place-based management approach to activities that use the ecosystem that explicitly recognises the connections and feedbacks linking human systems and ecosystems. EBM is also meant to be a science- and local knowledge-based process that involves stakeholders in an adaptive management process to identify the policy objectives at stake and to balance trade-offs to meet those objectives.



Source: WWF, 2016b (left), 2010 (right). Illustrations: Erik Lieberman.

The implementation of an ecosystem approach to the marine environment and the production of seafood can thus help to identify trade-offs across the multiple objectives of food security, ecosystem health and social well-being. In addition, an ecosystem approach to management allows decisions to be made in context, while at the same time it reflects broader long-term societal goals. It is therefore a key process in making the EU 2050 vision of 'living well, within the limits of our planet' a local reality across the diversity of the food production activities and communities in the EU. However the implementation of EBM in Europe and elsewhere has been slow. An emerging message from practitioners and researchers who are looking to make the ecosystem approach operational is that the central challenge today lies in understanding the impediments to the implementation of the ecosystem approach, rather than, for example, obtaining more information (ICES, 2016).

Barriers to the ecosystem approach in Europe's seas

For fisheries, it has been suggested that the major impediments to adopting EBM as part of the CFP are the broad nature and incompatibility of environmental, social and economic objectives and the lack of agreed guidance on the priority to be given to objectives when trade-offs have to be made (Jennings and Rice, 2011). Box 4.4 illustrates the underlying tension between concurrent objectives for the sustainable management of fish stocks in EU waters. Different stakeholders including fishers, company owners, processors, retailers, managers, politicians, non-governmental organisations, the general public, certification organisations and scientists prioritise the outcomes of fisheries differently. While all of these come under one unifying policy in the EU (the CFP), their objectives and value systems could be considered conflicting. Even among fishers — whether commercial, recreational or artisanal — there are differing objectives that need to be balanced (Trenkel et al., 2015). Once the fisheries policy is considered alongside environmental policies (i.e. the MSFD and the nature directives), a further challenge is introduced as the two fields operated in a compartmentalised manner until recently (Garcia et al., 2014).

Studies also suggest that a broader strategic approach to the implementation of EBM in Europe's seas is missing (Jennings and Rice, 2011; Ramirez-Monsalve et al., 2016a). The foundation of EBM is in the objectives of the new CFP, which addresses fisheries and aquaculture, and in the MSFD, which addresses all uses of the sea. However, the EU and its Member States have not yet formalised an explicit strategy for implementing EBM in an integrated way across the two policies. In addition, the strategic development of aquaculture is mostly adopting a sectoral approach, which aims to increase the sector's production and competiveness while addressing environmental constraints for the supply of raw material or the operations of the production sites (EC, 2013c, 2016b; STECF, 2014a). As such, the development of aquaculture in the EU is likely to underplay key systemic interactions and dependencies of the food system (e.g. those

Box 4.4 Achieving maximum sustainable yield in EU fisheries

The concept of maximum sustainable yield (MSY) holds that, over the long term, there is a maximum amount of fish that can be harvested by a fishery from a stock. As part of the most recent reform of the EU's Common Fisheries Policy (CFP), a legal obligation was introduced to manage fisheries with the objective of achieving MSY by 2015, where possible, and by 2020 at the latest for all stocks. Achieving MSY in fisheries can support the rebuilding of exploited fish populations and can increase landings, but would also bring a variety of social and economic benefits from increased landings (World Bank and FAO, 2009; Colloca et al., 2013). For example, direct job creation from achieving MSY in northeast Atlantic waters has been estimated to range from about 20 300 to over 64 000 on- and offshore jobs (Carpenter and Esteban, 2015). Achieving MSY could also deliver up to EUR 1.5 billion more in annual revenue in this area (Carpenter and Esteban, 2015).

Making MSY a reality across Europe's seas is a complex process. The EU and its Member States have often set annual total allowable catches at a different level from scientific recommendations for MSY at the annual EU Council of Ministers (Carpenter and Kleinjans, 2015; Veitch et al., 2015). This track record of decision-making at the level of the EU Council reveals the political dimension of fisheries management, compared with a science-only dimension. Greater transparency in the decision-making process of the EU Council would help improve the public debate about this crucial step for implementing MSY across Europe's seas (Transparency International, 2016).

Obtaining MSY in practice is also challenging at the operational management level, given the multiple interactions of species and ecosystem dynamics, and characteristics of individual fisheries. For example, achieving MSY for an individual stock can hamper the achievement of MSY for other stocks, as it is a stock-specific property. Given that the majority of European fisheries can be considered mixed, i.e. they catch a range of species even when targeting specific species, implementing MSY inevitably generates compromises in fishing practices and outcomes (Rindorf et al., 2016). Studies also suggest that it is difficult to achieve MSY with little impact on other marine populations and on the structure and function of the ecosystem (Worm et al., 2009). The refinement and redefinition of the MSY concept, taking into consideration ecological, economic and social concerns, was the focus of the EU 7th Framework Programme MyFish project ([8]) that, among other outcomes, developed decision support tools to reflect the effects and trade-offs of implementing different MSY options.

A core aspect of implementing MSY is therefore acknowledging the trade-offs between ecosystem health, the production of fish, and other economic and social outcomes at the appropriate level. In addition, understanding overfishing (i.e. fishing above MSY levels) should be seen from a systems perspective, focusing on more than just recognised primary causes such as profit maximisation or non-compliant behaviour from fishers. Implementing MSY requires the acknowledgement of and adaptation to complex temporal and cross-scale interactions between social, economic, political and ecological factors, which are still mostly not distinguished in fisheries or environmental management (Boonstra and Österblom, 2014).

Photo: © Stephen McGowan, 2006/Marine Photobank

([8]) www.myfishproject.eu.

related with marine and land-based feed ingredients as explored in Section 3.2). Such interactions also include those with other policy measures such as the landing obligation in the new CFP. The potential creation of an aquaculture market for discards of species in fisheries subject to this measure can deter the adoption of low impact practices aimed at reducing discards. Such unintended outcomes of the new landing obligation are mostly unknown and will require careful monitoring.

The complex European marine governance system that is currently in place is considered another key impediment to EBM in Europe's seas. This system is fragmented and considered to be insufficiently coordinated to deliver EBM across marine and maritime policies, although the regional frameworks emerging from the new CFP and MSFD offer opportunities for change (Ramirez-Monsalve et al., 2016a, 2016b). EBM is a transformation from the traditional approaches to resource management, which are mostly based on sectoral objectives such as those of fisheries or aquaculture, to a systems approach that aims to optimise social, environmental and economic objectives for the use of the ecosystem.

Transformations are a step-wise social learning process (Olsson et al., 2010). Changing institutional arrangements, such as the emphasis of the new CFP and MSFD, might not be sufficient to promote EBM, as this involves a different approach for most stakeholders to collaborate with each other and engage with the sea. To build transformative capacity for ecosystem stewardship and implement EBM, a broader set of issues needs to be addressed, such as power and social relations, political and economic dynamics, worldviews and cultural differences (Olsson et al., 2010; Schultz et al., 2015). It is thus suggested that practical experimentation may currently be a more realistic way to make progress and develop the capacity of the regional forums to support EBM, including the ability of science, policy, industry and civil society stakeholders to 'co-create' (Ramirez-Monsalve et al., 2016b).

Marine protected areas: a safety net for ecosystem health and long-term provision of seafood

Fisheries and aquaculture rely on healthy ecosystems for the stable production of key ecosystems services such as fish provision, either for direct consumption or as a raw material for the feed industry. Marine Protected Areas (MPAs) are a key policy measure and management tool that form part of the EBM tool box for safeguarding biodiversity and the services that marine ecosystems provide. As such, MPAs are essential to ensuring the long-term viability of fisheries, but also the resources on which the food supply-chain depends. The ecosystem approach introduced by the MSFD and the CFP provides an opportunity to employ a holistic approach for designing, managing and evaluating MPA networks in Europe's seas. Although the designation of MPAs can bring conflict to the users of the areas, such area-based measures can be designed as part of the solution for achieving the dual EU policy objectives of marine food security and halting the loss of biodiversity in Europe's seas (see Box 4.5 for an overview of the implementation of the current network of marine protected areas in Europe's seas).

In particular, the MSFD brings provisions for the establishment of compatible monitoring programmes, coherent and representative networks of MPAs and the requirement to cooperate with a marine region. It provides a key opportunity to build on current efforts under the nature directives and to advance further to achieve well-managed MPA networks in the EU. Achieving such MPA networks is critical to safeguarding the supply of fish as food for now and for future generations, but is also critical for the capacity of self-renewal of the ecosystem by enhancing the resilience of marine ecosystems. This self-renewal capacity is all the more important given that marine ecosystems in Europe and elsewhere are under pressure from an increasingly complex set of interactions between human activities and global environmental change (EEA, 2015c; UN, 2016).

Box 4.5 Implementing a coherent, representative and well-managed network of marine protected areas in Europe's seas

An EU policy framework for designating MPAs is in place in Europe's seas, which includes provisions from the nature directives (the Habitats and Birds Directives) and the MSFD. The main component of the MPA network in Europe's seas is the Natura 2000 network, which in 2012, covered over 300 000 km^2 (4.0 %) of Europe's seas. Nationally designated areas added an additional 1.9 % to this EU coverage (EEA, 2015d). Most of the Natura 2000 sites are considered multiple-use MPAs. However, this MPA network cannot yet be considered well-managed, given that gaps still exist in terms of representativeness, coherence and adequacy, as well as the uncertainty that exists in terms of management effectiveness (EEA, 2015d). This might partly be because the original drivers of the Natura 2000 network do not reflect a holistic understanding of marine ecosystems. The Natura 2000 network does not embody the principle of an EBM approach, and was not designed to build resilience for the system as a whole.

A key shortcoming of this network appears to be the small proportion of 'no take' MPAs, i.e. marine reserves, which could be an important measure to support the restoration of exploited fish populations. The existing marine reserves in Europe's seas have shown significant increases in biomass, density, species richness and average size of organisms (Fenberg et al., 2012). Currently, the reserves cover less than 0.5 % of Europe's seas. Inside a marine reserve, individual fish may grow older and larger, increasing their reproductive potential. This is highly relevant, as larger and older specimens tend to produce more eggs and larvae, with higher survival rates than young fish. Older specimens also add to the genetic resilience of the population (Russi et al., 2016). Marine reserves can thus be especially important for rebuilding stocks in cases where fishing practices are leading to populations dominated by juveniles, such as with cod in the North Sea. The International Council for the Exploration of the Sea (ICES) has shown that 93 % of cod, one of the main species consumed in the EU, is caught in the North Sea before it is able to reproduce (EC, 2009). In 2014, this situation appeared to have improved. It is also well documented that marine reserves can have positive effects on fish populations both inside and outside the area, with clear benefits for fisheries output (Birkeland and Dayton, 2005; Halpern, 2014).

Another challenge associated with the marine Natura 2000 network is that it focuses on a few, albeit rare or vulnerable, habitats and species, and thus does not reflect the diversity of European habitats and species. Similarly, the Natura 2000 network was not designed with the purpose of protecting commercially exploited fish species or habitats of special importance for fish species, e.g. forage or spawning areas. This leaves significant marine ecological features outside EU conservation requirements and, as such, the potential benefits of the EU MPA network are not optimised for securing healthy and productive ecosystems. A final hindrance of the marine Natura 2000 network is that some of the sites still lack management plans. As such, few details on conservation objectives and relevant site-based measures to achieve these objectives are available. This indicates that insufficient management measures have been put in place to enable the conservation benefits of these areas to both halt the loss of marine biodiversity and improve the state of commercial fish species (Russi et al., 2016).

Photo: EUO © OCEANA Carlos Suárez

5 Looking ahead — food for thought

> "You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."
>
> Buckminster Fuller

The transformation of our food system in line with sustainability goals is necessary, as it is for other related systems of production and consumption that allow us to meet our needs for energy, mobility and housing. This requires a common knowledge base to be developed and adapted in such a way that it takes the new rationale behind transitions decisions and pathways into account.

The world has already agreed to a new paradigm for sustainability in the 21st century (UN, 2015). The new global sustainable development agenda is built on people, the planet, prosperity and partnerships that together aim to transform the world by 2030. Europe has a vision of living well within the limits of our planet by 2050 through a transition to a green economy, centred on resource efficiency, ecosystem resilience and human well-being and equity. To make these goals a reality, a new sustainability narrative is needed, which envisions our global society as an interacting, evolving system that governments, markets and society can influence, but which cannot be managed by 'control and command' instruments. The food system approach allows such a narrative to be brought to Europe's food system.

A systems approach to sustainability allows us to understand how systems change and how to intervene at leverage points (Meadows, 1999), where a small shift can lead to fundamental changes in the system as a whole. Interventions that target the purpose of a system and its design are the most powerful ones for its transformation. Yet, they are also the most difficult to implement as they ask us to reframe the way we look at the world and act in it, and affect the underpinning values, goals and world views of people that influence the system. They are also long-term interventions, whose results tend to surface incrementally.

Interventions that target the purpose of a system are those that shape the paradigm or framework out of which the system goals, structure, rules and dynamics arise. In Europe, the mainstream policy narrative suggests that growth, innovation, jobs and competitiveness help to achieve development goals, and will deliver subsequently on well-being objectives. The transformation of Europe's food system — to one that will flourish in the 21st century society that the world and Europe envisions — would require a different narrative. Such a narrative would fundamentally recognise the interdependencies of our social, technological and natural systems. In this context, the development of a new European sustainability strategy has begun, which better reflects the international paradigm shift that considers people's well-being in tandem with ecosystem health (EPSC, 2016). Adopting such a paradigm shift in Europe's food system would entail moving beyond increased production or food security alone, to a system whose broader purpose would include enhanced nutrition and the ability to operate within environmental and social planetary boundaries.

Beyond working to change the purpose of a system, another powerful set of interventions that can lead to more desired system outcomes would target the system's design. These interventions address the social structures and institutions that manage interactions (e.g. between actors or those related to natural resource use) and that set standards for measures and quantifiable parameters (e.g. indicators). Policies are instrumental in shaping systems, as they establish a common framework for governance and action, shape incentives and direct research and innovation. The current EU policy framework for food is fragmented and is not implemented according to a food system approach (as explored in Chapter 4). As such, the consequences of key interactions — such as with international trade, supply-chain actors, producer practices and consumer choices (as explored in Chapter 3 and related to the journey of fish to fork) — can remain hidden. The need to re-design Europe's food system through a common approach to its

policies that fully incorporates both the systemic and global dimensions of food security has already been recognised (Maggio et al., 2015). Likewise, a review of the current EU research and innovation policy landscape for food security and nutrition calls for a broader food system approach, together with greater policy coherence and coordination encompassing food security, public health and environmental protection (EC, 2016d).

Transforming the food system will also require public policy to have a ripple effect beyond policy actors or the public policy sphere. The more public policy objectives can be aligned with those from business and civil society organisations, the better the chances of success in transforming the food system to meet sustainability goals. Emerging coalitions and partnerships of supply-chain actors (as explored in Chapter 3 in this report) offer policymakers an opportunity to make the most of business innovation (e.g. business to business investments for increased traceability) for sustainability by engaging with these market actors. To this end, forward-looking discussions within the EU and with industry, researchers and society that are currently taking place in order to future-proof Europe's food system and achieve food and nutrition for all could prove key (EC, 2015a).

The current societal momentum for the transformation of Europe's food system also provides an important opportunity to put marine and freshwater fish in its rightful position in EU food security and nutrition strategies, policies and programmes, as called for internationally (CFS, 2014). A food system approach allows fish to be framed as food rather than as a natural resource and can support the identification of key interactions between sea, land and actors in the food system (such as those related to aquaculture feed explored in Chapter 3). In addition, there is a tendency to focus the debate on food in Europe around terrestrial food production practices and outcomes. Building knowledge and governance bridges between fisheries and agriculture would enhance dialogue and mutual learning between these traditionally separate sectors. It would also provide a source of innovation and collaboration that would better influence or adapt to the supply and demand dynamics that lead to greater sustainability.

People are at the centre of interventions that target both the purpose and design of a system. This report looked at the importance of adapting our models of thinking in order to build a shared understanding of the food system at the EU level (Chapter 4). Although not explored in depth in this report, other recent findings on the psychological and social foundations of human behaviour are bringing greater awareness of the way in which people perceive information and make decisions. For example, it is well-known that people make most judgments and choices automatically but the rational view of decision-making is still often relied upon in policymaking (van Bavel et al., 2013). Also, people often use mental short-cuts to make complex choices, which can lead to choice bias, so the availability of more information is unlikely to change consumer behaviour (Umpfenbach, 2014). Paying attention to how humans think, and how history and context shape thinking can improve the design and implementation of policies. Applying behavioural insights to policymaking could greatly improve EU policy implementation and interventions designed to foster sustainability and development (World Bank, 2015; Lourenço et al., 2016).

Working with human behaviour is especially important in the context of food, since food is related to many other interweaving aspects of our lives such as education and culture. The issues around food have gained a lot of traction in the public domain. People are increasingly concerned by the social and environmental implications of food, illustrated by a range of mainstream books and documentaries that have flourished in recent years. A food system approach can focus the discussion on building communities and nurturing a food culture, where people are more than mere consumers, or a group of interested resource users such as fishers and farmers, or even business-oriented actors such as retailers. Building community through the topic of food connects consumers to producers, but also to regulators and the food industry. And by doing so, it can also improve knowledge and interest across the board on the food we eat, with the potential to co-create more creative, inclusive and effective solutions for healthy and sustainable food.

Working with complexity and making it tangible is essential if we are to find solutions to the sustainability issues of our time. This report aims to show that the complexity framework offered by a food system approach is complementary to existing policy frameworks, and can offer new ways for policymakers and other actors to search for effective answers to the difficult problems with our food. People will still hold different views, but they will have a much richer and more constructive environment for dialogue. In addition, the science of systems and the practice of applying it to real-world problems in order to tackle the persistent social and environmental challenges of our societies is flourishing (for examples, see Hassan, 2014; Scharmer and Kaufer, 2013; Sinha and Draimin, 2016; Narberhaus and Sheppard, 2015).

Embracing complexity goes beyond research and policy alone. It is a process that includes analysing

how one relates to oneself and to others, and it involves significant efforts across actors and society. Applying this new type of knowledge in order to for make sense of the world and support transformations will require learning and experimentation. Perhaps the late Donnella Meadows, a pioneering system thinker, put it best in terms of what it means to work with system change: 'There are no cheap tickets to mastery. You have to work hard at it, whether that means rigorously analysing a system or rigorously casting off your own paradigms and throwing yourself into the humility of Not Knowing' (Meadows, 1999).

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