MACRO-SCENARIOS

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The FEUFAR Project

Background
The goal of the project is to define the research required in the medium term (here taken as 10 years), to permit exploitation and farming of aquatic resources set against the context of key challenges and risks for meeting sustainability requirements. The main output of the exercise will be a publication outlining key challenges, strategic options and the research needs of capture fisheries and aquaculture in European waters and in waters in which European fleets operate under bilateral or multilateral agreements. The project is expected to contribute to the development and subsequent implementation of a European Maritime Policy and to further strengthen the European marine research area through anticipation of research needs in the field of fisheries and aquaculture.

Research Methodology
Basically, the methodology consists of three steps: (i) describe the system, (ii) detect the driving forces in the system and, (iii) by constructing hypotheses about the driving forces, sketch potential scenarios for the future. These different scenarios will provide the basis for the identification of issues, from an economical, ecological, societal and managerial (governance) perspective, which may need attention or be the key challenges in future. Based on the analysis, some of the key future needs for research in capture fisheries and aquaculture will be identified.

Contributions
FEUFAR will seek the opinions of appropriate stakeholders, and the analysis will consider the possible implications of gradual or catastrophic climate change, new technologies, changes in societal values and organizational structures, globalization of markets for fish and other marine products, food security and health, and changes in management practices or fishing techniques.

Stakeholder participation and dissemination of results is fully integrated into the project. An expert committee consisting of representatives of the research and funding communities will assist in providing feedback into the analysis, and stakeholder groups will be invited to formal brainstorming activities during the course of the project. One forum will set up a stakeholder network of representatives of research, industry and management areas at a regional, European and international scale. A second will take the form of an expert workshop, including a broad selection of (representatives of) research and advisory organizations across Europe. The wider audience (including Regional Advisory Council representatives, and hence representing production, processing, societal, and environmental interests) will be invited and/or consulted in order to present draft findings and to generate educated feedback.

CONTACT
You can log on to our project website where you will find more information about the project, the results of the activities as they become available, and a discussion forum:
www.feufar.eu

Funded by:

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1 Preface

After defining the system's boundaries, documenting the drivers of the system and developing hypothesis of the drivers and develop formulating micro-scenarios, the next step in the process is to develop macro-scenarios. A macro-scenario, or global scenario, a global scenario is a scenario for a full system based on the unique combination of micro-scenarios, including a micro-scenario for each subsystem. Micro-scenarios are in this way the hypotheses of the global system, as the hypotheses of the drivers were the building blocks for the micro-scenarios.

A combined stakeholder and expert workshop was held at the European Parliament in Brussels on the 11 of March 2008. The aim of the workshop was to translate the identified micro-scenarios about the potential future development of the sub-systems into a set of macro-scenarios, covering all parts of the fisheries and aquaculture system. In this report you will find a description of the several macro-scenarios.

The macro-scenarios are presented in a tabular format with explanatory notes below the table. On the left hand side in the table you will find the several sub-systems subsystem as described in more detail in Report 3: Systems & Drivers. In the columns under Hypothesis 1, 2 and so forth you will find the titles given to the micro-scenarios based on the drivers; hence the micro-scenarios are the hypotheses for the macro-scenarios. For details on the micro-scenarios the reader is referred to Report 5: Micro-scenarios.

The macro-scenarios (combinations of one box per row) are presented by use of formatting: hence all green boxes together or all underlined text together form one macro-scenario covering all sub-systems. The explanation to the colouring and details on the macro-scenarios is presented in the notes to the table.

The aim of the construction of the macro-scenario is to provide a basis for the prediction of the research needed to face all developments in fisheries and aquaculture. Each is discussed in detail on the following pages. For each macro-scenario you will find below the table a more detailed description of the macro-scenario (**synthesis)** and a description of the wider **context in the world** of the macro-scenario. The consequences of the macro- scenario will be described in terms of **regulation**, **research** and for **demand** and **supply.**

2 Macro-scenarios

2.1 Doomsday

Subsystem	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5	Hypothesis 6
A World Context	Free trade and Production Specialities	Short-Term Economy	Protectionism for Food	World Governance		
B Regulation	Industry Responsibility	Integrated Europe	Local Solutions for Local Problems			
C EU Seafood markets and economics	Responsible World	Innovative World	Shopping World	Expensive Fish	Ready Made Fish Meals	
D Social dynamics	Urban Ecology	Green Industrialization	Tourist Rather than Fisher	Fishers Know Better	We Need Production from the Sea	
E Ecosystems	Starts Bad but Gets Better	Global Meltdown	Local Solutions for Global Problems	Supergreen		
F Production	Free Market	The EU Promotes Aquaculture	Healthy and Diversified Products	Fisheries bounce back and natural food is the order of the day	Fishing Feeds Poor People and Aquaculture	Big Fish is a Luxury
G Research policies	Pop Idol	European Drive to Technology Transfer	Funding Nemo	C'est la Vie	Public Money Rules Research	

Doomsday (negative impact of EU fisheries and aquaculture on world ecosystems)
Synthesis

- rich countries scavenge the world for seafood product
- management does not reduce fishing capacity
- stock collapse
- research paid for by the customer does not solve the problem
- by 2020, a decline in aquaculture through a lack of fish feed and intensive use of antibiotics
- marine pollution and mad salmon disease
- the high temperature of the ocean (climate change) affects all ecosystems
- environmental restrictions are lifted to obtain short-term economic gain
- policies not enforced

World context

The world's economy outpaces precautionary principles. As some scientists feared, climate change is faster than expected, and recurrent extreme weather events drive the price of food grain up. Therefore, the world's price for meat increases, and meat proteins is less available to poorer countries. In those countries, the supply of small local fisheries becomes a more important source of animal protein. To secure a food supply at the cheapest price, rich countries agree to reduce their help to agriculture, and the Doha cycle succeeds in 2010. Rich regions compete to access fishing grounds around the world, with agreements including financial compensation, but this creates tensions in many poor countries, because western fleets compete with small local fisheries for a scarce resource.

Regulation

Economics and short-term food supply are more important than the environment and fisheries production sustainability in the long term. The EU has to deal with bigger economic and social concerns, such as food and energy security, trade agreements, or uncontrolled population migration. National and international concerns about food security are heightened. The efficiency of past regulation in helping stocks recover is questioned by fisheries. Fishers consider that they know better how to manage stocks and to protect their activity. They ask governments to give fisheries management back into their hands, to adapt regulation to local specific features. In any case, rapid climate change results in northward displacement of fish recruitment, and its replacement by southern (or tropical) species, including species brought in by ballast. The EU quota policy might not be fast enough to follow the fish migrations.

Nations take back fisheries management to find local, tailor-made solutions. Whatever the local regulation tool chosen, effort management or ITQ, it is generally not enforced because fish supply is a real concern for all fishing coastal communities. However, when fisher communities are powerful, local regulation succeeds in squeezing out recreational fisheries. Food supply is a more serious public good than leisure, so fish should be left to fisheries. Oceans are considered to be a place of food production, for wild fisheries and aquaculture.

Regulation does not reduce fishing capacity. A strong national fishing fleet is an asset for fish production in a world where food prices are increasing.

Research
The world's turmoil and increased competition among large regions lead to a change in research management priorities. The new motto is 'If you want it, pay for it'. Research must lead to fast application and developments to sell. The EU establishes a system to organize research and avoid research duplication in different countries, leasing out research rights/consents to Member States or third countries, to private and public bodies. This policy allows drastic cuts in public research budget at national and European levels. Public research agendas are not set up any more. A privatization wave reshapes the European Research Area (ERA) into a European Research Open Market (EROM), leading to a continued shift from basic to applied research and the privatization of key research infrastructure facilities, and thence the marketing of data. Fishers share their knowledge with vessel equipment manufacturers, which benefits both industries. Public information flow is limited: data collected in the context of market-driven research are not made available. This leads to poor uptake of research findings into policy and a decreasing awareness by the public, which is anyway more focused on day-to-day issues and its buying power.

Demand
By 2020, fresh product becomes too expensive and many people do not know how to (or want to) prepare it. The demand is for whitefish fillets, but whatever the quality of the fish, fresh fish sales slump. For a large portion of the European population, these fresh fish fillets become too expensive, so the processing industry creates fish dishes made with ingredients derived from fish waste and lower trophic level species, to offer low-cost but nutritional products.

Large retail chains increasingly market (eco-)labelled fish products if a premium is to be achieved, and fish of their own brand (labelled or not) is a quality standard. Low-price products are unbranded. To ensure minimum margins, retailing chains buy their fish products (fish fillets and fish dishes mainly) from foreign-based processing companies, so the processing industry tends to move to low-labour-cost countries. By 2020, poor people consume fish in the form of fish dishes made from waste fish, and richer people favour labelled (imported) fish fillets or fish. Fish fillets from traditional species caught in the wild are no longer available.

Supply
Because economics are more important than the environment, population pressure increases and/or activities release more contaminants and pollution, including organics, into the oceans. This leads, along with overfishing of the main target species of large predators, to less recruitment of the valued traditional species and to their collapse. Food production comes first, and there are few technical restrictions to fishing technology, so habitats are damaged. However, fishing improves in efficiency, so overfishing accelerates. Trophic cascade effects caused by overfishing lead to increases in populations of sea urchins and jellyfish, which graze down kelp forests. Fishing then turns to lower trophic level. Catches are sold as low quality fish to be included in fish products. Fishing also targets krill and mesopelagic fish, to increase the production of fish feed for aquaculture. This leads, by 2020, to an impossible recovery of lower trophic level stocks and to the collapse of most other stocks. In other words, large predators collapse first, and then fishing down the foodweb leads to total collapse of other stocks. The migration north of southern species, so becoming new invasive species, is a likely offshoot. These invasive species become new resources for fisheries (e.g. lessepsian species and comb jellies). Ultimately, fishing industry profitability decreases as a consequence of lower value production shared among a large fishing fleet.

Aquaculture focuses on farming large predator species intensively (mainly in cages). The concentration of the same species in a single area leads to an increased need for medication (antibiotics) to be used in a preventative manner. The cure is worse than the disease, and the chemicals end up polluting water and the

sediments. After a few news headlines about poisonous fish, aquaculture has to show its welfare concerns, so lowering the use of medications and growing just natural fish (no bio-engineered material), and settling boxes in places where pollution has less detrimental effects on coastal activities. The mass culture production of a few species is initially highly profitable, but it ultimately becomes less profitable because of the poor perception about farmed production, but also because of the lack of fish feed.

2.2 Delicatessen

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5	Hypothesis 6
A World Context	Free trade and Production Specialities	Short-Term Economy	Protectionism for Food	World Governance		
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C EU Seafood markets and economics	Responsible World	Innovative World	Shopping World	Expensive Fish	Ready Made Fish Meals	
D Social dynamics	Urban Ecology	Green Industrialization	Tourist Rather than Fisher	Fishers Know Better	We Need Production from the Sea	
E Ecosystems	Starts Bad but Gets Better	Global Meltdown	Local Solutions for Global Problems	Supergreen		
F Production	Free Market	The EU Promotes Aquaculture	Healthy and Diversified Products	Fisheries bounce back and natural food is the order of the day	Fishing Feeds Poor People and Aquaculture	Big Fish is a Luxury
G Research policies	Pop Idol	European Drive to Technology Transfer	Funding Nemo	C'est la Vie	Public Money Rules Research	

Delicatessen (fish a healthy food): new opportunities for European fisheries and aquaculture
Synthesis

- Europe wants to feed its people with healthy, clean seafood (gain on health spending)
- development of new knowledge and technologies
- increasing importance of ornamental fish for aquaculture
- consumer preferences scenario
- labelling and certification as a marketing tool (disinformation)
- fish product makes useful ingredients for other products; blooming industry for marine ingredients
- reduction of chronic pollution

Other **synthesis**

- EU prevents overfishing by high-tech surveillance
- Long-term resources important for EU
- seafood nutritional quality is what counts
- clean seafood (gain on health spending) also from marine ingredients and enhanced species in aquaculture
- High-tech processing industry
- Traceability as a trade barrier to protect aquaculture investments
- Fresh natural local fish is a luxury
- Stock and recruitment ultimately recover

World context

Despite food grain price volatility attributable to extreme weather events and Far Eastern (mainly Chinese) demand, average world prices of fish protein remain higher than meat protein. Climate change is as forecasted by the IPCC (global temperature increase of 0.4°C in 2020 over 2000, and an average sea-level rise of 6 cm). To open service markets, rich countries stop subsidizing agriculture and fishing, allowing the Doha cycle to succeed by 2010. Meat prices increase (especially bovine meat in Europe) which triggers demand for fish product in Europe. To counter the steady decline in European fish production, the European market increases its fish imports from Asian and African countries. This is somewhat balanced by the growth of meat exports (with Latin America and New Zealand also major suppliers and tough competitors) to Asia and Africa. However, from a European and world food security perspective, this situation is unsatisfactory: African countries also need their seafood for local consumption, and the EU relies too much on fish imports. In fact, the EU needs locally produced seafood, so marine resources have to be protected to allow future European fish supply.

Regulation

European seas are shared among countries and must be exploited in a responsible manner for local seafood production. Policies on the marine environment and the exploitation of marine resources have to be centralized at an EU level so that decisions and management tools are globally harmonized and controlled. Previously, it seems that the objectives and the management tools were correct, but enforcement, monitoring and control was lacking. Therefore, the EU takes central control of its objectives, making it mandatory to equip fishing vessels with standardized communication equipment. A hi-tech platform (Big Brother) monitors fishing activities, and a policy force controls all seagoing vessels and is present at all landing sites. High fines remove possible economic benefits from breaking rules. Further, EU policy takes some strong initiatives, such as using transferable quotas to reduce the fishing fleet between 2010 and 2015. The decrease in fishing effort is necessary because the fishing grounds are exhausted and to help recover spawning material of tuna and eel. The burden of proof is introduced for fishing vessels, leading to recovery of recruitment by 2020.

To protect the health of consumers in the face of quality issues and to avoid distorted competition, traceability records and equipment become mandatory for trading with the EU. Traceability definitions and processes are standardized globally. However, traceability also acts as a trade barrier for small producers in poorer countries. Fish imports into the EU increase but are made by big producers based in emerging countries who can afford the traceability technology required.

In terms of the marine environment, clean technologies for pollution and contaminants are adopted more often by the stakeholders (onshore industries, shipping). These investments are freely chosen to ensure that no penalties or shared costs of clean-up will be due in future according to the logic "the polluter pays". However, as the initiative of clean technology adoption is bound to the will and anticipation of the actors, the evolutionary path is quite different according to location and country. It ends up at a European level in a patchwork of productive and unproductive ecosystems for fishing and aquaculture. There is no equilibrium between different areas and there is also no stability in the system. Unintentional introduction of invasive species or biological pollution remains a risk, because regulations on ballasts, transfers, etc. are not efficient. Landing and fishing activities are better monitored by the regulator, but this is not the case for the global maritime transportation.

Research

Sources of funding for marine and fisheries research increase dramatically at European and national levels, because the activity is valued highly: the challenge is to restore ecosystems and a European fish supply. Fish supply and marine ingredients are fundamental to food security, but also to increase seafood consumption as a health enhancer of an ageing population. Enhancing consumer health in the long term might save health and welfare costs. The European Research Area (ERA) is fully achieved: barriers to transnational cooperation are overcome, and enablers are successfully implemented. The European Union manages to establish a consolidated structure to provide easy and free access to all European Marine Observation and Data, and also to improve inter-operability and reciprocal access to modern research infrastructure.

Fishers realize that they will benefit from sharing their knowledge with scientists. Transferable quotas and vessel monitoring by the mandatory communication systems make competition among fisheries useless. This results in better scientific advice, allowing enhanced stock management and more recovered stocks. Further, research opens new opportunities for fishers through fishing other marine resources as food additives, and in pharmaceuticals or cosmetics. Much new knowledge is created and communicated, and information is freely and widely available: research is driven by "public-good" and quality publications. Many highly attractive positions are available to researchers – scientifically well regarded, and well funded.

Demand

The ageing population of Europe wants more fish products because of their healthy properties. However, consumers spend less time cooking and the youth do not know how to prepare and cook a fresh fish. They want fish fillets or, better, ready-made fish meals. Premium quality fish is made with (eco-)labelled species, the origin and species being stated along with the nutritional features. A low-cost marine dish is made with other marine resources, less expensive than fish, but offers high nutritional value. Other than "real whitefish", ready-made product is the main sale. Labels and certifications are used as marketing tools by retailers.

To improve the health benefits of food products, the processing industry produces more ingredients (such as fish oil, omega 3, and cod sperm) from fish, but also from other marine resources (e.g. algae) that can be added to food products, not only to fish food products. More innovative products are made from fish and other marine resources, and more functional food is produced. Innovation from the processing industry creates a wide range of ready-made fish dishes, advertising different fish qualities, premium ones being labelled. For medium- and low-cost products, the processing industry can use a wide diversity of fish supply or marine ingredients, but supplies dishes whose taste must be the same through time. The processing industry drives the fish dish tastes: from any supply it produces different fish dishes with identified and consistent tastes. Therefore, the processing industry has to move to highly flexible, more precise and high-tech production lines. Parts of the automated processes are closer to those of pharmaceuticals. This technological innovation keeps the processing activity in Europe itself.

Supply

The need for other marine resources creates a new business for fisheries. The fishing industry provides not only fish, but also other marine resources (the basis of new ingredients) to the agro-food industries. There is massive fleet reduction, but technological improvement leads to increased efficiency, and the smaller fleet is profitable despite production decreasing. As commercial fisheries cannot deliver the fish quantities required, aquaculture is promoted at an EU level to fill the gap and to preclude too strong a reliance on imports.

Improvements in aquaculture are promoted in many directions: in biology (hybrid, triploids), in fish nutrition (fish feed requiring less wild fish), in fish health (vaccines and efficient networks for shellfish), and aquaculture technology (coastal and offshore in cages, and onshore). The success of biological research and development for aquaculture leads to farming of a limited number of new species in Europe, but with a variety of features targeting nutritional properties (hybrids, triploids and the same fish with different fish feed) and to diversification of seed ranching for new species. New farming technologies also focus on halting escapement. As the challenge is to increase aquaculture production by almost tenfold, no possibility for productivity improvement can be disregarded, even if alien fast-growing species are to be introduced into Europe. GM fish is the only exception and is not produced, because GM animals are still not accepted by European consumers.

Increased control and care of animal health in aquaculture production, using onshore farming when needed, leads to healthy production. The local production is protected from imports by better health controls in the EU. Further, local production benefits from labels and certification advertizing the nutritional value and increasing the price. Aquaculture production increases hugely, and the variety of production improvements (technology, health, species breeding, selection and nutrition) adapted to each species production and location (also helped by supporting EU policies) supports a decrease in operating costs. However, the variety of investments for farming a limited but larger number of species leads to an increase in the cost of fish production. Ornamental fish offer a growing niche production, benefiting from the innovations in aquaculture. Fish constitute healthy and diversified products, but tend to become more of a luxury when fresh local fish are required.

Apart from aquaculture, tourism (including recreational fisheries), is one means by which coastal communities develop to diversify employment. However, as commercial fisheries are tightly monitored, recreational fisheries have to be subject to the same control, and also have to pay for the privilege. Other activities, such as energy production (wind farms, tidal, nuclear) are encouraged along the coast. Coastal users form a network to ensure fair and equitable access to coastal and subtidal space for each activity. The limit of this scenario for the fishing industry is that marine ingredients from other resources than fish might also need to be farmed.

2.3 Regionalism

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5	Hypothesis 6
A World Context	Free trade and Production Specialities	Short-Term Economy	Protectionism for Food	World Governance		
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C EU Seafood markets and economics	Responsible World	Innovative World	Shopping World	Expensive Fish	Ready Made Fish Meals	
D Social dynamics	Urban Ecology	Green Industrialization	Tourist Rather than Fisher	Fishers Know Better	We Need Production from the Sea	
E Ecosystems	Starts Bad but Gets Better	Global Meltdown	Local Solutions for Global Problems	Supergreen		
F Production	Free Market	The EU Promotes Aquaculture	Healthy and Diversified Products	Fisheries bounce back and natural food is the order of the day	Fishing Feeds Poor People and Aquaculture	Big Fish is a Luxury
G Research policies	Pop Idol	European Drive to Technology Transfer	Funding Nemo	C'est la Vie	Public Money Rules Research	

Regionalism (local solutions for marine resources)

Synthesis

- migrating stocks suffer from poor cooperation, but local stocks flourish
- what is a region: from RAC regions to smaller regions (a mosaic of different regulations)
- CFP experiment has failed. Regain control of own sea/fish
- consumers prefer national-label products and fresh local products
- development of native species in aquaculture
- locally bred researchers (national preference)
- reduced cooperation among European institutes (but many experiments)
- tight control over imports and exports

Other **synthesis**

- imports from aquaculture, not overseas fishing grounds
- EU regulation on ecosystems; nations manage fisheries
- High-frontier research, applied research for locals
- Demand for locally labelled products
- Stocks depend on the local regulation and size of the region
- Region specialization: tourism and MPAs or aquaculture and energy
- Expensive fish: diversification of aquaculture, plus traceability and control

Note: The scale of the region determines whether it will be successful for cooperation in management and production

World Context

Global warming is taking place faster than anticipated, and it affects agricultural production. Energy prices keep rising, causing inflation and more economic tensions. These factors lead to greater protectionism in most regions, to secure food supply and independence. As international negotiations have fought tariff trade barriers for years, non-tariff barriers of "quality" are used, mainly by northern countries as a protection for imports. In return, southern countries with fishing industries stop giving access to their fishing grounds. There is a reduction in the number of bilateral agreements for fishing, and trade in fish product decreases. In coastal southern countries, fish is more available for local consumption, and yeilds a larger share of animal protein intake.

Regulation

Increasingly, EU marine regulation turns to ecosystem management and water quality criteria, because the Common Fisheries Policy has failed and stock depletion is rampant. At an EU level, the creation of local Marine Protected Areas (MPAs) is promoted as a local tool to reach water and ecosystem quality targets. For fisheries and aquaculture, rules and regulations are initiated from outside the classical playing field, reflecting the fact that fisheries and aquaculture are seen as rather minor stakeholders in the European environmental and economical discourse. Old fisheries networks (RACs) did not deliver the influence needed to see what is coming and to influence the decision-making process at a European level.

The social, cultural and economic importance of fishing and aquaculture activities in many countries and regions forces these nations to take fisheries management back into their own hands, and to find tailor-made solutions to the problems: overfishing results in recruitment depletion for major exploited species. Therefore, MPAs are among the local solutions advanced to help restore fish resources. The establishment of MPAs causes pollution to decrease in coastal and estuarine areas where they are implemented, but not continuously. However, MPAs cannot solve overcapacity and overfishing, although fishers wishing to continue to operate have to prove no damage from harvesting (rules for an MPA) to habitats and ecosystems. Moreover, there is need to develop and diversify activities in coastal communities, and

MPAs limit sea use. The number of MPAs increases depending on local drivers, but their distribution along the coast is not coordinated and optimized for ecosystems. There may well be different MPA rules for different countries. Local regulation may vary according to region and size, but the most common tools are effort management and ITQs, which lead to bargaining of "vouchers" similar to carbon credits. This is made efficient by strong enforcement, which can be either high-tech control or highly visible policing.

Research

The environment takes over the research agenda in most European nations, following the award of the 2007 Nobel Peace Prize to the Intergovernmental Panel on Climate Change (IPCC) and Al Gore for "their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change". A shift in the policy agenda occurs partly towards marine environment, as a new frontier for research and discoveries. European countries compete for international excellence, and public research targets shift from applied to basic research. Fierce competition takes place, stimulating research teams to aim for, e.g., a Nobel prize while at the same time impairing previous efforts to facilitate/share infrastructure and data. Collaborative approaches are deemed useless, and fragmentation and duplication are not issues any more. Basic researchers benefit from a *carte blanche* from their home organization, supported by large financial resources.

At least locally, public money is directed towards fundamental research on, e.g., fish disease, whereas private funding is targeted at practical aquaculture research issues. This applied research benefits from the genomic findings from basic research tat become freely accessible. Globally, Europe strengthens its position as the world's largest producer of scientific output, but the findings remain inappropriately focused for development. Applied research success is bound to the personal implication of researchers for the development of their territory. In such a case, researchers forego brilliant international careers, but benefit from local subsidies for this applied research.

Demand

Answering to the demand of consumers for more information about the food they purchase, retail chains use traceability information to generate consumer-targeted information and to segment markets. Through time, labelled products become the standard: instead of reaping a premium price, the labelled products drive out low-information products. Consumers' trust in production, retailing chains and labels becomes limited. High quality, luxury, fresh products must be produced locally with regional labels that have a story to tell. Imported fresh or frozen products with regular labels are lower cost products.

A high quality fish dish for most customers will mention the fish species used and detail its European origin. To increase the range of products advertising local origin, the processing industry increases its research investment to value what used to be called fish waste. The products made from this, used as food ingredients, are mainly taste-enhancers or "healthy" ingredients that the food industry can advertise as natural and locally produced. The processing industry becomes more high-tech and automated (closer to pharmaceutical processes), providing the market with a full range of products: from "Norway single fjord salmon pasta" to "French fish sauce pasta" the latter containing mainly fish waste. Fish imports to the EU, needed to provide the processing industry and retailing chains with low-label products, generally come from Asian aquaculture. These products are tightly controlled.

Supply

The size of a region determines whether it can successfully for cooperate in management and production. The best example is in the Faroe Islands, where fishers realize that exploitation of marine resources in a responsible, sustainable manner will ensure them a long-lasting, secure business, by allowing stocks to be maintained or recover, and that they will benefit from by sharing their knowledge with scientists. In other regions, however, for example where tuna are caught, responsible behaviour of local fishers has no effect on total stock health because international fleets or perhaps even neighbouring countries keep overfishing the resource and the fisheries die. Wild fish production from European seas varies according to the extent of regional regulation and enforcement, and mostly according to the size of the region. In some regions, local stocks flourish, but migrating stocks suffer from poor cooperation, and different regulation and enforcement between regions. Overall, there is massive fleet reduction, but ongoing technological improvement leads to increased efficiency. The (smaller) fleet is profitable, but fishery production decreases in terms of volume.

To diversify employment in coastal communities, tourism, aquaculture and energy production (wind farms, tidal, nuclear) are encouraged along the coast. In the most touristic places, MPAs are promoted. Recreational fisheries exist outside the MPAs, but users pay for the privilege and are tightly regulated. In many other places, aquaculture and energy production sites are implemented. When coastal users form a network to ensure fair and equitable access to coastal and subtidal space for each activity, the community thrives. However, other communities face competition for sea use, and the most powerful wins.

Aquaculture has to fill the gap left by diminishing wild fish demand, but with a great diversity of species, because locally produced species are premium product. The success of small teams in biological research and development for aquaculture has led to farming of many (around 40) new species in Europe, and to diversification of seed ranching for new species. Also, native species are fostered, along with introduced fast-growing species. There are major improvements in ensuring farmed animal health (hybrids, onshore farming when needed, medication). To secure investments made in aquaculture and health of seafood sold in EU markets, very tight quality control on imports limits their volume and increases their price. The trade protection of the EU, and the variety of investments made for farming a huge number of species (around 40, each produced in rather small quantities) leads to an increase in the cost of fish production, also helping fisheries to remain profitable. In this scenario, fish provide healthy and diversified product, but tend to become more of a luxury; only seafood dishes made with fish waste stays affordable to most. The limit of this scenario might be that fish demand may not be answered by affordable production, and fish consumption decreases.

2.4 Responsibility

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5	Hypothesis 6
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D Social dynamics	Urban Ecology	Green Industrialization	Tourist Rather than Fisher	Fishers Know Better	We Need Production from the Sea	
E Ecosystems	Starts Bad but Gets Better	Global Meltdown	Local Solutions for Global Problems	Supergreen		
F Production	Free Market	The EU Promotes Aquaculture	Healthy and Diversified Products	Fisheries bounce back and natural food is the order of the day	Fishing Feeds Poor People and Aquaculture	Big Fish is a Luxury
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Responsibility (an adult world)
Synthesis

- consumer only demands products from sustainable sources
- fishers understand that they need to maintain stocks
- non- (or less) polluting aquaculture; replacement of fishmeal and fish oil by vegetable and herbivorous species
- fishers develop less damaging gears and practices
- subsidies at the right place for the right thing
- fishing quotas owned and traded, but some bought by NGOs and recreational fishing operatives (solving overcapacity)
- participatory management of both fisheries and aquaculture

Context
As in the macroscenario above, the world's economy outpaces precautionary principles. Climate change is faster than expected and recurrent extreme weather events drive up the cost of food grain. The world price of meat increases and meat proteins are less available to the poorest countries. In those countries, the supply of small local fisheries becomes a crucial source of animal protein. To reduce food prices, richer countries agree to reduce their help to agriculture. Rich regions tend to compete to access fishing grounds around the world, with agreements including financial compensation, but such activities create riots in many poor countries, covered by the media, because western fleets compete with small local fisheries for scarce resources. Rich countries scavenging the world for seafood are made to appear scandalous in terms of European public opinion. Activists try to sway public opinion against buying wild fish imported from southern (poorer) countries.

Regulation
Environmental concerns with the speed of climate change and the consistently unpopular image of a fishing industry starving poorer people around the world by taking their fish leads the fishing industry to react. The industry understands that it can be a key actor in marine environment management, and fishers declare themselves custodians of the seas. Food security in the world and Europe is a major concern, and it is acknowledged too that the sea is needed for food production in Europe. However, the sea has to be exploited responsibly to achieve this goal. The importance of the marine environment supersedes national competencies, and the marine environment is governed centrally by the EU. In addition, the environmental policies leading marine governance are increasingly designed to address global fora. Along the way, though, the EU has to apply tighter control on seafood imports to avoid competition from low-quality products.

Fishers accept the principle of effective management, but political consensus is needed at a local or a regional level to gain buy-in by the different users of the sea (local communities and industry). Fishers also realize that they benefit from sharing their knowledge with scientists, not only to improve stock management but also to improve cross-sector management of different coastal activities (by preventing or encouraging, depending on the activity). Some fishers also realize that acknowledging stock depletion will value their catch higher in the market: what is rare is expensive!
Regional Advisory Councils (RACs) develop tools for management that either manage ITQs or ETQs, or both, or fisheries communities manage resources and access at a local level, depending on the local situation. The management tools depend on local consensus, and subsidies are tied to a clear and consensual process. Overall, fishers take more responsibility on marine resource management at a local level, but targets are set at an EU level. Fishing quotas are owned and traded, and

recreational fisheries have to buy quotas to participate. In places, NGOs buy quotas to protect marine mammals, for example. There is no need to introduce a burden of proof for fishing vessels, because the communities and local industry generally oversee the enforcement of targets they have decided and agreed. Tourism, including the recreational fishery, is one way that coastal communities adopt to diversify employment. Other activities include energy production (wind farms, tidal, nuclear) and aquaculture. Coast users form a network to ensure fair and equitable access to coastal and subtidal space for each activity, and scientists often ease the negotiations between users and the various activities. The community thrives, with good quality of life.

Research

Sources of funding for marine and fisheries research dramatically increases at European and national levels, because the activity is valued highly. Research also benefits from specific regional funding bound to local projects. The European Research Area (ERA) is fully achieved: barriers to transnational cooperation are overcome and enablers successfully implemented. The European Union manages (i) to establish a consolidated structure to provide easy and free access to all European Marine Observation and Data, (ii) to improve inter-operability and reciprocal access to modern research infrastructure, and (iii) to ensure transdisciplinarity of projects. Many highly attractive positions become available to researchers, most scientifically well regarded and well funded. Research is also attractive for its ethical dimension: helping stakeholders and local communities to achieve a social and sustainable economic equilibrium. In the research Eden, much new knowledge is created and communicated, and the information is widely and freely available.

Demand

Customers and politicians have a growing awareness of nature's physical limitations and of the need to restrict humanity to sustainable activities, changing the way industry and retail chains work. Fish waste (e.g. skin, bones) cannot just be thrown away and has to be valued. New ingredients are made from these almost free raw materials for many uses, including taste-enhancing ingredients for food products. Pushed by too many national aquaculture labelling initiatives and different eco-labels in the European market, the EU becomes the first region of the world to set up a unified quality standard for wild fish and aquaculture that takes into account both ecological and social criteria (such as small-scale, artisanal, regional production). Retail chains acting as wholesalers share the investment in labelling systems, with producers taking on part of the corporate social responsibility for actions they value, along with investors and customers.

Customers are eager to know more about the food they consume. Labelled fish is the first step for consumer quality insurance, and the second step is to know exactly where the fish has been caught, or raised and processed. EU regional labels (or regional fish specialities) appear attractive to customers as a guarantee of fresh local produce and genuinely local feeding (the fish has a story to tell!). It leads to higher value for fish that are produced locally. The responsible customer in this scenario eats less fish, but requires quality and local production.

Supply

The EU supports the adoption of new and clean technologies, to reduce pollution and contamination. This support aims at protecting the marine environment, but also at helping the "clean technology" industry, anticipating that these products will be an important share of industrial exports in future. These new technologies supply fishing as well as fish farming: new fishing gears catch only what is wanted, and new farming pens preclude escapement. Of course, the pace of adoption of new technologies and the pace of participatory management leading to visible results differs from region to region, and in 2020 the European coast is still a patchwork of highly productive and less productive ecosystems for aquaculture and fisheries. Overall, though, fisheries management processes lead to recovery of stock recruitment to the level of the past 20–30 years.

The unintentional introduction of alien species remains a risk, because regulations on ballast, transfers, etc. are not yet that efficient.

Fisheries catches are higher value as production volume decreases. The fishing industry diversifies (with the help of scientists) by fishing new marine organisms for non-food use. These fishing activities lead at the same time to sustained profitability of the industry and to a recovery of stocks to the level of the 1970s (including spawning material for eels and tuna). Small fish in the wild are no longer used for aquaculture, because such a process is ecologically flawed: small fish are essential to the foodweb and can be used for human food directly. Therefore, diversification of species for aquaculture is mainly on herbivorous species. To protect wild animals from disease and to avoid coastal biological pollution, aquaculture is often moved ashore. As customers want natural, healthy food, bio-engineered fish of all types are disregarded for aquaculture; only natural (no hybrids or GM) fish are farmed. Most regions in the world, especially Asia, do not have such tight quality criteria about seafood as Europe; more health control is applied to imported products. Fisheries bounce back and aquaculture is less productive and more expensive.

2.5 1984

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5	Hypothesis 6
A World Context	Free trade and Production Specialities	Short-Term Economy	Protectionism for Food	World Governance		
B Regulation	Industry Responsibility	Integrated Europe	Local Solutions for Local Problems			
C EU Seafood markets and economics	Responsible World	Innovative World	Shopping World	Expensive Fish	Ready Made Fish Meals	
D Social dynamics	Urban Ecology	Green Industrialization	Tourist Rather than Fisher	Fishers Know Better	We Need Production from the Sea	
E Ecosystems	Starts Bad but Gets Better	Global Meltdown	Local Solutions for Global Problems	Supergreen		
F Production	Free Market	The EU Promotes Aquaculture	Healthy and Diversified Products	Fisheries bounce back and natural food is the order of the day	Fishing Feeds Poor People and Aquaculture	Big Fish is a Luxury
G Research policies	Pop Idol	European Drive to Technology Transfer	Funding Nemo	C'est la Vie	Public Money Rules Research	

1984 (total European regulation and control to maintain seafood production)
Synthesis

- green scenario
- fleets are under control and stocks can recover
- efficiency in fishing, but standardization of products
- understanding of species/ecosystem relationship, to develop aquaculture
- technology-driven and technocratic system
- binding international agreements on biodiversity conservation and climate change
- EU maritime police force (EMPF)
- research and rigorous monitoring (surveillance, monitoring, technology)

Context

Climate change and energy supply concerns lead to major action to mitigate greenhouse gas emissions and to a new Kyoto agreement around 2010, including the USA (helped by the administration change in 2008). Sustainability and longer term views have been translated from generous motto into real actions though international agreements. These agreements on climate change and biodiversity conservation are more binding, to make sure they lead to real action. To avoid pollution from accidents involving ageing maritime fleets and better control of maritime transport, a global agreement on data sharing in ship identification and navigation is signed multilaterally (a worldwide automatic ship identification system). International regulation of shipping is very efficient, reducing accidents substantially. Bilateral agreements to access fishing grounds include sharing satellite data among countries and important capacity building support (vessels, technical, research and financial help) to enforce the maximum sustainable yield or other target finally decided. World fish production initially decreases, but then starts to increase after 2015, supported by growing aquaculture production.

Regulation

In Europe, fish supply is necessary for marine resource protection. EU policies on the environment, and on research and fisheries become more coordinated. Centralized policies prevail in the EU in terms of the exploitation of marine resources. Decisions and management tools are globally harmonized and controlled, and there is no room for measures and actions at a national or even a regional level. Past objectives and management tools were correct, and the only problem was their lack of enforcement, allied with weak monitoring and control.

The EU makes it mandatory to equip fishing vessels with standardized communications equipment. A high-tech platform monitors all fishing activities, and a special policy force controls all seagoing vessels, and is present at all fish landing sites. Large fines aim at taking away possible economic benefits from breaking the rules. The EU policy includes strong initiatives to reduce the fishing fleet between 2010 and 2015, because the fishing grounds are becoming exhausted and it is necessary to generate a recovery so that spawning material of tuna and eels can be accessed. Aquaculture is promoted, because fisheries cannot deliver sufficient volume of seafood.

European regulations on water quality result in decreased input and runoff of undesirable organic material, as well as reduced eutrophication of rivers and coastal waters (organic agriculture, reasonable use of medication by consumers and highly efficient waste treatment). European governance results in a coordinated net of Marine Protected Areas (MPAs). European and national governments decide that fisher knowledge and statements are unreliable, and decisions on access are made bureaucratically, dominated by environment-friendly options.

Research

The policy context helps the European community to address the "European Paradox" – i.e. that on the one hand the EU is the world's largest producer of scientific output, while on the other hand, R&D knowledge flows from science to technology are weak in the EU – strengthening the marine research agenda within the framework of European integrated maritime policy. In a parallel development, marine priorities drop off Member States' research agendas, which assume that these matters are already well addressed at a European level and therefore contain new sets of priorities (e.g. other specific industrial issues or public health issues). As a consequence, the European funding dedicated to marine fisheries research increases, whereas national funding decreases. The latter combination leads to a global decrease of available budget for marine fisheries research, and European attempts to take on the lead role fail: (i) European Commission funding cannot compensate for the loss of national funding; (ii) research remains a satellite component of integrated maritime policy, strongly led by transport and shipbuilding.

Marine research benefits from the vessels' communication data and cross-cutting data sources to create new knowledge: environment/climate, vessel positioning, fish stocks. The research is more allied to surveillance and vessel technology, and aquaculture. European industry develops and retains a steering role in setting the research agenda, which involves more industry stakeholders. As a direct consequence, there is a shift in applied research. Owing to the disengagement of Member States, though, infrastructure operators/users have to make the best of existing, ageing research infrastructure. The concept of a virtual centre of excellence is also developed to foster an as efficient as possible use of existing facilities and capacities.

The marine and fisheries research sector also faces job losses. However, the career becomes more attractive: research is conducted with an applied and interdisciplinary approach (such as understanding the relationship between the environment and fish behaviour). A wide range of challenging opportunities is offered to fewer but more fulfilled researchers. The knowledge produced is clearly targeted at industry, allowing sustained technology transfer for the benefit of the sector as a whole – Europe enters the virtuous triangle of information.

Demand

The EU manages the product and demand market, with a mix of regulation and incentives. Fish waste (skin, bones) cannot be thrown away any longer, and is banned outright. Instead, fish waste has to be recycled and used to add value elsewhere. New ingredients are made from these almost free raw materials for many uses, including taste-enhancing ingredients for food products. The EU becomes the first region of the world to set up a unified quality standard for wild fish and aquaculture, taking into account ecological criteria. Labelled fish are promoted as a first step to consumer quality insurance, and the second step is to make it mandatory to state exactly where the fish has been caught or raised and processed. EU regional labels (or regional fish specialities) appear attractive to customers as a guarantee of fresh, locally produced fish, but they benefit too from food miles subsidies (less greenhouse gas emissions through transportation).

Customers and politicians have growing awareness of the physical limitations of nature, and of the need to restrict humanity to sustainable activities, changing the way industry and retail chains work. Retail chains, acting as wholesalers, value investment in the labelling system as a quality insurance that consumers, eager to know more about the food they consume, can afford.

Supply

Ecology, considered from the perspective of a city-dweller, prevails. Animal welfare is a major concern, so sportfishing is considered to be too cruel. People want to preserve nature above all else. For fishing, new bycatch mitigation devices, such as separator panels, square mesh, T90 diamond mesh, and acoustic deterrents become commonplace, and are legally required in certain fisheries. New trawl gears are introduced, employing jets of water, electronic currents, etc. Fishing gears are generally less damaging to habitats and to non-target populations.

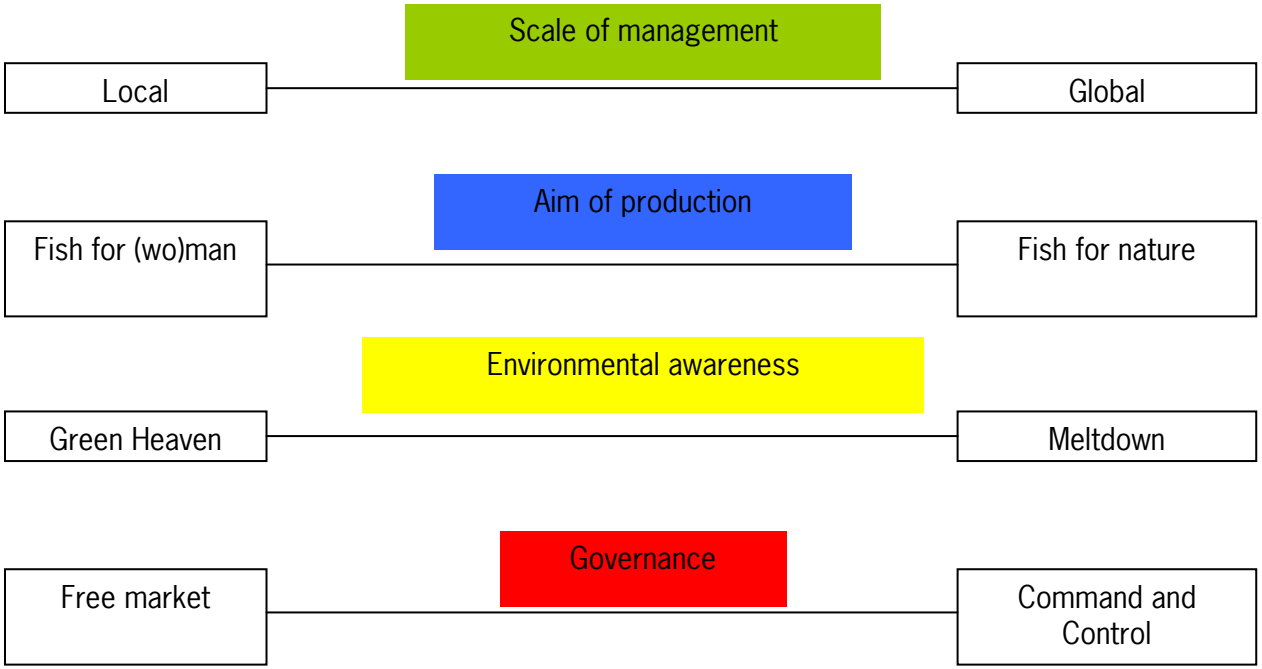
Management takes account of the changing environmental conditions, so sufficient fish survive to reach adulthood and maturity (including some large "megaspawners"). This results in sustained recruitment even in years when environmental conditions are poor. A well-developed age-structure "buffers" the stock against extreme recruitment variability. Essential spawning habitats and spawning aggregations of adults are protected. Discarding is banned throughout Europe, and all bycatch of non-target animals has to be brought into port for monitoring purposes and to be rendered into fishmeal (so reducing the demand for industrial fisheries). Bycatch of commercial species (undersized animals) are considered against quotas.

Harmful Algal Blooms have been explained, reduced, and now can be predicted. Clean and productive coastal and estuarine areas become available for developing aquaculture. Enhanced aquaculture is promoted in many directions: in fish nutrition (fish feed requires fewer wild fish), in fish health (organic vaccines and efficient networks for shellfish), and aquaculture technology (coastal and offshore in cages, and onshore). Of course, the technology development takes into account fish well-being, and the density of cages is strictly limited to ensure fish quality. Increased control and care of animal health in aquaculture production, using onshore farming when needed, leads to healthy production. Bio-engineered fish (GM but also hybrids and triploids) of all types are banned from aquaculture production. However, the challenge is to enhance aquaculture production, so herbivorous, often alien, fast-growing species (such as *Pangasius*) under strict control are introduced into Europe.

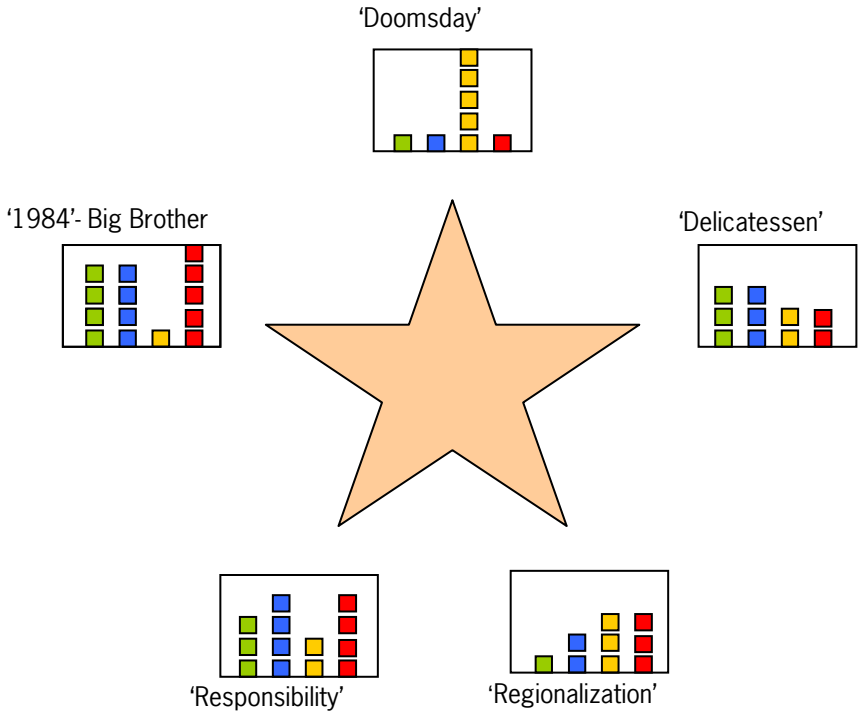
This scenario leads to huge investments in wild fish capture and aquaculture, and to limited production for the years 2010–2015. Fish becomes an expensive commodity, and the number of available species is limited for a while. However, recovery of the stocks to the level of the 1970s (including spawning material for eels and tuna) and the deployment of new aquaculture technologies, with economies of scale, allow European fish production to increase after 2015. Finally, the reduction of fishing activities and the fishing fleet between 2010 and 2015 leads to social problems in coastal communities dependent on the fishing industry. Development of the gear industry, the energy sector and aquaculture activities cannot balance out community opportunities during that period of time, but coastal communities recover with the increase in production after 2015.

3 Analysis

The scenarios described above can be differentiated along four axes:



Each of the five (macro)scenarios can therefore be sketched with a four-bar diagram along these four axes, as shown below:



- Scale of management
- Aim of production
- Environmental awareness
- Governance

The main features of the macro-scenario (S), in terms of drivers and actors, can also be summarized as follows:

	S1 Doomsday	**S2 Delicatessen**	**S3 Regionalism**	**S4 Responsibility**	**S5 1984**
Main driver	Short-term economy	Consumer demand	Local solutions	Social and environmental values	Technology
Main actor(s)	None	Processing industry	Local partnership including research	Fishing industry (and consumer ethic)	EU management

All scenarios, except S1 Doomsday, are different visions of the path to sustainable fisheries and aquaculture.

It is necessary here to restate the fact that these scenarios are just pictures of how possible futures might develop, with no special preference for a particular outcome (from S2 to S5), nor is there any certainty that the real future will resemble any of these “science fiction” views of tomorrow. Most probably, the true real future will fall in between (some of) these scenarios.