LITERATURE REVIEW: Appendices

Project Report, August, 2008 REPORT 2B

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This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area

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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Preface

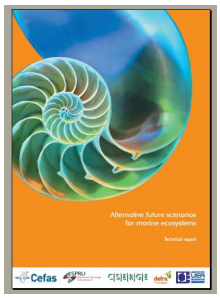
In order to summarize the key attributes of each 'futures' study a standard 'template' was devised (figure 1). For 17 of the studies this template has been completed (annex 1-25), and includes information on:

1. The report title
2. An identifying short title
3. The report authors
4. The written source (book, report etc.)
5. The geographic scope of the study
6. The focus & disciplinary scope
7. The stated objectives of the study
8. Time horizon over which predictions are made
9. The methods employed to construct scenarios
10. Whether any consultation was involved
11. The main drivers considered
12. The scenario structure or architecture
13. Whether shocks & catastrophes were considered
14. Any unique selling points of the particular study
15. Whether research drivers and/or priorities were considered
16. Possible recommendations made in the study or further uptake.

Table 1. 'Futures studies' of relevance to marine fisheries & aquaculture. [The studies indicated in red have been included in the synthesis report but have note been included in this section with templates]

Holistic scenarios for the marine environment	**Specific scenarios for fisheries & aquaculture**	**Personal visions for fisheries & aquaculture**	**Research priorities**
AFMEC (UK) (Pinnegar et al. 2006) [ANNEX 1]	*Fish to 2020* (Worldfish) (Delgado et al. 2003) [ANNEX 7]	Pauly et al. (2003) [ANNEX 16]	Sea Change: a marine knowledge & innovation strategy or Ireland (Marine Institute 2006) [ANNEX 21]
GAUFRE (Belgium) (Maes et al. 2005) [ANNEX 2]	*Net Benefits* (UK) (Prime Minister's Strategy Unit 2004) [ANNEX 8]	Garcia & Granger (2005) [ANNEX 17]	Canada's "*Marine & Ocean Industry Technology Roadmap*" (NRC 2003) [ANNEX 22]
Millennium Ecosystem Assessment (UN) (MEA 2005) [ANNEX 3]	*Aquaculture 2020* (Norway) (NRC 2005) [ANNEX 9]	Bruun et al. (2002) [ANNEX 18]	*Knowledge & Innovation Priorities* (Netherlands) (NRLO 1998) [ANNEX 23]
Global Environment Outlook (UNEP 2002) [ANNEX 4]	*State of World Fisheries & Aquaculture* (FAO 2004) [ANNEX 10]	Pope (1989) [ANNEX 19]	Australia's "Marine Science & Technology Plan" (COA 1999) [ANNEX 24]
Setting course for a sustainable future (New Zealand) (PCE 1999) [ANNEX 5]	NRLO – *Fishing for Research* (Netherlands) (Jagtman et al. 1997) [ANNEX 11]	Daan (1989) [ANNEX 20]	Aquaculture & fisheries in southern countries: prospective analysis of the research demand by 2025 (France) (IFREMER 2002) [ANNEX 25]
ELME – European Lifestyles & Marine Ecosystems (Langmead et al. 2007) [ANNEX 6]	*Future Fish* - Pew Initiative on Food and Biotechnology (Pew Initiative 2003) [ANNEX 12]		*Fisheries 2027* - a long term vision for sustainable fisheries (UK) (Defra 2007a) [ANNEX 26]
	Modelling Australia's fisheries to 2050 (Kearney et al. 2003) [ANNEX 13]		
	Ross & Rosenthal (2006) [ANNEX 14]		
	5 Scénarios pour la pisciculture Français en 2021 (INRA 2007) [ANNEX 15]		

ANNEX 1.



1. Title – Report title

Alternative Future Scenarios for Marine Ecosystems – Technical Report

2. Identifying short title:

AFMEC

3. Author(s)

CEFAS (Centre for Environment, Fisheries & Aquaculture Science)
CRU (Climatic Research Unit, University of East Anglia)
CSERGE (Centre for Social and Economic Research on the Global Environment, University of East Anglia)
SPRU (Science & Technology Policy Research Unit, University of Sussex)

4. Source (book chapter, FAO Report, etc) and date

(Report) Pinnegar, J.K., Viner, D., Hadley, D., Dye, S., Harris, M., Berkout, F., and Simpson, M. (2006) Alternative future scenarios for marine ecosystems: technical report. Cefas Lowestoft, 109pp.

5. Geographic scope

NE Atlantic (seas around the UK).

6. Focus or disciplinary scope

Past trends and future developments in marine climate, hydrography, fisheries, aquaculture, tourism/leisure, ports and shipping, anthropogenic inputs, aggregate extraction, oil and gas exploration, offshore energy, coastal geomorphology and defence.

7. Stated objectives of the study and the target audience

AFMEC is a strategic project funded under Defra's (Department for Environment, Food & Rural Affairs) 'Horizon Scanning' initiative. The Horizon Scanning Programme was established by Defra's Chief Scientific Adviser in 2002, in order to anticipate and prepare for new science risks and/or opportunities. Horizon scanning research aims to encourage crosscutting thinking in both the natural and social sciences.

The stated goal of the AFMEC study was to encourage debate about alternative futures for marine ecosystems, and to develop a series of future scenarios that could be used by Defra and other stakeholders for strategic planning.

In terms of future time-frames, the AFMEC scenarios were developed for the next 20-30 years and they were designed to be compatible with similar futures work carried out by the UK Office of Science and Technology (OST) and the UK Climate Impacts Programme (UKCIP).

8. Time horizon

Time horizon for scenarios up to 2025, marine climate scenarios up to 2080.

9. Method employed for the analysis

At two stakeholder workshops participants from a wide variety of marine-related disciplines were asked: (a) to outline what key issues should be elaborated under each scenario, and (b) to refine and amend scenarios once draft versions had been prepared.

At the first workshop (March 2004) participants were tasked with defining key 'attributes' within six activity domains: (1) offshore energy & construction, (2) fisheries, aquaculture & conservation, (3) marine inputs and water quality, (4) extractive industries in the marine environment), (5) ports & shipping, (6) tourism & leisure. 'Attributes' are considerations or factors which are likely to differ under each imagined future, and which would hence require further elaboration. The first workshop was attended mainly by representatives from government agencies (e.g. English Nature, Environment Agency etc.) and academic institutions, it aimed to provide much of the narrative for the four scenarios.

The second workshop (June 2004) was attended by a much broader range of stakeholders including representatives from companies and industry associations. The agenda comprised two main tasks: firstly to comment on the proposed draft scenarios, and to discuss how these might be improved; secondly to discuss possible low-probability 'extreme events'.

The four-quadrant approach, whereby the future 'possibility-space' is divided, based on two axes or dimensions (see below) has become commonplace following its earlier adoption by the Intergovernmental Panel on Climate Change (IPCC). This was the approach taken when developing the AFMEC scenarios. A number of prior 'givens' were agreed, concerning the rate of climate change under each of the 4 scenarios, as well as socio-political attitudes, this enabled the AFMEC scenarios to be compatible with other UK scenario schemes, and those of the IPCC and UN.

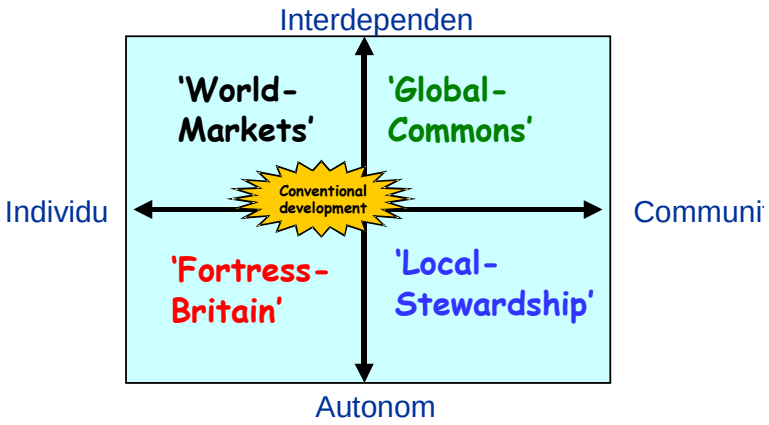
10. Consultee involvement

During the course of the project, two workshops were organised. These were attended by representatives from 31 organisations (listed in the report). Several representatives from the fishing industry, recreational angling and nature conservation sectors were consulted.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The basis of the 4-quadrant model is the identification of the two driving forces with the greatest importance and the highest uncertainty. Many exiting scenario exercises, seem to have also chosen similar criteria to define their 'possibility-space', with an axis representing 'local to global' and an axis representing societal/economic intervention (from community to consumerism).

The AFMEC scenarios follow the same basic format (figure 1). Indeed, many parameters which had been quantified in the earlier studies were taken 'as read'. UKCIP (UK Climate Impacts Partnership) provided useful estimates for GDP, exports, household numbers, population growth, agricultural production, water quality and investment in coastal defence under each of the 4 'futures'. Each AFMEC scenario assumed a specified level of climate change (as prescribed for the equivalent scenario by UKCIP).



What is the structure of the scenarios – mutually exclusive?

The four scenarios are not considered mutually exclusive. Conventional development (the present situation) is thought to be most similar to the 'World-Markets' socio-political view, but with aspects of all four possible 'futures'.

1) **World Markets –** Under this scenario the role of government is greatly reduced by 2020. Pressure grows to reduce taxes, and more public services are privatised or privately managed. By 2020, explicit monetary values are ascribed to a wide range of resources and environmental services. Access to these services is limited through charging, or by allocating rights that can be traded. Fisheries continue to be managed at a European scale although with greater emphasis on market forces, and fewer legal and technical restrictions. Economic yield and the demand for low food prices are important drivers, prompting fishermen to seek increasingly efficient methods. The industry becomes ever-more industrialised, global in scope and dominated by a few high-tech vessels. There is the rapid expansion of the fish- farming industry with many large-scale facilities, run by multinational companies. Fears about the environmental impact of fishing and aquaculture are primarily of concern to environmentalists who have little influence in this scenario.

2) **Fortress Britain –** Under this scenario, long-term economic growth is somewhat constrained by government policies that restrain international competition and protect key national industries. Maintaining the UK fishing industry and making the most of the UK's indigenous resources are key drivers. National governments assume greater responsibility and control over their territorial waters and the CFP focuses mainly on resolving conflicts over straddling stocks. A domestic cod-farming industry develops, aided by

government subsidies. The expansion of aquaculture would necessitate development of domestic industrial fisheries. Nature conservation policy is not sufficiently strong to restrict development pressures under this scenario. Sport fisheries would be 'squeezed out', both in terms of space and resources.

3) **Local Stewardship -** Under this scenario a key focus is on using technology and ingenuity to maximise the use of local and regional resources, while not damaging their long-term use.Tthe UK adopts a system of local governance and effectively withdraws from the EU Common Fisheries Policy (CFP). The industry is heavily subsidized to protect food security, local landscapes and habitats. Management responsibility is transferred to regional committees involving fishermen, government, environmentalists and scientists. The number of fishing vessels in the national fleet is reduced to a smaller but sustainable level. A system of temporary rotational closures allows the main commercial fish stocks to recover. There is a rapid growth in small-scale organic and low input fish-farming. Genetically modified fish are prohibited and the use of antibiotics and pesticides in this industry decreases.

4) **Global Commons -** Under this scenario sustainability is seen from a global perspective, including the maintenance of biodiversity, the protection of global commons (i.e., the atmosphere, oceans, wilderness areas) and the fair access to environmental resources. The aim of fisheries policy is to balance high yields with low environmental impacts. Resources are obtained from sustainable sources around the world, allowing some recovery in locally depleted fish populations. Support payments for fishermen are tied to the sustainable management. More of the prey-fish resource is allocated to natural predators (other fish, birds, mammals etc.), and it is agreed that a certain proportion can be taken by anglers. The recreational sector expands as a result of increased leisure time. Large-scale and environmentally damaging fish-farming practices become less acceptable.

12. Is there any addressing of catastrophes/extreme events?

Extreme, low-probability high-impact geological, astronomical, climatic, ecological and socio-political 'shock' events are considered and the likelihood of them occurring under each AFMEC scenario.

13. Originality or USPs (unique selling points)

Cross-cutting scenarios for the marine environment, that attempt to consider developments in many different sectors of the economy. Compatible with many other scenario schemes worldwide, including those of the IPCC, UNEP, UN.

14. Were original research or research drivers included

Neither research priorities nor research drivers were considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

The AFMEC report provided the following recommendations in 2006:

- Construction of a centralized 'marine scenarios gateway' on the internet to assist stakeholders in developing and assessing possible adaptation strategies (ongoing as part of the Marine Climate Change Impacts Partnership – MCCIP).
- Creative workshops using the AFMEC scenarios as a discussion tool.
- Establishment of a 'scientific forum' under Defra and NERC, to discuss how the AFMEC scenarios might be quantified further, also to outline and refine possible research project ideas.
- Wider dissemination of the AFMEC scenarios in the UK and within the European Community (ongoing, but launched at the annual *Coastal Futures* conference in January 2007, summary and technical reports distributed to participants)

ANNEX 2.

1. Title – Report title

"A Flood of Space: Towards a Spatial Structure Plan for Management of the North Sea"

2. Identifying short title:

GAUFRE

3. Author(s)

University of Gent (the Maritime Institute, the Center for Marine Geology and the Section of Marine Biology)
ECOLAS NV (Environmental Consultancy & Assistance)

4. Source (book chapter, FAO Report, etc) and date

(Book) Maes, F., Cliquet, A., Degraer, S., Derous, S., De Wachter, B., Douvere, F., Leroy, D., Schrijvers, J., Van Lancker, V., Verfaillie, E., Volckaert, A. (2005) *A Flood of Space: Towards a Spatial Structure Plan for Management of the North Sea.* Belgian Science Policy, Belgium. 204pp.

5. Geographic scope

North Sea (Belgian Sector)

6. Focus or disciplinary scope

Mapping human activities (and ecosystems) in the Belgian sector of the North Sea, including: pollution & dumping, underwater obstructions (wrecks, cables, pipelines, wind-farms, platforms), coastal defences, shipping, offshore fishing, aquaculture, dredging, sand & gravel extraction, military uses, tourism & recreation, nature conservation.

7. Stated objectives of the study and the target audience

"The most important objective of the project was to synthesize the scientific knowledge about the use and possible impact of different activities in the Belgian part of the North Sea (BPNS)".

"The major focus was on development of a specific methodology for spatial planning at sea with emphasis on interdisciplinary and public participation"

"The GAUFRE project went further than mapping the current activities and functions of the BPNS. Rather, the aim of the project was to outline future possibilities. The prospectives were drawn in order to inspire policy makers and end-users, and to envisage alternative ways in which the BPNS might be spatially managed in the future".

The GAUFRE project fits within the framework of the Second Scientific Support Plan for a Sustainable Development Policy (SPSD II) and was funded/commissioned by the Belgian Science Policy department (BELSPO).

8. Time horizon

Time horizon not specified for the 6 future scenarios.

9. Method employed for the analysis

Spatial mapping (GIS) of present-day ecosystems, biological resources, and human activities. Examination of compatible and non-compatible activities.

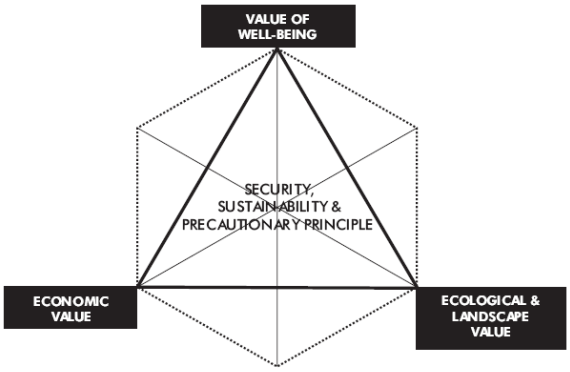
3 steps when attempting to derive scenarios:

- Identification of key values that determine each use within the North Sea (i.e. the relative dominance of ecological, economic, social well-being objectives)
- The different weight given to key values and the scientific knowledge on public needs, environment and impacts define the 'parameterspace' of new scenarios for the future management of the BPNS. Visions, spatial planning strategy and preferential areas of use are formulated within each of these scenarios.
- Formulation of a single ('best') vision and spatial plan, based on the differing scenarios. This vision will form the basis for the foundation of the future management of the BPNS.

10. Consultee involvement

During the course of the project, two workshops were organised. One workshop involved international experts and another dealt with stakeholders that are directly involved as 'actors' in the process (both policy makers and public).

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?



Every activity in the BPNS is viewed as being correlated to three key variables/drivers (well-being, economic value, ecological & landscape value). The designation of marine protected areas, for instance, is particularly related to the weight that policy makers put on the ecological and landscape value, whereas sand and gravel extraction would be linked to the percieved importance of the economic value of the North Sea. These three dimensions outline the 'parameter-space' for the 6 GAUFRE scenarios (see figure).

- "Well-being" recognises the potential value that society might place on the North Sea as an area for recreation.
- "Ecological & Landscape value" recognises the 'natural wealth' of the North Sea, including highly diverse networks of benthos, fish, marine mammals and birds. It also recognises 'heritage value' including the importance of protecting ship-wrecks and landscapes etc.
- "Economic value" recognises the financial 'goods' and 'services' provided by the North Sea. Scenarios which emphasise this aspect/driver, strive for greater utilisation – including making the most of sand and gravel resources, fish stocks and renewable energy opportunities. The North Sea is recognised as being important for the transport of goods and passengers.

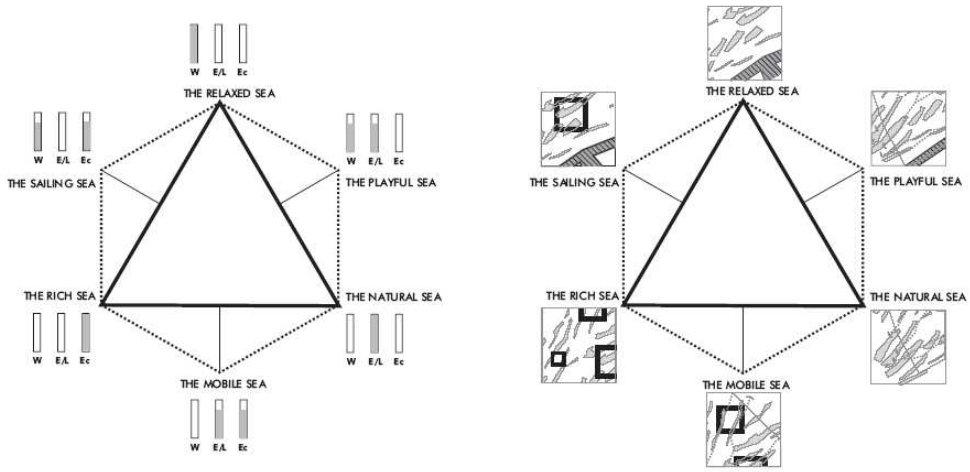
It is assumed that a similar rate of climate change and sea-level rise will occur under each of the GAUFRE scenarios.

12. What is the structure of the scenarios – mutually exclusive?

Six scenarios are developed for the future of the BPNS. Three of the scenarios strongly focus on one of the key values ('the Relaxed Sea', 'the Natural Sea', 'the Rich Sea'), the other three ('the Playful Sea', 'the Mobile Sea', 'the Sailing Sea') scenarios are based on crossovers between two of the key values.

Schematically, the six scenarios are presented on the six angles of a hexagon (see below). Each scenario has been elaborated to produce somewhat extreme and conflicting results. The scenarios reveal new, and previously inconceivable, possibilities and are designed to encourage the development of a policy that not only reflects present trends, but also anticipates future developments.

It was not the intention of the GAUFRE project to provide the ultimate spatial structure plan for the BPNS. A spatial structure plan for the BPNS should rather try to balance the key values, and would therefore be at the centre off the hexagon.



Each of the scenarios includes a number of 'givens' or 'fixed rules'. For example shipping is regulated by international agreements, and thus in terms of spatial planning the options are relatively limited. Fishing and/or gravel extraction can not take place in shipping routes or near existing cables and pipelines. Determining factors in fisheries are the cost-effective distance between the fishing ground and the ports of call (related to the specific fleet segments), whereas aquaculture requires areas that have few disturbances.

(1) **The Relaxed Sea –** In this scenario, attention is mainly given to the issue of consumer 'welfare'. Some activities (including fishing and aquaculture) will not be able to take place in the coastal zone due to the fact that they may hamper coastal leisure activities. An extended and long-term view of this scenario could see the cultivation of marine organisms in closed production systems (fish, shellfish, algae etc.) on land. New research centres, willing to specialise in such marine organisms, will contribute to developments in the coastal zone.

(2) **The Playful Sea –**This scenario goes beyond the beach and attempts to zone the entire sea for recreational purposes. Extending the fixed coastline with a range of coastal islands (comparable to the Dutch Wadden Sea islands) this adds to the tourism potential of the coastal strip. Recreational fishing and SCUBA diving become more important. Shallow areas between islands provide new opportunities for aquaculture.

(3) **The Natural Sea –** This scenario envisages the North Sea as a natural reserve. Preservation of the seas natural dynamics could lead to the delineation of large parts of the BPNS, where every form of use and consumption is banned or restricted (i.e. MPAs). In some cases, relocating activities will not be sufficient to protect the natural value. Some activities will have to be reduced or transformed (e.g. transformation of the trawling fishery into more ecologically sound alternatives).

(4) **The Mobile Sea –** In this scenario, activities (including fishing) are preferably located on sandbanks, this is because sandbanks provide a highly dynamic system that is capable of quickly regenerating following intervention. The North Sea is treated as a 'storage room' of resources where economy and ecology go hand in hand. Every use and exploitation is flexible and mobile, based on the natural dynamics of the sea.

(5) **The Rich Sea -** In this scenario economic development is the most important objective, and the sea is considered as a production space where many more resources can be exploited than at present. Conflicting uses that do not contribute to the economic exploitation of the BPNS must yield in favour of economic activities, or even disappear. Few restrictions will be imposed, including the abandonment of fisheries quotas. An extended and long-term view of this scenario would include 'concession zones' for beam trawler fisheries.

(6) **The Sailing Sea** – In this scenario a lot of attention is given to immobile structures such as port infrastructure, hard coastal defences, wind turbine parks that deliver sustainable energy. Attention is given to new means of transport. On the one hand, this means larger ships on the international shipping lanes, in conjunction with port activities at sea. Economic activities such as gravel extraction and fisheries need to transport and shipping as little as possible. Nature conservation does not have priority in this scenario.

13. Is there any addressing of catastrophes/extreme events?

Extreme events were not considered in any of the 6 GAUFRE scenarios.

14. Originality or USPs (unique selling points)

Spatial scenarios – including allocation/zoning of different geographic areas for different activities.

15. Were original research or research drivers included

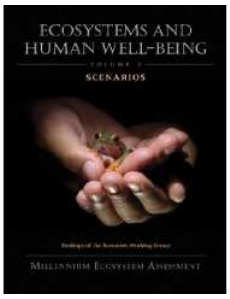
Neither research priorities nor research drivers were considered.

16. What happened next – e.g. are there recommendations and were any of them taken up?

(Not known)

ANNEX 3.

17. Title – Report title



"Ecosystems & Human Well Being: Scenarios"

1. Identifying short title:

MEA-Fish

2. Author(s)

Millennium Ecosystem Assessment (MEA): Carpenter S.R., Pingali P.L., Bennett E.M., Zurek M.B. (eds.).

3. Source (book chapter, FAO Report, etc) and date

(Report) MEA (2005) Ecosystems & Human Well Being: Scenarios Volume 2. Findings of the Scenarios Working Group of the Millennium Ecosystems Assessment, Carpenter S.R., Pingali P.L., Bennett E.M., Zurek M.B. (eds.). Island Press, Washington, 560pp.

4. Geographic scope

Although the scenarios focus on the global scale, many implications for regional and local ecosystems are examined.

5. Focus or disciplinary scope

Examines possible changes in ecosystem services during the twenty-first century by developing four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services and human well-being.

6. Stated objectives of the study and the target audience

Launched by Kofi Annan in June 2000. It is aimed at investigating the consequences of ecosystem change for human well-being, and at evaluating options for responding to these changes.

7. Time horizon

Considers plausible future development pathways until 2050.

8. Method employed for the analysis

Interviews with stakeholders and a literature review of major ecological 'dilemmas' were used to identify focal questions, key uncertainties, and cross cutting assumptions behind each scenario.

Scenarios were constructed by working through indirect drivers, direct drivers, ecosystem services and attributes of human well-being, using both qualitative and quantitative methods (**figure 1**).

Storyline development was complimented by building quantitative scenarios using a linked set of global models. The purpose of modelling exercise was both to test the consistency of the storylines but also to elaborate and illustrate the scenarios in numerical form. This 'quantification of scenarios' had 5 main steps: (1) assembling or adapting global models, (2) specifying a consistent set model inputs based on the scenario storylines, (3) running the models with the specified input parameters, (4) 'soft-linking' the models by using outputs from one model as input to another, (5) compiling and analyzing model outputs in terms of changes in ecosystem services and implications for human well-being. The models included: "IMPACT" (food supply, demand and trade), "WaterGAP" (wateruse and availability on a watershed scale), "AIM" (changes in land-cover, with emphasis on Asia), "IMAGE" (climate change & land-use), "Ecopath with Ecosim" (dynamics of marine ecosystems & fisheries).

The scenarios extended into the future beyond the situation described in the MEA document 'Current State & Trends' (volume 1).

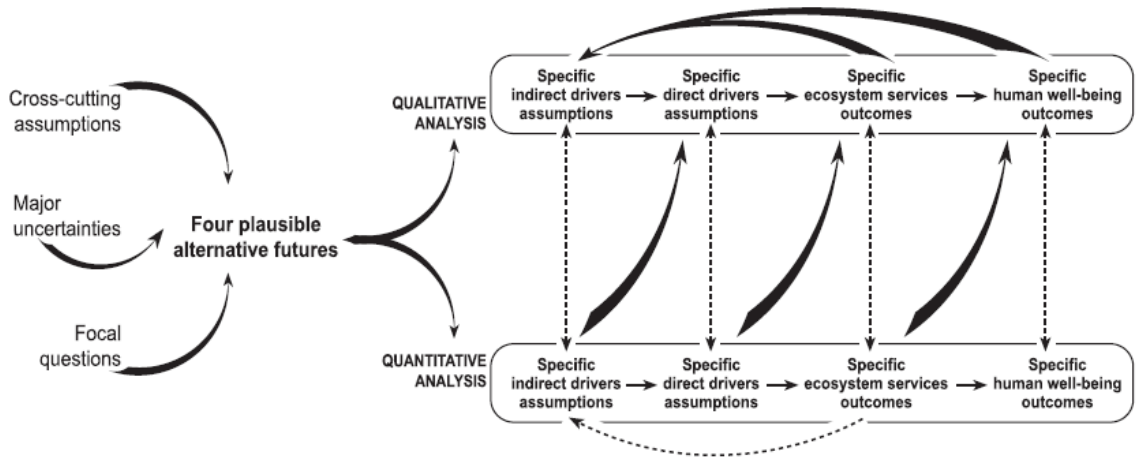


Figure 1. Flow chart of Millennium Ecosystem Assessment (MEA) scenario development.

9. Consultee involvement

(See above) Interviews with stakeholders were used to identify focal questions, key uncertainties, and cross cutting assumptions. In addition, the 'Scenario Guidance Team' conducted a series of interviews with potential 'users' to obtain input for developing the goals and focus of the scenarios.

10. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

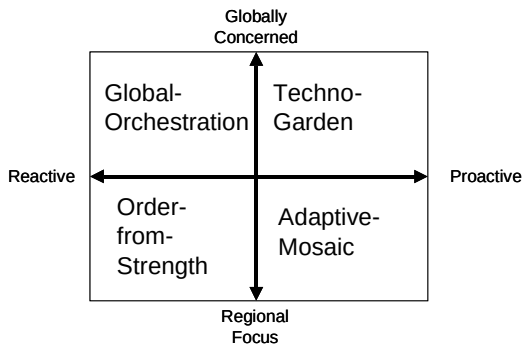
(see above) Scenarios were constructed by working through indirect drivers (population trends, income, GDP, investment, technology, attitudes, energy supply & demand, institutional structures, policies), direct drivers (land-use change, emissions, climate change, sea level rise, nutrient outputs), ecosystem services and attributes of human well-being, using both qualitative and quantitative methods (**figure 1**).

The four Millennium Ecosystem Assessment scenarios draw on earlier work by the United Nations and IIASA (population growth and human demography scenarios), IPCC-SRES (carbon emissions and climate change). They are also similar (in architecture and expected outcomes) to the United Nations Environment Programme (see FEUFAR summary for **UNEP-GEO**) having been developed using similar methods and by some of the same personnel.

What is the structure of the scenarios – mutually exclusive?

The framework underpinning the scenarios takes account of two kinds of transition – one in which the world becomes increasingly globalized as opposed to another in which it becomes increasingly regionalized (figure 2a). The authors also address two different approaches for governance and/or policy. In one case, management of ecosystems is reactive and most problems are addressed only after they become obvious. In the other case, management of ecosystems is proactive and policies deliberately seek to maintain ecosystems services for the long-term.

Framed in terms of these contrasts (**figure 2a**), the four scenarios developed by the Millennium Ecosystem Assessment were named: *Global orchestration, Techno-garden, Order-from-strength* and *Adaptive mosaic* (**figure 2a**).



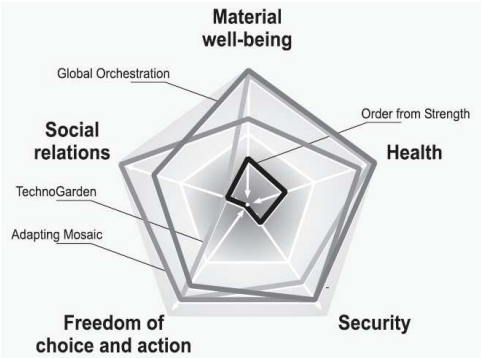


Figure 2a. Millennium Ecosystem Assessment scenarios. **Figure 2b.** Changes in Components of Human Well-being in 2050 in MEA Scenarios. The pentagon in the middle represents the situation in 2000. Moving outward from that

indicates an improvement in that component of human well-being in that scenario by the year 2050. Moving inward from the pentagon indicates a decline in that aspect of human well-being since 2000.

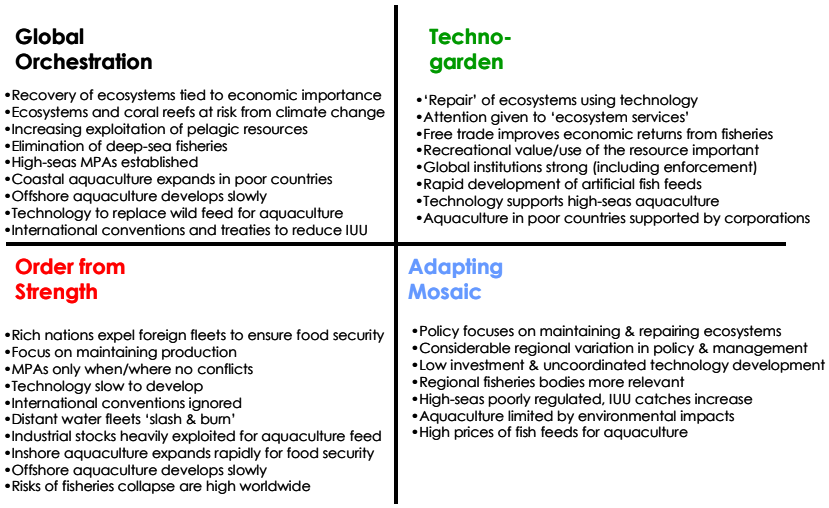
- The *Global Orchestration* scenario depicts a worldwide connected society in which global markets are well developed. Supra-national institutions are well placed to deal with global environmental problems, such as climate change and fisheries. However, their reactive approach to ecosystem management makes them vulnerable to surprises arising from delayed action or unexpected regional changes.

- The *Order from Strength* scenario represents a regionalized and fragmented world concerned with security and protection, emphasizing primarily regional markets, and paying little attention to the common goods, and with an individualistic attitude toward ecosystem management.

- The *Adapting Mosaic* scenario depicts a fragmented world resulting from discredited global institutions. It sees the rise of local ecosystem management strategies and the strengthening of local institutions. Investments in human and social capital are geared toward improving knowledge about ecosystem functioning and management, resulting in a better understanding of the importance of resilience, fragility, and local flexibility of ecosystems.

- The *TechnoGarden* scenario depicts a globally connected world relying strongly on technology and on highly managed and often-engineered ecosystems to deliver needed goods and services. Overall, eco-efficiency improves, but it is shadowed by the risks inherent in large-scale human-made solutions.

The consequences of each scenario for fisheries and aquaculture were elaborated in detail (summarized in **figure 3** and pages 271-275 of report).



11. Is there any addressing of catastrophes/extreme events?

The authors acknowledge (p8-10 of report) that the MEA scenarios address incremental changes but fail to address thresholds, risk of extreme events or the impact of large, extremely costly or irreversible changes in ecosystem services.

12. Originality or USPs (unique selling points)

Cross-sectoral, global scenarios with truly cohesive and well thought out socio-economic storylines. Very detailed treatment of 'drivers' and elaboration of detailed storylines for many relevant sectors (e.g. fisheries and aquaculture, marine biodiversity etc.).

13. Were original research or research drivers included

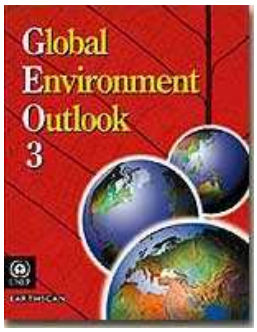
Some consideration of science and technology 'drivers' (pages195-199) and innovation, but seen as a driver of change and not an outcome, or means to achieve a particular outcome.

14. What happened next – e.g. are there recommendations and were any of them taken up?

No specific recommendations, but provided 'main messages, 'synthesis for key stakeholders', and 'lessons learnt', including "implications for: (1) Convention on Biological Diversity, (2) national governments, (3) communities & NGOs, (4) the private sector.

ANNEX 4.

1. Title – Report title



Global Environment Outlook 3: Past, Present and Future Perspective. Outlook 2002-2032.

2. Identifying short title:

UNEP-GEO

3. Author(s)

United Nations Environment Programme.

4. Source (book chapter, FAO Report, etc) and date

(Report) UNEP (2002) Global Environment Outlook 3: Past, Present and Future Perspective. Outlook 2002-2032, pp 320-400. United Nations Environment Programme. Earthscan Publications Ltd., London. 277 pages.

5. Geographic scope

The scenarios consider both global and regional perspectives (providing quantitative comparisons of key-indicators for the whole world, Africa, Asia & Pacific, Europe, Latin America & Caribbean, North America, west Asia, polar regions).

6. Focus or disciplinary scope

The scenarios developed for *GEO-3* have an environmental focus but recognize that the environment cannot be discussed without also considering what may be happening in the social and economic spheres. The scenarios therefore span eventualities in many overlapping areas, including population, economics, technology and governance.

The UNEP scenarios do not provide detailed storylines for the marine environment, fisheries or aquaculture (although see FEUFAR summary **PAULY2050**).

7. Stated objectives of the study and the target audience

The third UNEP Global Environment Outlook report (*GEO-3*) was timed to provide briefing material in the run-up to the 2002 World Summit on Sustainable Development (WSSD). The global-level analysis was extended to regions and sub-regions, identifying potential areas of vulnerability and hot spots of the future, and drawing attention to policy implications.

8. Time horizon

These scenarios cover the 30-year period from 2002-2032.

9. Method employed for the analysis

Drawing from previous work of the Global Scenario Group (see Raskin and Kemp-Benedict 2002), four global storylines were designed by a core scenario team of global and regional experts. An initial quantification for a small set of indicators was prepared at the level of the GEO sub-regions. Teams in each of the seven major GEO regions then elaborated the storylines at regional level and provided input to the quantitative analyses (see below), particularly with respect to key driving forces. The results of the regional efforts were used to refine the global narratives and to undertake the subsequent quantitative analyses associated with the scenario narratives. Further refinement of both the narratives and the quantitative analyses was achieved through an iterative process involving the core scenario team and the modelling groups.

Storyline development was complimented by building quantitative scenarios using a linked set of global models. The models included: “WaterGAP” (water-use and availability on a watershed scale), “AIM” (changes in land-cover, with emphasis on Asia and climate change policies), “IMAGE” (climate change & land-use), “GLOBIO” (cumulative impacts on biodiversity of human population growth), “PoleStar” (GIS framework including economic, resource and environmental data).

10. Consultee involvement

During the development process the work underwent two formal rounds of review and was scrutinized at a special workshop with a group of scenario experts from around the world. The four global storylines were designed by a core scenario team of global and regional experts.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

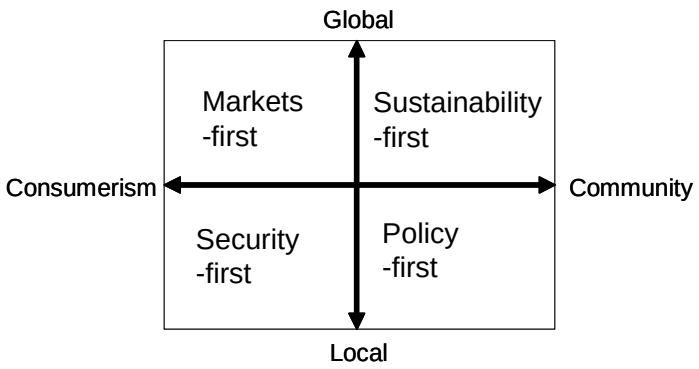
The scenarios were based on certain assumptions about how driving forces will evolve and interact with developing situations, potential future shocks and human choices. The seven driving forces under consideration were demography, economic development, human development, science and technology, governance, culture and environment.

- Demography (humans population size, structure and migration patterns)
- Economic development (distribution of wealth, global trade etc.)
- Human development (health, education, poverty, inequality)
- Science & technology (innovation, research priorities, technology transfer)
- Governance (actions, processes, traditions and institutions by which authority is exerted)
- Culture (values and institutions that enable society to develop and maintain its identity)
- Environment (human impacts on the atmosphere, land and water resources)

The four UNEP-GEO scenarios draw on earlier work by IPCC (carbon emissions and climate change) and the Global Scenario Group (see Raskin and Kemp-Benedict 2002, Technical Report). They are also similar (in architecture and expected outcomes) to the Millennium Ecosystem Assessment scenarios (see FEUFAR summary for **MEA-Fish**) having been developed using similar methods and quantitative models.

What is the structure of the scenarios – mutually exclusive?

The four UNEP-GEO scenarios were:



Drawing on the experience and work of other scenario initiatives, including those of the Global Scenario Group (Raskin and Kemp-Benedict 2002), a set of four scenarios was developed:.

- The *Markets First* scenario envisages a world in which market-driven developments converge on the values and expectations that prevail in industrialized countries;

- In a *Policy First* world, strong actions are undertaken by governments in an attempt to reach specific social and environmental goals;

- The *Security First* scenario assumes a world of great disparities, where inequality and conflict prevail, brought about by socio-economic and environmental stresses; and

- *Sustainability First* pictures a world in which a new development paradigm emerges in response to the challenge of sustainability, supported by new, more equitable values and institutions.

For each of these scenarios, an overall narrative — 'A tale of four futures' — describes the future in the next 30 years in a predominantly qualitative manner, providing both regional and global perspectives. The stories of the four scenarios were followed by a more detailed examination of their environmental implications, drawing on quantitative data derived from a number of analytical tools — and with a regional focus intended to highlight particular concerns in the different regions. Fisheries a global overfishing are mentioned some storylines (notably *Policy First* and *Sustainability First*) but are not dealt with in any detail. However, science, technology and research are mentioned throughout the 'outlook' (see figure 2 for contrasts between scenarios).

Markets -first

- Rapid technological advance driven by profits/markets
- Basic research given less priority
- Technology transfer and IPR important
- Environmental benefits as side-effect of efficient usage
- Emphasis on international institutions and free markets
- Cuts in subsidies to agriculture etc.,
- Exploitation of resources speeds up In polar regions
- Harmful algal blooms in Mediterranean & Indian Ocean
- Environmental standards fall & pressures remain severe

Sustainability -first

- Technological advance driven by public opinion
- More participation of individuals & grass-roots NGOs
- Stewardship of environment important in guiding science, governance and in shaping economic development
- Efforts to incorporate science into policy-making
- Attention paid to increasing accountability
- Greater emphasis on managing 'common resources'
- Ocean fisheries receive greater attention
- Arctic & Antarctic viewed as common global heritage

Security -first

- Diversion of public funds into ensuring national security
- Natural systems heavily impacted & fragile condition
- Momentum for sustainable development fizzles out
- Pressure on arctic resources increases
- Efforts to tackle problems, often late & ineffective
- Traditional livelihoods & communities erode
- Inequalities lead to civil unrest
- Slower technological progress

Policy -first

- Technological advance driven by government subsidies
- Strict government regulation (e.g. pollution taxes)
- Formal institutions and setting of very specific targets
- Efforts to share benefits of science & technology
- Government & societal caution help avoid side-effects
- More public-private co-operation, driven 'top-down'.
- Drastic measures at times (e.g.outright ban on over-fishing)
- Draconian efforts to reduce emissions, impact economy
- High taxation on energy sources & industrial chemicals

12. Is there any addressing of catastrophes/extreme events?

Within each storyline there is some consideration of extreme events such as tropical storms, droughts, floods, wildfires, earthquakes, industrial accidents etc. and whether or not institutions and society are likely to be robust to such disturbances. One notable example is included in the '*implications for…*' section (page 393) where readers are encouraged to "**Imagine… a crash in circumpolar Antarctic krill stocks".**

In the case of…

Markets First

_ Some regulatory steps are taken, but market mechanisms are the prime response measures used — reducing krill demand by raising prices, and harvesting by raising costs.
_ Harvesting switches to other species, including those that are not dependent upon krill themselves and may be competitors

Policy First

_ Moratoria on krill harvesting are agreed to allow stock recovery.
_ These steps are accompanied by reductions in fisheries activities across all target species.
_ Major research effort is directed to understanding what has happened and underpinning policy responses.

Security First

_ Measures are taken to ban some operators from the region as a way to curb pressures on krill stocks.
_ Market mechanisms are employed when they underpin the interests of key stakeholders in the region.
_ In a bid for short-term 'use-it-or-lose-it' exploitation, harvesting switches to other species, including those expected to decline steeply as a result of krill stock collapse.

Sustainability First

_ There is an immediate closure of all krill fisheries pending recovery of stocks.
_ Substantial reductions in other fisheries are introduced as a precautionary measure — although directed harvesting of particular predator populations is considered in some areas.
_ A renewed effort is made to understand the functioning of the Antarctic marine environment.

13. Originality or USPs (unique selling points)

Cross-sectoral, global scenarios with truly cohesive and well thought out socio-economic storylines. Detailed treatment of 'drivers' and compatibility with other schemes (e.g. those of **MEA** and **PAULY2050, AFMEC** etc.).

14. Were original research or research drivers included

Science, technology and research are mentioned throughout the 'outlook' (see figure 2 for contrasts between scenarios).

15. What happened next – e.g. are there recommendations and were any of them taken up?

'Outlook' provides a detailed account of "i*mplications for….*" specific regions of the world, also a summary of "*lessons learnt*" and "*reflections on the use of scenarios".* The specific lessons learnt are:

- Contrasting yet plausible stories can be told for how the world and its regions will develop in the next 30 years; each has fundamentally different implications for the environment.
- There can be significant delays between human actions, including policy decisions, and associated impacts on the environment.
- Achieving widely agreed environmental and social goals will require dramatic and coordinated action starting now and continuing for a number of years. Steps must include policies based on prevention and adaptation.
- Important linkages exist between different environmental issues and between environmental and broader social issues.
- The establishment of strong institutions for environmental governance is a prerequisite for almost all other policies.

ANNEX 5.

1. Title – Report title

Setting course for a sustainable future; the management of New Zealand's marine environment

2. Identifying short title:

SETCOURSE

3. Author(s)

Parliamentary Commissioner for the Environment: Te Kaitiaki Taiao a Whare Päremata.

4. Source (book chapter, FAO Report, etc) and date

(Report) *PCE (1999) Setting course for a sustainable future: the management of New Zealand's marine environment. Office of the Parliamentary Commission for the Environment, New Zealand. 111pp.*

5. Geographic scope

In geographical terms, New Zealand's marine environment encompasses the territorial sea and the exclusive economic zone (EEZ), as well as the seabed of the continental shelf extending beyond the EEZ. The marine environment includes coastal areas, sand dunes, beaches and cliffs, and New Zealand's 158 offshore islands. It includes the vessels – freighters, trawlers, tankers, ferries, waka, yachts, launches, dinghies, kayaks and other craft – that take people out onto the water. It includes the experiences, activities and purposes that take them there.

6. Focus or disciplinary scope

At attempt at a crosscutting, non sector-based assessment for the marine environment in New Zealand. Includes: **fishing industry**, communities and non-governmental organisations, science & information, coastal zone management, **aquaculture & marine f**arming, public awareness & education, air-force, coastguard, maritime safety authority and government.

7. Stated objectives of the study and the target audience

With the objective of maintaining and improving the quality of the environment (section 16(1)(a) New Zealand Environment Act 1986), the terms of reference were to identify:

- significant issues, strategic risks and opportunities that influence the management of New Zealand's marine environment; and
- critical issues, strategic risks and opportunities that require more detailed investigation.

8. Time horizon

Future vision (a single scenario) for 2043.

9. Method employed for the analysis

Extensive consultation (see below), as well as information and discussions of various issues gathered from official and published sources. The issues that were discussed were grouped under four principal areas:

- why the marine environment matters to New Zealanders – the different ways that people see the marine environment, the values and expectations they bring to their encounters and interactions with the sea, and the utilisation and fiscal value of marine resources;
- how the marine environment is managed – an outline of the statutes and formal systems, and an exploration of some of the points of interface between government structures and citizens;
- the various different kinds of rights, and expectations of rights, of stakeholders in the marine environment; and
- the adequacy of our information and knowledge about the marine environment.

10. Consultee involvement

The investigation team travelled from Whangarei to Bluff, meeting with as many people as practicable (85 organizations including fisheries representatives, recreational fisheries, academics, environmental NGOs, rescue services, government agencies, tourist authorities, shipping agents, defense services). The great diversity of people reflected the diversity of marine environmental issues and interests.

Each group and sector was consulted on the current issues and concerns relating to the marine environment, as well as those issues that will be relevant in the 21st century. Innovative solutions and creative practical ideas for managing the marine environment sustainably were of particular interest.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

No list of drivers, although detailed examination of sectors ('actors' and 'factors') in past and present section of the report.

What is the structure of the scenarios – mutually exclusive?

A single scenario/storyline for 2043.

"Despite valiant international efforts to halt global warming, the "fossil" policies of some nations have resulted in **accelerated rates of global warming**. A 3.5°C rise in global temperatures has led to worse than expected impacts on land, in the coastal zone, and at sea".

"In 2010 Government placed a "green incentive" on the commercial fishing sector. This scheme was based on the belief that competitive marketplaces would only work if industry paid the **full cost of production**. Negative environmental and social externalities incurred should be reflected in the price of the product. It became quite clear that integrating cost into pricing was a critical pathway to innovation and sustainable industries. Innovation and resilience had been identified early on as key factors in coping effectively with the added societal stresses associated with climate change".

"In 2014 the FAO announced that global overfishing was now affecting 92% of all fish stocks. This statistic, coupled with the "green incentive" and **growing consumer pressure for "green" fish**, led the fishing industry to voluntarily adopt "Standards for Sustainability". The Standards were so successful at meeting the goal of "sustainable marine ecosystems" that they were embodied in law in the Marine Ecosystems Act 2021".

The Standards made it mandatory to:

- Manage interactions between target fish and predators, competitors and prey species, **interactions between fish and the ecosystem**, the effect of fishing on the environment, and effects of climate on marine ecology.
- Shift the **burden of proof** so that fishing is allowed only after it is shown that healthy and diverse fish populations and marine ecosystems will not be negatively impacted.
- Rehabilitate the destructive impacts of former fishing practices on **fragile marine habitats** and ecosystems.
- **Reduce bycatch and discards** to levels approaching zero.
- Develop and maintain indicators of marine ecosystem health at the genetic, species, population and ecosystem level.
    - (a) Buy "**Marine Insurance**" requiring: fish populations to be maintained at a high percentage of the unfished biomass,
    - (b) fishing not to endanger fish species or prevent recovery.
    - (c) the application of the Precautionary Principle to all fisheries.
- Apply **sustainability principles** to the entire production cycle. For example, packaging reduces, re-uses, and recycles raw materials; energy consumption is strictly monitored and reduced to minimum levels; and CFCs, HCFCs, HFCs and other chemicals that are ozone depleting or contribute to global warming have been minimised and/or eliminated in all phases of production.

"The industry builds a strong international branding and marketing strategy, which has especially powerful appeal in the United States and Europe. As a result, over the last ten years the export value of New Zealand's distinct "green" fish products has grown consistently, at a rate of 10% per annum. New Zealand seafood exports are enjoyed by millions worldwide and are vastly more profitable than lamb or butter ever were".

"The strong representation of industry, NGOs and local communities in the 2006-7 revision of New Zealand's marine legislation proves crucial to the viability and public acceptance of the new laws. The review also allocated $10 million for **research,** education and network building, which went into the expansion of the NZAEE and NZMSS projects.

The quality and innovation of the science carried out by this network of laboratories is world-renowned. Each year there is keen competition for places in the visiting scholar and postgraduate research programmes. **Environmental education** is an integral part of the curriculum. Hands-on involvement of local people is a key principle. The immediacy of marine information sharing, giving community groups instant connections into national and international systems, has allowed them to develop innovative and locally-relevant solutions to resource management questions.

The **science of ecosystem modelling** and managing under multiple uncertainties (including climatic events, chaotic systems, and, in the early years, lack of information) was soon perfected in the New Zealand system. Gone are the days when scientists had to prescribe management measures based on a single-species approach. By the 20s, management plans for an individual fish stock were replaced with management plans for entire ecosystems.

The **Fishery Ecosystem Plan** (FEP) was one of the first tools developed for research and management. The Plans, which are based on a model developed by the US Congressional Ecosystem Advisory Panel, contain information on ecosystem structure and function as well as species composition, so that the ecosystem effects of individual management decisions can be evaluated. The FEPs prove to be critical in preventing the loss of biological diversity and the erosion of ecosystem function. The model has been adopted globally.

Rising sea levels and the boom-bust cycles experienced early in the century, resulted in the creation of new regulations in 2012 which ensured that aquaculture development proceeded with caution. Improved knowledge of the ecological risks guided the placement and total numbers of "farms". Since 2012 projects have been concentrated in designated "**aquaculture areas**". Sites have been chosen in consultation with tangata whenua and other community interests, and planning is guided by strict ecological and economic criteria. Coastal uses associated with the aquaculture industry have been integrated with New Zealand's coastal network of taiapure, maitaitai, and **marine reserves**.

These criteria ensured that the needs of the environment were protected while creating a context of stability for the extraordinary development and **consolidation of local and regional business enterprises** in the 20s, and the subsequent drop in New Zealand's unemployment. As a direct result, export markets have expanded significantly, as has local demand.

12. Is there any addressing of catastrophes/extreme events?

Under this (single) scenario the science of ecosystem modeling, and managing under multiple uncertainties (including climatic events and chaotic systems) is soon perfected in New Zealand.

13. Originality or USPs (unique selling points)

Cross-cutting scenarios for the marine environment, that attempt to consider developments in many different sectors of the economy.

14. Were original research or research drivers included

Research priorities, organisation and infrastructure are considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

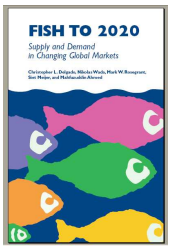
The recommendations are in two parts: those focused on areas requiring urgent action and one, a task force, aimed at putting in place a long-term strategy for the sustainable management of New Zealand's marine environment.

The review revealed a strong desire from all stakeholders for a greater role in the decision making processes that shape the way New Zealand's marine environment is managed. A task force is a robust way for Government to help consolidate that commitment and at the same time build up trust within and between stakeholders.

Specific recommendations to:

- Ministers of Environment, Conservation and Fisheries,
- Minister of Research, Science and Technology
- Prime Minister

ANNEX 7.



1. Title – Report title

"Fish to 2020: Supply & demand in changing global markets"

2. Identifying short title:

WORLDFISH

3. Author(s)

- The International Food Policy Research Institute (IFPRI), Washington, USA.
- The Worldfish Center, Penang, Malaysia.

4. Source (book chapter, FAO Report, etc) and date

(Report) Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S., Ahmed, M. (2003) *Fish to 2020: Supply & demand in changing global markets.* International Food Policy Research Institute (IFPRI) and Worldfish Center. WorldFish Center Technical Report 62. 223pp.

5. Geographic scope

Worldwide

6. Focus or disciplinary scope

Used a global economics model (IMPACT) to provide regional predictions (up to the year 2020) of fish prices, fish production, per capita fish consumption, and the contribution of aquaculture given six contrasting scenarios.

7. Stated objectives of the study and the target audience

The overall purpose of the study is to analyze the changing—and now critical— place of fisheries in global food policy issues. The focus is developing countries, although the analysis includes the developed world.

Many past and future developments in the fisheries sector can best be understood by considering fish as a series of commodities within a changing world supply and demand system for different food and feed items. The study concludes with a delineation of key domains for policy action within the fisheries sector that can improve outcomes for broader food and agricultural development policy objectives in developing countries. Thoughts on priorities for further food policy research in the fisheries area are also provided.

8. Time horizon

Time horizon for scenarios up to 2020.

9. Method employed for the analysis

IMPACT is specified as a set of country or regional submodels, within each of which supply, demand, and prices for agricultural commodities are determined. The present version of IMPACT (July 2002) covers 36 countries and regions (accounting for virtually all world food production and consumption) and 22 non-fish commodities, including all cereals, soybeans, roots and tubers, four meats, milk, eggs, oils, oilcakes, meals, sweeteners, fruits, and vegetables.

IMPACT uses a system of supply and demand elasticities for each commodity, different for each of the 36 markets and incorporated into a series of linear and nonlinear equations, to approximate the underlying supply and demand functions.

The new version of the model includes four categories of food fish. These are high-value finfish (such as salmon and tuna), low-value food fish (such as herring and carp), crustaceans (such as shrimp and crabs), and mollusks (such as clams and squid). It also includes two animal feed items made from fish: fishmeal and fish oil.

The determinants of fisheries demand in the IMPACT model can be separated into two broad categories: price-mediated drivers and nonprice-mediated drivers. On the demand side, IMPACT models responses to changes in own-prices, prices of competing and substitute goods in consumption, income, and population. On the supply side, IMPACT models responses to changes in own-prices, prices of competing and substitute goods in production, and input prices.

Population growth trends are a major determinant of demand growth in the IMPACT framework. Population growth estimates are based on medium-variant predictions from the United Nations (1998); they are specified for each IMPACT country group, and different rates are specified for each five-year period to 2020.

Income change is measured by growth rates in future national income projected by the World Bank (World Bank 2002). Generally cautious GDP projections show highest growth in China, India, and Southeast Asia. Developed world GDP growth projections are generally between 2 and 3 percent per year.

Nonprice factors in supply, including technological change and changes in investment, are modeled through trend growth factors that are allowed to differ across commodities and country groups.

10. Consultee involvement

The book grew out of broader collaboration between IFPRI and the WorldFish Center that started with a consultative conference held in Hirtshals, Denmark, in the summer of 1997. Attended by prominent fisheries policy analysts from developing countries, the purpose of the conference was to define the key policy research issues confronting fisheries in developing countries, and to help recommend a common agenda for policy research in fisheries between IFPRI, a food policy research institute, and the WorldFish Center, a specialist fisheries research agency. Participants identified the need for a study such as this one to illustrate the complex tradeoffs within the fisheries sector, the interactions with events outside the sector, and the impact of fisheries on food issues more broadly.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The determinants of fisheries demand in the IMPACT model can be separated into two broad categories: price-mediated drivers and nonprice-mediated drivers. On the demand side, IMPACT models responses to changes in own-prices, prices of competing and substitute goods in consumption, income, and population. On the supply side, IMPACT models responses to changes in own-prices, prices of competing and substitute goods in production, and input prices.

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Nonprice factors in supply, including technological change and changes in investment, are modeled through trend growth factors that are allowed to differ across commodities and country groups.

What is the structure of the scenarios – mutually exclusive?

The scenarios included:

- a **'best-guess'**, judged to be the most plausible;
- a scenario assuming **faster aquaculture expansion** world-wide;
- a scenario whereby feed **conversion efficiency** for fishmeal and fish-oil improved markedly;
- a scenario assuming **slower aquaculture expansion**;
- a scenario which attempted to modify the 'baseline' to account for the **over-estimation of Chinese fishery landings**;
- a scenario assuming complete **ecological collapse**.

Table 4.7 Total per capita consumption of food fish under different production scenarios, 2020

Region	Total consumption (kg/capita/year)						
	Actual 1997	Most likely (baseline)	Faster aqua-culture expansion	Lower China produc-tion	Fishmeal and fish oil efficiency	Slower aqua-culture expansion	Ecolo-gical collapse
China	26.5	35.9	41.0	30.9	36.1	32.1	30.4
Southeast Asia	23.0	25.8	28.5	25.8	26.0	23.7	21.7
India	4.7	5.8	6.5	5.8	5.9	5.3	4.8
Other South Asia	6.0	6.1	6.8	6.1	6.2	5.6	5.2
Latin America	7.8	8.6	9.4	8.6	8.7	7.9	7.3
West Asia and North Africa	6.2	6.4	7.1	6.4	6.4	5.8	5.4
Sub-Saharan Africa	6.7	6.6	7.6	6.7	6.7	5.9	5.5
United States	19.7	19.7	20.8	19.6	19.8	18.8	15.2
Japan	62.6	60.2	63.3	60.0	60.3	57.8	50.9
European Union 15	23.6	23.7	25.1	23.6	23.8	22.7	18.9
Eastern Europe and former Soviet Union	10.6	11.6	12.0	11.5	11.7	11.3	8.6
Other developed countries	14.7	14.0	14.8	13.9	14.0	13.4	10.9
Developing world	14.0	16.2	18.2	15.0	16.3	14.6	13.6
Developing world excluding China	9.2	9.9	11.1	10.0	10.0	9.1	8.3
Developed world	21.7	21.5	22.6	21.3	21.5	20.6	17.0
World	15.7	17.1	19.0	16.1	17.2	15.7	14.2

Sources: Actual data were calculated by authors from FAO 2002c; projections for 2020 are from IFPRI's IMPACT model (July 2002).
Note: See Table 4.1 for scenario descriptions.

Based on the most likely set of assumptions—the baseline scenario—global food fish production will increase slightly faster than global population through 2020. Per capita consumption is projected to rise, and real fish prices are also expected to rise between 4 and 16 percent, depending on the commodity.

Although developing countries will continue to dominate world fisheries production (79 percent of world food fish production in 2020, up from 73 percent in 1997), it should be noted that developing countries excluding China just manage to preserve their 38 percent global share of production in 2020 under the baseline scenario. China's gain in share mirrors the loss by industrialized countries, principally Eastern Europe and the former Soviet Union, the European Union, and Japan.

Global increases in consumption of food fish will predominantly take place in developing countries, where population is growing and higher incomes allow purchase of high-value fisheries items for the first time by many people.

12. Is there any addressing of catastrophes/extreme events?

Some consideration of supply shocks associated with climate variability. Price spikes during times of shortage, such as that which occurred during the 1997–98 El Niño event.

13. Originality or USPs (unique selling points)

Global predictions of supply and demand in the fisheries and aquaculture sectors.

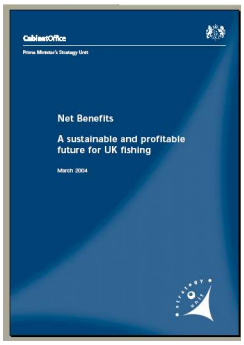
14. Were original research or research drivers included

Neither research priorities nor research drivers were considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

Provided 'Entry Points for Policy Action' also '**Priorities for Future Policy Research'**.

ANNEX 8.



1. Title – Report title

"Net Benefits: A sustainable and profitable future for UK fishing"

2. Identifying short title:

NET BENEFITS

3. Author(s)

Prime Minister's Strategy Unit, UK Cabinet Office

4. Source (book chapter, FAO Report, etc) and date

(Report) UK Cabinet Office (2004) *"Net Benefits: A sustainable and profitable future for UK fishing".* 168pp. www.strategy.gov.uk

5. Geographic scope

NE Atlantic (seas around the UK).

6. Focus or disciplinary scope

- A future vision of the UK fishing industry in the next 10–15 years.
- Detailed economic (competition, markets, costs and prices) scenarios, and possible impacts on employment and local communities.
- The discounted value of future earnings from the whitefish sector under different economic and stock futures.

7. Stated objectives of the study and the target audience

Tasked with developing options to achieve a **sustainable UK fishing industry** in the medium to long term (10-15 years).

8. Time horizon

Scenarios up to 2020

9. Method employed for the analysis

A comprehensive list of potential drivers of the future UK sea fishing industry was drawn up with the help of experts and stakeholders. The importance of these was then assessed analytically and through the Strategy Unit consultation process and a smaller set of key drivers/trends chosen. Three 'future worlds' were developed to define the possible economic and political environment inside which the sea fishing industry will need to operate: **Market World, Green World** and **Fortress Europe**. These worlds are outlined below

10. Consultee involvement

The review involved extensive consultation with all parts of the UK fishing industry as well as other stakeholders.

There was a strong view in many parts of the catching sector that the current UK fleet has dropped below its minimum size. Any further fleet reductions could result in a loss of capital and skills which would make UK fishing opportunities vulnerable to purchase by other EU fleets. Other respondents asserted that sea fishing is in the long run an unprofitable industry in the UK, and imports would supply UK bulk demand in the future, leaving only small-scale niche and artisanal activities available for any UK catching industry. The importance of the UK catching industry to communities was also disputed by respondents, with widely differing views about the extent of fisheries dependence and community vulnerability to changes in the catching sector. While many respondents wanted fisheries opportunities to be retained in small communities, others argued that this would not be economically viable and the fleet must concentrate to survive commercially.

These differing stakeholder visions of the future UK fishing industry imply radically different approaches to fisheries policy and management. However, they are obviously not compatible and form the extremes of a wide continuum.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The impact that the three different 'worlds' have on the key drivers and trends identified in the study is detailed below in Figure 4.1.

Figure 4.1: Impact of future "worlds" on key seafish industry drivers

Key Drivers	Green World	Market World	Fortress Europe
Tariffs	L	L	H
Non-tariff barriers	H	L	H
Transport Costs	H	L	H
Fuel Costs	H	L/M	L
Environmental Views	H	L/M	M/H
Global aquaculture	L	H	L/M
Subsidies	L	L	H
UK supply chain	L	H	M
Europe integration	H	L	M

H= High level M= Medium level L= Low level

Other drivers of competitive pressures

Aquaculture: Produce from aquaculture appeals to processors given the regular supply (compared to irregular wild-fish landings) and the ability to stipulate size. In future, the overall growth in the global supply of fish will be driven predominantly by the growth in aquaculture. However, availability and sustainability of feed, effects of climate change, and high labour and production costs could all work against the aquaculture industry, although cheaper production costs (eg in the Far East) could impact on important export markets for UK wild fish, especially pelagics. Analysis of the cost of future aquaculture in major whitefish species, especially cod, shows it is unlikely to make a significant impact on wild fish markets in the next decade.

Increasing pressure to reduce tariffs: The EU has 357 tariff lines for fisheries products. Of these, 10 are duty-free, 6 less than 3%, 127 in the 5–9.9% range, 60 in the 10–14.9% (high tariff) range, and as peaks (duties over 15%) 72 in the 15–19.9% range and 82 in the 20–26% range. The EU recognises that community supplies of certain fisheries products currently depend on imports from third countries and currently suspends in part or in whole the customs duties for certain amounts of the products in question (Autonomous Tariff Quotas). As a major fish importer from outside the EU, and an exporter to global markets, the UK as a whole would gain from lower overall tariffs and barriers to fish products. Even under a strongly liberal scenario, it could be some considerable time before third countries will be able to sell fish products into the EU without any barriers. However, the direction of change is firmly towards easier access, especially as fish products are linked to broader liberalisation of all industrial sectors in trade negotiations.

What is the structure of the scenarios – mutually exclusive?

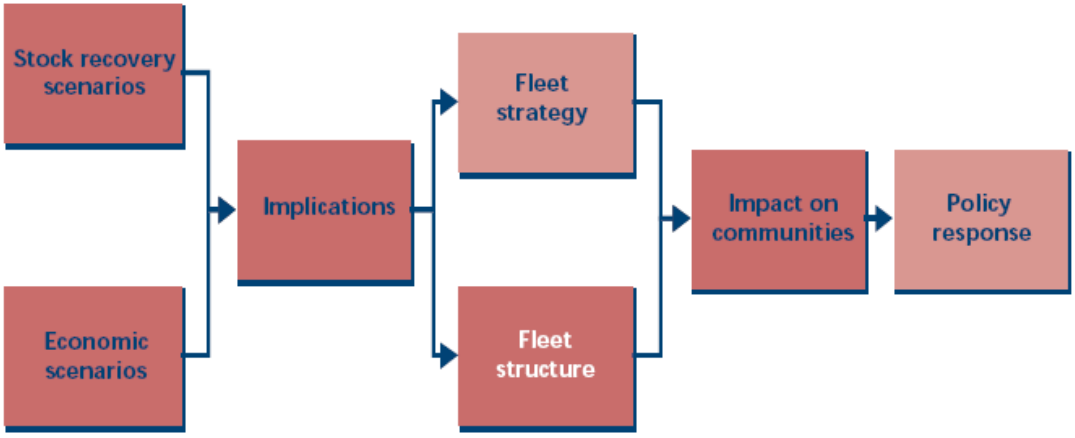
Market World: Continued expansion of free trade inside WTO and other organizations results in the removal of tariffs and subsidies on fish products and product markets become truly global, coupled with a rapid application of technology to fishing and aquaculture.

Green World: Growing impact of climate change drives an increase in environmental values, raising transport and fuel prices, increasing demand for sustainable and local produce and raising restrictions on the environmental impacts of fishing and aquaculture.

Fortress Europe: Continued security threats and failures in international institutions result in managed trade regimes with high tariffs and subsidies, low investment in technology and aquaculture and, high competition for protected resources.

These worlds provide the boundaries for both the general descriptive analysis and the numerical modelling work carried out on the UK fleet.

The framework for analysing the industry futures is illustrated below in Figure 4.3. The approach combines the biological modelling of stock recovery with the economic trends (driven by the futures analysis) in order to get a range for the likely structure and size of the sea fishing industry.



12. Is there any addressing of catastrophes/extreme events?

The Strategy Unit also considered possible events which would have a high impact on the future but may or may not happen, eg widespread farming of key whitefish species. Of all the shocks examined only climate change was considered both serious and likely enough to be included throughout the analysis.

13. Originality or USPs (unique selling points)

Involved a scenario consultation exercise as well as detailed quantitative analysis, leading to concrete proposals for transformation of the UK fishing fleet. (i.e. scenarios fully utilised and translated into useful proposals)

14. Were original research or research drivers included

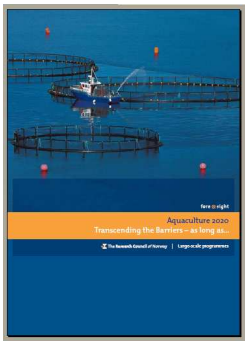
Neither research priorities nor research drivers were explicitly considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

Quantitative analyses of profits, revenues and costs in different fleet segments, and recommendations for the transformation of the UK fishing fleet over the next 10-15 years. Followed by Defra report, *"Securing the benefits"* setting out a strategy for sustainable fisheries (including fisheries research) in the UK. Recent consultation exercise *Fisheries 2027* sets out Defra's vision of the fisheries sector in 20 years' time (including management, fleets and science).

ANNEX 9.

1. Title – Report title



"Aquaculture 2020. Transcending the Barriers – as long as…"

2. Identifying short title:

AQUA2020

3. Author(s)

Rolf Giskeødegård, Research Council of Norway (RCN)
Magny Thomassen, Chairman of the Board, Aquaculture Programme RCN
Kathrine Angell-Hansen, Ministry of Fisheries and Coastal Affairs
Harald Sveier, EWOS Innovation
Kjell Maroni, Norwegian Seafood Federation (FHL)
Svein Hallbjørn Steien, Innovation Norway
Lars Horn, RCN
Erik F. Øverland, RCN
Lars. A. Ødegård, RCN

4. Source (book chapter, FAO Report, etc) and date

Report from The Research Council of Norway, 2005

5. Geographic scope

The scope is the Norwegian Fish-farming Industry. As the scope was not explicitly lineated, it was shaped y the stakeholders, and thus reflects the strong position of the (in Norway) all-dominant salmon farming industry. This means that the geographic scope is primarily on Norway, it is extended to worldwide markets and to production in Europe and North and South America.

6. Focus or disciplinary scope

The focus is on the Norwegian fish-farming industry.

7. Stated objectives of the study and the target audience

Objectives:
"… contribute to creating a better basis for the programme development work to be done at the Research Council of Norway in 2005 and 2005 for the Aquaculture sector".

Target audience:
Everyone involved in research programme development

8. Time horizon

Time horizon is 2020.

9. Method employed for the analysis

The foresight method employed was a scenario construction process in four steps:

1. Discussion of actors and factors expected to shape the aquaculture industry by 2020
2. future images were developed for all these actors and factors, resulting in 150 mini scenarios
3. groups constructed complete scenarios, using the mini scenarios as input. They were asked to integrate at least one crisis into each scenario, to promote growth-through-crisis scenarios.
4. Outlining of interesting research topics, strategic recommendations and measures for future development.

10. Consultee involvement

Four workshops were organised according to the process outlined above. The process involved a broad array of stakeholders, with close to 80 participants attending the workshops. Trade and industry was well represented, as well as research communities, consultants, trade organizations, government bodies and a few students. Professionals from adjacent potentially relevant fields and areas of activity were invited to take part, this included people from advertising, NGOs ICT and materials technology.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The most important factors and actors expected to influence the development of the aquaculture industry up to 2020 can be summarized in this table:

Factors	Actors
Market	Companies
Feed raw materials	Research, educational and competence communities
Innovation	Industry Organizations
Capital/Ownership	Investors
Development of competence (research and education)	Public Authorities
Sustainable development (environmental and food product safety)	Advocates
Policy	Consumers/customers

12. What is the structure of the scenarios – mutually exclusive?

The five scenarios are summed up in a table, which is here given in a key word form:

	Markets with no Frontiers	Feed for Everyone	Sustainability	Aquaculture University	New industrial neutrality
Ownership and control	Strong government ownership, Norwegian multinationals	Private capital, foreign capital	Active ownership, strong individuals	Foreign MNCs dominate	Private capital dominates
What kinds of companies?	Different sizes, specialization	Large parent companies	Small breeders, networks	Small breeders, many on contract for MNCs	Large companies, qualified suppliers
Industry policy/role of government	Active role of gov.	Less national, more EU governance	Gov. focuses on funding basic research	Gov. plays minor governance role	Gov. as avtive partner in industrial dev.
Access to capital	Gov. important	Private cap. dominat	Stock Exchange, Ocean Fund (replaced the Petroleum Fund)	Foreign capital dominates	Private and foreign cap.
Added value/ production/ new species	Added value-production for salmon, new species growing	Large number of new species are farmed	Large export of fillets from salmon and cod	By-products accounts for 30% of exports.	Fresh-fillet products and biochemicals
Transport and logistics	Advanced, junctures outside of Norway	Advanved. E-trade in addition.	Advanved. E-trade in addition.	Tracking and product info. systems	Large volumes quickly and flexibly to remote markets
E-trade	Key role	Directly to consumers. Just-in-time for producers	Central	Central	ICT important for logistics
Competition	Global competition	Comp. from Asian low-cost producers	Equipment produced in Asia. Norway leads in concept development	Comp. from other species like tilapia	Tough comp.
Alliances	Strategic alliances with large trading groups	Alliances with knowledge-based trade groups	Extensive sales to large international trade chains	All. With trade and fast food chains, McDonald, Coca-Cola	Vertical integration, alliance with R&D

Knowledge regime/ infrastructure	R&D in large corporations	Industry performs applied research	Food research	Multi-disciplinary, industry . Research	Publ. financed research crucial
Knowledge placement	Core knowledge situated in Norway	Industry-relevant knowledge in companies	Norwegian research in five large, regional units	Industry-relevant knowledge in the Aquaculture University	Industry-relevant knowledge in Norway
Demand for consumption	Global, differentiated food market	Global increase in seafood demand	Global increase in demand, conscious consumers	Demand for many species, advanced industry	Strong demand for fresh products
Access to export markets	Liberalized global market	Norway part of EU, plays a central role in EU resource management	EU and Russia most important markets		Norway part of EU, total access to markets. Other trade blocks difficult
New emerging markets		China and Russia buy upscale products	China and India more important markets	China and India more important markets	Asia more important, Africa on the verge.
Product innovation	Norway dominates product development; biotech.	Health, nutrition and functional food boost seafood demand	Differentiation by quality, documentation and brands	Customized qualities of fresh fish.New species	Fresh fish with documentable characteristics
Process innovation	New process knowledge	Escape-proof installations, fish farming in open waters	Escape-proof installations, fish farming in open waters. Fish welfare.	New technology has solved most problems with disease, escapement etc.	Process technology and automation: cost-effective primary prod.
Feed	Genetically modified feed more important	Gas-based feed production.	Gas-based feed production. Feeding based on wild-caught fish not considered sustainable	Difficult feed situation, species on lower trophic levels important	Vegetable feed substances crucial
Biotechnology	GMO in feed and special applications	GMO not used	GMO not used	GMO accepted, except for special applications, like vaccines	GMO used to develop adequate vegetable feed substances
Ethics/Animal welfare	Important and documented	Important and documented	Important and documented	Important and documented	Crucial
Climate and environment		Climate has changed, installations moved	Significant climate change	No significant climate and environmental changes	No significant climate and environmental changes, but Norwegian expertise in monitoring important

13. Is there any addressing of catastrophes/extreme events?

Some kind of crisis, to be overcome, in all scenarios.

14. Originality or USPs (unique selling points)

Wide stakeholder involvement.

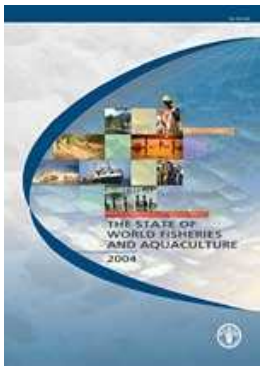
15. Were original research or research drivers included?

Research priorities were discussed, long table in the report.

16. What happened next – e.g. are there recommendations and were any of them taken up?

Background material for the new Aquaculture programme in the Research Council of Norway.

ANNEX 10.



1. Title – Report title

The State of World Fisheries & Aquaculture – 2004.

2. Identifying short title:

FAO-SOFIA

3. Author(s)

Fisheries Department, Food & Agriculture Organisation of the United Nations, Rome.

4. Source (book chapter, FAO Report, etc) and date

(Report) FAO (2004) The State of World Fisheries & Aquaculture – 2004. Part 4 – Outlook, pp 141-153. FAO Fisheries Department, Food & Agriculture Organisation of the United Nations, Rome.

FAO, 2004. *Future prospects for fish and fishery products: medium-term projections to the years 2010 and 2015*. FAO Fisheries Circular FIDI/972-1. Rome.

5. Geographic scope

Global

6. Focus or disciplinary scope

The "Outlook" section of the report describes and compares two recently completed studies of the future for world fisheries and aquaculture. The two studies, undertaken by FAO and by IFPRI (see ANNEX 7), use quantitative computer-based simulations to project supply and demand up to 2015 and 2020 respectively. These quantitative projections are then compared with projections reported in *The State of World Fisheries and Aquaculture 2002*.

7. Stated objectives of the study and the target audience

8. Time horizon

2015 (FAO study).

9. Method employed for the analysis

The FAO Food Demand Model (FDM) was used to make projections. Implications for price changes were derived by comparing the constant-price projections of supply and demand using a simple market-clearing model. The FDM makes projections of per capita and total demand for all commodities entering a country's diet, starting from basic assumptions on the growth of population and the gross domestic product (GDP), as a proxy for disposable income. The population forecasts for individual countries are based on the latest UN population projections (medium-fertility variant). The assumptions on GDP growth are those used for the FAO study *Agriculture: towards 2015/2030,* which, in turn, are based on the latest UN economic forecasts extrapolated to the year 2015. Demand projections for fishmeal are based on the foreseen expansion of aquaculture and of the broiler and pig weaning industries (derived from the most recent FAO projections) as well as on expected change in the price ratio between fishmeal and its close substitutes.

10. Consultee involvement

No – mainly an analytical study.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The modelling work explicitly considers important drivers such as population growth and the gross domestic product (GDP) of each country. Biological/ecological drivers and constraints are not considered.

What is the structure of the scenarios – mutually exclusive?

Only one, quantitative scenario is reported (compared to 6 possibilities in the IFPRI scenarios – ANNEX 7).

According to the projections there will be a global shortage of fish by 2015, although the severity of the shortage will differ among countries, and the overall effect will be a rise in the price of fish.

The world average per capita demand for all seafood could amount to 18.4 kg in 2010 and 19.1 kg in 2015, compared with 16.1 kg in 1999/2001. This increase in demand implies an 18 percent increase over the next 15 years compared with a 40 percent increase over the previous 20 years. Per capita demand for finfish would account for 13.7 kg in 2010 and 14.3 kg in 2015, respectively, while demand for shellfish and other aquatic animals would be 4.7 kg and 4.8 kg, respectively.

Prices for all types of fish would increase in real terms by 3.0 and 3.2 percent by the years 2010 and 2015, respectively.

The share of developing countries in world fish production is expected to increase from 75 percent in 1999/2001 to 81 percent by 2015.

World fishmeal and oil demand is projected to grow by only 1.1 percent (from 2000 to 2010) and 0.5 percent (from 2010 to 2015) annually.

Out of the expected increase of 43 million tonnes in global fish production from 1999/2001 to 2015, 73 percent would come from aquaculture, which is projected to account for 39 percent of global fish production in 2015 (up from 27.5 percent in 1999/2001).

A common denominator for these studies is that the world should not have to face any shortage of fish supplies in the next three decades and the impact on prices will be minimal. In concrete terms, this means that per capita supplies will be maintained, and are even likely to grow. Supplies will increase substantially thanks to sustainable aquaculture development combined with sustained capture fisheries production, mainly from the open-oceans.

Per capita fish consumption in the EU-25 countries3 during the period 2005–30 will show an increasing trend (varying from 1 to 12 percent) in 19 countries., This rise is supported by an increase in the consumption of convenience products. Frozen products tend to be on a downward trend, while the consumption of fresh fish will stagnate or decrease. The rising share of supermarkets in the retail of seafood products will also increase their availability, leading to increased consumption, while growing consideration of the health benefits of seafood may further fuel the positive trend in consumption.

Improvement of economic conditions is the main force behind the increased per capita consumption in the new member countries. The increase of the net supply will be possible because of a rise in imports from third countries (mainly Asian, African and South American countries) and an increase of aquaculture production in some countries (Greece, Spain, Norway and the United Kingdom). Decreasing trade barriers and improvements in the quality of processed fish products from developing countries will lead to restructuring within the European processing industry.

12. Is there any addressing of catastrophes/extreme events?

Sudden climate or environmental ‘shock’ events are not considered.

13. Originality or USPs (unique selling points)

Detailed (quantitative) predictions of supply and demand in the fisheries and aquaculture sectors.

14. Were original research or research drivers included

Research drivers, structures and organisation not considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

No specific recommendations.

ANNEX 11.

1. Title – Report title

"Fishing for research - a scenarios study on fisheries and eco-system."

[Original title: Onderzoek boven water - Een scenariostudie over visserij en ecosysteem]

2. Identifying short title:

NRLO-scenario

3. Author(s)

Drs. E. Jagtman (Rijksinstituut voor Kust en Zee/RIKZ)
Dr.Ir. P. de Jong (Rijksinstituut voor Visserij Onderzoek/RIVO)
Drs. E. Buisman (Landbouw Economisch Instituut/LEI)
Mw. P. Colette (Nationale Commissie voor Duurzame Ontwikkeling/NCDO)
Drs. M. van Berkel (RWS, Hoofddirectie Waterstaat, Afdeling Strategie)
Dr. P. Schütte (Stratix Consultants)

4. Source (book chapter, FAO Report, etc) and date

(Report) Jagtman, E., E. Buisman, P. de Jong en P. Schütte. Fishing for research - a scenarios study on fisheries and eco-system. The Hague (The Netherlands), National Council for Agricultural Research (NRLO), 1997. NRLO Report 97/35. [Original title: Onderzoek boven water - Een scenariostudie over visserij en ecosysteem]

5. Geographic scope

North Sea

6. Focus or disciplinary scope

A Multidisciplinary team looked at the developments in fisheries and the relation between fisheries and the wider ecosystem.

7. Stated objectives of the study and the target audience

What are the most critical factors in the interaction between the marine ecosystem and fisheries in the 15 to 20 years to come? And to what (new) research needs does the future development of these critical factors lead?

8. Time horizon

Time horizon for scenarios up to 2015

9. Method employed for the analysis

The study has used the following steps:
0. Definition of the problem
1. Identification of relevant trends
2. Develop vision on main influential factors
3. Develop scenarios
4. Analysis of the theme base don the scenario's
5. Develop possible strategies for solutions
6. Formulate options and priorities for research

Interviews with 8 representatives from the field were conducted in order to develop a more precise view on the issue at hand. This analysis resulted in 8 themes that were considered useful for further use and assessment. In a one day workshop with external invitees the most important drivers for the scenarios were identified. Based on this analysis three scenarios were developed. The scenarios were presented during a workshop to representatives of the field. The scenarios were both analysed and translated into the pursuant research requirement. This resulted in an analysis of future research requirements which was used for consultation of a wider group of nature- and conservation groups.

10. Consultee involvement

During the course of the project, interviews (8) and workshops were organised. These were attended by representatives from 17 organisations (listed in the report). Several representatives from the fishing industry, political arties and nature conservation sectors were consulted.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The analysis was based on a set of axis of drivers depicting the following dichotomies:
1. Short term exploitation versus sustainable exploitation
2. Individual versus collective action of fishermen
3. Consumer appreciation: environment important versus consumerism
4. Market forces versus government control
5. National versus European policy
6. Coherence or conflict between legislation, implementation and enforcement
7. Sector oriented versus integral fisheries policy
8. Property rights tradable nationally versus internationally
9. Damage minimisation versus catch maximisation
10. Output regulation versus of input regulation
11. Sale of fisheries: small scale or global

The participants in the workshop chose the following pair of axis to present the two most fundamental uncertain drivers steering the scenarios:

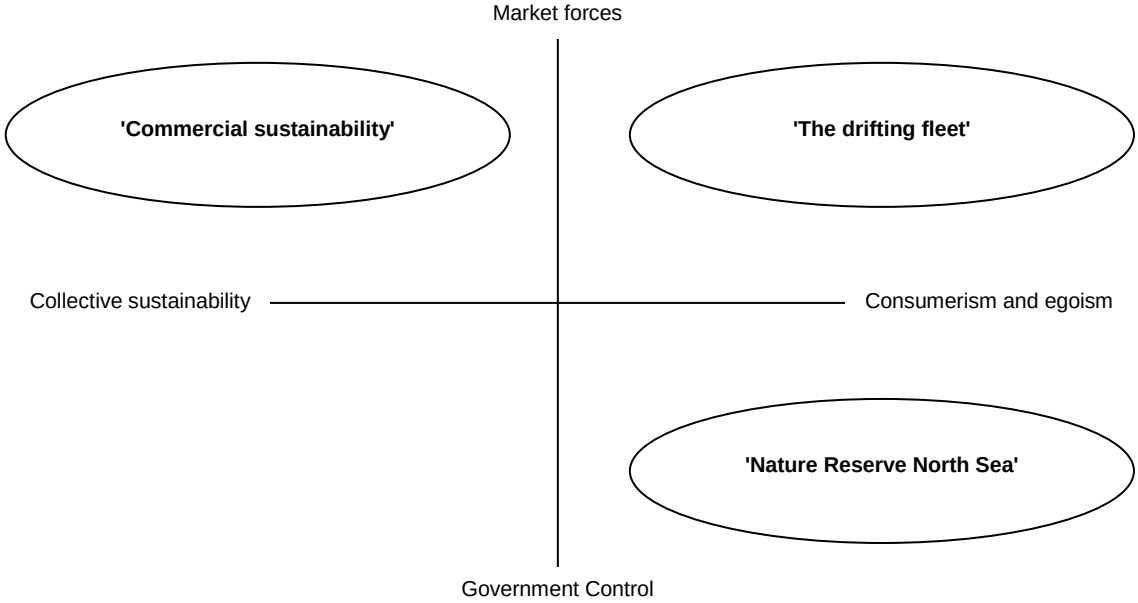
1. market forces versus government control
2. citizens as consumers with a high degree of collective sustainable caring perspective versus an individually acting perspective based on self interest and direct fulfilment of needs

What is the structure of the scenarios – mutually exclusive?

Based on the driver axis above and the set of two most fundament uncertain developments three scenarios for North Sea fisheries were developed. The scenarios are not mutually exclusive.:

1. **'Commercial sustainability'**. In this scenario the role of government is very limited, with a strong steering through market forces. At the same time, a development takes place that causes the general public to act more according to sustainability principles.
2. **'Nature Reserve North Sea'**. This scenario depicts a world in which governments start to concentrate on their core tasks and leave much to the responsibility of individuals. The management of environmental issues and nature will be among those core tasks. Although this leads to more effective European policies in these areas, it also gives rise to conflicts between member states; conflicts that cause the EU fisheries policy to end up in a deadlock position.
3. **'The drifting fleet'**, in the first period is characterised by a shift of political power to 'Brussels', a withdrawing (national) government, and a declining support for fisheries as an economic sector. Diminishing subsidies, and a 'Euro levy' on diesel fuel, increase the pressure on the profitability of the fisheries sector.

Leading up to the following picture:



12. Is there any addressing of catastrophes/extreme events?

Extreme events are only considered as part of the scenarios; hence extreme developments in for example market control and consumerism, leading up to a collapse of national North Sea fisheries and introducing global drifting fleets. Other exogenous extreme events are not considered.

13. Originality or USPs (unique selling points)

Interdisciplinary, stakeholder/expert based analysis of fisheries development as a basis for future research agenda setting.

14. Were original research or research drivers included

Focus of the report is through an analysis of possible futures construct a research agenda.

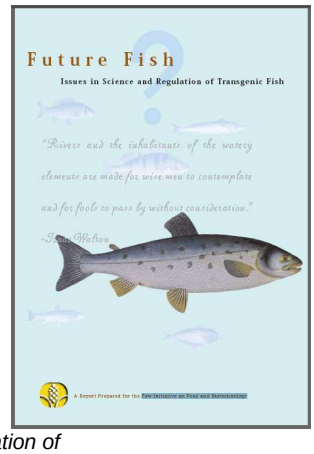
15. What happened next – e.g. are there recommendations and were any of them taken up?

NRLO as organisation over tije developed into the platform for Innovation and as such stick plays a role in setting the agenda for innovation in agriculture and fisheries. The study above resulted in a further publication ((Report) National Council for Agricultural Research, NRLO-report nr. 98/18E, The Hague, July 1998, ISBN: 90-5059-081-0, 35pp.) which provided specific recommendations for setting the research agenda.

ANNEX 12.

1. Title – Report title

Future Fish: Issues in Science and Regulation of Transgenic Fish



2. Identifying short title:

PEW

3. Author(s)

Pew Initiative on Food and Biotechnology, Washington

4. Source (book chapter, FAO Report, etc) and date

(Report) Pew Initiative on Food and Biotechnology (2003) *Future Fish: Issues in Science and Regulation of Transgenic Fish.* Washington, 71pp.

5. Geographic scope

Global (but focused mainly on US)

6. Focus or disciplinary scope

Recent applications of genetic engineering have led to the development of **genetically modified (GM) fish** for aquaculture. Endowed with characteristics such as faster growth or disease resistance, these fish offer the prospect of more efficient and less expensive production.

This report provides an **overview of the issues** surrounding transgenic fish and their potential escapement into the wild.

7. Stated objectives of the study and the target audience

This report provides an overview of the issues surrounding transgenic fish. The report reviews the development of aquaculture biotechnology, the status of current research, its potential economic, environmental, and other benefits, its possible food safety and environmental risks, and the application of current U.S. laws and regulations as it moves to commercial development. While the report does not contain specific policy recommendations, it highlights a number of key regulatory issues for policymakers.

8. Time horizon

No specific time horizon given.

9. Method employed for the analysis

One way researchers attempt to determine if a novel gene will flow to other populations is by assessing the "net fitness" of a particular type of fish. The term *net fitness* is scientific shorthand for the degree to which an organism succeeds at surviving and passing on its genes to future generations. The net effect of the following six traits fully determine the net fitness for any animal, including a transgenic fish:

- juvenile viability (chances of surviving to sexual maturity);
- adult viability (chances of surviving to procreate);
- fecundity (number of eggs produced by a female);
- fertility (percent of eggs successfully fertilized by male sperm);
- mating success (success at securing mates); and
- age at sexual maturity.

Scientists use mathematical models to combine these net fitness parameters to assess the potential for an organism—such as a transgenic fish that has escaped into a wild population— to either proliferate or die off. The net fitness methodology provides a comprehensive and cost-effective way to estimate the probability of gene flow and identify the most likely gene flow **scenario**. It requires first gathering data on the six fitness traits of both transgenic and wild fish in contained experiments and then entering the data into a computer simulation model.

10. Consultee involvement

Not clear

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

Drivers for the expansion and development of transgenic fish are discussed.

What is the structure of the scenarios – mutually exclusive?

Suggested three scenarios concerning the impact of transgenic escapees on wild populations:

1.The 'purge' scenario (fitness lower than in wild animals, genes 'purged' from population)
2.The 'spread' scenario (equal fitness, genes spread in wild population)
3.The 'Trojan gene' scenario (out-compete wild population)

All of the aforementioned scenarios could have consequences for wild fish populations, such as commercially significant, threatened, or endangered species. They could also have consequences for the wider aquatic communities in which the wild populations may play an important ecological role, as well as an impact on the resilience of those communities.

12. Is there any addressing of catastrophes/extreme events?

The escape of transgenic fish can be viewed as a sudden 'extreme' event.

13. Originality or USPs (unique selling points)

Detailed consideration of one particular issue/driver (transgenic fish and their escapement)

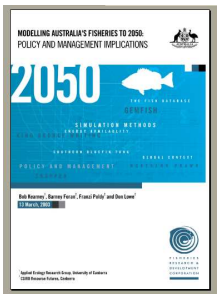
14. Were original research or research drivers included

Research drivers, structures and organisation not considered, research gaps and new initiatives are mentioned.

15. What happened next – e.g. are there recommendations and were any of them taken up?

No specific recommendations.

ANNEX 13.



1. Title – Report title

Modelling Australia's Fisheries to 2050: Policy and Management Implications

2. Identifying short title:

FISH2050

3. Author(s)

- Applied Ecology Research Group, University of Canberra
- CSIRO Resource Futures, Canberra

4. Source (book chapter, FAO Report, etc) and date

(Report) *Kearney, B., Foran, B., Poldy, F, Lowe, D. (2003) Modelling Australia's Fisheries to 2050: Policy and Management Implications. Fisheries Research and Development Corporation, Australia.*

5. Geographic scope

Australian EEZ

6. Focus or disciplinary scope

This study incorporates historical data on 220 individual Australian fisheries and simulations of future yields for each into a much broader model of Australia's future population growth, energy availability and total resource use and environmental quality (The Australian Stocks and Flows Framework) to simulate scenarios for future fisheries supply and demand to 2050. The study also considers aquaculture and imports, the effects of recreational fishing and simulated seal consumption, energy indicators (price and availability of fuel).

7. Stated objectives of the study and the target audience

"To provide a simplified interpretation of Australia's total long-term resource demands and likely production to enable the fishing industry to better understand their relationship with other resource users and with national development policies".

8. Time horizon

Models are projected forward in time to 2050, although information is also given for the year 2020.

9. Method employed for the analysis

The 'fish futures' model is a component within a wider, more holistic model of Australia's economy termed *The Australian Stocks and Flows Framework*, ASFF, (Poldy et al., 2001). In fish terms, the ASFF model calculates the fish catches (the flows) that are derived from fish stocks and accounts for the boats, fuel, labour and infrastructure required to enable the overall production to occur.

The fish model in ASFF is one of 32 linked models. The 'demand' side of ASFF is driven by a detailed human population model. The 'supply' side of the model is derived from basic resource models of agriculture, forestry, fishing and mining. An external trade calculator (imports and exports) and an industry calculator combine to produce the complement of physical goods required by a particular Australian population.

Good catch data for each fishery underpins the credibility of the simulation approach. The national fish data base was assembled with the enthusiastic help and facilitation of the project steering committee who represented most state and commonwealth managers and sources of fishing data. An ideal data set for each of the 220 fisheries modelled could be characterised as catch data for each year from 1950 to 2000 with specific commentary on major fluctuations in yearly catch.

10. Consultee involvement

No stakeholder consultation described in the report (although see 'methods' section above).

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The background structure to all scenarios has much in common. Ten important drivers are the same, allowing a focus on fisheries management rather than the millions of whole-economy interactions that may change appreciably over the next 50 years. The important and relevant drivers are as follows:

1. Domestic population reaches 25 million by 2050 in line with base case scenario in the CSIRO 'Future Dilemmas' population report (Foran and Poldy, 2002).
2. International inbound tourists reach 32 million per annum by 2050, who together with domestic tourists, have travel preferences mainly focused on Australia's east coast.
3. Domestic consumption of sea food increases to 17 kg per capita by 2020 and then increases again to 25 kg by 2050. This is against a global per capita consumption of 17 kg by 2020 (Delgado et al., 2002), noting that in many countries total consumption is much closer to total live weight of fish than is the case in Australia.
4. Aquaculture production doubles in physical terms (tonnage) by 2020 and then doubles again by 2050.
5. The recreational catch uses the physical and demographic results from the recent national recreational fishing survey (Henry, pers. comm.) and applies them (without change over time) to the evolving domestic population and international inbound visitors. Fish stocks so impacted are generally inshore, adjacent to centres of population and tourist activity.
6. Commodity exports continue to expand using trends from the last 20 years. Import volumes are used as indicators to balance the difference between domestic requirement (people by per capita consumption) and domestic availability (total production minus exports). We assume that we will be able to afford import requirements to 2050.
7. Given the possible roll-over of world oil supplies around 2020, we assume that fisheries production will not be constrained by fuel availability or price, since fuel will be imported or a switch will be made to compressed natural gas.
8. There are no overt environmental effects attributed to any fishery apart from those already embodied within the historical production record and stock assessments forming the basis of the simulation model for each fishery.
9. Each fishery is simulated as an individual unit with no ecological effects (density dependence or eating down the food chain etc) or secondary management effects (stock decline in one fishery giving rise to an increase in take from another fishery).
10. The seal effect is applied to fish units forming obvious and sizeable parts of seal diets. Current seal numbers are pro-rated geographically to the appropriate southern coast fisheries and different yearly consumption rates (kilograms per animal), from Goldsworthy et. al., 2002, applied for each type of seal and sea lion. No account is made for the reported increasing geographic distribution of seals. Under these assumptions, seals do not appreciably impact fisheries outside the 2000 range of the seal species, for example no impact is shown for NSW state fisheries.

What is the structure of the scenarios – mutually exclusive?

In addition to story telling, the authors were able to test the feasibility of several scenarios using industry catch data, and a simple mathematical models. Three fisheries management scenarios have been used:

1. The **'cautious' scenario** where, from the year 2001, an attempt is made to obtain the average catch for the last decade (1991 – 2000). If this catch rate pushes the fishery below 20% of virgin biomass, the fishery is closed until the 20% level is again reached. Fishing then re-commences at levels where yearly growth and yearly production are more or less balanced.
2. The **'optimum long-term' scenario** attempts to implement 'improved' management with initially lower catches designed to increase the level of biomass and its resilience. Where fish stocks are near virgin biomass levels (before fishing intensifies), catch rates are set to decrease stocks to approximately 72% of the biomass that supports theoretical maximum sustainable yield. Where fish stocks are low, catch rates are set to 80% of yearly growth rate. This allows some fishing to continue and the fish stock to gradually increase, particularly for longer lived species. In time the yearly catch rates also increase.
3. The **'continuous fishing' scenario** attempts to catch the average of the last ten years (1991 – 2000) in each fishery. Compared to the cautious scenario however, it does not implement better management when fish stock levels decrease below 20% of virgin biomass. The scenario allows current market ideologies and associated low discount rates (a preference for short term decisions) to dominate fisheries management.

Fisheries production declines in all three scenarios from levels experienced over the previous two decades.

The 'continuous fishing' scenario sees a steady decline in simulated wild caught production from around 200,000 tonnes currently to a more or less steady level of 130,000 tonnes after 2030. The 'cautious' scenario shows an immediate drop in simulated wild caught fisheries due to the scenario implementation starting in 2002 whereby fish stocks below 20% of virgin biomass are immediately closed to fishing until stocks recover. The 'optimum long term' scenario drops production sharply in 2002 as a result of the similar aggressive approach to the improvement of fish stocks and the catches derived therefrom. The simulated advantage for the more aggressive approach is a gradual improvement in fish catch and by 2020 it is 180,000 tonnes per annum or a little more than 10,000 tonnes per annum above the 'cautious' scenario. By 2050 this advantage increases to 20,000 tonnes per annum.

Most of the simulated decline in wild catch occurs in the fin-fish (including sharks and rays) fisheries. For the 'cautious' scenario, the crustaceans (lobsters and prawns etc) and molluscs (squid, octopus, abalone etc) provide an

underpinning resilience for the overall wild catch. While a few new fisheries will be found (eg the relatively recent discovery of the Patagonian tooth fish) they are unlikely to significantly impact the trend. Species such as skipjack tuna may be extensive, but the inability to date to take large catches of this species cost effectively does not promise a one-fishery solution to simulated declines in wild caught production.

The future of both **aquaculture and imports** are difficult to foresee. Aquaculture has considerable potential but is could be constrained by critical uncertainties. In many production systems it relies on other fish stocks to feed the high value aquaculture species. Also there appear to be planning, social and environmental restrictions on many proposed aquaculture developments. This study incorporates a simple projection of current aquaculture production to double by 2020 and double again by 2050. This is consistent with recent trends in aquaculture growth but may be conservative noting that the declines in Australia's and the world's capture fisheries production coupled with increases in demand will likely improve the economic climate for major investment in aquaculture.

The simulated **recreational fishery** for those stocks covered in this study grows from approximately 12,000 tonnes in the 1940s to 32,000 tonnes per annum by 2006 and then declines marginally to 29,000 tonnes per annum by 2050. The catch demand (the demographic growth x fishing participation rate x fish caught per fisher) continues to expand to 35,000 tonnes per year, suggesting more effort may be applied per fish caught and that other fish units may be targeted. This analysis must be constrained by the reality that approximately 30,000 tonnes are caught by recreational fishers currently (Kearney, 2002) and that only 16,000 tonnes of the commercially targeted species are represented in the simulated recreational catch.

In this study recovering populations of fur seals and sea lions are simulated to be currently consuming 300,000 tonnes per year of the species described in the model on the basis of the biological parameters and dietary information contained in Goldsworthy et al. (2002). Should the seal and sea lion populations continue to expand in the way that mammal ecologists anticipate, then their total feed requirement will exceed 1 million tonnes per year by 2035, that is, more than six times the likely total Australian commercial catch at that time.

12. Is there any addressing of catastrophes/extreme events?

Sudden climate or environmental 'shock' events are not considered.

13. Originality or USPs (unique selling points)

Detailed quantitative analysis, leading to suggestions for transformation of the Australian fishing fleet.

14. Were original research or research drivers included

Research drivers, structures and organisation not considered.

15. What happened next – e.g. are there recommendations and were any of them taken up?

No specific recommendations, but results from this study confirm the decoupling of Australia's capture fisheries production from human population growth. At the same time, they project increasing demand and expectations. They also highlight the need to develop strategies to accommodate at least the major external influences (habitat declines, marine mammal population recoveries, etc) in ongoing assessments of the status of resources. They suggest strongly, that there is a need for revision of policies which impact how resources are conserved and how they are allocated, intentionally or otherwise.

Advocated more holistic management of fisheries sub-sectors (including recreational fisheries) and including broader ecosystem impacts such as pollution, habitat degradation, etc., resulting from fisheries as well as other uses of aquatic resources.

ANNEX 15.

1. Title – Report title

5 Scénarios pour la pisciculture Français en 2021

2. Identifying short title:

INRA

3. Author(s)

Commission Filière Poissons, Institut National de la Recherce Agronomique (INRA), France

4. Source (book chapter, FAO Report, etc) and date

(Report) INRA (2007) 5 Scénarios pour la pisciculture Français en 2021. Commission Filière Poissons, Institut National de la Recherce Agronomique (INRA), France. 22pp.

5. Geographic scope

France

6. Focus or disciplinary scope

Provided five contrasting visions of the future (up to 2021) for finfish aquaculture in France.

7. Stated objectives of the study and the target audience

Aimed to engage stakeholders and participants in the French finfish aquaculture sector, to elaborate a range of coherent and contrasted futures, to promote the scenarios which appear the most favourable and to clarify the consequences of each one of them. In addition, the work aimed to identify the challenges which rise from each scenario, to define research agendas and establish priorities, to enable operators to address potential threats and exploit opportunities at the local, national and international level.

8. Time horizon

2021

9. Method employed for the analysis

Initially the project involved a period of intense brain-storming whereby strong trends, possible 'ruptures' and weak signals were identified. The resulting outputs were assembled into a set of draft proposals. The system was then split into 4 components and the proposals distributed to a series of working groups which worked independently to establish assumptions and storylines for each component. The four working groups addressed:

(a) Global economic, geopolitical and environmental context.
(b) Science, technology and innovation
(c) Professional organizations and aquaculture companies.
(d) Markets and consumer preferences

After identification of driving or dependent assumptions, each group constructed 3 to 5 partial scenarios.18 partial scenarios were combined into 5 basic storylines, which can be broadly characterised as: (1) changes at the global level lead to a national reprioritization, (2) liberalized world markets, (3) environmental focus forces aquaculture elsewhere, (4) European control and encouragement, (5) technological development, driven by consumers and convenience, solves all the problems.

For each of the five scenarios, the group attempted to identify (a) pathways and dependencies, i.e. how does one arrive at the particular outcome, and (b) the consequences for finfish aquaculture production and products in France.

14. Consultee involvement

Work was completed between January 2006 and April 2007 at 7 plenary meetings (as well as inter-sessional activity). Work was largely collegial until the drafting of the over-arching scenarios. The core 'resource group', which consisted of 13 individuals (from INRA, IFREMER, ENESA, CIPA, CIRAD, ITAVI, Ministère de l'Ecologie et du Développement Durable) drew on the experience of external experts and colleagues as well as existing 'futures' documents (such as those of the FAO and the Research Council of Norway).

15. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

An initial list of key drivers and trends was assembled. Three variables appeared major: (1) capacity of the French fishing industry to supply sufficient quantities of fish protein for the French market, (2) import and export strategies of the Asian countries (China in particular), (3) European and national policies/regulation on the environment and the development of finfish aquaculture. These three themes were examined under each of the five scenarios.

Whist constructing the INRA scenarios the 'resource group' drew on existing 'futures' studies such as the FAO-SOFIA scenarios, the 'Aquaculture 2020' scenarios and the Worldfish *'Fish to 2020'* scenarios).

What is the structure of the scenarios – mutually exclusive?

The 5 basic storylines, which can be broadly characterised as: (1) changes at the global level lead to a national reprioritization, (2) liberalized world markets, (3) environmental focus forces aquaculture elsewhere, (4) European control and encouragement, (5) technological development, driven by consumers and convenience. Specific attributes include:

Scenario 1. – National Reprioritization

- The exhaustion of the marine resources and an increase in the economic and ecological costs of transport reduce the international exchanges of fish.
- Asian countries are led to re-examine their models of development and concentrate on provisioning their own markets in the face of increasing demographic pressures.
- The national demand for marine products remains constant.
- Nutritional quality of products becomes a decisive criteria for French consumers.
- The fall of supply to French market supports a revival of the national pisciculture sector which becomes a recognized driver of the local development.
- The interest of the consumer affirms itself for products covered by ecolabels satisfying new requirements for quality, and conditions of production.

Scenario 2. -Liberalized Markets

- Multiplication and increased liberalization of trade in aquatic products around the world.
- The search for competitiveness leads to specialization of piscicultural production on a worldwide and local basis.
- Aquaculture is confronted with the lack of availability of fish-meal and oils for use in foods, in spite of the partial replacement of these ingredients by other raw materials in particular vegetable products
- The rise of intensive pisciculture in China and the formation of Asian aquiculture corporations are sources of conflict for the access to resources and of tension on the markets.
- The breeding of tropical fresh water species offers an alternative to mitigate against the shortage of fish on French markets.
- The industry becomes dominated by large multinational companies, smaller producers can not compete.

Scenario 3. - Pisciculture confronted with the environmental constraints

- Environmental groups target aquaculture producers. Public opinion is increasingly sensitized and informed with regard to environmental questions.
- Counts of indictment are numerous: plundering of the marine resources, consumption of energy, organic, chemical and pharmacological pollutants (antibiotic pesticides, hormones), escapement of farmed and GMO fish, introduction of exotic species.
- Regulation and legislation unfavourable for continued piscicultural activity in France.
- Strict regulation of capture fisheries at the European level lead to decline in the size of the fishing fleet and tight controls of illicit fishing.
- Aquaculture considered to be minor from an economic point of view, denounced by environmentalists and viewed poorly by citizens. French demand for fish met by capture fisheries together with imports from tropical countries.
- Capital and know-how are invested in other sectors or emerging opportunities abroad.

Scenario 4 - The revival of pisciculture in France and Europe

- Capture fisheries (including the supply of wild-caught industrial species) decline, the global provisioning of aquatic products is more heavily dependent on aquaculture.
- Worldwide, the demand for fish continues to grow. Media campaigns incite the public to consume fish emphasizing medicinal benefits of omega 3 fatty acids for protection against the cardiovascular diseases.
- Europe and national governments act to encourage aquaculture and avoid a possible world medical crisis.
- New technologies and new products developed by French aquaculture companies.
- Ecolabels, ISO standards and certification become increasingly important.
- Increased funding of research by Europe and national governments, leads to a new and profitable phase of development for French aquaculture producers.

Scenario 5 - Convenient technologies and a focus on consumers

- The attitude of consumers with respect to fish is changed. International campaigns denounce intensive aquaculture production and result in a reduction in international trade and transportation.
- Technologies offer new opportunities that the public tend to support: new piscicultural food products, new species, closed-loop production systems, new biotechnologies.
- Consumers demand practical, fast food that is easy to prepare. They also wish that these products surprise them with regard to their innovation and their diversity.
- Processors play an important role, strongly investing in the new presentation and manufacturing processes. They are faced with the decision to use less-expensive, raw materials on the international market or more expensive local products that consumers favour.
- French producers target specialised/niche markets.
- Greater emphasis is placed on the keeping of ornamental and pet fish. The sales turnover of ornamental fish exceeds that of cultured trout for human consumption.

16. Is there any addressing of catastrophes/extreme events?

Not specifically – although collapses of wild fish stocks are anticipated under certain scenarios.

17. Originality or USPs (unique selling points)

Detailed scenarios for the finfish aquaculture sector (specifically). Clear focus on consumer tastes and preferences.

18. Were original research or research drivers included

Although stated as a main objective of the project, research priorities are not clearly identified. Many issues, threats and opportunities are discussed but concrete recommendations with regard to funding priorities are not highlighted.

The role of new technology is discussed in detail, particularly in scenario 5.

19. What happened next – e.g. are there recommendations and were any of them taken up?

Not known.

ANNEX 16.

1. Title – Report title

The future for fisheries.

2. Identifying short title:

PAULY2050

3. Author(s)

- Seas Around Us Project, Fisheries Centre, University of British Columbia, Vancouver, Canada.
- Center for Limnology, University of Wisconsin, Madison, Wisconsin, USA.
- School of Resource & Environmental Science, Dalhousie University, Halifax, Nova Scotia, Canada.

4. Source (book chapter, FAO Report, etc) and date

(Scientific article) *Pauly, D., Alder, J., Bennett, E., Christensen, V., Tyedmers, P. and Watson, R. (2003) The future for fisheries. Science, 302: 1359-1361.*

5. Geographic scope

Global oceans

6. Focus or disciplinary scope

To investigate the future of marine fisheries and aquaculture world-wide, based on earlier work by the UN Environment Programme (UNEP).

7. Stated objectives of the study and the target audience

"To look at the future of fisheries through (i) identification and extrapolation of fundamental trends and (ii) development and exploration (with or without computer simulation) of possible futures.

8. Time horizon

Exploration of trends from 1900 to 2000 and projection forward to 2050.

9. Method employed for the analysis

Pending the detailed analysis of coastal and marine scenarios by the Millennium Ecosystem Assessment (see FEUFAR summary **MEA-Fish**) the authors based their 'futures' on the four scenarios developed under the United Nations Environment Programme 'Global Environmental Outlook III'
(see www.unep.org/GEO/geo3/english/pdfs/chapter4_outlook.pdf also FEUFAR summary **UNEP-GEO**).

The further elaboration of fisheries & aquaculture scenarios involved extrapolation of long-term trends in global fisheries (reported by Watson& Pauly 2001 – *Nature 414:534-)* and global fuel oil production (Heinberg 2003) (**fig. 1**). Also, the authors summarize results of regional simulation models (Ecopath with Ecosim), explicitly accounting for interspecific feeding interactions, within a range of ecosystem types and fisheries (see Christensen & Walters 2004, Bull. Mar. Sci 74:549-562).

10. Consultee involvement

The UNEP scenarios and quantitative framework (on which Pauly's scenarios are heavily based) were derived using a range of analytical tools, in consultation with many regional experts. Pauly at al.'s interpretations of the 4 UNEP 'futures' was mostly based on the personal opinions and knowledge of the authors.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

The **UNEP** 'Global Environmental Outlook III' scenarios on which Pauly et al.'s are based did consider 'driving forces' including : human demography, economic development, social development and attitudes, science & technology, governance, culture, environment (see FEUFAR summary **UNEP-GEO**).

Pauly et al. consider a range of 'factors' which are elaborated under each story line, including:

- Fisheries by-catch and IUU (Illegal, Unreported, Unregulated) catches.
- Depth expansion of fisheries after the 1950s.
- Over-capitalization of the fishing industry, including subsidies.
- Global fuel prices and energy efficiency of vessels (see fig 1).
- Conservation obligations/policies.
- Seafood prices and global demand for fish products.
- Development of aquaculture technologies including feed supplies (e.g. through industrial fisheries),
- Regulatory and management reforms (including 'governance').
- Coastal pollution (including eutrophication, harmful algal blooms, invasive species, diseases).

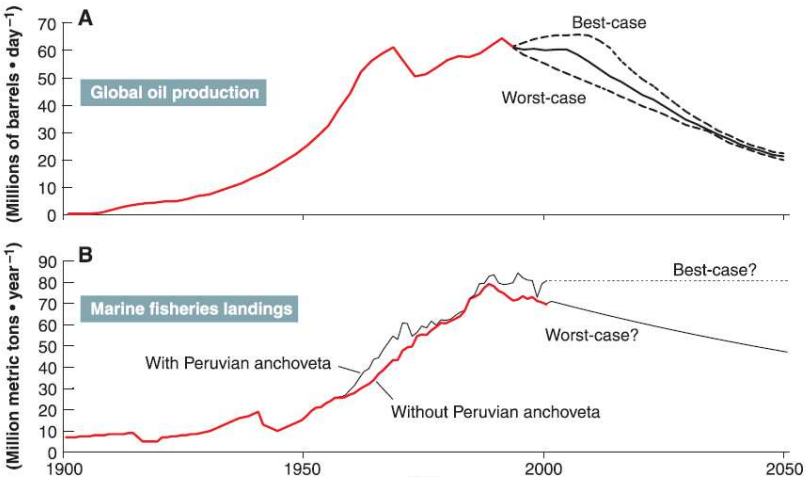
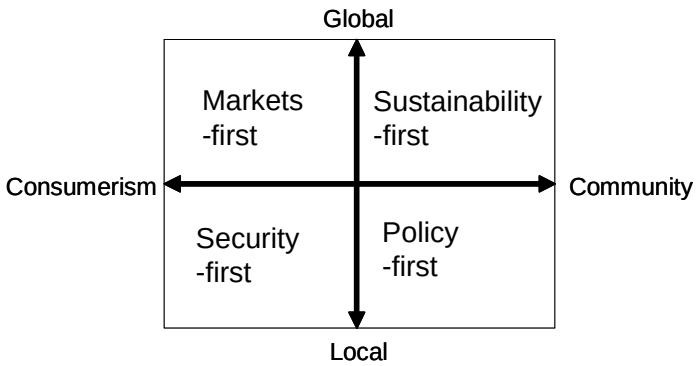


Figure 1. Recent historical patterns and near-future predictions of global oil production and fish catches (1900 to 2050).

What is the structure of the scenarios – mutually exclusive?

The four scenarios (based on UNEP) were:



- **Markets-first,** where environmental policy is subject to un-regulated market forces. This may imply gradual elimination of the subsidies fuelling overfishing. Putting markets first may also imply the suppression of IUU fishing (including flags of convenience), which distorts economic rationality as insider trading or fraudulent accounting does. Markets-first, by overcoming subsidies could also lead to decommissioning of fuel-guzzling distant –water fleets (especially large trawlers), and perhaps lead to a resurgence of small-scale fleets deploying energy efficient fixed-gears. This scenario allows for spontaneous emergence of quasi-, non-intended marine reserves (i.e. not economically fishable regions, particularly offshore), and thus may inadvertently reduce the impact on biodiversity. However, high-priced blue0fin tuna, groupers and other taxa (including invertebrates) would remain under pressure.

When modelled, this scenario corresponds to maximizing long-term fisheries 'rent' (ex-vessel values of catch minus fishing costs). This usually leads to combinations of fleets exerting about half of the present levels of effort, targeting profitable, mostly small, resilient invertebrates and keeping their predators (large fish) intentionally depressed. Shrimp trawlers presently operate in this way, with tremendous ecological impacts on bottom habitats.

- **Security First,** where national interests take precedence and conflicts and inequalities lead to strong socio-economic boundaries between rich and poor. This scenario, although implying some suppression of IUU fishing, would continue 'fishing down marine foodwebs', including the high-Arctic, and subsidization of rich counties fleets to their logical ends, including collapse of traditional fish stocks. This implies development of alternative fisheries targeting jellyfish and other zooplankton (particularly krill) for direct human consumption and as feed for farmed fish. This scenario, generally accentuating current trading patterns, would largely eliminate fish from the markets of countries still 'developing' in 2050.

  This scenario would also increase exports of polluting technologies to poorer countries, notably coastal aquaculture and/or fertilization of the open sea. This would have negative impacts on the remaining marine fisheries in the host countries, through harmful algal blooms, diseases, and invasive species. This scenario was simulated through fleet configurations maximizing long-term gross returns to fisheries (i.e. ex-vessel value of landings plus subsidies, without accounting for fishing costs). The results were increasing fishing effort, stagnating and declining catches (similar to the present situation) and loss of ecosystem components, i.e. a large impact on biodiversity.

- **Policy First,** where a range of actions is undertaken by governments to balance social equity and environmental concerns. Regulatory reforms, coordinated between countries, combined with marine reserve networks, massive reduction of fishing effort, especially gears that destroy bottom habitat and generate large 'by-catch', and abatement of coastal pollution, may bring fisheries back from the brink and reduce the danger of extinction for many species.

  This scenario corresponds to simulations where 'rent' is maximized subject to biodiversity constraints. No configuration of the models could be found for the fleet configurations favoured under 'Policy First' because the conceivable policies involve ethical and aesthetic values external to the fisheries sector (e.g. shutting down profitable fisheries that accidentally kill sea turtles or marine mammals).

- **Sustainability First,** where global and long-term sustainability of resources is the key driving force. This scenario, which implies governments' ratification of and adherence to international fisheries management agreements and bottom-up governance of local resources, would involve creating networks of marine reserves and careful monitoring and rebuilding a number of major stocks. This is because high biomasses provide the best safeguard against overestimates of catch quotas and environmental change.

  The authors simulate this scenario by identifying the fishing fleet structure that maximizes the biomass of long-lived organisms in the ecosystem. This required strong decreases in fishing effort, typically to 20 to 20% of current levels, and a redistribution of the remaining effort across trophic levels, from large top-predators to small prey species.

12. Is there any addressing of catastrophes/extreme events?

Sudden events are not considered in any of the four scenarios

13. Originality or USPs (unique selling points)

High-profile study in leading scientific journal. Scenarios that are compatible with other schemes (e.g. those of **MEA** and **UNEP-GEO**).

14. Were original research or research drivers included

Research is not mentioned by the authors, although it is considered throughout the **UNEP-GEO III** document, on which Pauly et al.'s scenarios are heavily based.

15. What happened next – e.g. are there recommendations and were any of them taken up?

The authors did not provide specific recommendations for policy or research.

ANNEX 23.

1. Title – Report title

"Fisheries and Aquaculture Knowledge and Innovation Priorities Aspirations for the 21st Century"

2. Identifying short title:

NRLO

3. Author(s)

National Council for Agricultural Research, based on a series of back ground studies:

- Jagtman, E., E. Buisman, P. de Jong and P. Schütte (1997). Fishing for research - a scenario study on fisheries and eco-system. The Hague, NRLO report 97/35
- Lindeboom, H., M. Fonds, W.J. Wolff and J.C.J. van Zon (1998). Oceans of opportunities - essays on aquatic biomass. The Hague, NRLO report 98/10
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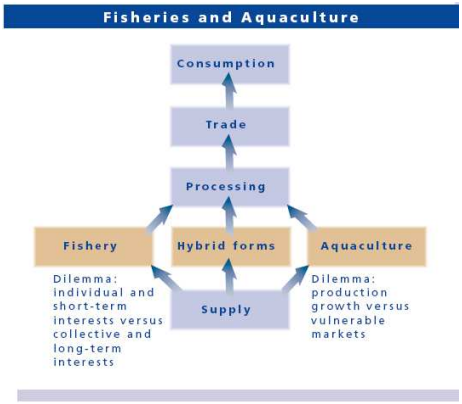
4. Source (book chapter, FAO Report, etc) and date

(Report) National Council for Agricultural Research, NRLO-report nr. 98/18E, The Hague, July 1998, ISBN: 90-5059-081-0, 35pp.

5. Geographic scope

The study takes a sector focus and not a geographical focus. It centres on the impact of development on the fish industry, policy implications and needs for research.

6. Focus or disciplinary scope



The study focuses on the sector, hence activities and (market) chain, with a special focus on research (NRLO is a research council). The study focuses on the wide variety of activities involved in the utilisation of aquatic resources as a whole (hence both fisheries and aquaculture or, briefly, the fishing industry). The fishing industry not only includes production, but also other segments such as supply, processing and distribution.

The study takes a multi-disciplinary (yet not integrated) focus based on a pallet of disciplinary expert reports.

The report is rather descriptive and its analysis based upon other publications than producing trends and predictions by itself.

7. Stated objectives of the study and the target audience

The issue addressed in the report is the future of fisheries and aquaculture. The highly dynamic and heterogeneous fishing industry is faced with a number of challenges that follow directly from major changes in its environment. It has to find answers to questions such as, 'How can the growing demand for fish-based animal proteins be met?' 'How can the sector respond to changing consumer desires?' 'What can the sector do to improve its position in society?' Or, 'What can be done to achieve a widely accepted form of fisheries management?' Another issue then is how knowledge development and innovation may help to meet future challenges faced by fisheries and aquaculture.

The aim of the study is to set the policy agenda, especially towards research, hence targeted at an audience of policy makers and those influencing the policy agenda.

8. Time horizon

There is no distinct time horizon in the analysis, yet it aims at setting the stage for the period 1998-2010

9. Method employed for the analysis

The analysis is based on several back ground expert studies on subsystems such as aquaculture development, marine ecosystem development and market and market chain development.

10. Consultee involvement

Since the report is based on back ground studies it cannot be determined form this report whether stakeholders have been involved. Looking at the back ground material it seems to be expert assessments.

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

There are four main categories in which the most significant changes that have been taking place in the immediate environment of the fishing industry in recent years - and are expected to continue if not intensify, are captured.

- 'markets',
- 'policy-making',
- 'ecology'
- 'space and water'.

Below per category the main developments and drivers

Markets

Growing global demand for fish and fish products

- The growing world population

Growing demand in high-income countries

- Increasingly, consumers with great purchasing power are regarding fish as a healthy and easily digestible food.
- Another major trend in western markets for consumer products is that 'the average consumer' is more and more becoming a meaningless generalisation. The fact that it has become more difficult to 'serve' consumers (custom-made service) is one of the reasons why distributors and especially retailers have gained stronger positions in the supply chain

Policy-Making

Government interventions in the fishing industry have addressed production (or rather: landings), the market (through instruments such as trade policies) and the structure of the fishing industry (through instruments such as modernization and restructuring policies). The general objective of current EU fishery policies is to preserve the ecological state of EU waters as well as the socio-economic position of fisheries.

The fishing industry can be regarded as a strongly government-regulated sector, at least in Europe. In times of selfregulation, internationalisation and privatisation, in which governments tend to step back, it does not seem possible to maintain this situation for long.

Ecology: Fish Stock Development

- catches exceeding the reproduction speed of fish stocks
- understanding of the composition and dynamics of marine 'food webs' has greatly improved, enabling us not only to get a clearer view of the impact of fishing on ecosystems but also to be more specific about alternative ways of utilising aquatic biomass

Space and Water

- A 'battle' over the use of coastal space.
- Especially for aquaculture the availability and quality of water

The developments recognized lead up to the following identified policy priorities:

- ***Realising market potential***
  - shift from supply driven sector to a consumer preferences focus
  - make use of world wide demand for fish products
  - increase and widen supply
  - strengthen the sector in
    - Fish farming
    - Marification: making use of new resources (algae, pharmaceuticals)
    - Market Chain Development (product and product concept development)

- ***Working towards a more sustainable fishing industry***
  - Alternative methods for fish stock management (stakeholder involvement)
    - Co-management
    - ITQs
    - Certification, MSC labeling
  - Ecological and social embedding; focus on *Coastal Zone Management*

Figure 8
The objects of Coastal Zone Management (Source: after Buisman, 1996)

Land system	Coastal system	Sea system
agriculture	coastal defence	energy extraction
industry	sand extraction	recreation
cities	water collection,	tourism
infrastructure	recreation	waste
nature values	tourism	disposal
	cities, ports	shipping
	nature values	nature values
	aquaculture	fisheries

With the following set of knowledge and innovation priorities:
- Strengthening research into (increased) valorisation possibilities of fish products
- Appoint an 'innovation group' focussing on marification opportunities
- Stimulate research education and innovation in aquaculture
- Strengthen the international element in Dutch an European fisheries research
- Stimulate interdisciplinary research into alternative administrative arrangements with intensive stakeholder participation
- Incest in basic multidisciplinary knowledge of marine ecosystems
- Broaden the knowledge bases needed for Coastal Zone Management

What is the structure of the scenarios – mutually exclusive?

There are no scenario's, just a presentation of trends

12. Is there any addressing of catastrophes/extreme events?

No

13. Originality or USPs (unique selling points)

Focus on the 'business' hence the entire sector and its chain; activities embedded in their wider market and policy context.

14. Were original research or research drivers included

Research priorities were considered as a result of the analysis made. No stand alone analysis of research drivers and developments.

15. What happened next – e.g. are there recommendations and were any of them taken up?

The NRLO report provided the following recommendations in 1998:
- Strengthen research into (further) valorisation possibilities of fish products.
- Appoint an 'innovation group' of scientists, technologists and entrepreneurs who will focus exclusively on marification opportunities.

- Give an impetus to research, education and innovation to promote fish farming on land and in coastal zones.
- Strengthen the international component in Dutch and European fishery research.
- Encourage interdisciplinary research into alternative administrative arrangements for managing fish stocks and ensure intense participation by all stakeholders.
- Reduce the strong focus on biological research into commercially interesting fish species limited to the North Sea and extend basic and interdisciplinary knowledge on marine ecosystems, e.g. by taking a more active part in international research programmes in this field.
- Ensure that knowledge required for *Coastal Zone Management* is broadened in both research and education by achieving a programmed concentration of relevant parts of the knowledge infrastructure that is present in the Netherlands and in other countries.

This report is part of a series of NRLO reports aimed at setting policy and research agenda's. As such it plays a role. In hind side a lot of the elements mentioned in this report (for example CZM, stimulating aquaculture, develop alternative participatory methods for fish stock management) have had a clear influence on both the policy and research agenda.

ANNEX 25.

1. Title – Report title

Aquaculture and fisheries in southern countries: foresight analysis (2025) of research demand.

Original Title: Aquaculture et pêche dans les pays du Sud : Analyse prospective (2025) de la demande en recherche.

2. Identifying short title:

AFSOUTH

3. Author(s)

IFREMER (Institut français de recherche pour l'exploitation de la mer)

4. Source (book chapter, FAO Report, etc) and date

Aquaculture et pêche dans les pays du Sud : analyse prospective 2025 de la demande en recherche. Jacques Fuchs coordinator, 2002. J.P. Blancheton, J. Fuchs, D. Lacroix, N. Lacroix, Ph. Lemercier, J. Marin, L. Antoine*. Ed. Ifremer, Bilans & Prospectives, 126 p.*

5. Geographic scope

Developing countries

6. Focus or disciplinary scope

Fisheries and aquaculture research, geography, scientific and technical cooperation.

7. Stated objectives of the study and the target audience

AFSOUTH is the report of a foresight exercise asked by the Living Resources Director and the International Director of Ifremer in 1997. The goal was to evaluate the future research needs of Southern countries for developing marine aquaculture and fisheries, and to estimate Ifremer capacity to answer under different scenarios, knowing the present knowledge of Ifremer own experts. Returns for Ifremer in terms of scientific, technical and financial benefits were examined and evaluated.

8. Time horizon

Time horizon for scenarios up to 2025.

9. Method employed for the analysis

- The study was done from 1997 to 2001 by a working team, meeting regularly during one or two days. The group started with the help of methodological support of CNAM[1] specialist in prospective analysis.
- The group has analysed retrospectively Ifremer skills and expertise in aquaculture and fisheries, previous experience, cooperative studies and contracts in southern countries.
- Southern countries were classified following criteria like climate, development level, fish production, coastal length, EEZ surface, Countries could be grouped in large, medium and small size countries, then grouped in 5 main geographic areas: Africa, Latin America, Asia, Mediterranean and Oceania.
- Different scenarios of tendency and evolution were examined under a set of driving forces and their consequences on needs in the different areas were projected, then crossed with potential of expertise in Ifremer. Finally the study had to evaluate the needs of strategic evolution for Ifremer to face the demand.

10. Consultee involvement

The report was submitted before final redaction to a panel of experts from various origins: army, economics, research, private companies. Their remarks and recommendations were included in the final report.

[1] *Conservatoire National des Arts et Métiers* (National Institute of Applied sciences)

11. Is there a list of drivers, and if so, what are the main ones? Is there a relation with earlier work, e.g. climate change scenarios?

A set of 16 drivers were selected pooled in 3 main categories:

- drivers linked with "living world": climate, agriculture, water availability (3)
- drivers linked with "Matter and technology": energy, materials, communication, transport (4)
- drivers linked with "Society": urbanisation, demography, health, education, conflicts, economy-finance, industry, religions, cultures (9).

What is the structure of the scenarios – mutually exclusive?

Each driver was examined under "heavy trends" *e.g.* global temperature increase of 2°C in 2100, fresh water scarcity, food availability for fish farming, increase of coastal urbanization and population. Potential changing factors were introduced *e.g.* positive effect of Kyoto convention, new technologies for water recycling, vegetable in carnivorous fishfood, etc. Consequences on aquaculture and fisheries were projected in 3 scenarios named as:

- Continuation of following present trends;
- optimistic scenario
- pessimistic scenario

Each scenario was applied in the 5 main geographic areas, changes in aquaculture and fisheries and consequences in terms of cooperative research and expertise were drawn; their predictable impact on Ifremer capacities was proposed.

12. Is there any addressing of catastrophes/extreme events?

No

13. Originality or USPs (unique selling points)

14. Were original research or research drivers included

No

15. What happened next – e.g. are there recommendations and were any of them taken up?

- The report gives recommendations for research orientations in Ifremer: *e.g.* improve rearing performance of species (genetics, pathology), of food; better approach of interactions aquaculture/environment, fisheries/environment, technology (fishing gears, scientific echo sounders) etc. Recommendations were also proposed for organising and improving reactivity within the institute for increasing capacity to satisfy demand and improve competitivity. The report was given to the Directors in 2001.
- Ifremer decided to reorganise in 2004 and achieved in 2005. Recommendations were partly taken in account more as general tendency of R&T than as referred to the report. The main weakness of the project was the excessive duration and insufficient implication of the team over the time invested (to much dispersion for the actors).