MICRO-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

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1 Preface

After defining the system's boundaries and documenting the drivers of the system the next step in the process is to develop micro-scenarios. A micro-scenario is a scenario for a single subsystem based on a unique combination of hypotheses, including one hypothesis for each of the drivers of that subsystem. Hence based on the hypothesis developed for each of the drivers for each of the subsystems a set of micro-scenarios are developed for each subsystem.

An Expert workshop was held in Brussels on the 27 November 2007, during which focus was on translating identified drivers and hypothesis about the potential future development of the identified drivers into a set of scenarios. The output of the workshop and the analysis made by the project team was used to develop a set of micro-scenarios. In this report you will find a description of the several micro-scenarios.

The micro-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 drivers of the 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 tiles given to hypothesis of each of the drivers. For details on the hypothesis the reader is referred to Report 3: Systems & Drivers.

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

2 Micro-scenarios

2.1 A – World Context

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3
A1 Climate Change	Main IPCC trend	Faster warming	Fast Mitigation
A2 International Agreements	New Protectionism from all Sides	Free Trade in Fishing	Johannesburg++/Automatic Identification
A3 Food security	Fish vs. Meat	High Fish Supply	Fish Supply a Major Part of Food Security

Yellow Micro-scenario: Free trade and production specialities. Despite food grain prices volatility attributable to extreme weather events and demand from the Far East, especially China, the average world price for fish protein stays higher than that of meat protein. Climate change is as forecast by the International Panel on Climate Change (IPCC): a global temperature increase of 0.4°C in 2020 compared with 2000, along with an average sea level rise of 6 cm. To open service markets, rich countries gradually stop subsidizing agricultural and fishing activities, and the Doha cycle succeeds in 2010. Meat prices (especially for bovine meat in Europe) increase, triggering production. The demand of European (and other western) ageing populations for quality fish is high, leading to increased fish imports from southern (Asian, African, etc) countries to northern ones and increasing meat exports from northern countries (and Latin America) to Asia and Africa.

Red Micro-scenario: Short-term Economy. The world's economy outpaces precautionary principles. As some scientists feared, climate change is faster than expected and recurrent extreme weather events drives up the cost and value of grain. Therefore, the global value and price of meat increases and meat protein is less available to poorer countries. In those countries, the supply of animal protein by small local fisheries becomes more important. To secure their supply of food at the cheapest price, rich countries agree to reduce their aid to agriculture, and the Doha cycle succeeds in 2010. Rich countries compete for access to global fishing grounds, and agreements include financial compensation, but this system creates tensions in many poor countries because western fleets are competing with small local fisheries for ever-scarcer resources.

Underlined Micro-scenario: Protectionism for food. The demand for energy and global warming increases faster than anticipated, with serious effects on agricultural production and added protectionism in most regions, to secure local food supply and independence. As trade barriers and tariffs were rebelled against in many international negotiations over the years, non-tariff barriers of "quality" are mainly used by northern countries. In return, southern countries with fishing industries stop granting access to their fishing grounds, there is a decrease in bilateral fishing agreements and the trade in fish products decreases. In coastal southern countries fish is more available for local consumption and becomes a higher share of animal protein uptake there.

Blue Micro-scenario: World Governance. The effects of climate change and competition for sustainable energy lead to major actions to mitigate greenhouse gas emissions and to some kind of new Kyoto agreement around 2010, but including the USA (helped by the anticipated administration change in late 2008). Sustainability and longer term views have been translated from positive statements into real actions though international agreements. To avoid pollution resulting from accidents with an ageing world fleet and with better control of maritime transport a global, multilateral agreement is signed on data sharing in terms of ship identification and navigation (a world-wide automatic ship identification system). Bilateral agreements to access fishing grounds include the sharing of satellite data among countries and vital support for capacity building (through boats, technical, research and financial help), to help enforce the maximum sustainable yield (MSY) decided. Fish production initially decreases but then starts to increase strongly after 2015, also with the help of burgeoning aquaculture production.

2.2 B – Regulation

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5
B1 EU policies	The Blind Corner (regulation from other marine concerns)	Blue Haven (successful implementation also by producers of all marine policies)	Global Warning (marine environment supersedes national competencies)	National Village (local rules supersede regional rules)	
B2 Governance policies	Participation Frenzy (many stakeholders; a long process)	Governance will Rule (past stakeholder participation pays)	Fisher Management	The Sea– cret Police (high-tech control)	
B3 Management tools	Something's Got to Give (same tools, year-on-year plans)	A Brand New Day (effort management with transferable quotas that other stakeholder can buy)	We can work it out (local management contracts and control)	The Long and Winding Road (slow change of tools and institution; too late)	
B4 National policies	One Size Fits All	Tailor-made Solutions (local, RAC level)	Splendid Isolation (back to nations)		
B5 Politics	Technocropolis (biology defines management)	Agora (political consensus, RAC and ACFA make stocks an economic asset)	The Global Economy (fish protein supply is EU priority)	Small is not that Bad (national fisheries management and competition over shared stocks)	Ifisheries (personal perception in the EU guides policies)

Red Micro-scenario: Industry responsibility. The system is driven by Industry, which also interprets global warning signs, and fishers declare themselves custodians of the seas. The importance of the marine environment supersedes national competencies, so the marine environment is governed centrally by the EU. In addition, the environmental policies that underpin marine governance are increasingly being designed at global fora. The fishing industry understands that it can be a key actor in marine environmental management. Fishers accept the principle of effective management and the tools associated with it, but political consensus is needed at a local or a regional level among the different users of the sea (local communities and industry). RACs develop the tools for management that either manage ITQs or ETQs, or fisheries communities manage the resources and access at a local level, depending on the local situation. Therefore, the management tools depend on local consensus, but overall, fishers take more responsibility for marine resource management.

Yellow Micro-scenario: Integrated Europe. Central enforcement of objectives by the EU. Centralized policies prevail in terms of exploiting marine resources, and there is no room for measures and actions at a national or even a regional level. Decisions and management tools are globally harmonized and controlled. There is a

major issue regarding protection of marine resources, to permit a robust European fish supply, and although the objectives and the management tools are correct, the main problem is their enforcement, strict monitoring and control. Therefore, the EU makes it mandatory for fishing vessels to carry standardized communications equipment. A hi-tech platform ("Big Brother") monitors all fishing activities, and a special policy force controls all seagoing vessels and is present at all landing sites. Very high and EU-harmonized fines remove all possible economic benefits that could accrue if rules are broken.

Underlined Micro-scenario: Subregional governance, i.e. local solutions for local problems (inspired by the Mediterranean area). From the perspective of fisheries and aquaculture, rules and regulations are increasingly being initiated from outside the traditional playing field. Therefore, old networks (many stakeholders and a long process) is understaood not to deliver the influence needed to see what is coming and to influence decision-making. Moreover, fisheries and aquaculture are seen as minor stakeholders in the overall discourse. The result is a cacophony that brings nations to the point where they take fisheries management back into their own hands and develop tailor-made solutions such as effort management and ITQs that lead to bargaining of "vouchers" similar to carbon credits. This form of governance is made efficient through strict enforcement, either high-tech control or highly visible policing, using international inspectors.

2.3 C – Seafood markets and economics

[1] Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4	Hypothesis 5
C4 Consumer choice	Ethical Consumer	Healthy Consumer	Narcissist Consumer (taste and luxury)	Poor Consumer	Convenience Consumer
C1 Product diversification	From Waste to Taste	Functional Fish (ingredients)	From Waste to Taste (B)	From Waste to Taste (P)	Fish (ready-made meals)
C2 Processing	Regional Fish	Techno-Fish	Regional Fish	Lost Business (processing in countries with low labour costs)	Techno-Fish
C3 Channels of distribution	Sustainability First	EU Security First (traceability mandatory, and trade barriers)	Information Overload (labelled product as a standard)	Retail Management	Retail Management
C5 World supply	Endless Demand (high prices)	The Other Market (production increases from other marine resources)	Endless Demand (high prices)	Whatever is Left	The Other Market (production increases from other marine resources)
C6 EU trade within global trade	Limited trade (more local consumption in southern countries, less exports)	Import Armageddon (more imports for EU)	Import Armageddon (more imports for EU)	World Free Trade (trade dominated by whitefish blocks)	World Free Trade (trade dominated by whitefish blocks)

Red Micro-scenario: Responsible world. The key words of this scenario are environmental concerns and sustainability. Customer and political growing awareness nature's physical limitations and of the need to restrict humankind to sustainable activities changes the way industry and retail chains work. Fish waste (skin, bones...) cannot be discarded and has to be valued. New ingredients are made from these virtually gratis raw materials for many uses, including taste-enhancing ingredients for food products. Pushed by many national aquaculture label initiatives and different eco-labels used 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 ecological and social criteria (such as small-scale, artisanal, regional production).
Retail chains, acting as wholesalers, share the investment in labelling systems, and with producers also acting as part of their corporate social responsibility, they value investors and customers more. Customers are eager to know more about the food they consume, and eco-labelled fish is the first step for consumer quality insurance; 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

[1] The order of the factors of this subsystem has been changed since a main determinant in the subsystem derives form consumer choice. Hence numbering starts deliberately with C4 in stead of C1. Also for reading convenience some titles of hypotheses are duplicated in the table.

attractive to customers as a guarantee of fish being produced fresh and locally, of fish that did not travel from the other side of the world (food miles lead to more greenhouse gas emissions) and of a genuine local feeding (the fish has a story to tell!). This scenario leads to higher costs for fish that are produced locally.

Yellow Micro-scenario: Innovative world. In this scenario, the economy is driven by technology and innovation, yielding a society of healthier, older people, who want more fish products because of their health properties. In response, the processing industry produces more ingredients (such as fish oil, omega 3, cod sperm...) from fish, but also from other marine resources (e.g. algae) that can be added to food products, and not only fish products. More innovative products are made from fish and other marine resources, and more functional food is produced. The processing industry tends to move to more precise, high-tech automated processes closer to those in the pharmaceutical industry. The fishing industry provides not only fish, but also other marine resources (as the basis of new ingredients) to the processing industry. For sanitary reasons and also to provide quality traceability of the raw products in case of problems within the processing industry, traceablity records and equipments become mandatory for trading with the EU. Traceability definitions and processes evolve to a shared standardization and definition at a world level. Traceability acts as a trade barrier for small producers from poorer countries. Fish imports into the EU increase tremendously, but they derive from large producers in emerging countries who can afford the traceability technologies required.

Underlined Micro-scenario: Shopping world ("shop until you drop"). Retailing and pleasing the narcissist customer drives this scenario. Answering the demand of consumers for more information on the food they purchase, retailing chains use more traceability information to generate consumer-targeted data and to segment markets. Through time, labelled products become the standard, and rather than reaping a premium price, the labelled products drive out low-information products. High quality, luxury fresh products are produced locally with regional labels that have a story to tell, and imported fresh or frozen products with regular labels are lower cost products. The processing industry increases its research investment to value what used to be fish waste. The products made of former fish waste, when 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: e.g. from "Norway single fjord salmon pasta" to "Vietnamese fish sauce pasta", the second dish containing mainly fish waste ingredients. More fish imports to the EU are needed to provide raw material to the processing industry and retailing chains (for low-cost products). A high quality fish dish for most customers will state the fish species used and detail its European origin.

Blue Micro-scenario: Expensive fish. Retailing chains import material for poorer people. Chains increasingly market labelled fish product for premium prices, and fish with their brand (labelled or not) is a quality standard. Low price products are unbranded. However, whatever the fish quality, fresh fish sales decrease as fresh product becomes too expensive and many do not know how to (or even want to) prepare it. The demand is for whitefish fillets. To ensure minimum margins, the retailing chains buy their fish product (fish fillets and fish dishes mainly) from foreign-based companies, so the processing industry tends to move to low-labour-cost countries. Nevertheless, for a large portion of the European population, even these fresh fish fillets are too expensive. The processing industry creates fish dishes with fish ingredients made of fish waste to offer low cost quality nutritional product. Poor people eat fish in dishes made with fish waste, richer people favour labelled fish fillets or fresh fish.

Green Micro-scenario: Ready made fish meals. The processing industry drives the fish dishes through taste. Consumers spend less time cooking and the youth do not know how to prepare and cook a fresh fish. They want fish fillet, or better, ready-made fish meals. Innovation from the processing industry creates a full range of ready-made fish dishes advertising different fish qualities. The premium quality fish dish is made with labelled specified species, and the origin of the fish is mentioned for these products. The low price marine dish is made with other marine resources, less expensive than fish, but offers high nutritional value. In between, "real whitefish" ready-made product is the mainstream sale. The need for other marine resources creates a new business for fisheries, but the need for highly flexible production lines in the processing industry tends to keep this activity in Europe: for medium- and low-cost products, the processing industry can use a great diversity of fish supply or marine ingredient, but delivers products with consistent taste through time. The processing industry has learned to adapt to any supply and to produce different fish dishes with identified and consistent taste.

2.4 D – Social dynamics

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
D1 Recreational fisheries	The Oceans as a Playground (increased leisure, some stocks dedicated to recreation)	**Pay to Play (ITQs purchased by sport fishers and others)**	*Sport Squeezed Out (food security first, favoured species disappear anyway)*	Welfare Worries (sport fishing is cruel)
D2 Public perception of fisheries	The Conservationist (environmental views dominate)	***The Ruthless Exploitationist (food security first)***	The Fisher (with optimistic views about stock status prevailing)	The Politician (public uncertainty)
D3 Activities in coastal areas	*The Fishing Fantasist (the decline of coastal communities)*	**The Realist (new industries encouraged)**	The Marine Entrepreneur (personal or community entrepreneurship)	
D4 Competing use of seashore	Free for All	Big Brother (bureaucratic environmentally friendly options)	The Mafia (the power of money)	***Collaborative Control (coastal users)***
D5 Fisherfolk attitude toward future	*Fisher self- management (optimistic: only fishers know)*	**Partnership (reality faced, partnership for improvement)**	Bureaucracy (war between regulators and fishers)	
D6 Social capital	*What's Mine's My Own (fishers do not share their knowledge)*	**The Benefactor Approach (fishers and scientists share knowledge)**	We don't Believe You Anyway (fishers knowledge not trusted)	

Green Micro-scenario: Urban ecology prevails. Ecological issues considered from an urban perspective prevail. Animal welfare is a major concern, so sport fishing is too cruel. People want to preserve nature before everything else. The EC and national governments decide that fisher knowledge and statements are unreliable, so decisions on access are made bureaucratically, dominated by environmental friendly options. Coastal communities, among them fishing communities, do not evolve, and become poorer.

Underlined Micro-scenario: Green industrialization. Public opinion is dominated by environmental concerns. Natural resources are used for leisure and should be protected, but recreational fisheries are still possible within a regulatory framework, but must be paid for. The approach is realist, with new industries and alternative and tourist activities coming to the fore, and with different uses of the coastal area. The "big brother" approach dominates, and fishers are omitted from the decision processes. Simply, a bureaucratic option, fishers are not listened to, and environmental views prevail.

Red Micro-scenario: Tourist rather than fisher. The sea and the coast are used first for tourism and leisure. With an extension of leisure time, the recreational fishery develops and many fishers convert their vessel and activity to accommodate recreational fishing tourists. They change their culture to join the developing community of marine entrepreneurs, promoting the benefit of the sea to human health. Access to coastal resources will be open to everybody who can afford it. Although fishers decide to share knowledge, the knowledge is not trusted bureaucratically. The EC and national governments take total control of fisheries management and the attitude in the few remaining fishing communities hardens. Citizens do not know exactly how dangerous the situation is, because it is masked by political expedience and currency.

***Italicized* Micro-scenario: Fishers know better.** Fishers believe that they know better than anyone else how to manage stocks and, to protect their livelihoods, they refuse to share knowledge and information with scientists and governments. They refuse to believe that their traditional way of life cannot continue as it has in the past and continue to fish intensively, to supply fish in answer to the increased demand for fish and protein. Indeed, national and international concerns about food security are heightened. Consequently, the oceans are considered to be a place for food production, by wild fisheries and aquaculture. Recreational fisheries are squeezed out, and a decline in tourism leads to a decline in coastal communities. Fish stocks continue to decrease, including stocks of the large fish favoured by sportfishers. Aquaculture develops unhindered.

Emboldened Micro-scenario: We need production from the sea. The sea is needed to produce food, because world and European food security is a major concern. However, the sea has to be exploited responsibly. Fishers realize that they can benefit from sharing their knowledge with scientists, resulting in better scientific advice, enhanced stock management, and stock recovery. Recreational fisheries exist but users have to pay and are tightly regulated. Tourism, including the recreational fishery, is one of the ways coastal communities develop to diversify local employment. Other activities, such as energy production (wind farms, tidal power, nuclear energy) are encouraged along the coast, along with aquaculture. Coastal users form a network to ensure fair and equitable access to coastal and subtidal space for each activity. The coastal community thrives, with good quality of life.

2.5 E – Ecosystems

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
E1 Pollutants and contaminants	Economy over Environment	*Localized Stewardship (green pieces in a black puzzle)*	Global Stewardship (towards global sustainability)	
E2 Recruitment	Back to the Future (same as the mean of the past 20–30 years)	*No Parents, no Children (but improvement in non-target species)*	Let the Spawners Survive (sustained level of recruitment)	In Hot Water (recruitment moves north with climate change)
E3 Invasive species	Alien Attacks (an increase in invasive species, and negative impact, but new stocks)	Green Pieces in a Black Puzzle (patchwork of productive and unproductive areas)	*The Sea is a Kitchen Garden (intentional species introduction is a success)*	
E4 Escapement	Wild Salmon Collapse (genetic pollution)	*Land-Locked Salmon (moves ashore)*	Sterile Salmon	New technologies
E5 Impact of gears on habitat and organisms	The Norwegian example (discarding is disallowed)	Compulsory mitigation (bycatch-mitigation devices)	No Worries (food production first, and few technical restrictions)	*Burden of Proof (vessel owners have to prove no damage from their processes: less damaging gears)*

Grey Micro-scenario: Start bad, but gets better. Over a period of time, new technology is developed, initially focusing on economics rather than the environment, but in some cases clean technologies for pollution and contaminants ensure that no penalties (or sharing of clean-up costs) will be due in future. These new technologies also apply to aquaculture in some areas, helping to preclude escapement of farmed material into the wild. Some areas appear as oases in a world dominated by local/regional regulations, but without efficient coordination. The burden of proof is introduced for fishing vessels, leading to a recovery in recruitment to the level of the past 20–30 years. However, the discrepancy in levels of adoption of clean technologies results in a patchwork of productive aquaculture and wild fisheries and unproductive ecosystems, where fishing and/or cultivation are not possible. Equilibrium between different areas is not possible or stable, and economic sustainability is impossible. Unintentional introductions remain a risk as regulations on ballasts, transfers, etc., are inefficient.

Red Micro-scenario: Global meltdown. Because economics are more important than the environment, population pressure increases and/or activities release more contaminants and pollutants including organic material, into the oceans. Food production comes first, and there are few technical restrictions on the fishing technology, so habitats are increasingly damaged. Trophic cascade effects caused by overfishing lead to increases in sea urchins, etc., which graze down kelp

forests. This leads, in conjunction with overfishing, to less recruitment of valuable species. Rapid climate change results in northward displacement of recruitment, and replacement by southern (or tropical) species, including species brought in by ballast, classifying these southern species as new invasive species.

Italicized **Micro-scenario: Local solutions to global problems.** Local solutions such as costal marine protected areas (MPAs) permit pollution to decrease in coastal and estuarine areas and then to be subject to control in different places, though not continuously. However, MPAs cannot solve overcapacity and overfishing. The result is recruitment depletion for the major exploited species, and at the same time fishers, although too numerous, have to prove no damage to stocks from their activities (rules for MPA), and introduced species under local control succeed in becoming established. Escapement from fish farms is made impossible by land-locking the facilities.

Underlined Micro-scenario: Supergreen. International cooperation results in decrease of inputs and runoff as well as eutrophication in all rivers and coastal waters (organic agriculture, reasonable use of medicines by consumers, and highly efficient waste treatment). .Global governance results in a coordinated network of Marine Protected Areas. Harmful Algal Blooms become predictable, and can be explained and reduced. Clean and productive coastal and estuarine areas are available for developing aquaculture. International regulation of shipping is highly efficient, reducing accidents. For aquaculture, new technologies (including sterile species) preclude escapement and hence genetic pollution. For wild fishing, new bycatch-mitigation devices, such as separator panels, square mesh, and acoustic deterrents become common and required by law in certain fisheries. New trawling gear is introduced, employing jets of water, electronic currents, etc. Fishing gears are generally less damaging to habitats and to non-target populations. Moreover, discarding is banned throughout Europe and all bycatch of non-target animals must be brought ashore for monitoring and to be rendered into fishmeal (so reducing the demand for industrial fisheries). Bycaught commercial species (generally undersized) are considered against quotas. Management takes account of changing environmental conditions, such that a sufficient number of adult fish survive to reach maturity (including some large “megaspawners”). This results in a sustained level of recruitment even in years when environmental conditions are poor. A well developed age-structure buffers stocks against extreme variability in recruitment. Essential spawning habitats and spawning aggregations of adults are protected.

2.6 F – Production

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
F1 Marine "ingredients"	Chase for Organic Products	Chemistry Wins	***Aquaculture Helps***	
F2 Fleet structure and technology	*The Same Old Story (fleet reduction, but improved fishing efficiency)*	What a Wonderful World (new fishing grounds and no discards: no fleet reduction)	***Bad News (fishing grounds exhausted, no help from technology, strong fleet reduction)***	
F3 Stock trends	*No Change (most stocks fully or overexploited)*	Back to the Future (stock recovery to the level of the 1970s)	**Terminator (stocks collapse, no recovery possible)**	**Changes in Fish Empires (stocks of large predators collapse, slight changes in other stocks)**
F4 Development of fish feed	Science will solve the Problem (vegetables including GM vegetables)	Fish for Food (rearing of herbivorous species only)	Fish for Feed (fishmeal and fish oil dedicated to aquaculture)	**Other Marine Resources (use of mesopelagics, krill; all of low trophic level)**
F5 Aquaculture hardware technology	**Boxes Full of Fish in the World Ocean**	Marine Fish become Terrestrial	*Technological Improvements in Several Directions (all systems cohabit)*	
F6 Species diversification in aquaculture	Something New from the East (few farmed in Europe, new species imported)	Some New Species (around 40 new species produced)	*Introduction of Alien Fast Growers (compete with or replace native species)*	**The Big Five Dictatorship (science focuses on a small number of species)**
F7 Genome manipulation in breeding and selection	Bio-Engineered Fish (everything accepted and produced, including GM fish)	*All except GM fish*	**Back to Nature**	
F8 Animal health	World Propagation of Diseases	*More and More Healthy Animals (quarantine, vaccine and efficient network for shellfish)*	**Too Late (antibiotics and pollutants stay in the water and sediments: new pathologies)**	
F9 Seed availability for ranching	Collapse (eel and tuna)	*Miracle (eel and tuna)*	**Diversification (other species)**	

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
F10 Health risk of seafood	Fortress Europe (only seafood produced in Europe allowed)	*Seafood as Healthy Product (improvement of world seafood, better sanitary control in the EU)*	**Russian Roulette (increased pollution, healthy seafood is scarce)**	
C7 Costs and earnings of fisheries	***Down the Drain (cost increase, fish price stable)***	A Healthy Mean and Lean (fleet profitable)	*Smaller fleet, non-profitable*	Improved Technology allows cost control
C8 Costs and earnings of aquaculture	**Steady Variability (productivity, profitability bound to prices)**	Pelagic Shortage (high costs)	Wasting Money (farming ashore, high costs low production)	*Improved Technology allows cost control*

Red Micro-scenario: Free market. Everything is driven by the market. Stocks collapse, and aquaculture focuses on a few species for mass production (raised in offshore boxes). GM fish are accepted because they have some advantage (growth, nutritional quality). However, intensive aquaculture leads to a global propagation of disease, which spreads to wild animals, and medicines are inefficient. Therefore, fish stock depletion accelerates and healthy seafood becomes scarce. Fishing turns to lower trophic level species because stocks of large predators have collapsed, and fishing becomes less profitable, leading to massive fleet reduction. For aquaculture production, science helps to feed farmed fish with vegetable material, including GM vegetables producing omega 3, or with a small quantity of fish oil. Aquaculture productivity increases (economies of scale, fast growth GM fish and a decrease in the cost of fish feed) and mass-produces a limited number of species (around five) more in global value than wild fish production. The fast investments in mass production aquaculture (technology) and in the development of enhanced species (GM fish) has to be paid for by the consumer.

***Italicized* Micro-scenario: The EU promotes aquaculture.** The EU policy has relative success because fisheries cannot deliver what is required. No major changes in the fish stocks, fleet reductions, and aquaculture policy will support improvements in the sector. Health protection systems work. In this scenario, EU policy takes serious action to reduce the fishing fleet between 2010 and 2015, because the fishing grounds are becoming barren and to help recover the availability of seed material for tuna and eels. Aquaculture is promoted, because fisheries cannot deliver the quantities required. Improved aquaculture is 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 ashore). As the challenge is to multiply aquaculture production by almost ten, no track record of productivity improvement can be disregarded, and even alien fast growers are introduced into Europe. GM fish are the only exception and are not produced, because GM animals are still not accepted by European consumers. There is increased control and care of animal health in aquaculture production, using land-based farming when needed, leading to healthy production. Local production is protected from imports by better sanitary control in the EU. Industrial fishing tends to disappear slowly, because non-food organism production by farming tends to ramp up slowly. Aquaculture makes productivity leaps and profitability is bound to demand and market prices, but the variety of production improvements (technology, health, species breeding, selection and nutrition) adapted to the production of each species and its location (also helped by supporting EU policies) results in a decrease in costs larger than in the scenario above.

Yellow box Micro-scenario: Healthy and diversified products. Aquaculture fills the gap, no change in stocks, science helps, and regulation works for the consumer. For fishing, there is massive fleet reduction, but technological improvement leads to an increase in efficiency and the (smaller) fleet is profitable despite fishing production decreasing. Aquaculture has to fill the gap to answer fish demand, but with a greater diversity of species produced. The success of biological research and development in aquaculture leads to farming of many (around 40) new species in Europe, and to diversification of seed ranching for new species. Therefore, compared with the scenario above, more local species diversity is available for the EU market. As in the scenario above, there are improvements in farmed animal health (hybrids, onshore farming when needed, medication), but investments in aquaculture and sanitary quality of seafood being sold on EU markets are protected by Europe only allowing the sale of aquaculture output produced in Europe. Trade protection of the EU, and the variety of investments for farming a very large number of species (each produced in small quantities) leads to an increase in production prices, helping fisheries to stay profitable. Fish are healthy and of a diversity of product, but tend to become more of a luxury in the household.

Green letters Micro-scenario: Fisheries bounce back and natural food is the order of the day. The demand for healthy products, legislation, and science and technological development help the recovery of fisheries and the protection of citizens' health. The growing awareness of the parlous state of fish stocks leads to better use of catches and tighter control. Small wild-caught fish are not used for aquaculture for ecological reasons (small fish are essential to the foodweb and can be used for human food directly), so the diversification of species for aquaculture is only with herbivorous species. The fishing industry discovers that it can fish new marine organisms for non-food uses. The enforcement of regulation, the technological improvement of the fishing gears that "catch" only what is sought and the new fishing for marine product ingredients leads at the same time to sustained profitability of the fishing industry and to a recovery of the stocks to the level of the 1970s (including seed material for eels and tuna). To protect wild animals from disease and to avoid coastal biological pollution, aquaculture is moved onshore. As customers want natural and healthy food, bio-engineered fish of all kinds are disregarded for aquaculture production. Only natural fish are farmed, but only herbivorous species. As most regions of the world, especially Asia, do not have such tight quality criteria on seafood, enhanced sanitary control of imported products is introduced. Wild fisheries bounce back, and aquaculture is less productive and more costly.

Emboldened Micro-scenario: Fishing feeds poor people and aquaculture. The demand for the main large predator fish species leads to collapse of these stocks. Fishing turns to lower trophic levels sold as low-quality fish to be included in fish product, and to krill or mesopelagic fish to increase the production of fish feed for aquaculture. This leads ultimately to an impossible recovery of lower trophic level stocks and to collapse of most other stocks (in other words, stock collapse of large predators first, then fishing down the foodweb to total collapse of stocks). Aquaculture focuses on large predator species to farm intensively (mainly in boxes). The concentration of certain species in the same area leads to an increased need for medication (antibiotics, pesticides) as preventatives in aquaculture. The cure is worse than the disease, however, and the end result is pollution of the water and sediments. After a few news headlines about "poisonous fish", aquaculture has to show its environmental consideration by reducing the density of boxes, decreasing the use of medication and growing just natural fish (no bio-engineered material). The result is a decrease in fishing industry profitability because of the low value of production, even with the massive reduction in fleet size. For aquaculture, the mass production of a few species is initially highly profitable, but the industry ultimately becomes less profitable because of the poor perception of the health and sanitary condition of farmed production.

Underlined Micro-scenario: Big fish is a luxury. Many hypotheses of the previous scenaruios are the same, but the story line is different (the consequence of the previous scenario is the starting point of this one). Pollution and fish disease lead to protests against man-made changes to nature. Genome manipulation is banned and aquaculture is moved ashore to stop polluting the oceans with medications. New fishing grounds are found by fishing mesopelagic species and krill for use in aquaculture, as well as for seafood product made with these ingredients. Marine aquaculture is more dedicated to non-food, new ingredient, and shellfish production. Production by the fishing industry remains of low value material. Aquaculture becomes more costly as it moves ashore because of the pollution generated. Aquaculture remaining in the sea is mainly to produce high-technology non-food product (e.g. algae, producing raw material for pharmaceuticals or perhaps bio-diesel) and shellfish that clean seawater (e.g. filter-feeders). This scenario might not lead to total collapse of most stocks as in the previous scenario, because aquaculture is moved ashore at the beginning of the scenario, leading to less volume production in aquaculture and less demand for fish feed.

2.7 G – Research policies

Driver	Hypothesis 1	Hypothesis 2	Hypothesis 3	Hypothesis 4
G1 Sources and allocation of funding	The EU Acts as a Facilitator for Marine Research (better use of stable EU and Member State budgets)	The EU Acts as an Integrator for Marine Research (less funding overall, more from the EU but less from the Member States)	EU and Member States Act as a "Terminator" for Marine Research (drastic cuts, new priorities)	**EU and Member States act as a "Stimulator" for Marine Research (drastic increase, marine research is a priority)
G2 Governance of European research	More cooperative research but not more competitive	Continued Shift from Basic to Applied Research at an EU Level	*Back to Basic (shift from applied to basic research at an EU level)*	None
G3 Access to infrastructure	Improved Cooperation (findings and equipment)	*Poor Cooperation (findings and equipment)*	Privatization (findings to purchase and equipment to rent)	
G4 Research training and management	Unvalued Knowledge (underfunded and unattractive research)	EU Marie Curie Programme – a Catalyst for National Funds (research attractive, underfunded)	Well-funded, unattractive research	**Well funded and attractive
G5 Information flows	The More Communication about its Results, the more Financial Support Marine Research Gets	Market-Driven Research	*Research is not Innovation (free research findings but inappropriately focused)*	Education = Research = Innovation ; the "virtuous triangle" (research agenda set by private interests, but findings freely available)

Yellow letter Micro-scenario: Pop idol. A change in priorities as Europe succeeds in building its new identity in the global economy, one of numerous consequences: research funding shifts from marine and fisheries to, e.g., pop music and recreation. The EU establishes a system allowing (i) leasing out of research rights/consent to Member States or to third countries, to either private or public bodies; (ii) selling days at sea. The motto "'If you want it –pay for it" is implemented within the framework of research funding, leading to drastic cuts in public research budget, at both national and European levels. Public research agendas are no longer set up, a privatization wave reshapes the European Research Area (ERA) into a European Research Open Market (EROM), which leads to (i) a continued shift from basic to applied research; (ii) privatization of key research infrastructure facilities and the marketing of data. Research becomes less attractive as a career, the EROM offering little challenging opportunities for professionals to engage in the conception or creation of new knowledge/products. Information flow is limited: data collected in the context of market-driven research are not made widely available, which leads to (i) poor uptake of research findings into policy, and (ii) decreasing awareness among the public, which is anyway more focused on, e.g., pop music and recreational issues.

Red Micro-scenario: European drive to technology transfer. This addresses the European Paradox, as the EU sets its main priority: (i) addressing the "European Paradox", i.e. on the one hand the EU is the world's largest producer of scientific output, on the other hand, R&D knowledge flow from science to technology is weak in the EU; (ii) strengthening the marine research agenda within the framework of European integrated maritime policy. In a parallel development, marine priorities drop off the research agenda of Member States, who assume that these matters are already well addressed at a European level and set their own new priorities (e.g. energy or public health issues, the latter associated with the increasing costs of treating people. As a consequence, European funding dedicated to marine fisheries research increases, and national funding decreases, a combination of events leading to a global decrease in the budget available for marine and fisheries research. European attempts to take on a leading role in the initiative fail: (i) EC efforts cannot compensate for the loss of national funding; (ii) research remains a satellite component of integrated maritime policy, which is led strongly by transport and shipbuilding. European industry develops and retains a steering role in setting the research agenda, which involves the industrial stakeholders mre. As a direct consequence, there is a shift to applied research. Owing to the disengagement of Member States, infrastructure operators/users are deemed to make the best out of existing, ageing research infrastructure; the concept of a virtual centre of excellence is developed to foster as efficient as possible use of existing facilities/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, and 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.

Underlined Micro-scenario: Funding Nemo. Here, public Science is the basis of the knowledge-based maritime economy of Europe. The sources of funding for marine and fisheries research increase dramatically at both European and national levels, because the activity is valued highly. The European Research Area (ERA) is fully achieved: barriers to transnational cooperation are overcome and enablers successfully implemented. The EU 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 infrastructures. Many attractive positions are available to researchers, scientifically well regarded and well funded. In the research "Eden" a lot of new knowledge is created and communicated, and information is widely freely available: research is driven by public-good and quality publications.

Grey-cell Micro-scenario: C'est la vie. It is now business as usual. The marine budget is stable (at both EU and Member State levels), but national marine programmes are better coordinated, mainly thanks to European incentives. Funding is used in a more efficient manner for research relating to marine, maritime, fisheries and aquaculture matters. There is a continued shift from basic to applied research at an EU level: research is supported and strengthened to address European social, economic, environmental, public health and industrial challenges, aiming at serving public good. A move towards improved cooperation in terms of access to and renewal of research infrastructure is dramatically slow, owing to a lack of efficient incentives from the EC. For other aspects such as training and management, despite incentives coming from the EC (e.g. the Marie Curie scheme), attempts to gain efficiency in the use of funds dedicated to marine and fisheries work have not allowed investment in career development for researchers in a coherent way among Member States. Finally, efforts aimed at financial efficiency missed out on content efficiency, because research finding are still inappropriately focused and suffer from poor uptake by industry.

***Italicized* Micro-scenario: Public money rules research.** This will happen when competition overtakes cooperation. 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", there is a shift in the policy agenda partly towards the marine environment. The budget for marine research at all levels increases drastically. There is high-level frontier research at European and national levels, building on excellence in Europe and raising its profile at an international level, and a complete shift from applied to basic research follows. Researchers benefit from a *carte blanche* from their home organization supported by a unlimited financial resources. Europe offers challenging, well-financed career opportunities to European and non-European researchers. There is fierce competition between research teams aiming for, e.g., Nobel prizes, at the same time impairing previous efforts to facilitate/share infrastructure/data. Any collaborative approach is deemed useless, and fragmentation and duplication are not issues. Given the financial support available, each country/organization can afford to build its own research facilities, collect its own data, etc. The European Paradox is exacerbated: Europe strengthens its position as the world's largest producer of scientific output, but findings remain inappropriately focused and suffer from poor policy by industry.