



# **THE FUTURE OF FISHERIES AND AQUACULTURE:**

## ***TRENDS AND DEVELOPMENTS***

Project Report, December 2007.



Luc van Hoof, Wageningen *IMARES*, Project coordinator (editor)  
Andy Payne, CEFAS (editor)  
Audun Iversen, Fiskeriforskning  
Chantal Cahu, Ifremer  
George Tserpes, HCMR  
John Pinnegar, CEFAS  
Loïc Antoine, Ifremer  
Maud Evrard, Marine Board  
Véronique Lamblin, Futuribles

*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](http://www.feufar.eu)

Funded by:  



## Table of Contents

<b>WORLD CONTEXT</b> .....	<b>6</b>
<i>A1 Climate change</i> .....	7
<i>A2 International agreements</i> .....	12
<i>A3 Food security in the world, inc. demography</i> .....	19
<b>EU REGULATION</b> .....	<b>25</b>
<i>B1 EU policies</i> .....	26
<i>B2 Governance and Stakeholder Participation</i> .....	32
<i>B3 Management tools</i> .....	39
<i>B4 National policies</i> .....	45
<i>B5 Politics</i> .....	48
<b>SEAFOOD MARKETS AND ECONOMICS</b> .....	<b>51</b>
<i>C1 Product diversification</i> .....	52
<i>C2 Processing (capabilities)</i> .....	54
<i>C3 Distribution channels (value, quality, custody)</i> .....	58
<i>C4 Consumer choices (prices, preferences, ethics)</i> .....	66
<i>C5 World production of fish and fish products by region</i> .....	69
<i>C6 EU trade within world trade in fish and fish products</i> .....	75
<i>C7 COSTS AND EARNINGS OF FISHERIES</i> .....	79
<b>SOCIAL DYNAMIC</b> .....	<b>84</b>
<i>D1 Recreational fisheries</i> .....	85
<i>D2 Public perception of fisheries/aquaculture (communication)</i> .....	89
<i>D3 Activities in Coastal Areas (including employment for fishers in other sectors)</i> ...	93
<i>D4 Competing Use Of Seashore (energy, leisure activities, urbanization)</i> .....	97
<i>D5 Fisherfolk attitude towards the future (including education, training, tradition and the attractiveness of the career)</i> .....	100
<i>D6 Social capital (skills and expertise)</i> .....	104
<b>ECOSYSTEMS</b> .....	<b>108</b>
<i>E1 Pollutants and contaminants (inc. nutrients)</i> .....	109
<i>E2 Recruitment</i> .....	116
<i>E3 Invasive Species</i> .....	120
<i>E4 Escapement (inc. GMO, parasites)</i> .....	126
<i>E5 Impact of gears on habitat and organisms</i> .....	130
<b>PRODUCTION</b> .....	<b>134</b>
<i>F1 Marine “ingredients”, by-products, and bio prospecting</i> .....	135
<i>F2 Fleet structure, size and technology (including selectivity, discards)</i> .....	141
<i>F3 Stock Development (commercial stocks, potential commercial stocks, restocking,)</i> .....	148
<i>F4 Fish feed development and availability</i> .....	154
<i>F5 Aquaculture hardware technologies</i> .....	159
<i>F6 Species Diversification Aquaculture</i> .....	162
<i>F7 Breeding, selection and genome manipulation</i> .....	166
<i>F8 Health of animals</i> .....	170
<i>F9 Resources available for catch-based aquaculture (tuna and eel ranching)</i> .....	177
<i>F10 Health risk of seafood</i> .....	181
<b>RESEARCH</b> .....	<b>189</b>
<i>G1 Sources and allocation of funding for European marine research (including data collection, short term crisis)</i> .....	190
<i>G2 Organisation of European Marine Research</i> .....	195
<i>G3 Access To Infrastructure</i> .....	198
<i>G4 Research Training And Management</i> .....	204
<i>G5 Communication flows (inc. IPR)</i> .....	209

## **WORLD CONTEXT**

**WORLD CONTEXT**

**A1 Climate change**

**Driver Definition**

Climate variability can have an enormous impact on marine ecosystems. Long-term climate change may well affect the physical, biological, and biogeochemical characteristics of oceans and coasts, modifying ecosystems and the way that they function.

**Relevant Indicators**

- Water temperature
- Sea level
- Ocean colour
- NAO anomalies, ENSO,
- pH, salinity
- Frequency of storms

**Developments over the past 20 years**

The 'greenhouse effect' is a natural phenomenon, but there is strong evidence that human emissions, mainly CO<sub>2</sub> from fossil fuel consumption and burning, has amplified and accelerated this trend.

Global air temperature has risen by about 0.8°C over the past 100 years, as has the concentration of carbon dioxide in the atmosphere (Figure 1). Warming has become more rapid over the past two decades (~0.2°C per decade), and it has been greater on average in Europe than in the rest of the world.

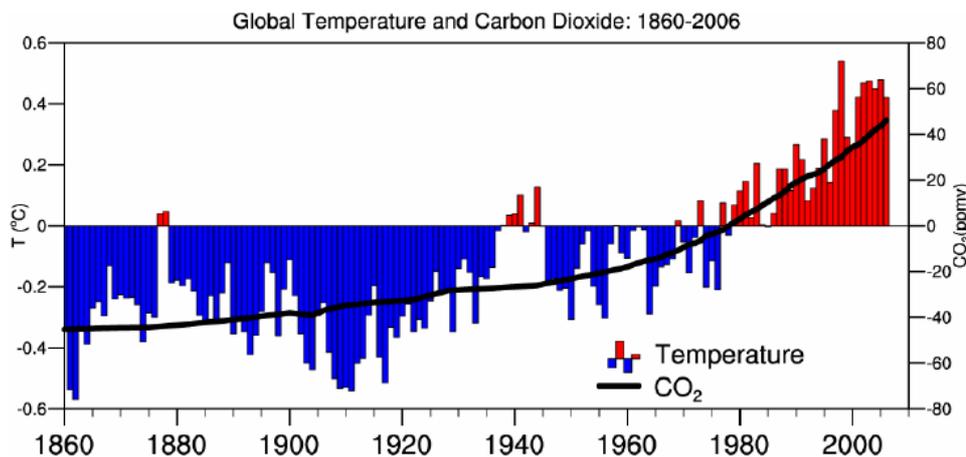


Figure 1. Time series of annual global mean temperature departures for 1861-2006 from a 1961-90 mean (bars), left scale, and the annual mean carbon dioxide from Mauna Loa after 1957 linked to values from bubbles of air in ice cores prior to then. The zero value for 1961-90 for temperature corresponds to 14°C and for carbon dioxide 334 parts per million by volume (ppmv). Updated from Karl and Trenberth (2003).

Warming over land has been accompanied by an equally dramatic warming of coastal and oceanic waters (Figure 2). The ocean has absorbed more than 80% of the heat added to the climate system.

The North Atlantic Oscillation (NAO) is a phenomenon associated with winter fluctuations in temperature, rainfall and storm occurrence over much of Europe. When the NAO is 'positive', westerly winds are stronger or more persistent, northern Europe tends to be warmer and wetter than average, and southern Europe colder and drier. When the NAO is 'negative', westerly winds are weaker or less persistent, northern Europe is colder and drier and southern Europe warmer and wetter than average.

In recent decades the winter NAO index has increased markedly, surface pressure falling over Iceland by around 7hpa over the past 30 years. Most climate models assume that the winter NAO index will continue to rise in response to increasing concentrations of greenhouse gases. Hence, for northern Europe it is suggested that winters will become more “westerly” in nature - milder, windier and wetter.

Changes in wind speeds over ocean areas will be an important factor driving changes in extreme sea levels and increasing the risks of coastal erosion and floods. The heights of waves are dependent on wind strengths and, as with gale frequencies, wave heights are also related to the behaviour of the North Atlantic Oscillation (NAO). Direct measurements of wave heights in Europe (1960s to present) together with inferences drawn from pressure and tide gauge data (1880 to present) have indicated substantial variability in wave height, depending on season and location. Although there have been no clear trends through the 20th century, the wave climate roughened appreciably between the 1960s and the 1990s.

The amount of total water vapour in the atmosphere has increased over the global oceans by  $1.3 \pm 0.3\%$  from 1988 to 2003. This increase, and hence the supply of atmospheric moisture to storms, increases the intensity of precipitation events. The pattern of precipitation change is one of increases generally at higher northern latitudes and drying in the tropics and subtropics over land. In Europe there has been a significant shift in the seasonality of precipitation. Of the total amount of rain and snow falling, the proportion that falls in winter relative to summer has changed over time. Winters have been getting wetter and summers drier.

Arnell and Reynard (1996) attempted to extrapolate from climate change scenarios, to predict future river-flows. For nearly all catchments, annual river runoff was predicted to decline markedly by 2050. The percentage change in annual runoff was predicted to be greatest for catchments in the south and east (of the UK), relative to those in the humid northwest.

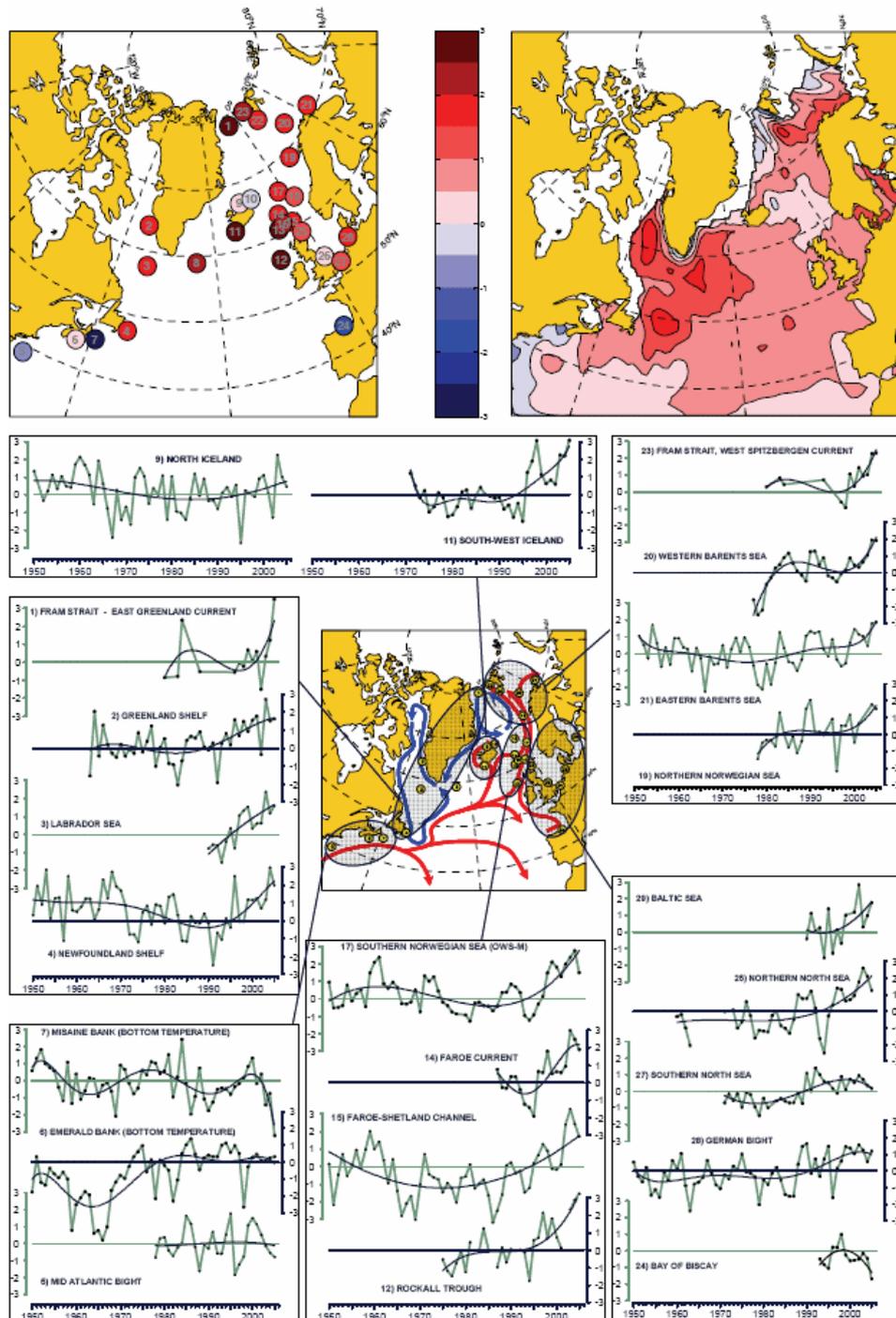
The relative mildness of northern European winters is, in part, attributable to warm water transported by the Gulf Stream, and its northeastward extension, the North Atlantic Drift. The Gulf Stream is driven partly by surface wind patterns and partly by differences in water density caused by spatial variations in temperature and salinity. The density-driven component is part of a larger ocean circulation, known as the “thermohaline circulation” (THC). Surface water in two areas of the north Atlantic is cooled by cold winds from the Arctic, becomes denser and sinks.

The formation of such deep water could theoretically be reduced by a decrease in the density of North Atlantic surface waters, for example through a large input of fresh water at the surface. If this occurs, we might experience a reduction, or even a shutdown of the THC, including the Gulf Stream. Dickson *et al.* (2002) used long-term hydrographic records to demonstrate sustained and widespread freshening of the deep ocean throughout the North Atlantic. This is in line with predictions based on the climate scenarios. When the Hadley Centre model was run with no human influences on climate, the THC exhibited no long-term trend. When greenhouse gas concentrations were increased, the strength of the THC steadily decreased, declining by about 25% by 2100. A full shut-down of the THC is not predicted by the model over the next century, although further analysis shows that one of the two deep-water formation areas – i.e. that near Labrador – does appear to cease operating.

Global-average sea level rose by about 1.5 mm per year during the 20<sup>th</sup> century, believed to be due to a number of factors including thermal expansion of warming ocean waters and the melting of glaciers on land. Whether the faster rate of sea level rise for the period 1993–2003 reflects decadal variability or an increase in the longer-term trend is unclear. 60% of sea level

rise is attributable to thermal expansion and 40% to ice melting. The predicted change in future sea levels will not be the same everywhere. Regional differences can be substantial.

**Figure 2:** Upper ocean temperature anomalies across the North Atlantic. Temperature data are presented as anomalies from the long-term mean; section and station anomalies are normalized with respect to the standard deviation, e.g. a value of +2 indicates 2 standard deviations above normal. The maps show conditions in 2005 (colour intervals are 0.5, reds are positive/warm, blues are negative/cool); the curves below show selected time series. Figure extracted from ICES Report on Ocean Climate 2005 (ICES, 2006).



Most carbon dioxide released into the atmosphere as a result of burning fossil fuels will eventually be absorbed into the ocean. As the amount of CO<sub>2</sub> in the atmosphere rises, more of the gas reacts with seawater to produce bicarbonate and hydrogen ions, so increasing the acidity of the surface layer. Ocean pH was around 8.2 before CO<sub>2</sub> emissions took off in the industrial era (CO<sub>2</sub> in the atmosphere amounted to around 280 parts per million [ppm]). Ocean pH is now 8.1, with an atmospheric CO<sub>2</sub> concentration of around 380 ppm.

Caldeira and Wickett (2003) used an ocean circulation model, together with observed atmospheric CO<sub>2</sub> data (1975–2000), and projected CO<sub>2</sub> emissions from the Intergovernmental Panel on Climate Change, to predict future changes in ocean acidity. They concluded that atmospheric CO<sub>2</sub> will exceed 1900 ppm by the year 2300, and that this could result in a pH reduction at the ocean surface to 7.4.

Observations over the past 50 years have demonstrated a marked decline in the extent of Arctic sea ice. Recent studies estimate an Arctic-wide reduction in annual average sea-ice extent of about 5–10% and a reduction in average thickness of about 10–15% over the past few decades. Meanwhile, measurements taken by submarine sonar in the central Arctic Ocean have revealed a 40% reduction in ice thickness, and climate models project an acceleration of this trend.

A recent survey published by the Arctic Climate Impact Assessment (ACIA) has predicted that the navigation season for the Northern Sea Route (NSR) from Eurasia to the Bering Sea, will increase from the current 20–30 days per year to 90–100 days by 2080. Opening of shipping routes and extending the navigation season could have major implications for transportation as well as for access to natural resources.

### The Future

According to the IPCC report in 2007:

- Projected warming in the 21st century shows scenario-independent geographical patterns similar to those observed over the past several decades. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and parts of the North Atlantic.
- The resilience of many ecosystems is likely (meaning 66–99% probability) to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g. flooding, drought, ocean acidification). The progressive acidification of oceans is expected to have negative impact on marine organisms (e.g. cold-water corals) and their dependent species.

For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected, mainly because of the slow response of the oceans.

Climate change will not only cause changes in average temperatures, but will also trigger more so-called extreme weather events. Global warming is predicted to change the frequency, intensity and duration of events, leading to more hot days, heat waves, flash floods and heavy precipitation (snow or rainfall).

The 'return period' for a climatic event is defined as the average elapsed time between events of a given magnitude. The UK Climate Impacts Programme (UKCIP) predicts that extremely hot August temperatures, such as those experienced in 2003, whereby the average temperature was 3.4°C above normal in Europe, may occur as often as one year in five by the 2050s. Similar changes are expected for intense precipitation events.

Most climate experts now agree that throughout the 21<sup>st</sup> century, climate change could significantly influence the strength and seriousness of hurricanes in the western Atlantic and typhoons in the Pacific. Warmer oceans and increased moisture could intensify the showers and thunderstorms that fuel hurricanes. Consequently, although it is not clear whether there will be more or fewer hurricanes in the future than nowadays, the seriousness of the damage

caused looks set to escalate. In August 2005, Hurricane Katrina caused devastation in and around New Orleans, Louisiana and Mississippi. Katrina is estimated to be responsible for \$75 billion in damages, making it the costliest hurricane in US history. The storm is thought to have killed at least 1604 people, making it the deadliest US hurricane since 1928. Hurricanes well in excess of this magnitude may become common in future.

For many years, stories of freak or rogue waves as tall as 10-storey buildings, and responsible for the mysterious sinking of ships, were written off as fantasy. Scientists clung to statistical models stating that monstrous deviations from the normal sea state would only occur once every 1000 years, or only following major geological upheavals. However, a recent study using satellite data from the European Space Agency has confirmed that such phenomena in fact occur regularly. The study detected 10 giant waves, all 25 m high, within a three-week period. Over the past two decades more than 200 super-carriers – cargo ships >200 m long – have been lost at sea. Understanding how wave heights may change as climate warms is important.

## Hypotheses (2020)

- 1. Main IPCC trend:** The global air temperature increases by 0.4°C and sea level rises by an average of 6 cm compared to 2000.
- 2. Faster warming:** The climate is more sensitive to the greenhouse gas concentration than previously thought (air pollutants have masked the climate response to greenhouse gases, their reduction increases warming). Global temperature increases of 0.6°C and sea level rises by 9 cm compared to 2000.
- 3. Fast mitigation:** Energy mitigation policies in rich countries allows greenhouse gas concentration in 2015 to be at 2000 level. Global temperature increases by only 0.25°C and sea level rises by 4 to 5 cm compared to 2000.

## Sources

- Kevin E. Trenberth, National Center for Atmospheric research, testimony before the Committee on Science and Technology, United States House of Representatives, 8 february 2007.
- IPCC, Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Paris, February 2007.
- IPCC, Climate Change 2007: Impacts, Adaptation and Vulnerability, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Brussels, April 2007.
- Le journal du CNRS : Océan et climat, l'équilibre menacé, N° 198-199, July-August 2006.
- 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.
- Stern Review of Economics : What is the Economics of Climate Change?, Technical Annex The science of climate change, 31 January 2006.

## WORLD CONTEXT

### A2 International agreements

#### Driver Definition

This refers to agreements between two or more countries (including the EU as a whole) regulating access to fishing grounds and stocks and modes of fishing, fish production and trade. Agreements are not permanent: cyclical negotiations are frequent. International agreements include conventions, agreements, pacts, accords, protocols and declarations. They can either be:

- Bi- /tri- /multilateral; and
- Characterized by the consecutive mechanisms of adoption, ratification, entry into force.

In terms of fisheries and aquaculture, the most important international agreements focus on direct guidance for fisheries (e.g. the FAO Code of Conduct for Responsible Fisheries), or have a direct bearing on fisheries and aquaculture, such as regulations and protocols derived from the Kyoto Protocol and the Johannesburg declaration, or have a more general orientation, yet still impact on fisheries and aquaculture, for example by regulating trade, as under the WTO.

The open access nature of many fishing grounds means that the rights and responsibilities of resource users are not well defined, and competition among fishers intensifies as the resource becomes scarcer. Even where there are clear laws and regulations that define rights, enforcement is a challenge for developed and developing countries alike, often resulting in conflicts among different user groups. In this context, fisheries resources are difficult to manage effectively and prone to the 'tragedy of the commons'. These issues are compounded by the subsidisation of distant-water fishing fleets. Countries that do not subsidise their fisheries and restrain their total fish catch to maintain the resource lose the extra catch to countries that do otherwise. Competition from subsidised distant-water fleets can make it economically non-feasible for developing countries to expand their own fisheries and to realise the full benefits of their jurisdiction over their 200-mile exclusive economic zone (EEZ).

#### Relevant Indicators

##### Environmental

- Type of agreements: principle declarations, objectives with or without implementation plans, legally binding objectives
- Identification of the parties involved
- Level of adherence: number of countries adhering to the agreements.

##### Maritime access

- Number of agreements (national agreements + EU agreements), duration, cost (sanction or implementation). RFMO (Regional Fisheries Management Organisation) regulations
- International agreements, such as the UN Conference on the Law of the Sea (UNCLOS)
- Trade agreements
  - Trade agreements about fish and fish products ; quality (health and safety) or environmental requirements included in these agreements
  - Reports of negotiations
  - Barriers to international trade and investment.

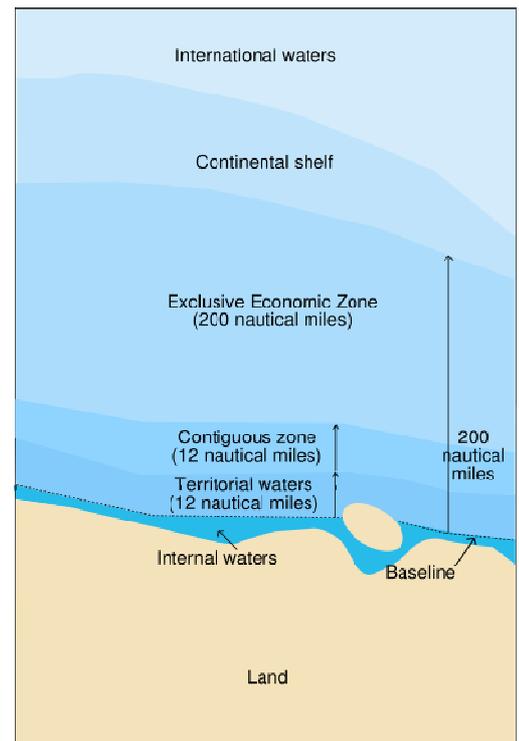
## Developments over the past 20 years

### A) General International Law of the Sea

The main modern landmark in International Law of the Sea history is the result of the UN Conference on the Law of the Sea (UNCLOS). The resulting Convention, generally known as the "Montego Bay Convention", entered into force in 1994.

This Convention is the foundation of a written International Law system for the sea, coming after centuries of custom law, mainly based on the "freedom of the seas" principle (Grotius *mare liberum* concept), except for the coastlines and the belt of water from it to the "cannon shot" 3 nautical miles limit.

We note that the US is not part of the convention, claiming it is damaging for the US economy. However, they are part of the additional "Agreement for the implementation of the provisions of the Convention relating to the conservation and management of straddling fish stocks and highly migratory fish stocks". The convention sets the limit for various areas, measured from a carefully defined baseline. (Normally, a sea baseline follows the low-water line, but when the coastline is deeply indented, has fringing islands or is highly unstable, straight baselines may be used). The areas are as follows:



**Internal waters:** this is water and waterways on the landward side of the baseline. The coastal nation is free to set laws, regulate use, and to use any resource. Foreign vessels have no right of passage within internal waters.

**Territorial waters:** Out to 12 nautical miles from the baseline, the coastal state is free to set laws, regulate use, and to use any resource. Vessels were given the right of "innocent passage" through any territorial waters. Fishing, polluting, weapons practice and spying are not allowed.

**Contiguous zone:** A further 12 nautical miles beyond the Territorial waters, the contiguous zone, is an area in which a state could continue to enforce laws regarding activities such as smuggling or illegal immigration.

**Exclusive economic zones (EEZ):** Extends 200 nautical miles from the baseline. This is the main point, regarding fishery, of this convention: *within this area, the coastal nation has sole exploitation rights over all natural resources*. EEZs were introduced to halt the increasingly heated clashes over fishing rights. Their creation has had a significant influence on the shift of fish production in favour of developing countries.

**Continental Shelf:** This is defined as a natural prolongation of the land territory to the continental margin's outer edge. A state's continental shelf may exceed 200 nautical miles until the natural prolongation ends, but it may never exceed 350 nautical miles. States have the right to harvest mineral and non-living material in the subsoil of its continental shelf, to the exclusion of others.

Aside from its provisions defining ocean boundaries, the convention establishes general obligations to safeguard the marine environment and protect the freedom of scientific research on the high seas, and also creates an innovative legal regime for controlling mineral resource exploitation in deep seabed areas beyond national jurisdiction, through an International Seabed Authority, which is the part that the US never accepted.

### B) Specific International Agreements about Fishing

First, we note that the current value of global fish trade is close to US\$60 billion, up from about US\$15 billion in the early 1980s. Developing countries hold approximately half the global export value of fish and 18% of the global import value.<sup>1</sup>

<sup>1</sup> MAHFUZ, Ahmed. *Market Access and Trade Liberalisation in Fisheries*. Genève – ICTSD, Issue Paper No. 4, juin 2006, 57 p.

- Convention on Fishing and Conservation of Living Resources of the High Seas: opened for signature - 29 April 1958 entered into force - 20 March 1966. This was the first international agreement on that issue<sup>2</sup>. It was designed to solve through international cooperation the problems involved in the conservation of living resources of the high seas, considering that because of the development of modern technology, some of these resources are in danger of being overexploited.
- FAO Code of Conduct for Responsible Fisheries. This was elaborated by the FAO Committee on Fisheries (COFI) and adopted by the FAO Conference in 1995. It is a *voluntary instrument*, and is the first international instrument of its type to have been concluded for the fisheries sector. The Code has 12 articles. However, the substantive articles of the Code are found in articles 7–12.

*Fisheries Management:* Article 7 on fisheries management contains many subheadings concerning management objectives, management framework and procedures, data gathering and management advice, the precautionary approach, capacity management measures, implementation and financial institutions. The need for fisheries management to be based on effective data is stressed.

*Fishing Operations:* Article 8 deals with fisheries operations and has provisions on the duties of flag states and port states, as well as provisions on harbours, protection of the environment and the abandonment of structures and reefs. The overall objective of this article is to promote a framework that would encourage sustainable development, foster protection of the aquatic environment and the maintenance of biodiversity and make a significant contribution to the safety of fishing operations.

*Aquaculture:* Article 9 contains provisions on aquaculture development (which includes both aquaculture and culture-based fisheries). The Code urges States to establish a framework for promoting responsible aquaculture development, including initiating regular oversight and review to ensure minimal adverse impacts and ecological change. States should implement international codes of practice to ensure genetic diversity of the farm stocks and prevent introduction of non-native species.

*Coastal Area Management:* The Integration of Fisheries into Coastal Management, covered in Article 10, contains provisions relating to the institutional framework, policy measures, regional cooperation and implementation. The Code calls for the promotion of the precautionary approach for coastal area management and stresses the need to take into account the fragility of coastal ecosystems, to consult those involved in the use of resources, to value coastal resources, and the need for the exchange of information.

*Post-Harvest Practices and Trade:* Article 11 deals with post-harvest practices and trade, and has provisions dealing with responsible use of fish including measures to protect consumer health, responsible international trade and laws and regulations relating to fish trade.

*Fisheries Research:* Article 12 deals with fisheries research. It stresses the importance to responsible fisheries of the availability of a sound scientific basis to decisions concerning fisheries management.

In March 2005, the FAO adopted guidelines for the eco-labelling of fish and fishery products, including the need for reliable, independent auditing, transparency of standard-setting and accountability, and the need for standards to be based on good science.

*However, measures to control over-fishing and curb destructive fishing practices are increasingly hampered by the widespread incidence of illegal, unreported and unregulated fishing.*

### C) Trade agreements impacting fisheries

The main WTO agreements with special significance to fish trade:

- Agreement on Sanitary and Phytosanitary Measures;
- Agreement on Technical Barriers to Trade;
- Agreement on Subsidies and Countervailing Measures;
- Agreement on Import Licensing Procedures;

<sup>2</sup> <http://www.oceanlaw.net/texts/genevafish.htm>

- Anti-Dumping Agreement;
- Agreement on Rules of Origin;
- Agreement on Safeguards.

Negotiations facilitated by the GATT succeeded in reducing average tariffs for fish trade by 25%. After the Uruguay Round, the average tariff on fish produce was 4.5% for developed countries and <20% for developing countries. These initial reductions, however, were balanced by pervasive tariff peaks and tariff escalation that are predominantly applied to processed or value-added fish products in key import markets.

Globally, just 3% of fish imports are subject to peaks >15%. The average tariffs for industrialised countries are lower than those of developing countries by approximately 6.2% for raw fish foods, 8.6% for intermediate seafood products, and 10.2% for processed seafood. Although tariffs on fish and fishery products are generally higher in developing countries, tariff structures vary significantly between countries. Average tariffs for developing countries are 19.4% for raw foods, 22% for intermediate products and 23.8% for processed food.

However, the main obstacles to fish products trade are now non-tariff barriers. Major importing regions and countries have set stringent standards and regulations to cover trade in endangered species, labelling of origin, traceability, chain of custody, and zero tolerance for certain veterinary drug residues. Certain importers, such as the EU, are increasing the number of notifications of standards and technical regulations to the WTO. In 2003, the EU made 545 notifications for fish, crustaceans and molluscs compared with 480 in 2002 and 232 in 2001. These notifications accounted for almost one-third of all the EU food notifications. The use of non-tariff barriers is a major subject of negotiations in the WTO Doha Round.

*Technical Barriers to Trade* are a major issue now:

- Sanitary and phytosanitary measures, which cover food safety and animal and plant health measures and involve inspection, examination and certification procedures.
- Certification and Labelling. "Eco-labelled products, though not yet prominent in any market, may become increasingly important as consumers refer to these standards in response to increasing environmental awareness (Roheim and Sutinen, 2006). There is also the risk that eco-labels may impose unjustifiable barriers to trade because the organisation and management of eco-labels are likely to be discriminatory in nature. However, there is currently a lack of internationally agreed guidelines on product labelling and certification, choice of information and transparency of process. The relationship between WTO rules and voluntary labelling schemes, including organic and 'fair trade' labelling, needs to be clarified."<sup>3</sup>
- Traceability (or 'product tracing') and country of origin labelling.

Moreover, the Doha Agenda underlines the importance of providing technical assistance and capacity-building to developing countries to adjust to WTO rules.

#### D) Other international agreements having impacts on fishing

##### *D-1 Johannesburg*

The 2002 Johannesburg Declaration initiated a Plan for implementation of the World Summit on Sustainable Development. According to the latter, the achievement of sustainable fisheries requires that stocks be maintained at or restored to levels that can produce the maximum sustainable yield, for depleted stocks on an urgent basis and where possible not later than 2015. The EU Member States signed up to limiting fishing to sustainable levels by maintaining or restoring stocks to levels that can produce the maximum sustainable yield. The agreement reached at the Summit also committed Signatories to strong action against illegal, unreported and unregulated fishing which is a priority for the Union and the subject of an EU Action Plan."<sup>4</sup>

<sup>3</sup> MAHFUZ, Ahmed. Market Access and Trade Liberalisation in Fisheries. Genève – ICTSD, Issue Paper No. 4, juin 2006, 57 p.

<sup>4</sup><http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/06/268&format=HTML&aged=0&language=EN&uiLanguage=en> .

In ecological concept, maximum sustainable yield (or MSY) is, theoretically, the largest yield/catch that can be taken from a stock over an indefinite period. MSY is extensively used for fisheries management, where it largely depends on the life history of the species and the age-specific selectivity of the fishing method. Fishing at MSY levels means catching the maximum proportion of a fish stock that can safely be removed from the stock while, at the same time, maintaining its capacity to produce maximum sustainable returns, in the long term. Errors in estimating the population dynamics of a species can lead to setting the maximum sustainable yield too high (or too low), as it was the case, for instance, for the New Zealand orange roughy fishery.

#### *D-2 Bilateral agreements*

Fishing agreements (FAs) and Fisheries Partnership Agreements (FPAs) are arrangements between two governments or between a government and private sector companies or associations in order to gain access to fishing rights within the Exclusive Economic Zone (EEZ) of a particular country.

There are a number of different types of fishing agreement:

- Fishing agreements with regional economic organisations (EU fishing agreements and fisheries partnership agreements with ACP countries);
- Individual government-to-government fishing agreements, including agreements between governments within a region (Mauritius and Seychelles; Senegal and Mauritania);
- Agreements between governments and private companies (private agreements with Mauritania and the Irish fishing company; Madagascar's agreements with Spanish fishing associations; Seychelles agreements with Japanese fishing associations);
- Agreements between governments and public sector/parastatal/public-private partnerships, for example some of the historical agreements between Mauritania and foreign state-owned companies.

Some of the agreements with PR China may also fall into this category.

The first FPA was signed in 2005, and the main differences between FPAs and FAs relate to the way the financial contribution is calculated and the change from targeted actions to support for defining and implementing a sectoral fisheries policy. FPAs are an attempt to move beyond purely commercial agreements, and to contribute more effectively to sustainable fisheries management.

In an international context, it is important to take into account the access to both the international waters and the way in which this is regulated, and the access of European fleets and operations to other than EU waters, as for example under the Fisheries Agreements. The EU currently has fishing agreements with 17 developing countries (Cape Verde, the Comoros, Côte d'Ivoire, Gabon, Guinea, Guinea-Bissau, Kiribati, Madagascar, Mauritania, Mauritius, the Federated States of Micronesia, Morocco (starting in 2006), Mozambique, São Tomé and Príncipe, Senegal, the Seychelles and the Solomon Islands) which are intended to give the EU rights to the "surplus" marine resources of these countries in return for financial compensation (ranging from around €400000 to €8600000 per country per year). Over the past five years the annual compensation payments made through fisheries agreements have averaged €150 million.

The EU's first fisheries agreement was with Senegal in 1979. The number of agreements rose sharply in the 1980s (Figure 2-1), following the ratification of UNCLOS and also the accession of Spain and Portugal to the EU in 1986, who brought with them a number of bilateral agreements with other countries, particularly in West Africa. The number of agreements peaked in the early 1990s, but then started to decline as several agreements were cancelled or not renewed in the 1990s (e.g. Mozambique, Tanzania, Gambia, Morocco). In recent years, despite the loss of previously important agreements in Senegal and Angola, the number of agreements has increased, due mainly to the new agreements being signed in the Pacific. In January 2007, 84% of agreements (16 of 19) were with developing countries.

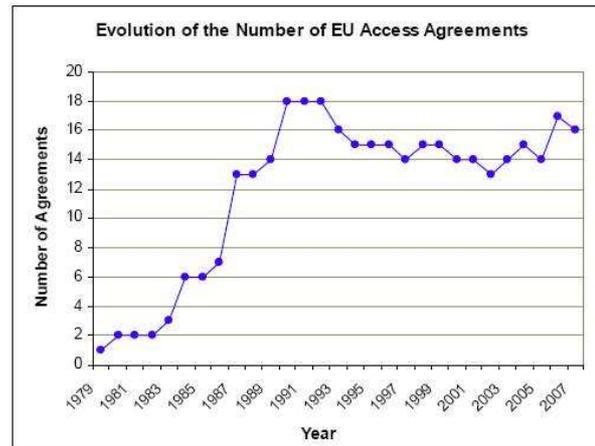


Figure 2-1 Number of EU fisheries agreements with developing countries over time

### D-3 Kyoto

Under the United Nations Framework Convention on Climate Change and its 1997 Kyoto Protocol, which took effect on 16 February 2005, more than 30 industrialised countries are bound by concrete and legally binding emission reduction targets (e.g. 8% reduction compared to 1990 for EU Member States) during the period 2008–2012. The future of Kyoto, after 2012, agreement is under discussion but EU decided unilaterally to reduce greenhouse gas emission by 20% from now to 2020. Ocean is a natural carbon sink but it is thought to reach the emission target also by capturing and storing CO<sub>2</sub> in deep-sea saline aquifers. Moreover, oceans are also a source of renewable (and non-renewable like methane hydrates) energy: marine energies include wave, offshore wind, currents and tides... and microalgae (that could substitute for oil use). Therefore, climate change mitigation could lead to a more intensive use of oceans.

### E) Specific trends affecting international agreements about fishery

#### E-1 Automatic Ship Identification Systems

As a result of an initiative by the International Maritime Organization an international consultation aimed at establishing a worldwide automatic ship identification system is underway. Viewed schematically, the automatic ship identification system would use a ship's own navigation and communications systems to calculate and transmit the ship's position to authorities local to the area where it is operating. Despite its origin in the world of maritime safety, there is consensus that such a system, when operational, could be used for other purposes, such as vessel monitoring for customs or fisheries protection purposes. One could envisage that such a system could provide invaluable data on the international movements of vessels, particularly those that, because of their questionable activities, would tend to avoid fisheries which required Vessel Monitoring System compliance<sup>5</sup>.

Vessels falling into this category would be those which use registration with flags of convenience to avoid regulation by responsible flag states. In this respect, an automatic ship identification system would be a valuable tool. Other vessels whose movements would attract the attention of authorities, and whose activities could be tracked, at least partially, by automatic ship identification systems, would be those engaging in now illegal activities such as driftnet fishing.

Unfortunately, to date, agreement is still required on the necessary approach, technology or standards to implement automatic ship identification services. When these issues are resolved, perhaps the basis will exist for some cooperation, or even homogenization, of

<sup>5</sup> On VMS :

[http://ec.europa.eu/fisheries/publications/information\\_notes/archives/effective\\_monitoring\\_2000/vms\\_en.htm](http://ec.europa.eu/fisheries/publications/information_notes/archives/effective_monitoring_2000/vms_en.htm)

vessel Monitoring System and automatic ship identification, but it is too early to make such an assertion.”<sup>6</sup>

## Hypotheses (2020)

**1. New protectionism from both sides:** The Doha negotiations cycle fails, leading to a major growth of non tariff barriers in international fish trading. Media and political expediency spreads suspicion about “foreign” products: using a true problem, they use this issue to build an efficient new form of protectionism, using quality and sanitary issues (e.g. zero tolerance about bacteria, antibiotics), There will be a decrease in bilateral agreements for both trade and access to fishing grounds.

**2. Free trade in fishing:** The Doha negotiation cycle finally succeeds in 2010. Reduced non-tariff barriers in fishing trade on the basis of a “Most-Favoured Nation” (MFN) clause (WTO). Increasing inter-regional agreements to access fishing grounds, using financial compensation tools (e.g. EU with Economic Community of West African States (ECOWAS); NAFTA with Mercosur).

**3: Johannesburg ++ / Automatic Ship Identification Systems:** General political agreement about data sharing in ship identification and navigation is signed on a multilateral basis. All bilateral agreements signed by the EU to access fishing grounds abroad include the share of satellite data among countries and true capacity-building support (boats or financial help) to enforce the maximum sustainable catches decided. Increase in bilateral agreements.

## Sources

- OECD, *Globefish*; 1995
- SATIA, Benedict P. *FAO Code of Conduct For Responsible Fisheries – Development Considerations and Challenges for ACP Countries*. Roma – FAO, International Institutions and Liaison Service Fisheries Department.
- MAHFUZ, Ahmed. *Market Access and Trade Liberalisation in Fisheries*. Geneva – ICTSD, Issue Paper No. 4, June 2006, 57 p.
- The European Community External Fisheries Policy. Brussels EU Commission, 2005, [http://ec.europa.eu/fisheries/publications/externalpolicy\\_en.pdf](http://ec.europa.eu/fisheries/publications/externalpolicy_en.pdf)
- *FAO Technical Guidelines for Responsible Fisheries*. Rome – FAO, 1998. <http://www.fao.org/docrep/003/w9633e/w9633e00.htm#Contents>
- *Fisheries trade issues in the WTO*, FAO support to the WTO negotiations, 2003. <ftp://ftp.fao.org/docrep/fao/005/y4852e/y4852e07.pdf>
- MRAG FOR THE UK'S DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS (DEFRA) AND DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (DFID). *COMPARATIVE STUDY OF THE IMPACT OF FISHERIES PARTNERSHIP AGREEMENTS - TECHNICAL REPORT- MAY 2007*

<sup>6</sup> *FAO Technical Guidelines for Responsible Fisheries*. Rome – FAO, 1998. <http://www.fao.org/docrep/003/w9633e/w9633e00.htm#Contents>

## WORLD CONTEXT

### A3 Food security in the world, inc. demography

#### Driver Definition

World food demand will increase with the increase in the world's population (300 million more Chinese over the 30 next years, similar increase in India). Available land and water for cultivation could be limiting. Fish and shellfish take an important place in food security (sufficient food for the world's population) in the world because fish provides for >2.8 billion people, mainly in developing countries, half of the world's population, with almost 20% of their average *per capita* intake of animal protein.

The EU population will increase more slowly than elsewhere in the world. However, human migrations will occur regionally and broadly might change the traditional demography of EU countries. People from Africa and Asia with different food preferences could emigrate in Europe. The percentage of people living in coastal areas will increase in future, inducing greater consumption of seafood. Moreover, the age distribution of the European population will change, older people becoming increasingly prevalent, and they prefer to eat healthy food (fish rather than meat) but also smaller quantities than younger people.

#### Relevant Indicators

- Increase in world population
- Increase in European population, ageing of EU population,
- Increase in total protein demand to feed the increasing population
- Part of terrestrial and aquatic supply in the world food.
- *Per capita* seafood consumption

#### Developments over the past 20 years

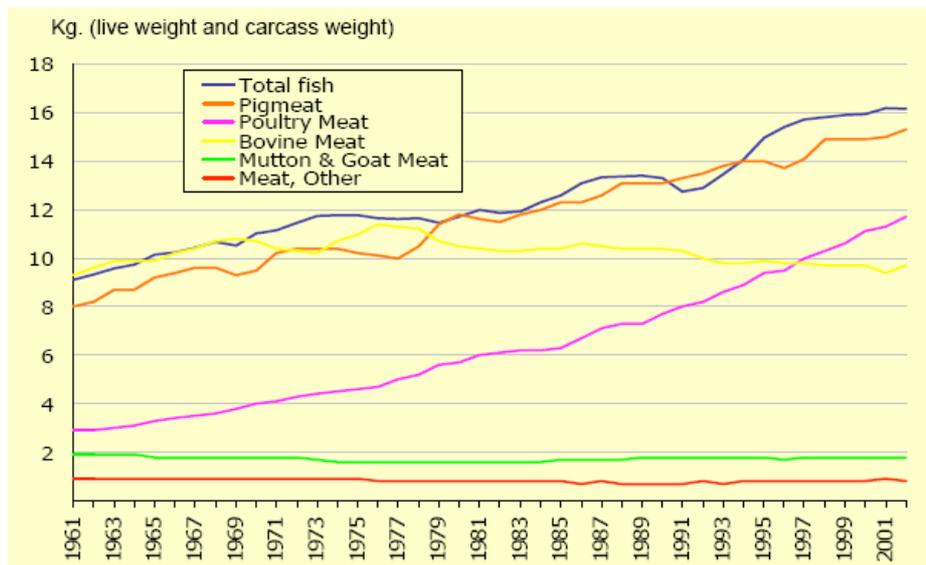
Global *per capita* food consumption has been increasing. The average global calorie supply per person increased worldwide by 16% from 1969/71 to 2000/02 and increased by 25% on average in developing countries. Yet, in 2001/03, according to FAO estimates, 856 million people in the world were undernourished, 61% of whom were in Asia and the Pacific (16% of the population is estimated to be undernourished). The greatest prevalence of undernourishment is in sub-Saharan Africa, where 32% of the population is undernourished.

Fish is nutritious and rich in micronutrients, minerals, essential fatty acids and proteins. In many countries, especially developing countries, the average *per capita* fish consumption may be low, but even in small quantities, fish can have a significant positive impact on improving the quality of dietary protein by complementing the essential amino acids that are often present only in low quantities in vegetable-based diets. In terms of food security, the contribution of fish is crucial in some densely populated countries where total protein intake levels may be low. For instance, fish contributes to, or exceeds, 50 percent of total animal protein intake in some small island developing states, as well as in Bangladesh, Equatorial Guinea, the Gambia, Guinea, Indonesia, Myanmar, Senegal, Sierra Leone and Sri Lanka. These countries are located in sub-Saharan Africa or Asia.

Global *per capita* fish consumption has risen from 9.0 kg in 1961 to an estimated 16.5 kg in 2003, but China has been responsible for most of this increase (though official values for China may be overestimated). If China is excluded, the *per capita* fish supply has been stable at about 14.2 kg since the mid-1980s:

- During the 1990s, world *per capita* fish supply, excluding China, was relatively stable at 13.2–13.8 kg. This can be attributed mainly to faster population growth than food fish supply during the 1990s (1.6% p.a. compared with 1.1%, respectively).

- Since the early 2000s, there has been an inversion of this trend, with the rate of food fish supply increasing faster than that of the human population (2.4% p.a. compared with 1.1%). Preliminary estimates for 2004 indicate a slight increase in global *per capita* fish supply, to about 16.6 kg.

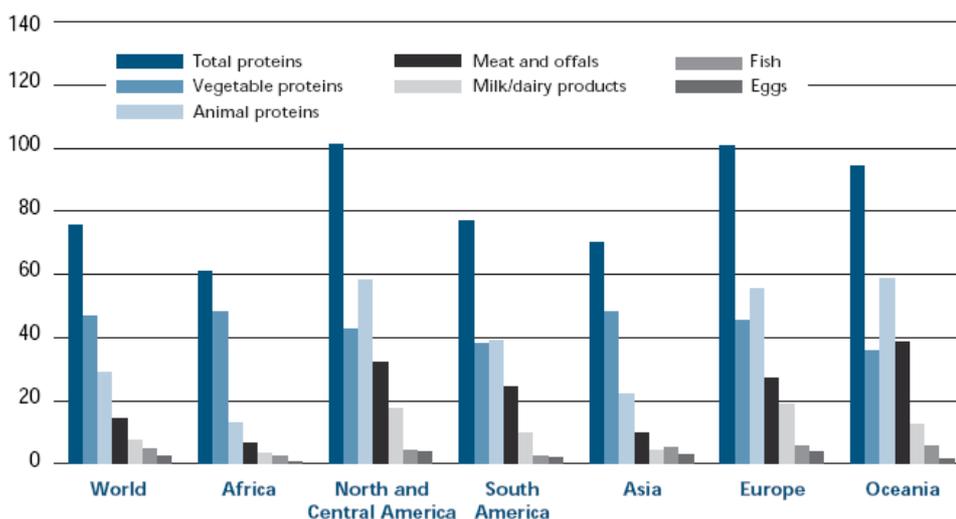


### World per capita consumption of fish and meat

Source : *Overview of Production and Trade – the Role of Aquaculture Fish Supply* by Mr Jochen Nierentz, Senior Officer, FAO GLOBEFISH. Global Trade Conference, May 2007, China.

The contribution of fish proteins to total world animal protein supplies rose from 13.7% in 1961 to peak at 16.0% in 1996, before declining somewhat to 15.5% in 2003. Corresponding figures for the world, excluding China, show an increase from 12.9% in 1961 to 15.45 in 1989, and then to 14.6% in 2003.

g/capita per day



Source : FAO, *The state of the world fisheries and aquaculture 2006*

In industrialized countries, the contribution of fish to total protein intake rose remarkably during the period 1961–89 (6.5–8.5%), before gradually declining as a consequence of the increase in consumption of other animal protein: by 2003, its share (7.8%) was back at levels prevailing in the mid-1980s. Since the early 1990s, the consumption of fish protein has remained relatively stable at around 8.2–8.6 g *per capita* per day, whereas the intake of other animal proteins has continued to grow.

In developing countries, the average *per capita* apparent fish supply was one-quarter of the estimated supply in industrialized countries until the mid-1980s. The gap has been reduced progressively, with stronger growth since the mid-1990s. In 2003 at 14.1 kg, it stood at about a half that of industrialized countries (29.7 kg). However, if China is excluded, *per capita* supply in the other developing countries is still relatively low, at an estimated 8.7 kg in 2003. However, the contribution of fish to total animal protein intake in 2003 was significant at about 20%, and may be greater than indicated by official statistics in view of the unrecorded contribution of subsistence fisheries (13% in rich countries). Yet, since 1975, when it peaked at 24.1%, this share has slightly declined notwithstanding the continued growth of fish protein consumption (from 2.2 g to 2.7 g *per capita* per day from 1975 to 2003). This is because of the increase in the consumption of other animal proteins.

**Table 1 Total per capita consumption of fish as food, 1973–97**

REGION/COUNTRY	TOTAL CONSUMPTION (KG/CAPITA/YEAR)			ANNUAL GROWTH RATE
	1973	1985	1997	1985–97 (%)
China	5.5	8.1	26.5	10.4
Southeast Asia	17.6	19.8	23.0	1.3
India	3.1	3.6	4.7	2.3
Other South Asia	6.2	5.4	6.0	0.9
Latin America	7.0	9.0	7.8	-1.2
West Asia and North Africa	3.4	6.2	6.2	0.0
Sub-Saharan Africa	9.0	9.2	6.7	-2.6
United States	13.5	18.5	19.7	0.5
Japan	70.2	61.5	62.6	0.2
European Union 15	18.2	20.3	23.6	1.3
Eastern Europe and former Soviet Union	20.3	22.7	10.6	-6.1
Other developed countries	11.2	13.4	14.7	0.8
Developing world	7.3	9.0	14.0	3.8
Developing world excluding China	8.1	9.4	9.2	-0.1
Developed world	22.6	24.3	21.7	-1.0
World	11.6	12.8	15.7	1.7

SOURCE: Calculated by authors from FAO statistical databases, [www.apps.fao.org/subscriber](http://www.apps.fao.org/subscriber) (accessed January 2002).

NOTES: Data are three-year averages centered on 1973, 1985, and 1997, respectively. Growth rates are exponential, compounded annually using three-year averages as endpoints.

Source : IFPRI, Outlook for Fish to 2020; 2003

In some regions, including many of the countries where fish proteins are crucial to food security (south Asia, sub-Saharan Africa), with fish contributing to 50% or more of total protein intake, there was a lower fish *per capita* consumption in 1997 than in 1973. Eastern Europe saw a sharp decline of fish consumption in the 1990s probably due to the difficult political transition they experienced then. This can be explained by the fact that over the past 30 years, fish has become more expensive relative to other food. Whereas the price of meat is half what it was in the early 1970s, the real prices of fish have not fallen. Prices for most fish products are firm because fish demand, primarily in developing countries, is outstripping supply. It is also possible that the increasing globalization of fisheries and the rise of high-end fish exports from poor countries place upward pressure on low-value fish prices, as producers switch focus to high-value export commodities.

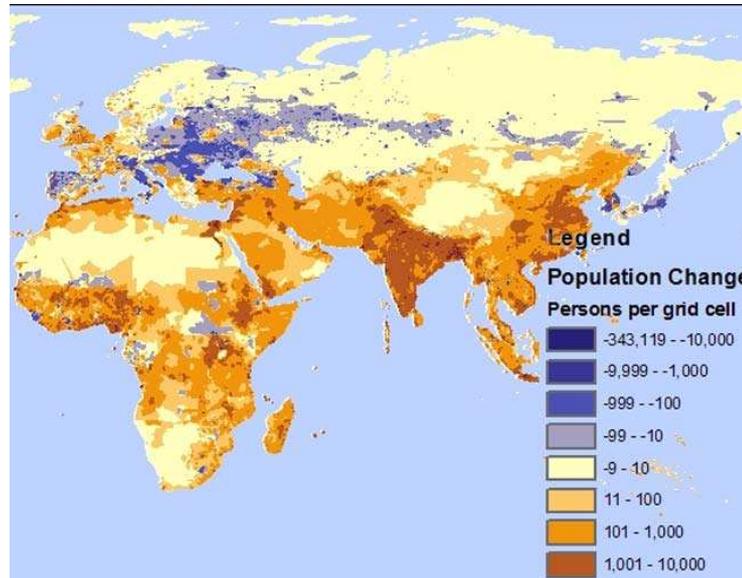
### Future trends in demography

According to a UN forecast<sup>7</sup>, world population would increase from 6.7 billion people in 2007 to a range of 7.2 to 7.8 billion in 2020 (medium variant forecast being 7.5 billion). Most of the increase in the world's population will be in the least developed countries. Overall population

<sup>7</sup> World Population Prospects : The 2006 Revision. New York : United Nations, March 2007, 110 pp.  
<http://www.un.org/esa/population/publications/wpp2006/wpp2006.htm>

growth rate will be far slower than in the past because of a global trend of decreasing fertility rates with economic development. The share of the European population within the world population should keep declining.

**Population increase 1995-2025**



Source : GAFFIN Stuart and alii, CCSR, 2006.

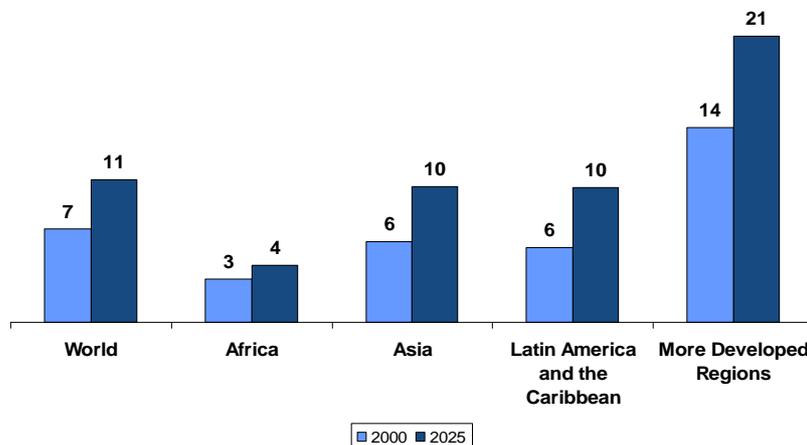
Other trends:

- 1) The ageing of the world's population :

**Trends in Aging, by World Region**

**Population Ages 65 and Older**

Percent



Source: United Nations, *World Population Prospects: The 2004 Revision (medium scenario)*, 2005.

© 2006 Population Reference Bureau

By 2025, more than 20% of the population in more developed regions will be aged 65 and older.

- By 2025, one-tenth of the world's population will be aged 65 and older.
- Asia will see the proportion of its elderly population almost double, from about 6% in 2000 to 10% in 2025.

2) Urbanization

The population growth will be far more important in the urban zones of the least developed regions (2.3% per year between 2000 and 2030). In industrialized countries, it is forecast that urban populations will increase more slowly (0.5% per year between 2000 and 2030), because the majority already live in cities.

Share of urban population (in % of total population)

	1950	1975	2005	2020
Africa	14,7	25,4	38,3	45,3
Asia	16,8	24	39,8	48,1
Europe	50,5	65,6	72,2	75,1
Latin America	42,0	61,2	77,4	81,9
Northern America	63,9	73,8	80,7	84,6
World	29	37,2	48,7	55,1

Source : United Nations : World Urbanization Prospects, 2005 Revision

3) Coastal population

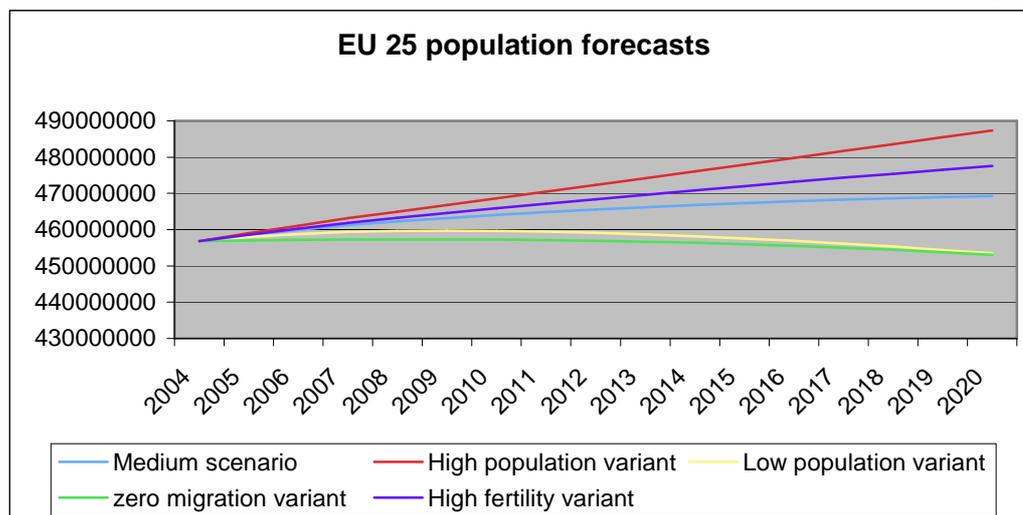
United Nations assessed, in 2001, that 44% of the world population lived <150 km from the sea and that half lived 200 km or less from the sea<sup>8</sup>.

Researchers from the Center for Climate Systems Research at Columbia University<sup>9</sup>, assume that the number of people living 100 km from the sea or closer will increase by 35% between 1995 and 2025.

4) EU population

In the central scenario, the EU25 population would peak around 2025, then decrease.

In Europe 25, natural population change (birth – death) is quite low, <0.5 million per year) for at least the last 15 years. Some countries like Germany or Greece already show a negative natural population change. Net migration is the main factor behind population increase in Europe and is the main uncertainty about European demography for the next 15 years. However, forecasts of net migration, because of sensitivity about the topic, are sometimes lower than recent real numbers. Net migration was on average <1 million people per year from 1960 to 2000 in EU25, but increased from 2000 to 2005 to reach 1.5–2 million per year.



Source : Eurostat yearbook 2006-2007

<sup>8</sup> UN Atlas of the Oceans, <http://www.oceansatlas.org/>

<sup>9</sup> CCSR (Center for Climate Systems Research). *It's 2025. Where Do Most People Live?* 11/2006 <http://www.earthinstitute.columbia.edu/news/2006/story07-11-06.php>

## Hypotheses (2020)

**1. Fish against meat:** The value of fish proteins leads low-income fish-producing countries to export their valuable production to rich countries and to import meat to meet their own needs. Fish consumption increases in rich countries (including recovery of eastern European countries) and decreases in Africa and some Asian countries. This hypothesis is compatible with faster population growth than fish supply and/or a strong increase in fish demand (and less meat, just like happened to bovine meat) for health purposes in rich and ageing countries. Recurrent sanitary crises affecting land animals, such as avian flu, could also lead to this hypothesis.

**2: High fish supply:** Fish supply increases faster than the world's population and global *per capita* fish consumption increases almost everywhere in the world. This hypothesis implies a greater productivity in the fishing and aquaculture sectors and slower growth of the world's population.

**3. Fish supply a major part of food security:** Recurrent droughts and the use of food grain for non-food purposes reduces the availability of feed for cattle or poultry breeding. Meat protein becomes more expensive. Therefore, fish becomes a more important target of animal protein intake on average, although average volume consumption *per capita* might be stable in rich countries and decreasing in developing countries.

## Sources

- Outlook for fish to 2020 Meeting Global Demand, C.L. Delgado, N. Wada, M.W.Rosegrant, S. Meijer, M. Ahmed ; IFPRI – Woldfish center, October 2003.
- The state of World Fisheries and Aquaculture 2006 , FAO, Rome 2007

## EU REGULATION

## EU REGULATION

### B1 EU policies (CFP, maritime, water framework, bathing water, marine strategy, habitat and bird directives)

#### Driver Definition

##### *Common Fisheries Policy*

Set of laws enacted by an Authority (EU) concerning fishing activities (including markets) and resulting obligations for Member States

##### *Maritime policy*

Evolution (creation, implementation, reform) of EU policies impacting on maritime activities: fisheries, environment, transport, maritime safety and security, research, industrial policy, etc. including the Water Framework Directive, bathing waters and marine strategy

The European Commission is currently examining all European economic activities which are linked to or impact on the oceans and seas, as well as all the policies dealing with them, with a view to finding the best way to extract more benefit from the oceans in a sustainable manner. Therefore, on 7 June 2006, the European Commission adopted the Green Paper<sup>10</sup> "Towards a future Maritime Policy for the Union: A European vision for the oceans and seas". Through a consultation process, stakeholders (individuals, institutions, governments and international organisations) were invited to provide feedback to the Green Paper by 30 June 2007. The resultant synthesis may lead to the publication of a White Paper<sup>\*\*11</sup>, translating the conclusions of the debate into practical proposals for European Union to plan out an integrated maritime policy.

The Water Framework Directive – WFD - (2000/60/EC) established a framework for action in the field of water policy. The WFD expands the scope of water protection to all waters and sets a clear objectives that "good status" must be achieved for all European waters by 2015 and that sustainable water use is ensured throughout Europe.

The WFD aims at providing a legal stimulus at EU level for integrated planning, including implementation of Integrated Coastal Zone Management (ICZM), as it applies to waters up to one nautical mile (1.852 km) offshore.

#### Relevant Indicators

- Compendium of legislation, obligations agreements within CFP.

##### Maritime policies

- Quantitative and qualitative (categorisation of responders) assessment of responses to the Green Paper submitted to the European Commission;
- Adoption of a White Paper and definition of an action programme for the European Union towards an integrated maritime policy.
- Level of national commitment to the proposed maritime policy (potential Member States concerns re. subsidiarity)
- Results of past maritime policies

<sup>10</sup> Green Papers are documents published by the European Commission to stimulate discussion on specific topics at European level.

<sup>11</sup> White Papers are documents containing proposals for Community action in a specific area. In some cases they follow a Green Paper. When a White Paper is favourably received by the Council, it can lead to an action programme for the Union in the area concerned.

## For Water

- Evolution of European water situations (surface water pollution, groundwater exploitation, drinking water quality, area of irrigated land, etc.)
- Assessment of the WFD implementation (monitoring programmes, river basin management plans)
- Agencies responsible for WFD per country (mandate with a marine/maritime component?)
- Extent of areas closed to fishing/aquaculture

## Developments over the past 20 years

### *CFP*

The Common Fisheries Policy (CFP) is the fisheries policy of the European Union. It was created to manage fish stocks for the European Union as a whole. Article 38 of the 1957 Treaty of Rome which created the European Communities (now European Union) stated that there should be a common policy for fisheries. In practice, fisheries policy is considered as one of the handful of 'exclusive competences' reserved for the European Union. This would formally place fisheries policy outside the jurisdiction of individual nation states, although decisions would still be made primarily by the Council of Ministers, as is the case now.

Just before Norway and the UK applied for membership of the EEC in 1970, the six original members drew up Council Regulation, 2141/70, giving each other 'equal access' to each others fishing waters. This was done with such unseemly haste that it was only adopted on the morning of 30 June, the day the British application for membership arrived. The reason for this was that approximately 70–80% of the 'European' fish stocks were to be found within UK National Waters and, as a new member of the EEC, the UK would have to accept all existing European Legislation. All subsequent members of the EU, including the UK, have accepted the CFP principle of equal access to fishing grounds (although the UK has a concession that gives UK fishers exclusive fishing rights up to six miles off its coast).

However, this principle has been modified. In 1983 Total Allowable Catches (TACs), species quotas and minimum net sizes were introduced, in an attempt to curb overfishing. Moreover, in 1991 the European Court of Justice (ECJ) overruled a court decision in the UK and legalised the practice of quota hopping. This set a precedent that national fleets (Spanish, in this instance) could register their boats and buy quotas in other member states to avoid fishing restrictions.

In light of severely reduced fish stocks the EU has, since 1992, consistently ordered all national fleets to reduce their 'fishing effort'; the UK had its fleet cut by 19% and by a further 40% in 1996. The latest deal, hammered out in December 2006, sees cod catches west of Scotland and the Celtic Sea cut by 20% and all other catches cut by 15% . Reforms to the CFP in 2003 also allow for tougher action against those who break the rules. The CFP says that EU waters are a shared resource that can be fished by any national fleet. It tries to manage this through the use of quotas and TACs to control who catches what. However, because quotas are managed by member states' governments, the CFP depends on commitment at a national level. As a result of poor implementation by some national governments (most notably Spain), the CFP has seen fish stocks decrease dramatically. Billions of dead fish have been thrown back into the sea because they did not meet species quotas.

The EU has also expanded its fishing area by paying other governments to allow EU ships to fish in their waters. These 'third-country agreements' have proved controversial as some claim that fishing by EU vessels off the coast of North Africa, for instance, has crippled local fishing communities.

The European Fisheries Fund (EFF) was established in August 2006. This replaced the Financial Instrument for Fisheries Guidance as the main fund through which the EU supported fisheries across the union, with a budget of around €4.3 billion.

The 2002 reform of the CFP identified limitation of fishing effort together with limitation of catches (TACs) and technical measures as the main measures to be used in the management of fisheries. The reform furthermore heralded a longer-term approach to fisheries management, involving the establishment of multi-annual recovery plans for stocks outside safe biological limits and of multi-annual management plans for other stocks. The European Commission has launched an Action Plan to ensure that environmental protection requirements are integrated into the CFP. By-catches and discards negatively impact the marine ecosystem. Juvenile fish and vulnerable species such as dolphins, sharks or marine birds are particularly affected by fishing activities.

To address these problems, the Commission has initiated measures to promote the protection of vulnerable species. Measures have been proposed to ensure the protection of sharks, including the prohibition of "finning" - involving the removal of fins and discarding of carcasses - of sharks in EU waters, and to reduce bycatch of sharks. The Commission also advocates the introduction of more selective fishing gear, such as nets with larger meshes or fitted with square-meshed panels, restrictions on fishing to protect juvenile fish, sensitive non-target species and habitats, minimum landing sizes in line with the selectivity of the gear concerned, "discard ban trials" in which representative samples of fishing vessels would be encouraged through economic incentives to retain their entire catch, and the development of economic incentives for the use of more selective fishing practices.

#### *Maritime policy*

On 2 March 2005, the European Commission started work on a Green Paper for an all-embracing Maritime Policy, which was adopted on 7 June 2006. It is the basis for a broad consultation, and is the result of more than a year of consulting with stakeholders, identifying gaps between sea-related sectoral policy areas and attempting to adopt best practice and learn from obstacles and challenges. The mandate has been to examine all economic activities of Europeans which are linked to or impact the oceans and seas, as well as all the policies dealing with them, with a view to finding the best way to extract more benefit from the oceans in a sustainable manner.

On 10 October 2007 the so called Blue paper on the Maritime Policy was launched. In this Blue paper, the Commission lists a range of concrete actions to be launched. These actions cover a wide spectrum of issues ranging from maritime transport to the competitiveness of maritime businesses, employment, scientific research, fisheries and the protection of the marine environment. They include:

- A European Maritime Transport Space without barriers
- A European Strategy for Marine Research
- National integrated maritime policies to be developed by Member States
- An integrated network for maritime surveillance
- A Roadmap towards maritime spatial planning by Member States
- Elimination of pirate fishing and destructive high seas bottom trawling
- Promotion of a European network of maritime clusters
- A review of EU labour law exemptions for the shipping and fishing sectors
- A European Marine Observation and Data Network
- A Strategy to mitigate the effects of climate change on coastal regions.

#### *Marine Strategy Directive*

In October 2005 the European Commission released its proposals for a new Marine Strategy Directive, which will complement the existing Water Framework Directive and seek to address three key issues:

1. Increasing pressures on the marine environment (e.g., land-based pollution, overfishing, oil spills, shipping, oil and gas exploration) and threats to marine ecosystems (biodiversity loss, habitat destruction, and the capacity of our seas to provide food).
2. Knowledge gaps, because assessment and monitoring programmes are not integrated or complete, and there are weak links between research needs and policy priorities.

3. Governance systems which lack co-ordination across Europe. The many regional and global strategies and environmental agreements, institutions and policies affecting the marine environment (e.g. Common Fisheries Policy, Marine Transport Policy, Common Agricultural Policy, Water Policy) are poorly integrated and often not specifically designed to protect the marine environment.

The Strategy's vision is that "we and future generations can enjoy and benefit from biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive". The proposed Directive aims to translate this vision into a legal objective to achieve good environmental status of the EU's marine waters by 2021. It is expected that the detailed application and implementation of the Directive will be through the regional sea conventions, including the Convention for the Protection of the Marine Environment for the North-East Atlantic (OSPAR). It is expected to have the following elements:

- Description and assessment of current environmental status, including the environmental impact of human activities.
- Determination of good environmental status.
- Establishment of environmental targets.
- A monitoring programme.
- A programme of measures towards good environmental status.

#### *Water Framework Directive*

The EU Water Framework Directive (WFD), adopted in 2000, is a milestone in the history of water polices in Europe. The directive establishes a common framework for the sustainable and integrated management of all waters. It covers groundwater, inland surface waters, transitional waters and coastal waters and requires that all impact factors as well as economic implications are taken into account. The ultimate objective of the Directive is to achieve good status of all water bodies in the EU member states and associated states by 2015. Although integrated water management has been the goal for a long time, there is now a legislative incentive to implement this concept fully within a short time frame.

European Union Water Policy History:

- 1976–1996, sector-orientated approach
- almost 20 different pieces of water legislation
- incoherent piecemeal approach
- European waters under threat

The WFD states the following:

- Protection of water status within river basins will provide economic benefits by contributing towards the protection of fish populations, including coastal fish populations.
- Surface water status to be determined, *inter alia*:
  - Biological elements
  - Composition, abundance and biomass of phytoplankton
  - Composition and abundance of other aquatic flora
  - Composition and abundance of benthic invertebrate fauna
  - Hydromorphological elements supporting the biological elements
  - Tidal regime
  - Pollution by all priority substances identified as being discharged into the body of water
  - Pollution by other substances identified as being discharged in significant quantities into the body of water

#### *Habitats Directive*

The 1992 EU Directive on the conservation of natural habitats and wild fauna and flora – the Habitats Directive - represents the cornerstone of EU nature conservation policy. Proposed by the European Commission in the late 1980s, the Directive was to respond to a continuing deterioration of European natural habitats and an increasing number of seriously threatened wild species. More than a decade later, it remains the single most important EU instrument for safeguarding biodiversity across the 15 Member States. In providing a legally binding and

directly enforceable regime of habitat and species conservation, the Directive also serves as the EU's instrument for implementing the 1979 Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention).

The Directive's principal aim is to "contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States" (Article 2). This aim is pursued by formally providing for site-based measures promoting the conservation of habitats and habitats of species, which together with sites designated for the protection of birds and their habitats, make up the 'Natura 2000' network. Site-based measures are to be complemented by non-site specific measures for the protection of species, as well as a number of additional measures such as the protection of ecological corridors and stepping-stones, and research. Collectively, these measures are to ensure the restoration or maintenance of natural and semi-natural habitats and wild species of Community interest to a "favourable conservation status".

#### *The Habitats and Birds Directives*

The European Union's Habitats Directive, in conjunction with the Birds Directive, is the main legal tool of the European Union for nature conservation. The Habitat Directive's fundamental purpose is to establish a network of protected sites through Community territory, the Natura 2000 network. The Habitats Directive also recognises that migratory species cannot be protected by the Natura 2000 network alone and may require non-site based, general management of human activities for their protection.

The Natura 2000 network is designed to maintain or help maintain both the distribution and abundance of threatened or potentially threatened species and habitats, both terrestrial and marine. The Natura 2000 site-selection process is a shared responsibility between EU Member States and the European Commission. Member States propose sites to protect habitats and species listed in the Directive. The lists are subject to a process of assessment and negotiation between the Commission and the Member States through a series of Biogeographic Region (BGR) seminars, before a final list of Sites of Community Importance is adopted.

There has been a lack of clarification for many years as to whether or not the Habitats Directive applies in the marine environment offshore (out to the 200 mile Exclusive Economic Zone (EEZ) or other national fishing/continental shelf limit if the Member State has not declared an EEZ under The UN Law of the Sea). The geographical coverage of the Habitats Directive in European Union waters was referred to by the Commission in a document COM (1999) 363 final Communication from the Commission to the Council and the European Parliament "Fisheries Management and Nature Conservation in the Marine Environment". On p .10, the following statement is made: "The provisions of the "Habitats" Directive automatically apply to marine habitats and marine species located in territorial waters (maximum 12 miles). However, if a Member State exerts its sovereign rights in an exclusive economic zone of 200 nautical miles (for example, the granting of an operating license for a drilling platform), it thereby considers itself competent to enforce national laws in that area, and consequently the Commission considers in this case that the "Habitats" Directive also applies, in that Community legislation is an integral part of national legislation". There are at least two habitats listed in the Annex 1 of the Habitats Directive that occur beyond 12 nautical miles offshore. These habitats are "reefs" (Natura 2000 Code 1170) and "submerged sandbanks" (Natura 2000 Code 1110), as defined by the Interpretation Manual of European Union Habitats (EUR15/2). Another habitat listed on the Habitats Directive is "sub-marine structures made by leaking gases" (Natura 2000 Code 1180, refer to Annex V). Its definition could describe further offshore features. It is also of note that several offshore marine species, including harbour porpoise, bottlenose dolphin and monk, common and grey seals, are listed in the Habitats Directive for potential site selection. Bird species listed in the Birds Directive may also qualify.

#### *Analysis*

If we consider the past 20 years of policy development in relation to fisheries and aquaculture and the marine environment in particular it can be noted that increasingly the marine environment is become part of specific legislation. Taken from the perspective of fisheries, for

example, at first the main policies relating to fisheries came under the CFP. Of late the CFP of course has broadened its pallet of measures to include alongside technical measures, output regulations and access regulation, measures of closed temporal and spatial areas and zero catch options.

Fisheries have always been part of wider labour, environmental and economic rules and regulations. In the past 10 years, however, we see that legislation such as the bird and habitat directives, the water directive and the forthcoming marine directive play an increasing role in guiding fisheries and aquaculture development. Also, as discussed elsewhere, international agreements such as the Johannesburg measures for sustainable fisheries with concrete targets of installing MPAs and having stocks at MSY level by 2015, increasingly determine the playing field for fisheries operations.

These developments call for strengthened attention to governance aspects especially when concerned with participation, transparency and consistency. Although in the process of bringing about all the individual directives, attention is given to operate a participatory and transparent system, when taken at full scale consistency and proportionality of sets of measures and the specific impact on any particular (economic) activity could be queried specifically.

## Hypotheses (2020)

1. **The Blind Corner:** From the perspectives of Fisheries and Aquaculture, rules and regulations are initiated increasingly from 'outside' the classic playing field. Hence, old networks do not deliver the influence needed to see what is coming and to influence the decision-making process. In this it also reflects the fact that fisheries and aquaculture are seen as a rather minor stakeholder in the total discourse.

2. **Blue Haven:** The successful implementation of the entire body of directives and regulations on the marine environment, ranging from CFP to marine directive and Natura 2000 implementation, leads to a possibly increased marine production. Traditional producers play an important role in implementation and monitoring of the directives, and are seen as key players in the successful set-up of governing the marine environment.

3. **Global Warning:** The importance of the marine environment supersedes national competencies and therefore the marine environment is governed centrally by the EU. In addition, the environmental policies, leading marine governance, are increasingly being designed at global fora.

4. **National village:** Local rules supersede regional and international rules. The EU no longer has the prerogative for setting polices such as the CFP. Subsidiarity is brought back to its original meaning. Only those issues that cannot be solved at a local level will be delegated to a national or international level.

## Sources

- [http://ec.europa.eu/fisheries/cfp\\_en.htm](http://ec.europa.eu/fisheries/cfp_en.htm)
- <http://www.civitas.org.uk/eufacts/FSPOL/AG5.htm>
- [http://homepages.tcp.co.uk/~ukip/bs\\_cfp\\_1\\_3\\_1.html](http://homepages.tcp.co.uk/~ukip/bs_cfp_1_3_1.html)
- <http://www.dhigroup.com/Solutions/HealthAndSafety/EUWaterFrameworkDirective.aspx>
- <http://web.sfc.keio.ac.jp/~kgw/Research/JPJRP/ResearchPaper2003/Monika.pdf>
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy *Official Journal L 327* , 22/12/2000 P. 0001 – 0073
- The Eu Habitats Directive: Generating Strong Responses Project Deliverable No. D 7 (March 2003) Clare Coffey and Saskia Richartz Institute for European Environmental Policy
- [http://ec.europa.eu/environment/water/marine/index\\_en.htm](http://ec.europa.eu/environment/water/marine/index_en.htm)
- [http://ec.europa.eu/environment/water/water-framework/index\\_en.html](http://ec.europa.eu/environment/water/water-framework/index_en.html)

## EU REGULATION

### B2 Governance and Stakeholder Participation

#### Driver Definition

The term "governance" is a very versatile one. It is used in connection with several contemporary social sciences, especially economics and political science. It originates from the need of economics (as regards corporate governance) and political science (as regards State governance) for an all-embracing concept capable of conveying diverse meanings not covered by the traditional term "government". Referring to the exercise of power overall, the term "governance", in both corporate and State contexts, embraces action by executive bodies, assemblies (e.g. national parliaments) and judicial bodies (e.g. national courts and tribunals). The term "governance" corresponds to the so-called post-modern form of economic and political organisations.

In fisheries management one can, for example, look at the way in which TACs and quotas are established. This process might be perceived as a "game" involving scientific advice, political pressure and negotiations with third party states such as Russia, Iceland or Norway. This process might make quota development hard to predict, because it carries elements of different perspectives and stakes from both ecological, socio-economic, societal and political points of view. In addition it caters for different views from a market perspective, a government perspective and a social-midfield perspective. Also it centres on flows of information and therefore communication between, for example, science, politics and industry, and the way different stakeholders have an influence on the process.

Governance focuses not only on the mere result criteria (effectivity, efficiency and equity) but also on the process. Focusing on the policy-making process it is suggested to explicitly address design issues in relation to governance principles going beyond the particular resource use situation at hand, such as pertaining to the quality of representative democracy and the legitimisation of power. This raises questions such as where to put the locus of decision making, who should be represented, and what should be the scope of the jurisdiction. In this case the evaluative criteria are not just technical economic (efficiency and equity). Following the EU white paper on Governance, five criteria based on the principles of good governance can be identified: openness, participation, accountability, effectiveness and coherence. In the realm of fisheries, of importance in this triad are also the notions of relative stability and subsidiarity.

**Openness.** Institutions should work in an open manner. They should actively communicate about actions and decisions using a language that is accessible and understandable for the general public.

**Participation.** The quality, relevance and effectiveness of (EU) policies depend on ensuring wide participation throughout the policy chain – from conception to implementation. Improved participation is likely to create more confidence in the end result and in the Institutions that deliver policies. Participation crucially depends on central governments following an inclusive approach when developing and implementing (EU) policies.

**Accountability.** Roles in the legislative and executive processes need to be clearer. Each of the EU Institutions must explain and take responsibility for what it does in Europe. However, there is also a need for greater clarity and responsibility from Member States and all those involved in developing and implementing EU policy at whatever level.

**Effectiveness.** Policies must be effective and timely, delivering what is needed on the basis of clear objectives, an evaluation of future impact and, where available, of past experience.

Effectiveness also depends on implementing EU policies in a proportionate manner and on taking decisions at the most appropriate level.

**Coherence.** Policies and action must be coherent and easily understood. The need for coherence in the Union is increasing: the range of tasks has grown; enlargement will increase diversity; challenges such as climate and demographic change cross the boundaries of the sectoral policies on which the Union has been built; regional and local authorities are increasingly involved in EU policies. Coherence requires political leadership and a strong responsibility on the part of the Institutions to ensure a consistent approach within a complex system.

#### *Stakeholders*

A "stakeholder" is a person or organization that has a legitimate interest in a project or entity. The Stakeholders are people who affect, and are affected by, this activity, project or entity. This means that an undertaking or activity in this view has to take cognizance of the needs and desires of many different people, ranging from the local population and customers to their own employees and owners.

The main issue in this is who is to be considered a stakeholder in fisheries and aquaculture activities. The definition of the stakeholders determines whose opinions and interests will be represented during the debate.

As a result of the management process one can look at *Compliance with regulations* as an indicator of how well the governance system caters for the different perspectives and stakes.

*Compliance with regulations* refers to the degree to which citizens adhere to the rules and regulations, in this case in particular the various fisheries management regulations. In fact this indicator provides insight into the effectiveness of the management system in translating policy into concrete management measures. On the other hand it provides insight into the way the measures are supported by the people that have to operate by the rules. Currently (as reflected in the green paper on the CFP), member states and their fishers are supposed to be aware of regulations, but it is widely acknowledged that a major failure of the CFP is lack of compliance at different levels (member state, industry, individuals).

Stakeholder cooperation (fisheries, research)

The capacity of fisherfolk to associate with scientists in co-expertise, e.g. "Sentinel fisheries" in Canada (DFO)

## **Relevant Indicators**

See above; governance is to be measured along lines of openness, participation, accountability, effectiveness and coherence

#### Stakeholders

- Groups considered stakeholders
- Different stakes of the different groups
- Power of the different groups: facts or relevant indicators to show it
- Socio-economic and political clout and importance of the stake

#### Compliance with regulations

- Estimates of illegal, unregulated and unreported (IUU) catches.
- Illegal fishing effort estimates
- TACS and quotas: decided vs. effective
- infringement records
- Discards of undersized commercial fish
- Catches of endangered species (IUCN red list)

## Developments over the past 20 years

In discussions on the reform of the CFP, the conclusions of the Commission on the implementation of the CFP were generally supported by the fishing industry, Member State authorities, the Parliament and the Council. It was notably concluded that :

- Poor implementation undermines effectiveness of conservation measures;
- A lack of uniformity results in the absence of a level playing field in control and enforcement at a Community level.

There are two formal ways in which stakeholders can give advice to policymakers in the EU. The two stakeholder fora are ACFA and RACs.

The implementation of the rules of the Common Fisheries Policy requires that the opinion of stakeholders is taken into consideration as well as encouraging the formulation of analyses and of joint positions. Work in these fora requires consensus to be efficient, which means that advice from ACFA and RACs will have to be agreed by both the industry and the other stakeholders for the fora to work as intended.

The stakeholders engaged in fisheries issues and the marine environment mainly consist of representatives from the fishing industry including the catching sector, processing industry, retailers, aquaculture industry, and Non-Governmental Organisations (NGOs) such as environmental, developmental and consumer groups.

### ACFA

ACFA, the Advisory Committee on Fisheries and Aquaculture, is an advisory group to the Commission. This Committee, which represents all major groups of stakeholders at a European level, was created in 1971.

ACFA consists of 21 representatives of the following interests: organisations representing the production sector, the processing industry and trade in fishery and aquaculture products, and NGOs representing the interests of consumers, the environment and development. This effectively means that three out of 21 representatives are NGOs and 18 are industry representatives.

The Members of ACFA are appointed by the Commission following proposals from the organisations set up at Community level, which are the most representative of the interests concerned. They meet according to an annual work programme adopted in agreement with the Commission.

Decisions in ACFA are taken in the ACFA Plenary and prepared in the Bureau, the steering group of ACFA. All decisions and positions are prepared and discussed in the Working Groups. There are four Working Groups (WGs). WG 1: Access to fisheries resources and management of fishing activities, WG 2: Aquaculture: fish, shellfish and molluscs, WG 3: Markets and Trade Policy, and WG 4: General questions: economics and sector analysis.

### RACs

The creation of Regional Advisory Councils (RACs) was one of the pillars of the 2002 reform of the Common Fisheries Policy (CFP), in response to the EU's and stakeholders' desire to increase participation of stakeholders in the CFP process.

The RACs prepare recommendations and suggestions on fisheries aspects in the area they cover and transmit them to the Commission or to the relevant national authorities. Submissions may be in response to a request from these bodies or on the RACs' own initiative. The RACs are made up of representatives of the fisheries sector and other groups affected by the CFP, whereas scientists are invited to participate in the meetings of the RACs as experts. Some 2/3 of the RACs are industry, and 1/3 are "other interest groups" such as NGOs. The latter group also includes aquaculture producers. The Commission and regional and national representatives of Member States may be present at the meetings as observers.

Often the RACs have several Working Groups. Each RAC is free to establish the groups they need to perform their work. For example: the Baltic RAC has three WGs: Demersal WG, Pelagic WG and the Salmonid WG. The WGs prepare the work for the Executive Committee, which decides on the advice.

By November 2006, four RACs had been established: The North Sea RAC (NSRAC), the Northwestern waters RAC (NWWRAC), the Pelagic RAC, and the Baltic Sea RAC (BSRAC). Three other RACs were in the process of establishment: the Mediterranean RAC (MedRAC), the Southwestern waters RAC (SWWRAC), and the Long Distance RAC (LDRAC).

**2004 fisheries compliance scoreboard: "Member States must do better"**

**Preventing overfishing**

Member States must keep a close eye on the catches of their vessels so that fishing can be stopped on time to respect the quotas set by the Council of Fisheries Ministers on the basis of scientific advice. While there has been some improvement compared to last year, Denmark was the only Member State which complied fully with the rules by submitting all the required catch reports on time.

The number of quotas that were overshot decreased from 3% in 2002 to 2% in 2003. The extent of overfishing of the quota concerned varies substantially from less than 1% to 76% as do the related quantities. The Member States most concerned are Belgium, Spain and, for the third year, the Netherlands.

**Monitoring and control**

In July 1999, the Council adopted a list of types of conduct which seriously infringe CFP rules. Member States must report annually on the action taken following the detection of serious breaches to the rules. The Commission notes that shortcomings in the reports received make comparison difficult.

From the data received, it appears that the number of serious infringements went down in 2002 with 6,756 cases from 8,139 cases in 2001. As in last year's edition, half of these relate to illegal fishing either without authorisation or in prohibited areas.

**Infringement procedures**

Three-quarters (61) of the infringements procedures currently pending against Member States (81) relate to fishing beyond allocated quotas. All Member States, except for Greece and Italy "only subject to one quota" are concerned: Denmark (10), Spain (9), Belgium, France and the UK (7), Sweden (6), Ireland and Portugal (5), Germany and Finland (2) and the Netherlands (1). Eight more relate to failure to notify catch data. Four new infringement procedures have been launched. Two were initiated against Spain and the UK for serious failings in their enforcement obligations, while the other two concern France and Spain for unsatisfactory monitoring of technical measures (use of driftnets).

**Compliance Scoreboard 2005**

**Catch reporting:** It is crucial that the information submitted by Member States on catches of vessels operating both in EU and non-Community waters be accurate, consistent and timely. In 2004, there have not been substantial improvements in the submission of catch reports compared with the previous year and, globally, compliance with reporting obligations was inconsistent. Only three Member States, Denmark, Sweden and the UK, fully complied with all monthly and quarterly catch reporting obligations on time while three Member States (Cyprus, Malta and Slovenia) failed to send any reports. As for the required monthly reports, only 10 Member States transmitted them within the established deadlines. Moreover, the submission of quarterly reports continued to be unsatisfactory in terms of overall response, in particular for reports regarding catching beyond EU waters. Spain, Italy, Cyprus, Lithuania, Malta and Slovenia failed to submit any quarterly reports.

**Quota overruns:** On the basis of information sent by Member States, there was a marginal reduction in overruns with a 1.8% overrun reported for 2004 (16 out of 875 quotas have been overshoot), compared with 2% in 2003 (16 out of 811 quotas). The Member States recording the most overruns are Spain and Ireland. The extent of overruns concerned can vary from 0.04% at one end of the scale to 68% at the other. More than two-thirds of the infringement procedures currently pending against Member states refer to cases of overfishing. (More information on these procedures can be found in the chapter on infringement procedures).

**Fishing effort declarations:** The situation in 2004 has regressed compared to 2003. Only two Member States, Belgium and Sweden, met in 2004 their obligations on fishing effort declarations, compared with three, Denmark, Finland and Sweden, the year before. France, Ireland and Portugal failed, for the third consecutive year, to transmit any data about their fishing effort.

**Fleet register:** The quality of the information submitted by Member States to the Community Fleet Register has shown some improvement compared to 2003. While almost all the new Member States are in full compliance with their fleet register obligations, the information submitted by Greece, Spain, France, Italy and Portugal was again incomplete in various degrees. In the case of Spain, France and Italy, the missing information concerned a large number of vessels. Ireland and the UK, which had some missing information last year, are now in full compliance with fleet register obligations.

**Remeasuring of fishing vessels in GT:** All Member States should have met the remeasurement deadline which expired in 2003 and this is the case for most of them. The overall situation has considerably improved from last year, particularly in the case of Portugal where significant effort has been exerted on this issue. Spain is the Member State which has the higher number of vessels to be remeasured with 1,450 vessels out of 14,002. France, Italy, Poland and, marginally, the UK are the other Member States that have failed to complete the re-measurement exercise. Other obligations related to fishing vessels: Compliance with the obligation to provide information on the name and address of a vessel's agent, owner and place of construction was almost universal. This is thanks to a major effort on the part of Portugal, Italy and, to a lesser extent, Ireland, which were lagging behind last year in this area. Compliance with the Entry - Exit Regime and the Reference levels for the fleet at the end of 2003: Most Member States comply with the Entry-Exit regime ceilings, with the exception of Belgium and Italy. Moreover, all Member states, except for Belgium, have met their reference levels.

**Structural aid:** Compliance with the obligation to submit progress reports on the implementation of structural programmes under the Financial Instrument for Fisheries Guidance (FIFG) has improved considerably compared to the previous editions of the Scoreboard. Around 35 % of the reports for 2003 (21 out of 60) and 40% for 2004 (24 out of 60) were received on time compared to 26 % for 2002 (9 out of 49). On the other hand, only one report for 2003 (United Kingdom-Cornwall) and one report for 2004 (Italy) were not submitted compared to three for 2002. In addition, the number of reports that were submitted more than 30 days late has progressively decreased from 25 in 2001 to 10 in 2004. With regard to reports on the implementation of control measures related to the use of structural funds, 39 reports out of 60 were received on time for 2004 compared to 9 out of 49 for 2003. Three reports for 2004 (2 from Italy and 1 from The Netherlands) have still to be transmitted to the Commission.

**Environmental issues:** Only Sweden submitted its 2004 national report on shark finning on time, while five Member States (Ireland, Italy, Malta, The Netherlands and Slovenia) failed to submit their report. All Member States concerned submitted their report for 2003 well after the deadline expired. As for the list of vessels authorised to use drifnets in the Baltic Sea, Germany and Sweden sent their lists for the year 2005 on time, while Poland failed to send its list. In 2004, only Sweden respected the deadline established by the relevant Community rules.

**Serious infringements:** The number of serious infringements detected and reported to the Commission rose to 9,502 in 2003 compared to 6,756 in 2002. As in previous years, the commonest form of serious infringement was unauthorised fishing. In addition, the level of fines being applied across the Community for wrong-doing is not acting as a deterrent and, basically, more needs to be done to deter lawbreakers.

**Infringement procedures:** The majority of the 69 infringement procedures currently pending relate to allegations of

**Governance: Greater involvement of the fisheries sector and other interested parties**

The European Commission believes that it is essential to engage in dialogue with the fisheries industry and other groups affected by the Common Fisheries Policy (CFP). Real dialogue is a prerequisite for successful policies as it generates an exchange of views with fishermen and other stakeholders and provides the Commission with better knowledge about their problems and expectations which in turn can be taken into consideration when proposals for fisheries rules are drafted by the Commission. The industry is also more likely to accept and implement CFP rules if it has been involved in the formulation of these rules.

This is why the European Commission throughout the years has taken a series of measures to strengthen the dialogue with the fisheries sector and other interested parties. One of the first measures was to set up the Advisory Committee on Fisheries at the beginning of the 1970s. The Committee was reformed in 2000 to make it more efficient and to broaden the dialogue with the industry and other stakeholders. New interest groups (aquaculture, Non-Governmental Organisations (NGOs) and scientists) became involved in the committee which was baptised Advisory Committee on Fisheries and Aquaculture (ACFA). ACFA is made up of 21 members representing different interests ranging from vessel owners and fishermen to fish farmers and NGOs. It is consulted by the Commission on measures related to the CFP or it issues an opinion on its own initiative.

The 2000 reform of the ACFA was foreseen in a Commission action plan presented in 1999 aimed at creating the conditions for well-informed and transparent dialogue with all those actively concerned by the CFP. Apart from the renewal of the ACFA, the action plan has given an impetus to a strengthening of the dialogue with the sector through the following actions: 1) Reinforcement of European trade organisations to allow them to better carry out their tasks following the reorganisation of the ACFA. A financial contribution is now available to organisations so that they can meet in Brussels to prepare for meetings of the ACFA; 2) Improving communication to ensure that stakeholders are better informed about the CFP, legislative proposals in the pipeline, scientific advice as well as other aspects related to the CFP. Activities include, for example, the setting-up of various communication tools such as the web site of the Directorate-General for Fisheries on the internet server EUROPA, the bi-monthly magazine "Fisheries and aquaculture in Europe", conferences, targeted information material (printed and audiovisual) as well as contacts with the media.

Despite the progress achieved in terms of strengthening the dialogue with stakeholders, the consultation of the fisheries industry in the framework of the 2002 reform of the CFP clearly showed that there was a need to do more. Stakeholders did not feel sufficiently involved in some important aspects of the CFP, such as, for example, the provision of scientific advice and the adoption of technical measures. Many fishermen, in particular, believed that their views and knowledge were not sufficiently taken into account by managers and scientists.

To address this shortcoming, the Commission proposed to create a network of Regional Advisory Councils (RACs) involving fishermen, scientists and other stakeholders on a regional level. On the basis of the Commission proposal, the Council adopted ( ~ 54 Kb) in July 2004 a common framework for RACs which foresees the establishment of 7 RACs covering 5 geographical areas as well as pelagic stocks and the high seas fleet. They will enable the fishing sector to work more closely with scientists in collating reliable data and discussing ways of improving scientific advice. RACs will submit recommendations and suggestions on any aspects of the fisheries they cover to the Commission and the Member States concerned.

Other consultation initiatives launched by the Commission include Regional Workshops and ad hoc consultations which have been organised to facilitate better understanding between the Commission, Member States, fishermen and scientists. The Regional Workshops have focused on specific fishing grounds or stocks (for example the Mediterranean and Baltic seas, cod, hake and sardine). The Commission has also organised a series of public hearings on key areas of the CFP, such as hearings on monitoring and control and on fleet capacity in 2000 as well as a hearing on the reform of the CFP in 2001. During the comprehensive consultation of stakeholders up to the 2002 CFP reform, the Commission also sent out a questionnaire to 350 fisheries organisations and held more than 30 regional meetings with stakeholders in Member States.

**Analysis**

With the evaluation of the CFP in the early 2000s and its consecutive proposed reforms, the Commission rendered ample attention to the further introduction of participation of the sector in the coming about of fisheries' policy. Today, RACs play an important role in the arena of fisheries policy, bringing together representatives from the fishing industry, angler associations, and environmental and consumer groups.

It might be too early in the development, or perhaps the day-to-day affairs of fisheries are still in dire straits, but looking at the compliance scoreboard a large number of infringements are still noted.

Also, noting the debate around *inter alia* *Ecosystem Approach to Fisheries Management*, *Rights Based Management*, *Effort Based Management*, *Multi Annual management plans*, *Impact Assessment of Management plans*, the commission is searching for an innovative way

to restructure the fisheries management system away from the pomp and circumstance of the TAC and quota regime. In this process, ample input from those concerned is sought.

Having said this, some groups with a declared stake in the issue still feel left outside the debate and groups of fishers are still not convinced they have any influence in the development of measures taken under the CFP.

## Hypotheses (2020)

**1. Participation Frenzy:** Increasingly, stakes and their holders are recognized as being important contributors to the establishment of effective and efficient management measures. However, equity and proportionality aspects result in lengthy, time-consuming procedures bringing the policy process to a halt. The final result is an arena crowded with stakeholders representing different angles and perspectives, unable to arrive at a common ground for further policy-making, so hampering appropriate action being taken.

**2. Governance will Rule:** Within 15 years of the inception of the CFP reforms, putting emphasis on stakeholder participation and general principles of good governance in fisheries management, the development starts bearing fruit. Because the CFP measures are based on a mutually agreed perception of the difficulties needing to be addressed and an open, transparent and responsible process of designing measures, all stakeholders support the management procedures. Infringements are a relic of the past.

**3. Fisherman's Management:** The incapability of the CFP to result in an effective fisheries management system and consequent effective governing of the balance between available fishing capacity and marine resources has brought fishers to the point where they understand that the only way forward is self management. Fishers declare themselves Custodians of the Oceans and come up with a firm management regime for the fish resource.

**4. The Sea-cret Police:** Unable to develop popular support for CFP management measures, the only route left to enforce the regime is by strict Monitoring and Control. A hi-tech platform (Big Brother) monitors all fishing activities. A special policy force controls all seagoing vessels and is present at all fish landing places. High fines aim at taking away possible economic benefits from breaking the rules.

## Sources

- Brussels, 11.06.2003 COM(2003)344 final Communication From The Commission Compliance With The Rules Of The Common Fisheries Policy "Compliance Work Plan And Scoreboard "
- EUROPEAN GOVERNANCE A WHITE PAPER, COM(2001) 428, 2001,
- Hoof, L. van et al , 2003. Evaluating the division of responsibilities in European Fisheries Management Paper presented at the MARE conference People and the Sea II, Amsterdam, The Netherlands, 4-6 September 2003
- [http://ec.europa.eu/fisheries/cfp/governance\\_en.htm](http://ec.europa.eu/fisheries/cfp/governance_en.htm)
- [http://ec.europa.eu/fisheries/cfp/control\\_enforcement\\_en.htm](http://ec.europa.eu/fisheries/cfp/control_enforcement_en.htm)

## EU REGULATION

### B3 Management tools

#### Driver Definition

This driver refers to the tools used for the rational management of marine resources. They include:

- *TACs and Quotas*: Total allowable catches fix maximum quantities of fish that in accordance with the management objectives can be taken from a specific stock over a period. It is a key conservation measure in the CFP. TACS are subdivided into quotas among Member States (MS).
- *Effort control regulations*, which are an alternative management system to TACs. Since 2003, the EU has started to use both management systems in parallel by supplementing the traditional TAC restrictions with days-at-sea restrictions. Effort management is based on homogeneous fleet units, rather than on stock units, as in a TAC system, and the fleet units are regulated according to their capacity, activity, and fishing pattern.
- *Technical measures* which focus on: (a) improvements to fishing gears, and (b) minimum landing size regulations. Fishing gear improvements refer to a range of technological solutions that aim to improve selectivity in order to reduce catches of protected species. Hence, the main goal of technical regulations is to reduce the catches of undersized fish and endangered species.
- *Spatial fishery closures*, including Marine Protected Areas (MPAs), which can be beneficial in providing refuge to threatened species, protecting ecosystems or habitats with particularly rich biodiversity, facilitating recovery of areas that are already damaged, protecting breeding stocks, improving recruitment to neighbouring areas, or restocking marine species of commercial interest. MPAs are a particularly useful tool in the case of ecosystem management.
- *Relative stability, subsidies and property rights*

#### Relevant Indicators

- Compendium of legislation, obligations agreements within CFP.
- TAC by stock/species; quotas attributed to MS. Quota management by MS (e.g. ITQs,)
- Restrictions on fleet size (total number of fishing vessels) and fleet capacity (gross tonnage) ;
- Minimum landing size regulations
- Working time restrictions (number of days at sea) for the fishing fleets
- Subsidies
- Evolution in the establishment of MPAs (e.g. percentage of total fishing grounds)

#### Developments over the past 20 years<sup>12</sup>

To promote the sustainability of fishing activities in EU waters and to protect a specific stock or a group of stocks, the EU may use a number of conservation measures. These measures include:

- Total Allowable Catches (TACs) to limit the maximum amount of fish that can be caught from a specific stock over a given period of time.
- Technical measures, such as mesh sizes, selective fishing gear, closed areas, minimum landing sizes, and by-catch limits. Fisheries in EU waters and by EU

---

<sup>12</sup> Also see Driver F2

vessels in international waters are covered by different technical measure regulations, one for each of the areas of the Mediterranean (Council regulation 1626/1994), the North Sea (including Kattegat and Skagerrak) and the Atlantic (Council regulation 850/1998), the Baltic Sea (Council regulation 88/1998) and the Antarctic (regulation 600/2004). Given the nature of fisheries and the extension, over the years, of European Union waters, it is not surprising that the regulations on technical measures have evolved in an *ad hoc* manner. For example, the main legislation concerning the North Sea originally consisted of a set of rules established in 1986. After some 20 amendments it was replaced, in 1997, by a new regulation (Council regulation 850/1998) which came into effect in the year 2000. Rules were simplified and adapted to the current needs of the industry and to promote conservation of fish stocks.

- Limiting fishing effort by reducing the number of fishing days at sea of fishing vessels. Fishing effort can be reduced in various ways. Since 1995 all vessels fishing in EU waters and EU vessels operating outside EU areas are required to carry a fishing licence. Fishing effort can be regulated through the allocation of special fishing permits stating the terms of access, time and specific fisheries. The Council of Ministers decides which fisheries require such permits and the conditions attached to fishing. Fishing effort reductions may also take the form of a permanent withdrawal of vessels or the temporary cessation of fishing activities. Such measures may receive financial support from the Financial Instrument for Fisheries Guidance, although temporary cessation of fishing activities will only be supported in the following cases:
  - in the event of unforeseeable circumstances, particularly those caused by biological factors;
  - where a fisheries agreement is not renewed, or where it is suspended,
  - where a recovery or management plan is adopted by the Council or where emergency measures are decided by the Commission or by one or more Member States,

The 2002 reform of the CFP identified limitation of fishing effort together with limitation of catches (TACs) and technical measures as the main measures to be used in managing fisheries. The reform furthermore opened a more long-term approach to fisheries management, involving the establishment of multi-annual recovery plans for stocks outside safe biological limits and of multi-annual management plans for other stocks. These plans - tailor-made to the state and characteristics of each stock and the fisheries in which they are caught - include multi-annual catch targets and effort limitations adapted to these targets, when necessary to achieve the plan's objective. They also include other measures as appropriate. An important element of the plans is to avoid sudden changes in catch limits (TACs) from one year to the next, and to allow fishers to operate under more stable conditions and to plan their fishing activities better. A number of recovery plans have already been put in place (for a series of cod stocks (Regulation (EC) 423/2004 ) and for northern hake (Regulation (EC) 811/2004 ) while plans for other stocks will follow.

- Fixing the number and type of fishing vessels authorised to fish

*TACs and Quotas are for fishing zone VIa (West of Scotland). Source: Europa (www.europa.eu.int).*

Species	TAC (Tonnes)		
	2007	2006	2005
Cod	490	613	721
Haddock	7,200	7,810	7,600
Whiting	1,020	1,360	1,600
Saithe	12,787	12,787	15,044
Plaice	786	786	982
Anglerfish	5,155	4,686	4,686
Megrims	2,880	2,880	2,880
Herring	47,860	49,400	44,100
Herring (Clyde)	800	800	1,000
Mackerel	422,551	415,824	420,000
Blue Whiting	N/A	N/A	N/A
Norway Lobster	19,885	17,675	12,700

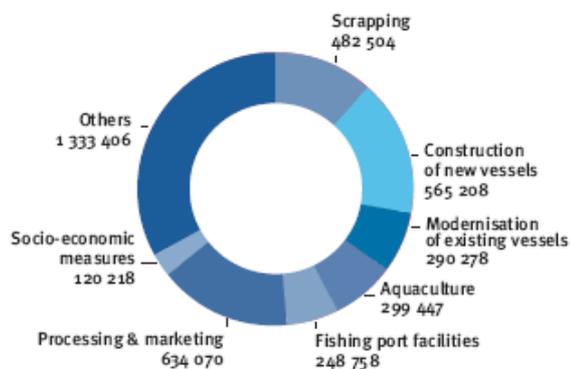
**2007 DAYS AT SEA REGIME**  
(provisional – subject to clarification)

Gear Type	Region	Base Days	Decomm days	Total
120mm+	North Sea	96	60	156
	West of Scotland	85	60	145
	Irish Sea	114	60	174
100 – 120 mm	North Sea	95	60	155
	West of Scotland	84	60	144
	Irish Sea	105	60	165
90 – 99 mm (incl nephrops)	North Sea	209	0	209
	West of Scotland	227	0	227
	Irish Sea	227	0	227
	Eastern Channel	227	0	227
70 – 89 mm (incl nephrops)	North Sea	204	0	204
	West of Scotland	227	0	227
	Irish Sea	227	0	227
	Eastern Channel	221	0	221
Beam Trawl		132	12	144

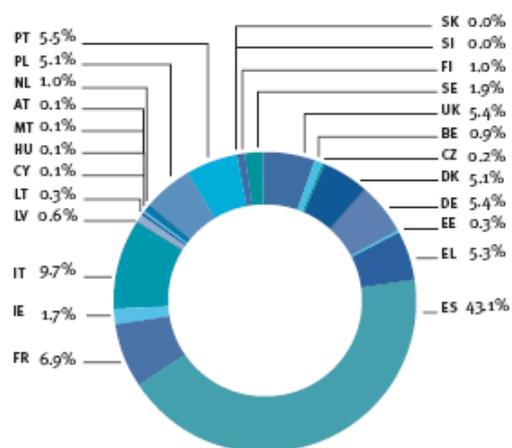
Additional days for: Accepting Administrative Penalties  
Enhanced Monitoring  
Voluntary Participation in Irish Sea Discard Project

Source: DEFRA Sea Fisheries Conservation Division

**Distribution of FIGG allocations by area of assistance for the 2000-2006 programming period**  
(in thousands of EUR)



**Share of total EU structural aid by Member State (2000-2006 programming period)**



**EU and national aid to the fisheries sector**  
**Distribution by Member State for the 2000-2006 programming period** (in thousands of EUR)

	Total	Total public aid		Scrapping		Construction of new vessels		Modernisation of existing vessels	
		EU	National	EU	National	EU	National	EU	National
BE	68 927	37 035	31 892	-	-	3 730	4 973	6 000	6 000
CZ	10 331	7 252	3 080	-	-	-	-	-	-
DK	3 07 800	204 500	103 300	16 800	16 800	30 300	10 100	40 300	13 400
DE	289 375	216 478	72 897	6 700	6 334	16 239	2 971	15 817	2 886
EE	18 408	12 469	5 939	2 030	507	-	-	-	-
EL	286 078	211 100	74 978	45 175	15 058	17 093	2 442	15 195	2 171
ES	2 413 473	1 712 000	701 373	126 364	52 362	3 69 807	116 498	103 229	36 815
FR	5 52 060	274 482	277 578	11 144	10 381	35 264	56 910	21 926	33 557
IE	87 386	69 530	17 856	4 760	1 720	11 690	2 530	11 690	2 530
IT	757 516	385 923	371 593	104 513	104 468	19 190	8 837	28 785	13 255
CY	7 738	3 419	4 319	1 486	1 486	-	-	188	313
LV	32 187	24 335	7 852	-	-	-	-	-	-
LT	17 188	12 117	5 071	-	-	-	-	-	-
HU	5 731	4 390	1 341	-	-	-	-	-	-
MT	3 593	2 838	756	-	-	-	-	-	-
NL	86 000	38 100	47 900	2 068	2 068	-	-	6 850	6 850
AT	11 302	5 026	6 276	-	-	-	-	-	-
PL	281 945	201 832	80 113	80 121	26 707	4 747	678	16 276	2 374
PT	283 448	217 745	65 703	18 432	5 810	39 112	10 974	8 332	2 231
SI	2 375	1 781	594	-	-	-	-	-	-
SK	2 613	1 829	784	-	-	-	-	-	-
FI	89 086	38 953	50 133	2 500	2 500	1 035	1 765	2 040	3 510
SE	114 132	74 067	40 065	5 514	5 438	8 000	2 665	8 000	2 665
UK	320 269	216 588	103 681	54 898	47 794	9 000	2 900	5 650	558
EU-25	6 048 999	3 973 889	2 075 071	482 504	299 433	565 208	224 244	290 278	129 114

*Marine Spatial Planning (MSP)* is a much more recent idea and is seen as a way of improving decision-making and delivering an ecosystem-based approach to the management of marine activities. In essence, it is a plan-led framework that allows integrated, forward-looking, consistent decision-making on the use of the sea. MSP will also provide a more transparent process of conflict resolution in a situation where there are many demands for the use of marine resources and sea space. The main elements of MSP are likely to include an interlinked system of plans, policies and regulations; the components of environmental management systems (e.g. setting objectives, initial assessment, implementation, monitoring, audit and review); and some of the many tools that are already used for land-use planning. Whatever the building blocks, the essential consideration is that they need to work across sectors and to give a geographic context in which to make decisions about the use of resources, development, and the management of activities in the marine environment. There is momentum for the establishment of MPAs and development of a system of MSPs driven by international, European and national initiatives. In the case of MPAs, commitments stemming from the Convention on Biological Diversity (CBD) and the Oslo & Paris Commission (OSPAR) are important influences. The CBD and the Jakarta Mandate include principles and timetables relevant to MPAs. The CBD has marine and coastal protected areas as one of its themes, and it has taken on board the goal adopted at the 2002 World Summit on Sustainable Development to establish representative networks of protected areas in the maritime environment by 2012. The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) came into force in 1998. Annex V (on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area) gives the OSPAR Commission a duty to develop means, consistent with international law, for instituting protective, conservation, restorative or precautionary measures related to specific areas or sites or related to particular species of habitats. Workshops under the auspices of the OSPAR working group on Marine Protected Areas and Species & Habitats (MASH) have developed guidelines for identifying, selecting and managing MPAs. A target date of 2010 has been set to achieve “an ecologically coherent network of well managed Marine Protected Areas”. This is linked to an agreement made by environment ministers at the Fifth North Sea Conference to establish such a network of MPAs by that date. At a European level, the EU Habitats and Species Directive (92/43/EEC) has had a major influence on the UK MPA programme. The Directive requires the establishment of protected areas (Special Areas of Conservation – SACs) for a number of listed habitats and species in areas of sea under the jurisdiction of member states (i.e. out to the 200 nautical mile limit). By 2000, 33 reserves had been created in the northwestern Mediterranean alone by EU member-states.

The European Commission (EC) is also promoting the idea of marine spatial planning. In its strategy for the marine environment, published in 2002, it indicated that it “will address the integration of nature protection measures and the various sectoral activities impacting on the marine environment, including spatial planning”. A subsequent stakeholder conference on the strategy concluded that “principles from spatial planning should be considered to establish a good basis for a more integrated approach of the marine area”. There is no indication yet as to how the Commission might help put this into practice. The EC initiative on Integrated Coastal Zone Management (ICZM) is also relevant. A Council Recommendation, adopted in 2002, called on Member States to carry out “stocktakes” to analyse which actors, laws and institutions influence the planning and management of their coastal zones.

The area of MPAs ranges from 21.5 hectares (Medes Sea Park in Spain, Catalonia) to 220,000 hectares (Alonnisos National Park in Greece).

*Analysis:*

- *TACs and Quotas:* these are currently pivotal in the management system. Discussion on quota system continues, especially aspects of transferability of quota. TACs are not stable, but vary over time. One of the criticisms of the TAC system is the highly volatile nature of the year-on-year advice. The Sector and the Commission are looking into ways of obtaining a) advice earlier in the year in order to allow for a proper consultation on the advice, and b) more long term management objectives.
- *Effort control regulations:* these have been debated for quite some time. Currently the CFP has a two-tier system with a TAC limiting landings and days-at-sea limiting fishing effort. An effort regime might develop into the alternative for the current TAC-based system
- *Technical measures:* A wide range of measures exist (such as minimum landing sizes, mesh sizes) and continue to play a role in management.
- *Spatial fishery closures:* temporal spatial closures (such as the plaice box and the cod recovery plan) are increasingly utilised to manage fisheries. In future, following WSSD-agreed measures, MPAs will increasingly be used. Debate on (restricted) utilisation of MPAs for activities such as fisheries is currently taking place.
- *Relative stability:* this fixed key of dividing TAC over nation states is one of the fundamentals of the CFP. It is acknowledged that the introduction of transferable rights will pressurize this instrument. On the other hand, with quota swaps and quota trade already, an international flow of fishing rights already occurs.
- *Subsidies:* Despite a policy of reducing the utilisation of subsidies, subsidies still play an important role in fisheries management.
- *Property rights:* At this moment, the Commission and Parliament are holding a debate on fisheries management through the use of property rights.

**Hypotheses (2020)**

1. **Something’s got to give:** Fisheries management will remain based on TAC/quota, technical measures, effort control, and days-at-sea. The problems of this management regime, such as the rather *ad hoc* year-on-year plans, an economically underperforming fleet and overfishing of some stocks, will become bigger in future as the limits of the system are reached.

2. **A brand new day:** the basis of the fisheries management system is changed. Although still based on rigorous stock assessment and harvest control rules, the fabric of the management system is based on effort management through a system of transferable effort titles. This market approach enables other stakeholders (NGOs, recreational groups...) to buy quota or access.

3. **We can work it out:** Following the participation trend and good governance principles, the basis of fisheries management will shift towards a dialogue between fishers and fisheries managers. Long-term management contracts will be concluded based on local knowledge; fishers become fish managers and local groups will police their interests. Fishing communities will regulate and control access.

**4. The long and winding road:** Instead of a sudden change in the management regime, rather upsetting the existing management structure and arrangements, the new management institutions and instruments are introduced gradually. While safeguarding vested interests, the gradual change also implies that benefits of the management regime only become tangible slowly. Change comes too slowly to have any real effect.

## Sources

- "The Knowledge Base for Fisheries Management". Eds. L. Motos, D.C. Wilson. Elsevier, Oxford, Developments in Aquaculture and Fisheries Science, 2006.
- European Commission Facts and figures on the CFP Basic data on the Common Fisheries Policy Luxembourg: Office for Official Publications of the European Communities 2006 – 37 pp. — 14.8 x 21 cm ISBN 92-79-00898-6
- Aberdeenshire Statistics Fishing Industry Statistics TACs and Quotas April 2007
- MARINE RESERVES — PRESSING PROBLEMS
- <http://www.biodiversity.ru/eng/publications/znpn/archive/n39/marine.html>
- Marine Protected Areas in the context of Marine Spatial Planning – discussing the links A report for WWF-UK by Dr Susan Gubbay 2004

## EU REGULATION

### B4 National policies

#### Driver Definition

Especially in fisheries management, distinctively more than in aquaculture policy, the primacy for regulations lies in Brussels (the subsidiarity principal). However, the way in which these general management directives are operationalised differs widely depending on the local context, be it on a national or even a local scale. In order to fully comprehend local management practices a basic understanding of the context in which this is taking place and the wider institutional and governance tradition in which it is embedded is needed.

#### Relevant Indicators

- Management context and institutional setting and development

#### Developments over the past 20 years

The RESPONSIBLE study (2006) concludes:

Public policy-making in fisheries is rooted in institutions and traditions that emphasise consultative practices and user involvement across a wide range of sectors and industries. Whether we are talking of fisheries, farming, water, aquaculture or the environment, some form of stakeholder involvement is clear. Centralisation of decision-making is probably no stronger in fisheries than elsewhere, even though both Denmark and Norway have stuck to structures that retain much power and influence in the hands of central government. Other countries - France, Spain, Netherlands and the UK - have 'experimented' with decentralised structures to an extent that justifies the, albeit tentative, conclusion that fisheries management does not differ significantly from other policy areas in this regard.

On the other hand, corporatist traditions are probably stronger and more prevalent in fisheries than in the other sectors. Recent developments - in the Common Fisheries Policy (CFP) as well as in Norwegian fisheries management - indicate that the difference between fisheries and other sectors may be shrinking. Within the CFP, there is greater emphasis on participation, accountability and transparency, and the concept of 'stakeholder' is replacing that of 'user groups' in public debates on fisheries management.

A highly dynamic relationship exists between EU-level fisheries management and national fisheries management systems. EU countries that differ in socio-political traditions will also differ in their visions of how decisions should be taken at a European (EU) level. Furthermore, desires expressed as to preferred changes to the system, be they articulated by national authorities or specific interest groups, may well be based on vested interests. So far, the EU system has tackled this issue by centralising decision-making in the hands of the Commission and the Council of Ministers with regard to policy making, and by attempting to delegate responsibilities towards the fishery sector and Member States with regard to implementation and enforcement. Following the Green Paper, in order to tackle one of the main weaknesses of the system, the 2002 reform seeks to modify the consultative framework at policy conception level.

Accountability within the EU decision-making system leaves much to be desired. The increasing numbers of consultations before or after the Commission's proposals are not making the process more open and/or transparent. In addition the knowledge base of the CFP at present is exclusively focused on stock assessment. This is due to the fact that the management system is based on a set quota share per country: the principle of relative stability. As a consequence, setting EU quotas has become an object of bargaining at all

levels of the decision-making system. This is partly recognised in the Green Paper, in its proposal to centralise more decisions at EU Commission level when it comes to the management of endangered stocks. Within this configuration, centralisation may be the only feasible solution but, as we know, centralisation may lead to problems that might weaken the performance of the management system. The discussion on how to share responsibilities in fisheries management is therefore also one of how to facilitate institutional reforms within European fisheries management and how to adapt to the institutional environments.

Reforms in fisheries management institutions take place within - and are influenced by - the historical tradition of policy formulation in the specific countries. The first step in reforming fisheries management in Europe, then, is to understand the present institutional landscape. It is impossible to establish a uniform institutional landscape in European fisheries, especially when taking into account the many institutional divergences that can be observed in Europe. On the other hand, some form of uniformity is needed at the general EU level in order to generate integration and equal opportunities for European citizens and ensure sustainable resource exploitation. The challenge is to balance the EU requirements for uniformity against the diversified cultural and political traditions in the various countries.

Focusing on the policy-making process it is suggested we address design issues in relation to governance principles - moving beyond the particular resource use situations at hand, such as those pertaining to the quality of representative democracy and the legitimisation of power. This raises questions such as where to put the locus of decision making, who should be represented, and what should be the scope of the jurisdiction. In this case the evaluative criteria are not just economic efficiency and social equity. Therefore, the evaluation of fisheries management systems should focus on the process of policy-making, implementation and enforcement.

Attempts to decentralise European fisheries management have taken two different routes: a move towards regionalisation in countries such as Spain, France and the UK (descending order of significance); no division of responsibilities to regions in countries such as Denmark and the Netherlands (ascending level of centralisation), but degrees of devolution through a system of (corporatist) consultation with professional organisations, user groups and other stakeholders involved.

Although stakeholders can have an influence on management decisions either through an advisory role or via lobbying, final decisions are taken by the relevant Fisheries Ministries. Despite cases of regional decentralisation, little is seen in terms of formal local level management (although some forms of shared management or co-management can be found). In addition, participation in policy-making processes has become a professional activity requiring particular resources and skills.

When it comes to other stakeholders, such as the fish processing and trade industry, other user groups and interest groups (such as environmental groups), the direct participation in fisheries management is rather limited. However, through lobbying and other strategies, these other stakeholders can have a significant influence on the design of fisheries management systems.

For the EU member states, domestic policies are increasingly being shaped by the CFP. The sheer magnitude of policies and measures - for resource conservation, structural adjustments, market conditions and for alleviating social and economic impacts - have resulted in a myriad of rules and regulations, at times contradictory and lacking in coherence.

Taking all of the above and the experiences of individual countries into consideration, it is not surprising that the effectiveness of the fisheries management systems leaves room for improvement. Having said this, however, our starting point should be that in all cases a working fisheries management system is in place that fits the existing political and institutional traditions. These systems have developed from, and are embedded in, the cultural, social, historical, physical and institutional context of each country. Therefore, it is not an aim to develop one single alternative for all the systems covered by our research.

In each country fisheries management is entangled in an ongoing process of change. This change is incremental, proceeding step by step, triggered by factors that are both internal and external to the fishing industry and to the fisheries administration. Outcomes of this process seem to be quite unpredictable; there is no grand design, no overall strategy based on a comprehensive analysis of what institutional reform is needed. One of the 'drivers' for change in European fisheries, however, is the CFP itself. Although the CFP is conceived as an external force, it comes from within the EU countries through the Commission, Parliament and especially the EU council. Legitimacy, or the lack of it, continues to be an issue in the CFP.

The sharing of responsibilities, or devolution, is generally perceived to be a response to this lack of legitimacy, because it is an obvious way of closing the gap between decision-makers and stakeholders. Devolution does not always have to be legitimised as a step towards greater efficiency, but may be something that would be regarded as a step towards more democracy because it would mean the involvement of segments of society and stakeholders that were previously not allowed to play a role in the decision-making process. More transparency may in some instances be contrary to a more effective management process, because it facilitates the creation of veto points where management decisions can be challenged and overturned.

Openness and participation, as two essentials of good governance, are no guarantee for less conflict and dispute in fisheries management. Fisheries management is indeed inherently conflictive, because it is about regulating social relations among parties with different worldviews and interests. Managing conflict will, under any circumstance, be an important part of the game.

In many instances, fisheries management needs a regional, supra-national focus as several countries share the same common pool resource. Consequently, decentralisation and devolution may take the shape of regionalisation at the level of, for example, the North Sea.

## **Hypotheses (2020)**

1. **One size fits all:** The heterogeneity of fisheries management instruments and institutions at national level is replaced by a centrally run European structure, bringing about a level playing field with a homogenous set of tools to be applied in all cases.
2. **Tailor-made solutions:** Noting that all national institutional settings require specific solutions, subsidiarity is still the principle for which Brussels has the prime role in devising fisheries management measures, but the solutions are at the local level, tailored to specific requirements. The RACs play an important role in devising these measures. This results in a patchwork structure of different management regimes across EU waters as the broad Brussels' guidelines leave leeway for specific management systems.
3. **Splendid Isolation:** The lengthy and unstructured process of reform of the CFP, taking a prolonged period of time and lacking a concrete end goal, has fed Euro-scepticism especially in Fisheries Management. This has led nations to back away from a central CFP and to start managing the resources by themselves.

## **Sources**

- Hoof, L. van et al. Sharing responsibilities in fisheries management, August 2005 Report 7.05.05, LEI, The Hague, EU FP6 project. ISBN 90-8615-023-3;

**EU REGULATION**

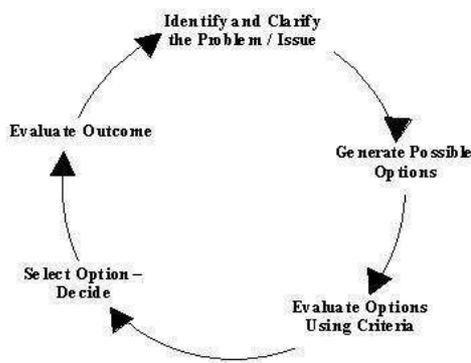
**B5 Politics**

**Driver Definition**

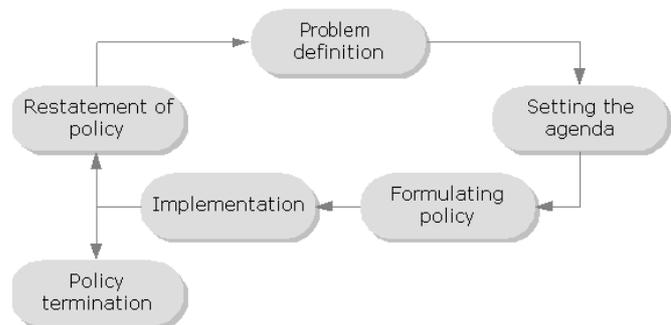
Where governance focuses on the process of governing the system, taking different perspectives, institutional settings and (stakeholder) involvement into consideration, this driver focuses solely on the influence of the political decision-making process. In the political model the individuals involved do not accomplish the decision task through rational choice in regard to objectives. Decision-makers are motivated by and act on their own needs and perceptions. This process involves a cycle of bargaining among the decision-makers in order for each to try to get his or her perspective to be the one of choice. More specifically, this process involves each decision-maker trying to sway powerful people within the situation to adopt his or her viewpoint and to influence the remaining decision-makers (Allison, 1971; Cheshire & Feroz, 1989; Lyles & Thomas, 1988; Schneider, Shawver & Martin, 1993).

Furthermore, the political model does not involve making full information available or a focus on the optimal viewpoint like that of the rational model (Lyles & Thomas, 1988). Full information is highly unlikely, since the political model operates based upon negotiation that is often influenced by power and favours. In fact, information is often withheld in order to better manoeuvre a given perspective. As information is often withheld and subsequently incomplete, the optimal viewpoint is not a key aspect of this model.

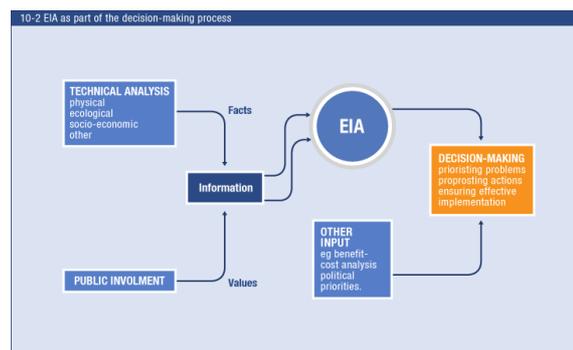
Compared with the basic decision cycle (see below) the political decision cycle centres on formulating policy based on setting a (political) agenda. This political agenda is influenced by an array of factors stemming from views of the constituency, public opinion, as for example generated in the media, and political priorities. This renders politics a special niche in the decision-making process as is depicted below: after facts and values have been considered, the final decision takes place in the political arena.



**Basic decision cycle**



This situation has on the one hand a clear bearing on governance aspects (especially on criteria such as access to the decision-making process, stakeholder participation, transparency, openness and responsibility and accountability). On the other hand, if one wants to predict a possible future one has to take the political climate and political fashion into consideration. Current political trends centre for example on globalisation versus localisation and regionalisation; public versus private tasks in the public domain; free market



trade versus protected interest; towards one EU federal state versus nation states.

## Relevant Indicators

It is quite difficult to capture a volatile system such as politics in a simple set of clear relevant Indicators. Tying in with governance, the starting point is a description of the institutional setting and the tradition in which the political system is embedded. Building on this one can look at:

- Political trust
- The current political situation
- Political expectations

## Developments over the past 20 years

Next to looking at macro trends, in fisheries and aquaculture one has to take specific political trends into consideration. For example, in fisheries it is clear that a system based on a TAC/quota is prone to political influence. Whereas the scientific basis of TAC advice lies in stock surveys and the advice of ICES and the STECF, it is the prerogative of the Council of Ministers to decide on the specific policies.

First and for all, the perceived importance of national fisheries, in economic, social or political terms, plays a major role in the position of nations in the fisheries debate. In the debate, there are clusters of opinions. For example there is a divide between the so called “Friends of the Fish” (countries with mainly a stock and nature conservation goal) and the “Friends of the Fisher” (countries that try to maintain [local] fisheries activities). Part of this divide parallels the perception in national policies of fisheries being an economic activity, just as any other activity, vs fisheries being perceived as an important form of local employment and a fundamental of the coastal community fabric. Next to this we can find a number of countries who put great emphasis on the environmental parts of fisheries. Those nations in which fisheries are relatively unimportant in a macro-economic sense are in this group.

Next to this direct perception of fisheries, as articulated in a national fisheries policy signature, two other phenomena can be witnessed in the European arena. The first is the negotiation tactics. For one it is clear that in the bargaining process towards a decision, nations enter a process of give and take. Of course this can be directly related to fisheries (“we accept this decision but then you have to agree to...”), but it can also be used in a wider political arena: “if today in fisheries we agree to allow you to .... Then you have to agree to ....” – in another dossier).

The second phenomenon can be labelled the general principle. Some nations in a debate choose to let a more general principle prevail over a concrete opinion on a fisheries subject (for example: no subsidies.. even if this implies that it will affect their own fisheries severely).

## Hypotheses (2020)

1. **Technocropolis:** Fisheries management is taken out of the political arena. Fisheries management is perceived as a rather technical matter in which the biological limits ( $B_{lim}$ ,  $B_{pa}$ ) set off predefined management measures. Social and economic consequences are assessed but are perceived as logical outcome of this process.

2. **Agora:** Following the participation trend in fisheries management, fisheries management increasingly moves away from objective scientific values and towards political consensus. Fora such as the RACs and ACFA design the policy measure to be taken and the Council follows this advice. Basic make-up is a long-term framework of targets from an ecological, economic and societal perspective. Owing to this long-term commitment, the fishing industry is more likely to treat stocks as an economic asset in which it is worthwhile investing

3. **The Global Economy:** The trend towards globalisation and privatisation gives the EU no other option than to regard fisheries as an ordinary economic activity in a competing world market. International fish flows take away competence from nations in terms of managing fisheries. EU COM becomes the sole manager of marine natural resources including the living resources. The main focus is obtaining enough marine animal protein to feed Europe.

4. **Small ain't that bad:** Fear of losing control over fisheries management, and hence its importance for local communities and economies, brings nations to the point where they take fisheries management back into their own hands. EU DGFISH, already on the brink of being dissolved as fisheries is globally not perceived as an important dossier, ceases to exist. Shared stocks become a source of heated debate between countries.

5. **I-fisheries:** The influence of personal dominant perception guides policies. Short-term interests govern fishery decisions. A common property is turned into a selfish managed produce.

## Sources

- [http://eia.unu.edu/course/?page\\_id=173](http://eia.unu.edu/course/?page_id=173)

## **SEAFOOD MARKETS AND ECONOMICS**

# SEAFOOD MARKETS AND ECONOMICS

## C1 Product diversification

### Driver Definition

Changes in consumer preferences and habits are driving the development of new seafood products. New products are a response to the needs for tasty, healthy, convenient and/or functional food.

### Functional food

Consumers and producers are becoming increasingly aware of the link between food stuffs and diet and health aspects. This is why we are constantly seeing new products being launched onto the market that are fortified with additives that are supposed to provide additional health benefits beyond basic nutrition. This is referred to as "functional foods".

Functional food or medicinal food is any fresh or processed food claimed to have a health-promoting and/or disease-preventing property beyond the basic nutritional function of supplying nutrients, although there is no consensus on an exact definition of the term.

This is an emerging field in food science, in which such foods are usually accompanied by health claims for marketing purposes, such as, "*cereal is a significant source of fibre. Studies have shown that an increased amount of fibre in one's diet can decrease the risk of certain types of cancer in individuals.*"

Functional foods are closely related to the notion of *nutraceuticals*, a blend of the words nutrition and pharmaceutical, referring to food, or parts of food, that provide medical or health benefits, including the prevention and treatment of disease. The general category includes processed food made from functional food ingredients, or fortified with health-promoting additives, like "vitamin-enriched" products, and also, fresh foods (e.g. vegetables) that have specific claims attached. Fermented foods with live cultures are often also considered to be functional foods with probiotic benefits.

The term was first used in Japan in the 1980s, where there is a government approval process for functional foods, called Foods for Specified Health Use (FOSHU). Some countries, such as Canada and Sweden, have specific laws concerning the labelling of such products.

### Relevant Indicators

- Number of new products in supermarkets shelves for a given period
- New "functions" (for functional food)

### Developments over the past 20 years

Functional food is imbedded in a array of different themes, like for instance:

- new functional food ingredients: cardiovascular health.
- new functional food ingredients: cancers and oxidative degradation.
- dietary fat and cardiovascular disease:
- diet and cardiovascular disease:
- diet and bone health:
- diet and cancer:
- plant foods and cancer prevention:
- food allergy:
- obesity:

- nutrition and healthy ageing:
- probiotics (microorganisms, like bacterias et.c)  
antioxidants in the diet
- weight control and health

### Functional food in the seafood sector

One important trend is the assigning of functions to food. By adding ingredients into food, it could serve a function in improving health. Some functions has been covered for some time, like Omega 3 for avoiding cardiovascular diseases.

Several possibilities are being researched in the seafood sector:

#### *Fish powder*

Fish powder is used in particular in the manufacture of health food products, but also as flavouring agent in fish products. During the production of powder, antioxidants are being destroyed. The current solution is to add synthetic antioxidants. "*If we can retain more of the natural antioxidants in the raw fish material, we can gain a product with improved taste and oxidation stability.*"

#### *A future for roe and milt?*

Researchers now look for components in herring roe and milt that for usage as ingredient in healthier foods and/or development of new medicine. Fatty substances, proteins and water-soluble components are the most interesting.

Many studies have documented the prophylactic effect on several diseases. But we have little knowledge about the reasons for the medicinal effects. Several studies have documented that the positive health effects from seafood cannot be explained by ingestion of fish fat alone, studies also indicate that components with positive health effects are removed through various production processes, such as heat treatment and refining.

#### *Marifunc*

There is still limited knowledge about the connections between different components in fish and crustaceans and the actual health-related effects. This is the focus of the Marifunc-project.

## **\_Hypotheses (2020)**

1. **Functional consumer:** Most products consumed in 2020 perform a function for improved health or beauty; examples ranges from heart-friendly butter to chocolate making your skin softer.
2. **Eight days a week:** The processing industry has not been able to produce any new products. Fish is mainly sold in it's traditional forms. Advanced food markets are dominated by produce from farmed animals.
3. **From waste to taste:** Extensive research on the alternative use of skin, bones and other fish waste has led to a wide array of products and uses. Reshaping and taste-enhancing.

## SEAFOOD MARKETS AND ECONOMICS

### C2 Processing (capabilities)

#### Driver Definition

Before any fishery product is marketed it is often handled, prepared or processed in some way. This includes cutting, filleting, salting, drying, smoking, cooking, smoking, freezing and/or canning.

The European fish processing sector employs a significant number of people throughout the Union. More than 135,000 people are employed in the sector Union-wide<sup>13</sup>. Processing of seafood is an important activity in many parts of Europe.

The most important types of products produced by the fish processing industry are processed and canned fish (€6.7 billion) followed by fresh, chilled, frozen, smoked or dried fish (€5.2 billion). Companies in the fish processing sector are especially vulnerable to the fluctuations in supply. To ensure a regular supply of fishery products, EU companies have to rely on imports.

The consumption of processed fish products, especially in the form of prepared meals, has increased in the Community. The value of processed fishery products produced by the sector stands at about €18 billion a year, almost twice the value of European landings and aquaculture production combined. Production has continued to grow in recent years.

#### Relevant Indicators

- Employment
- Processed products and raw material flows
- Turn over of the processing industry

#### Developments over the past 20 years

##### Processing

In 2004, about 75 % of world fish production was used for direct human consumption, while 25 % was used for fishmeal and oil.

The EU market for seafood is steadily growing, with about 1,5 % a year (Salz 2006). Increasing demand for seafood in the EU results in new business opportunities for some, while other businesses struggle to survive. The processing industry face problems related to labour costs, raw material supply and competition from imports.

##### Globalisation puts a pressure on EU-processing

Some firms in the seafood industry have grown to become true Multi National Companies, with both production facilities and sales offices on all continents. Alliances and joint ventures, along with mergers and acquisitions, are surely in vogue. This has lead firms to become larger, more integrated and more international. This development is in many ways a response to the restructuring of supply chains and retail markets. With large retail chains oligopolizing the market, producers of fish need to be larger and more international to be able to serve these customers.

<sup>13</sup> According to the European Commission :  
[http://ec.europa.eu/fisheries/cfp/aquaculture\\_processing/processing\\_en.htm](http://ec.europa.eu/fisheries/cfp/aquaculture_processing/processing_en.htm)

In a not so distant past, most fish was landed by coastal vessels, processed by local industry and then exported. An important technological shift is the growth of on-board freezing facilities, thus enabling long-distance transportation of frozen fish to the processing site. With improved logistics and cheaper transportation, frozen cod may be sourced in the North Atlantic, processed in low-wage countries like China or the Baltic, and then brought back to traditional core markets for cod, like the UK or Germany. Thus, the advantage of being located close to the fishing grounds is severely reduced (Iversen 2004). And as a result, during the last ten years, processing of seafood has to a larger extent moved to locations with cheaper labour.

As a result, employment in processing is decreasing in many European countries. Large shares of production are rationalised or automated, while a restructuring of the processing industry takes place. Many smaller companies stop their business as customers get larger and fewer. This is especially the case in regions dependent on fisheries. In processing of aquaculture products, employment is increasing. Processing of farmed salmon is estimated to support 31.000 jobs in the EU (Winther, Sandberg et al. 2005).

#### *Employment*

Employment in the European fish processing industry has seen a steady overall decrease, but with different development for different countries and regions. In 2002/2003 the EU fish processing industry employed 147.000 people<sup>14</sup>. In 2005 this was reduced to 137.000<sup>15</sup>.

The distribution of employment in fish processing is quite different to that of employment in marine fishing. Fish processing is more evenly distributed throughout the EU, with the UK accounting for 18,140 jobs (20% of the EU total in this activity). France, with 11,899 (13%) and Spain with 15,449 (17%) employed also have significant employment in fish processing. Italy and Greece, despite having relatively high numbers employed in fishing (18% and 17% of fishers) have only relatively low levels of employment in processing (accounting for 7% and 3% of processing employment). This is the converse of the situation in Germany, which has a relatively large processing sector of 11,280 (13% of the EU processing employment), compared to employment in fishing of only 2,932 (1% of fishers).

Despite the expansion of the EU, employment in fish processing fell from 104,316 in 1990 to 89,468 in 1998 (a decline of just over 14%). Portugal and Denmark experienced the largest apparent declines in employment in processing. Significant declines were also suffered in Italy, France and the UK (around 20% over the period). Spain experienced a lesser decline (around 12%) and numbers employed in fish processing appear to have increased slightly in Belgium and in Germany.

#### **Dependency of the processing sector on the EU fishing industry**

Whereas numbers employed in processing have fallen by 14%, employment in fishing has declined by 21% over the same period. In many sectors of the EU processing industry there is no directly proportional link between employment at sea and employment in processing. It is known that the EU imports substantial quantities of fish to be used as raw material for processing and the importance of imported raw material in sustaining employment in the fish processing industry is recognised by the Common Fisheries Policy in the establishment of import tariffs for fishery products.

Some of the major imports are white fish fillet blocks, herring, tuna for canning and frozen crustacea<sup>16</sup>. Overall, only an estimated 53% of processing jobs appeared to be dependent on EU landings in 1996/97. Sectors of the EU processing industry which are considered to be

<sup>14</sup> [http://ec.europa.eu/fisheries/publications/studies/employment\\_study\\_2006\\_summary.pdf](http://ec.europa.eu/fisheries/publications/studies/employment_study_2006_summary.pdf)

<sup>15</sup> [http://ec.europa.eu/fisheries/publications/transformation05\\_en.pdf](http://ec.europa.eu/fisheries/publications/transformation05_en.pdf)

<sup>16</sup> Today white-fish fillet blocks is less important, as production of white-fish to a certain extent has moved to China or other low-labour-cost countries. Salmon, on the other hand, has increased in importance, to (probably) the most important.

still substantially dependent on EU landings are tuna and sardine canning, and the primary processing of white fish.

The tuna canning sectors of Spain, France and Portugal are respectively substantially dependent on EU landings into Galicia, Brittany and the Azores. The Italian tuna canning industry is considered to be exceptional, since it is now almost 100% dependent on imported raw material from third countries.

In most of the more northern EU countries such as Belgium, Germany, Denmark, Sweden, and in parts of the UK, the EU-landing related employment in processing is limited to primary processing of whitefish and some shellfish processing (e.g. shrimp processing in Netherlands and Denmark). In Germany, nearly 100% of the processing inputs (fillet blocks and herring) are imported, and there are few, if any links to landings. In Belgium also, the larger industrial processors rely on imports. In Denmark although the fish meal industry does rely exclusively on local landings, it provides little employment relative to the volume of material processed.

### Employment in other fisheries activities

The aquaculture sector accounts for 61,898 of the fishery-related jobs in the EU (about 15%) and more than 80% of these are in marine aquaculture. Spain and France are the two countries with substantial employment in marine aquaculture, with 14,500 employed in the former and 14,055 in the latter, between them accounting for 57% of employment in the marine aquaculture sector. Most of these jobs are in the culture of bivalve molluscs. Italy also has substantial employment in this activity (8,665 jobs). Greece and UK (in particular Scotland) are the two regions where there is a substantial production of fish (seabass/seabream and salmon respectively). Here employment is lower at 2,910 (5.8% of EU employed in the sector) and 1,617 (3.24%) respectively, despite the relatively higher value of production. Inland aquaculture in the EU employs 11,569, with the major centres of employment found in Germany (2,825), Austria (2,300) and Italy (2,142). Although all other regions have some employment in this activity, France is the only other country in which employment exceeds 1000.

Inland fishing accounts for only 2.3% of fishery sector employment. However there is no data for some regions and under-recording is suspected in the regions where zero employment is reported. Greece (2,701 employed), France (2,501 employed), Portugal (1,939 employed) and Finland (995) are the regions in which substantial numbers are recorded.

### Hypotheses (2020)

1. **Lost business:** Most processing will take place in low-labour-cost countries due to prohibitive labour costs.
2. **Inbound work:** Processing of seafood is brought back to Europe due to tariffs, environmental regulation and consumer preferences for short-travelled food (basically the Food-miles argument)
3. **Technofish:** Improved technology, requiring less labour in production, makes possible the profitable production of more processed products, new varieties and more advanced products. EU processing industry thrives.
4. **Regional fish:** The processing industry leaves frozen products to China, while thriving on the exploitation of non-imitable competitive advantages: fresh fish distributed daily, traditional treatment, fish with a story to tell, fish with regional particularities. "Single fjord" salmon, marketed by the estuary from which it gets its fresh water.

## Sources

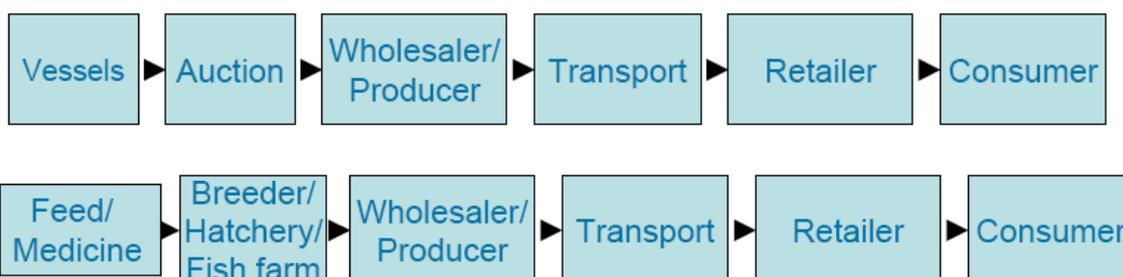
- Iversen, A. (2004). "Responding to globalisation - strategic options in the Norwegian seafood industry." *European Business Journal* 16(1).
- Salz, P. (2006). Summary of the final report of the study "Employment in the fisheries sector: current situation (FISH/2004/4)".
- Winther, U., M. G. Sandberg, et al. (2005). *Employment in the EU based on Norwegian farmed salmon*. Trondheim, SINTEF: 53.

## SEAFOOD MARKETS AND ECONOMICS

### C3 Distribution channels (value, quality, custody)

#### Driver definition

The **market chain** or the **supply chain** from fish to dish includes all links from the point of production (point of catch or farm site for aquaculture) to the enduser or the final consumer. It therefore includes all mechanisms, flows interchanges, services and operators, which determine the relationships between producer earnings and the supply of physical products.



Of course the market chain is different depending on the specific (type) of product (processed fish or chilled fish) and/or the specific distribution channel: fishmongers or supermarket chains with their own buying group acting as wholesaler toward producers or processors.

**Traceability** is interconnected to the supply chain since the EU commission defines traceability<sup>17</sup> as “*the possibility to find and follow the trace, throughout all the stages of production, processing and distribution of a foodstuff, feedstuff, an animal destined for food production or a substance destined to be incorporated in foodstuff or feedstuff or with a probability of being used as such*”.

Traceability regards the ability to trace seafood produce all the way from the consumer and back to its origin. *External traceability*, refers to systems aimed to allow the traceability of a product and/or attribute(s) of that product through the successive stages of the distribution chain (boat/fish-farm to table). This product information is either received from or provided to other members of the supply chain. *Internal traceability* refers to the traceability of raw materials, intermediate and final products within a productive or commercial unit (e.g. within a fish plant). Internal traceability systems aim also at productivity improvement and cost reduction. Traceability is important for food safety, i.e. consumer protection and assurance (through recall and withdrawal) and for resource management (preventing illegal, unreported and unregulated catch from entering the legal seafood supply chain).

There can be a direct relationship between a traceability system and **food labelling**. For instance, traceability could be used for product identification (e.g. fish species or origin of the product) that usually is information appearing on labels. A traceability system may be applied without being used for labelling. But labelling to be trustful requires some kind of traceability and control.

#### Relevant Indicators

Structure of the chain : value quality, custody

Traceability :

- Systems for traceability
- Standards for traceability
- Use of the above

<sup>17</sup> Art. 3. Regulation (EU) No 178/ 2002 of the European Parliament and the Council of 28 January 2002.

- Labels indicating or requiring traceability

Labels : types and uses

## Developments over the past 20 years

### A) The value chain

#### Auctions

In principle, a product can be sold in two ways: through private or direct sale or through public selling such as auctions. An auction is a regulated public sale in which goods are sold to the highest bidder. A large number of countries use auctions for the sale of locally produced fish on the first hand.

With the availability of the Internet, electronic trading of seafood is becoming a reality. Although volumes at present are not significant, the potential of electronic trading is large, including that of electronic auctions. In particular, networks based on business to business trading are increasing its share of the total transaction volume. The development of business-to-business sites can be explained by three main factors: lower transaction costs, improved efficiency, and greater market reach. Combined with improved logistics, the marketplace has effectively widened and reduced the importance of country of origin. This is especially the case for frozen products where global sourcing is becoming increasingly the norm.

#### Wholesale markets

Wholesale markets play an important role in the distribution of fish and fishery products. They are generally divided into two categories; first hand wholesale markets that act as distribution centres for locally produced fish, and second hand wholesale markets that distribute products imported from other regions or from abroad.

Over time, fish is increasingly reaching the consumer through large supermarket and hypermarket chains. Thanks to improved logistics and reduced barriers to trade many of these retailers buy directly from abroad or from domestic producers.

#### Distribution

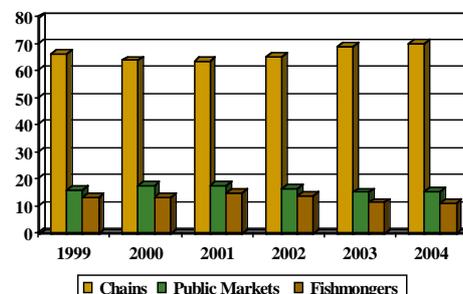
Traditionally, the distribution channels in most import countries were characterized by a series of different levels such as importers, distributors, wholesalers and retailers as well as food brokers and agents, with each level performing a specific task. More recently, increased competition and improved logistics have shortened the chain in many markets with imported products often being bought directly from source by the wholesaler or by the retail chain operator.

While this is especially the case for frozen, preserved and canned seafood, the distribution patterns for fresh and chilled seafood are also changing<sup>18</sup>. *The absence of branded fresh seafood also leads to easy substitution of product and of supplier.* In fact, increased international trade in fishery products and expansion of free-trade areas have led to a proliferation of smaller operators on the wholesale level.

#### Retail

Numerous international studies document the increasing power exercised in food distribution by the retail chains. Despite the negative competitive impact on suppliers and

Example of french market : share of retail seafood sales by distributor type chilled fish products



Olmer / TNS Worldpanel

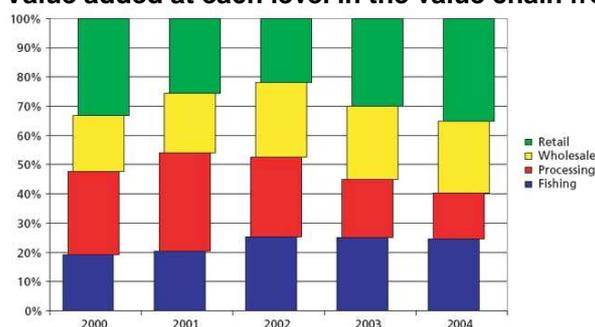
<sup>18</sup> Taking the example of the French market : The national chains dominate retail seafood sales in France. The chains are strongest in the branded segments such as canned, frozen and smoked seafood (almost 100% for canned and frozen). Traditional outlets still play a significant role in the unbranded chilled segment (with the notable exception of chilled cooked shrimp). In recent years, the discount chains have increased market share in specific branded segments at the expense of hyper- and supermarkets.

smaller retailers and fish mongers, the overall positive effects of modern retail channels includes lower prices to the consumer, improved accessibility and added convenience.

It is also obvious that supermarket chains present important opportunities for volume sales for low-cost producers. In the European and North American markets for example, the chains have played an important role in promotion and volume sales of aquaculture products such as salmon, bass, bream and catfish.

The successful formula of retail chains is a balanced mix of competitive pricing, large share of fresh produce and high quality standards obtained through narrow product specifications, modern logistics and stringent controls. In fact, one recurring result in consumer surveys is the trust placed by the consumer in the supermarket brand. That this phenomenon is not only confined to developed countries is evidenced by the proliferation of supermarket chains also in developing countries, not the least in urban areas in Asia and South America.

### Value added at each level in the value chain from 2000 – 2004 for icelandic cod



Source : Revenue distribution through the seafood value chain, FAO Fisheries Circular No. 1019, 2006<sup>19</sup>.

### B) Traceability

What makes fish and fishery products (when fresh) so special is the vulnerability of the products, given their limited shelf life. This leads to important requirements in terms of handling, quality and temperature control, as well as timeliness. A given product may also be subject at different stages of the chain to different “traceability” systems.

In addition to the obvious fact that it is impossible to tag wild fish at birth, there are a number of aspects which cannot be ascertained; for instance, information on capture area is important, but fish stocks are very often on the move and therefore some possible public health aspects (e.g. parasites or Cd contamination) can only be put within a possibility framework. Since it is not practical or logical, for example, to imagine an analysis of each possible safety attribute on each fish captured (among other things because very often analyses are destructive), the concept of “batch” coding is utilized *de facto* in current wild fish traceability systems.

Certainly after capture (on board and after landing) each *specific traceable unit* could in principle be either labelled individually or as part of an initial batch, the latter being more common. Whereas tagging of individual wild fish is theoretically possible after capture, and is sometimes done (e.g. in the case of tuna, sole, or large cod), it does not necessarily provide advantageous information in addition to proper initial batch box coding and handling. Moreover a traceable unit can be one catch, one day catch or one week catch (one day of production, one shift of production), it is up to the industry to define it. Once *each traceable unit* is appropriately labelled to allow for univocal identification, the traceability system should provide for the production, storage and recovery of data on the selected attributes chosen for the *specific unit* all along the food chain. It should be borne in mind that until the appropriate labelling of *each traceable unit*, or appropriate “batch” coding, is defined and implemented, the entire traceability system could in practice represent no more than an expensive paper trail.

<sup>19</sup> <ftp://ftp.fao.org/docrep/fao/009/a0564e/a0564e00.pdf>

*In Practise within EU<sup>20</sup>*

- A receipt is adequate documentation
- Only one step up, one step down
- No demand for internal traceability systems (traceability within the company)
- No maximum batch size
- No traceability label demands - towards consumers
- Companies are responsible for recall and withdrawal

*Implementation of traceability at international level*

The "Guidance on the implementation of Regulation (EC) No 178/ 2002 on General Food Law" from the EU specifically states that: "The traceability provisions of the Regulation do not have an extra-territorial effect outside the EU. Furthermore: "Exporters in trading partner countries are not legally required to fulfil the traceability requirement imposed within the EU (except in circumstances where there are special bilateral agreements for certain sensitive sectors or where there are specific Community legal requirements, for example in the veterinary sector)". Since the import of fish and fish products in the EU is regulated through "special bilateral agreements", EU fish inspectors in third countries may ask for proof of traceability in relation to fish safety, consistently with regulations including traceability provisions. In the case of primary production in fisheries, an important question is how artisanal and small exploitations can cope with regulatory and contractual traceability requirements. Traceability may be used as a trade barrier if complex and expensive systems are mandatory.

*Aquaculture traceability technologies*

Aquaculture presents a situation where, in theory, each traceable unit could be labelled and therefore subject to a traceability system from the very beginning. The possibility of labelling aquaculture fish before slaughtering has been subject to a large number of studies and discussions. Live fish tagging, in particular with external tags (e.g. Carlin, Floy or Petersen tags) have been used for research purposes, however, in addition to the increase in handling in the case of massive aquaculture production, it has been found that external tags give rise to lesions in the fish causing secondary fungal infections and algal attachments in the wounds. Other methods of external tagging have been applied not only to fish but also to molluscs and crustaceans, though at present there is not a single method that could provide satisfactory results in terms of fish mortality, positive recovery of information, practical applicability and costs. The use of DNA profiling techniques and the use of electronic tags in the form of PIT or also as radio-frequency identification devices (RFID) seems to have some advantages over the others.

Pressure for improved traceability in aquaculture fish is also linked and related to regulations. Most of the labelling methods for live fish tested have been studied with purposes other than that of traceability for fish safety purposes (e.g. environmental issues, or commercial protection of improved fish strains). Current regulations on aquaculture fish around the world do not enforce, for instance, HACCP (Hazard Analysis and Critical Control Point) in farm production, or the application of Good Hygiene and Good Manufacturing (Production) Practices (GHP and GMP) in aquaculture. Fish feed production is almost outside any type of control related to fish as food safety.

**C Labelling**

January 2002 traceability demand in EU obliges fish retailers to indicate :

- species : scientific name and trade name
- catch area : with liberal definition, i.e. Northeast atlantic for baltic sea as example or Pacific ocean considered as one (huge) fishing region
- method : caught, caught in sea or freshwater, raised.

The idea behind this is to provide the consumer with more detailed knowledge on the type of fish bought. However, this EU directive is being viewed rather controversially since it only

<sup>20</sup> M. Frederiksen « Introduction to traceability », Quality Assurance Challenges in the Seafood Industry Seminar, Copenhagen, 13-15 December 2006, Eurofish - FAO

affects the retail sector. For hotels, restaurants and the processing industry it is “business as usual”.

Moreover the labelling directive does not apply to the following products:

- Breaded fish products
- Fish-in-sauce products
- Fish marinades
- Canned fish products
- Fish fillets with toppings
- Breaded crustacean and mollusc products
- Caviar and caviar substitute

This **mandatory labelling** creates more transparency and clarity during buying, and prevents cheating thus benefits traders. There are benefits too for the customer provided he has enough informations to make conscious decisions when shopping.

The *certification schemes for higher than mandatory quality fishery products* that have developed over the past decade are different when dealing with wild and aquaculture fish production. The picture is relatively clear when we look at the supply side,

- wild fisheries is under eco-labeling,
- aquaculture is under organic labelling,
- some few other labelling schemes, that can include geographic labelling (oyster of the Normandy) or quality (Label rouge for some fish species), Kosher and Halal.

### *Ecolabels*

Ecolabels started with private initiatives under NGO’s pressure.

#### Ecolabels: Historical overview

- The first “green stamps” were launched in the early nineties in the USA,
- They focused on a specific by-catch issue, such as the Dolphin by catch by tuna seiners (Dolphin safe), or the turtle by catch of shrimpers (Turtle safe),
- In 1997 a public awareness campaign in the USA “give swordfish a break” turned out to be the first wide scale campaign asking consumers to help impact fishing practices,
- In 1997 MSC<sup>21</sup>, today world leading ecolabel was created.
- Since 2000, three other ecolabels on the market: Krav, Friend of the Sea, Naturland.

Seafood Choices Alliance is a global trade association for the issue of ocean-friendly seafood. Founded in the United States in 2001, the Alliance helps the seafood industry – from fishermen and fish farmers to distributors, wholesalers, retailers and restaurants – to make the seafood marketplace environmentally and economically sustainable.

Large scale processors whose today and future business is dependent upon the sustainability of their seafood supplies have entered into the arena for sustainability. Processing companies are just now starting to use eco-labels on their products. Several importers interviewed, who are MSC certified, said they did it for one of their clients. Some said they were “forced”. They see in MSC certified products a moderate additional constraint imposed by ever more demanding clients. Supermarkets are adapting the eco-labelling schemes to their sourcing policies these last years :

- ban of certain endangered species
- ban of fishing gears
- minimum commercial size above legal size

The MSC label is curebtly used in twelve European retail chains. The use of the logo for an own brand product can be seen as a recognition by the retailer of the potential marketing value of such a logo.

<sup>21</sup> From MSC site : The MSC is an independent, global, non-profit organisation which was set up to find a solution to the problem of overfishing. We were first established by Unilever, the world’s largest buyer of seafood, and WWF, the international conservation organisation, in 1997. In 1999 we became fully independent from both organisations and today we are funded by a wide range of organisations including charitable foundations and corporate organisations around the world.

*Aquaculture bio labels* (<http://www.fao.org/DOCREP/005/Y4137E/y4137e06.htm>)

Naturland, based in Germany, launched their activities in 1995 with development of organic aquaculture standards and initial certification of organic carp and tench production in Southern Germany using traditional pond culture techniques. The development of standards for salmonid and mussel farmers in Ireland followed a few years later with organic salmon and mussels reaching markets in 1996 and 1999, respectively.

The slow initial growth of organic aquaculture has been due the absence of internationally recognized and universally accepted regulations and standards for producing and handling organic aquaculture products. Realising the need to address this issue, the International Federation of Organic Agriculture Movements (IFOAM) drafted Basic Standards for Organic Aquaculture Production. These guidelines were first prepared in 1998 and adopted as draft standards by IFOAM at its General Assembly in Basel, Switzerland, in 2000.

In the absence of these international/regional standards, it has been left to individual member states and private/non-governmental certifying agents to set and develop their own specific organic aquaculture standards and accreditation bodies.

#### Private labels

- Global Aquaculture Alliance set up Aquaculture Certification Council Inc. (USA)
- United Kingdom private certifiers : SOIL, Food Certification Scotland Ltd , the Organic Food Federation),
- Switzerland : Biosuisse
- Norway : Debio
- Sweden : Krav

#### National aquaculture labels

- France and UK : organic aquaculture standards since 2000
- Thai GAP certification
- Italian API certification
- Crianza del Mar (España)

The organic market is relatively underdeveloped in terms of processed value-added products. Very few organic aquaculture products<sup>22</sup> have reached the market. An example is fish fingers made of organic pangasius from Deutsche See, this product is available in the German supermarkets.

Basically, organic aquaculture has to assure biodiversity, the integrity of biological cycles and biological activity. Getting an organic label or good practices stamp has a cost which is perceived as high to small scale producers or processors. By contrast with ecolabelling wild fish, organic certification commands a premium in price. The higher production cost is passed all through the value chain to the consumers. In addition, the willingness to pay for organic food has been evidenced in many researches.

#### *Eco and organic labelling*

In volume terms, the overall market for labelled products is still very limited. During a storecheck carried out in three major markets (in Spain, France and the UK) out of a 558 shrimp product observed only 7 were organic (1.2%) and 2 said to come from "sustainable source". By country the results vary slightly. In the UK, 6 out of 62 tropical shrimps observed were organic (10%), 2 out of 232 products in France (1%), and 1 out of 264 articles (0%) in Spain.

Despite the interest of European retailers, current retail sales of products with sustainability logos remain marginal in the context of overall seafood sales in Europe; current European retail sales of products with an ecolabel are well below 1% of total retail seafood sales. With the pressure from the press, NGOs and to a certain extent supermarkets, it is surprising to see that importers, processors and caterers are very slow in taking up the eco/biolabel idea. It

<sup>22</sup> For example : fish fingers product made of organic pangasius from Deutsche See. This product is available in the German supermarkets Karstadt, Rewe, Edeka and Toom.

probably shows that they have more experience with their market than the other players, and are reluctant to get too much involved in the labelling issue.

Consumers are often confused with the discussion on overfishing of resources and health concerns of antibiotics in cultured fish. In addition there is confusion about the mushrooming of labels on fish and fishery products.

Developing countries are very worried that eco/bio and other labels (traceability) could be used by importing countries as a non tariff barrier to trade. In addition, some countries have difficulties in guaranteeing quality aspects of all their capture or culture fish production.

## Hypotheses (2020)

This driver deals in fact with 3 topics

1. The value chain with wholesalers and retail chains gaining more power and value within the chain. Although the value of fishing or farming may increase, the power of big retailing chains can be considered an heavy trend for the next 13 years.
2. Traceability with two issues : standard of definitions and processes to trace products from production to the consumer and the technologies that would help the enforcement of traceability.
3. Labels : ecolabels for wild fish and organic label for aquaculture. Their importance may rise especially with a clear understanding by consumers of what is certified by the labels and probably more standards about labels. Guidelines for labelling can be public or private.

Based on current estimates of certified organic aquaculture production and an anticipated compound annual growth rate of 30 percent from 2001 to 2010, 20 percent from 2011 to 2020, and 10 percent from 2021 to 2030, it is estimated that production will increase 240-fold from 5 000 tonnes in 2000 to 1.2 tonnes by 2030. Such a production of certified aquatic products would be equivalent to 0.6 percent of the total estimated aquaculture production in 2030.

The following hypothesis are based on different assumptions about labels and traceability evolution.

1. **Retail management:** Main retail chains have two layers of fish products differing in quality and value: low price (low margin) standard products and high end, high price, high margin specialty top quality niche products. Chains increasingly market fish produce with their brand name attached to it. Low price products are unbranded. Tracking and tracing have become standard practise, fuelled by legal requirements (i.a. GMO labelling), HACCP system and the desire to have product recalls minimised. Labelling is opportunistically applied if a premium is to be achieved. If this is the case retail chains are willing to invest in the development of a label.
2. **Security first:** traceability definitions and processes evolve to a more shared standardization and definition at world level. Technological equipment becomes de facto mandatory, for trading with EU, to provide regulators with traceability precise data, also for processed seafood. Traceability acts like trade barrier toward small producers of poor countries.
3. **World label:** (eco)Labels appear to be the main eco-quality warranty for products and Europe is the first region to set up a unified quality standard for wild fish as well as aquaculture that takes into account both ecological as social criteria (such as small scale, artisanal, regional production). Retail chains acting as wholesalers share the investment in labeling systems with producers as part of their corporate social responsibility actions they value with investors and customers. At European level, eco labelling evolves to geographic (or special quality species) labelling and for aquaculture the label becomes eco-organic taking into account the environment as well as fish quality.
4. **Information Overload:** Through labeling, tracking and tracing requirements and chain of custody information needs a large amount of data is available at any stage of the production, processing and marketing chain. With new technology it is increasingly possible to attach this information to the product. Retailers increasingly use these data to generate consumer targeted information and to segment markets

(no frills, no info products versus the story of the product, regional label products). Consumers increasingly shy away from product information as it does not relate to making better informed choices. Labeled products are becoming the standard; instead of reaping a premium price the labeled products drive out the low-information products.

## Sources

- FAO Fisheries Circular No. 1019, E. Gudmundsson, Frank Asche, Max Nielsen, « Revenue Distribution through the Seafood Value Chain », 2006.
- Structure of french retail seafood distribution, Gerry O' Sullivan, January 2006, source Ofimer and TNS Woldpan.
- Quality Assurance Challenges in the Seafood Industry, Eurofish – FAO seminar Copenhagen 13-15 december 2006, "Introduction to traceability", Marco Frederiksen, Danish Institute for Fisheries Research
- ICT driving change in the fishing industry: A review of the years 1990-2002, European Monitoring Center of Change, European Foundation for the Improvement of Living and Working Conditions, 2003, Dublin.
- Traceability, Hector Lupin, FAO/FIU – April 2006<sup>23</sup>
- Traceability and labelling in fish trade, FAO Committee on fisheries Sub-committee on fish trade ninth session, COFI:FT/IX/2004/5, Bremen Germany 10-14 February 2004
- Market-based Quality Schemes, Certification, Organic Labels, Helga Josupeit, Fishery Industry Officer, FAO, Rome, May 2007
- "Organic agriculture, environment and food security" edited by Nadia El-Hage Scialabba and Caroline Hattam ; FAO, Rome, 2002
- Gerry O'Sullivan, *FAO Globefish 2005*, <http://www.globefish.org/index.php?id=2495>
- Article from *Eurofish Magazine*, issue 2 / 2003, April

---

<sup>23</sup> This document was presented for discussion at the Committee On Fisheries, Sub-Committee On Fish Trade (COFI:FT), Tenth Session, Santiago de Compostela, Spain, 30 May – 02 June 2006

## SEAFOOD MARKETS AND ECONOMICS

### C4 Consumer choices (prices, preferences, ethics)

#### Driver Definition

Global fish consumption per capita has increased over the past four decades, rising from 9 kg in 1961 to an estimated 16.5 kg in 2003 (FAO 2006). In the industrialised countries, the consumption increased from 20 to 29.7 kg/capita during the same period.

##### *Food consumption and seafood preferences*

There are many trends regarding food consumption, most of which may affect markets for seafood: organic food, vegetarian, slow food, short-travelled food, fair trade, healthy food, low fat food, functional food, ready-to-eat, ready-to-cook, convenience, meal solutions, etc.

Many of the trends listed above may be grouped under one of what seems to be four megatrends:

1. Health
2. Convenience
3. Taste
4. Ethical issues

The drivers behind these trends seems to be quite different, but then again often interrelated.

##### *Relative prices*

Fish consumption is not only depending on the consumer's taste and preferences, but also, depends on purchasing power, availability and price relative to other types of food, like poultry. In case the price for fish and fish products goes up, the consumption of poultry products increases. And vice versa, when an outbreak of bird flue occurs, demand for fish and fish products might increase.

#### Relevant Indicators

##### *Consumer perception of*

- sea food safety
- quality,
- attitudes

##### *Relevant Indicators for ethical issues*

- Debates on ethical issues (articles in daily press, industry press, internet forums et.c )
- Maximum biomass density in cages
- Acceptance of fish diets by consumers (vegetable diets, high energy diets

##### *Indicator for quality demand :*

- Demand in fat and omega 3 in fish and shellfish
- Control of sanitary quality in shellfish

##### *Preferences, prices*

- Ratio meat/fish in daily ration; consumption of animal protein per head
- Consumption of cooked dishes/basic food to cook
- Availability of other competing products in the market : relative price of fish compared to poultry or other meats
- Prices relative to substitutes

#### Developments over the past 20 years

Research on food consumption of environmentally or ethically labelled products show that consumers tend to be confused about the terminology and the content regarding such products and the labelling of them (Caswell and Padberg 1992; Caswell 1998) and results in buying decisions being often less informed (Oliver and Winer 1987).

### 1) Health

Safety and quality of food is regarded by consumers as being important. One interesting aspect of healthy food, is the many possibilities arriving with new technology. We see products with less fat, less energy, less sugar, and at the same time with the addition of fibre or Omega3 added.

The demand for high quality seafood products is increasing in EU. Nutritional quality is required: the omega 3 only contained in fresh water and mainly marine products are well known as protector of cardiovascular system compared to the fat included in meat. Sanitary quality is also required: particular attention is given on dioxin level, methyl mercury and, for shellfish, toxic algae.

### 2) Convenience

New household patterns, with more families where both parents are working outside the house and with more single-person households, develop a trend towards products that require less time and effort in preparation. Products ready-to-eat, ready-to-cook and complete meal solutions are examples of this trend.

### 3) Taste

Discriminating consumers want to have the best of raw material available for their week-end meals, when they have time for enjoying, and experimenting with, more advanced cooking. Slow food is a relevant trend in this setting, another is the self-realisation through cooking. As people in developed countries move up the Maslow hierarchy of needs, food consumption turns from a necessity, through fulfilling of social needs to a means of self-actualisation.

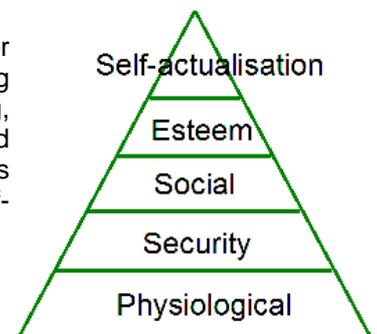


Figure: Maslow's Hierarchy of Needs

### 4) Ethical issues

A fourth megatrend is related to ethical issues, such as the environment or animal welfare, leading to what could be referred to as "the caring consumer". A problem in dealing with consumers motivation, is that while consumer's attitudes might be strong, this is not necessarily reflected in their actual buying behaviour (Belk, Devinney et al. 2005).

Ethical issues in fisheries relate to environmental stewardship, such as the healthy management of stocks. (Ecolabelling is also covered in driver C3 – Distribution channels).

#### *Ethics in aquaculture*

In aquaculture concerns mainly pertain to the farming, caging and killing taking into account ethic considerations. Consideration concern the maximum fish biomass in cages. For slaughtering, methods are being tested for more "humane" killing.

#### *Ethics in production*

Consumers are increasingly concerned about the use of energy in farming and processing. Products manufactured with methods using less energy is favoured. Less use of energy also means less CO<sub>2</sub> released.

### **Organic Seafood**

There is currently no universally accepted standard for organic seafood, but different standards exist in different markets (Toften 2007). The debate has mostly been centered around farmed salmon, as this is the largest product reared in netpens. From the debate over organic salmon, it seems clear that different standards are hindering the growth of organic salmon. And it seems that work is needed to clarify the concept and bring forward common standards.

### **Potential for organic fish?**

With the short history of organic fish, and the problems due to missing or different standards, it is hard to estimate future development. If problems are solved, there might be a huge potential for growth.

### **Hypotheses (2020)**

1. **Ethical man:** Consumer choice will increasingly be driven by environmental consciousness. Seafood industry prospers, processing takes place in Europe.
2. **Healthy man:** Consumer choice will increasingly be driven by health consciousness. Seafood is well positioned to prosper.
3. **Narcissist man:** Consumer choice will increasingly be driven by taste and luxury trends.
4. **Poor man:** Consumption driven by the realities of cost.
5. **Convenience man:** Consumption driven by the realities of time-constraints.

### **Sources**

- Belk, R. W., T. Devinney, et al. (2005). "Consumer ethics across cultures." *Consumption, Markets and Culture* 12(2): 275-289.
- Caswell, J. A. (1998). "How labelling of safety and process attributes affects markets for food." *Agricultural and Resource Economics Review*(October): 151-158.
- Caswell, J. A. and D. I. Padberg (1992). "Toward a more comprehensive theory of Food labels." *American Agricultural economics association* 74(2): 460-468.
- FAO (2005). *Ethical issues in fisheries*. Rome, FAO.
- FAO (2006). *The state of world fisheries and aquaculture*. Rome, FAO: 164.
- Franz, N. (2005). *Overview of Organic Markets*. Rome, Globefish: 102.
- Harper, G. and Makatouni (2002). "Consumer perception of organic food production and animal welfare." *British Foods Journal* 104(3-5): 287-299.
- Honkanen, P., B. Verplanken, et al. (2006). "Ethical values and motives driving organic food choice." *Journal of Consumer Behaviour*(5): 420-430.
- Oliver, R. L. and R. S. Winer (1987). "A framework for the formation and structure of consumer expectations: Review and propositions." *Journal of Economic Psychology*(8): 469-499.
- Toften, K. (2007). *Nye krav til miljøvennlig og etisk sjømat: Trusler eller muligheter for norsk sjømatnæring?* Tromsø, Fiskeriforskning: 10.

## SEAFOOD MARKETS AND ECONOMICS

### C5 World production of fish and fish products by region

#### Driver Definition

World demand/supply for fish and fish products: total quantity and quality of fish and fish products (by product) available on the world market and the demand for fish and fish products in terms of quantity, quality and prices.

#### Relevant Indicators

- Fish category of species in tonnes by region
- Category of species and share of the value by production mode (fishing, marine aquaculture, continental aquaculture) and by region
- Availability of fish and fish products in the market by product, quantity, quality, price
- Demand for fish and fish products in the market by product, quantity, quality, price

COUNTRIES	Capture Fisheries and Aquaculture (1000 tonnes)							
	Freshwater & Diad. Fish	Demersal Marine Fish	Pelagic Marine Fish	Marine Fishes	Crustaceans	Molluscs	Cephalopods	Miscel. Aquatic Animals
Afghanistan								
Albania	2	2	0	0	0	1	0	0
Algeria	1	12	115	9	3	0	1	
American Samoa		0	4	0				
Angola	10	87	102	35	4		2	
Antigua and Barbuda		2	0	0	0	1		
Argentina	37	711	46	4	29	50	77	0
Armenia	1				0			
Australia	21	75	64	17	55	29	5	0
Austria	3							
Azerbaijan	9	0			0			
Bahamas		1	0	0	9	1		0
Bahrain	0	6	1	1	6		0	0
Bangladesh	1756		0	234	112			
Barbados		0	2	0				
Belarus	5							
Belgium	2	23	0	0	1	1	1	
Belize	0			0	12	2	0	
Benin	19	5	9	1	7		0	0
Bhutan	0							
Bolivia	6		1					
Bosnia and Herzegovina	8	0				0		
Botswana	0							
Brazil	420	208	155	73	137	19	4	1

Source: Data are from FAOSTAT

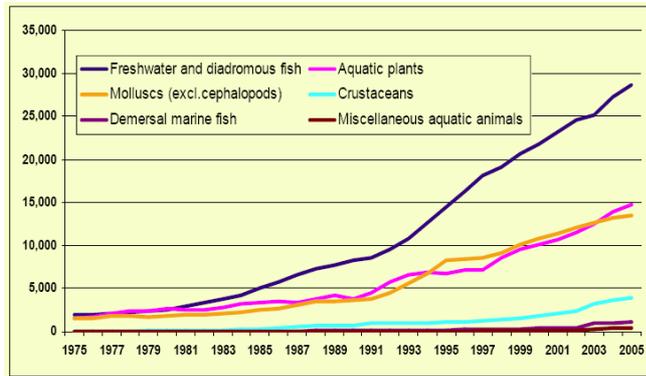
- Fish catch and production statistics (FAO = worldwide, and national)
- Worldwide catch quotas and stock health (science-based belief)
- Seasonal spikes in, e.g., pelagic fish catches, squid seasons

## Developments over the past 20 years

Table 1  
World fisheries and aquaculture production and utilization

	2000	2001	2002	2003	2004	2005 <sup>1</sup>
(Million tonnes)						
<b>PRODUCTION</b>						
<b>INLAND</b>						
Capture	8.8	8.9	8.8	9.0	9.2	9.6
Aquaculture	21.2	22.5	23.9	25.4	27.2	28.9
Total inland	30.0	31.4	32.7	34.4	36.4	38.5
<b>MARINE</b>						
Capture	86.8	84.2	84.5	81.5	85.8	84.2
Aquaculture	14.3	15.4	16.5	17.3	18.3	18.9
Total marine	101.1	99.6	101.0	98.8	104.1	103.1
<b>TOTAL CAPTURE</b>	95.6	93.1	93.3	90.5	95.0	93.8
<b>TOTAL AQUACULTURE</b>	35.5	37.9	40.4	42.7	45.5	47.8
<b>TOTAL WORLD FISHERIES</b>	131.1	131.0	133.7	133.2	140.5	141.6
<b>UTILIZATION</b>						
Human consumption	96.9	99.7	100.2	102.7	105.6	107.2
Non-food uses	34.2	31.3	33.5	30.5	34.8	34.4
Population (billions)	6.1	6.1	6.2	6.3	6.4	6.5
Per capita food fish supply (kg)	16.0	16.2	16.1	16.3	16.6	16.6

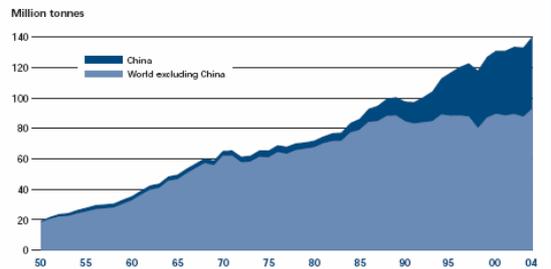
Note: Excluding aquatic plants.  
<sup>1</sup>Preliminary estimate.



Trend of world aquaculture production by major species group, 1975-2005

Figure 1

World capture and aquaculture production



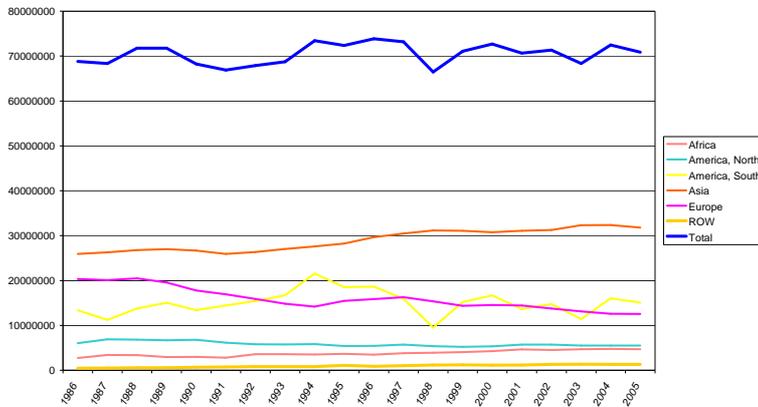
Source: The state of World Fisheries and Aquaculture 2006, FAO, Rome 2007

Table 2  
World fisheries and aquaculture production and utilization, excluding China

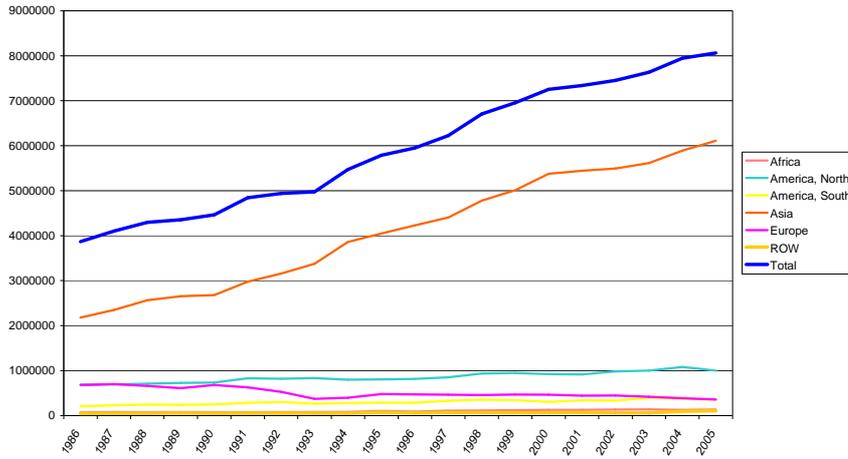
	2000	2001	2002	2003	2004	2005 <sup>1</sup>
(million tonnes)						
<b>PRODUCTION</b>						
<b>INLAND</b>						
Capture	6.6	6.7	6.5	6.6	6.8	7.0
Aquaculture	6.0	6.5	7.0	7.6	8.3	8.8
Total inland	12.6	13.3	13.5	14.2	15.1	15.8
<b>MARINE</b>						
Capture	72.0	69.8	70.2	67.2	71.3	69.7
Aquaculture	4.9	5.3	5.6	6.1	6.6	6.6
Total marine	76.9	75.2	75.8	73.3	77.9	76.3
<b>TOTAL CAPTURE</b>	78.6	76.6	76.7	73.8	78.1	76.7
<b>TOTAL AQUACULTURE</b>	10.9	11.9	12.6	13.8	14.9	15.4
<b>TOTAL FISHERIES</b>	89.5	88.4	89.3	87.5	93.0	92.1
<b>UTILIZATION</b>						
Human consumption	63.9	65.7	65.7	67.5	68.9	69.0
Non-food uses	25.7	22.7	23.7	20.1	24.0	23.1
Population (billions)	4.8	4.9	5.0	5.0	5.1	5.1
Per capita food fish supply (kg)	13.3	13.4	13.3	13.4	13.5	13.4

Note: Excluding aquatic plants.  
<sup>1</sup>Preliminary estimate.

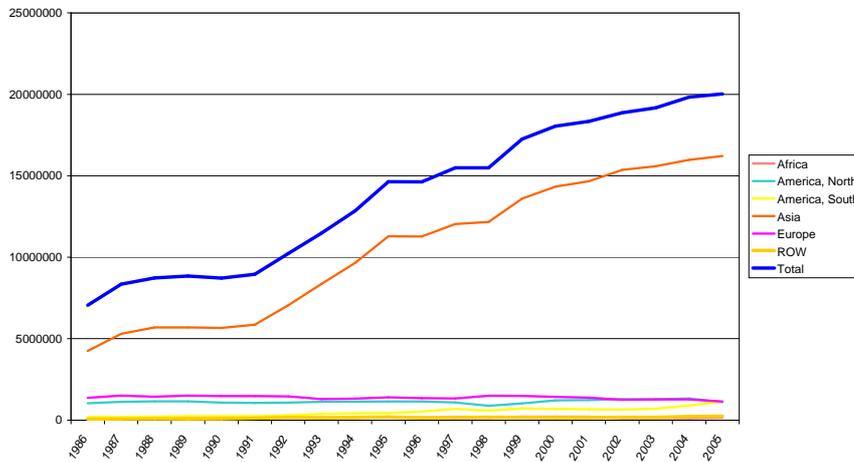
World Marine Fish production



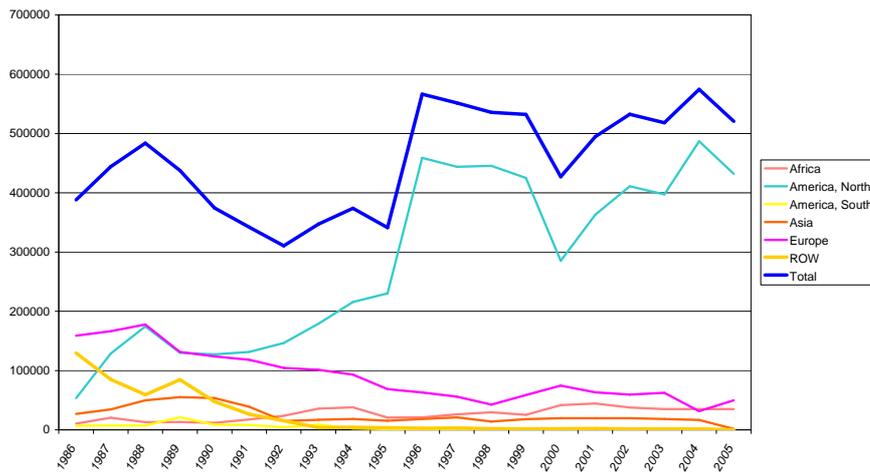
**World Marine Crustacean production**



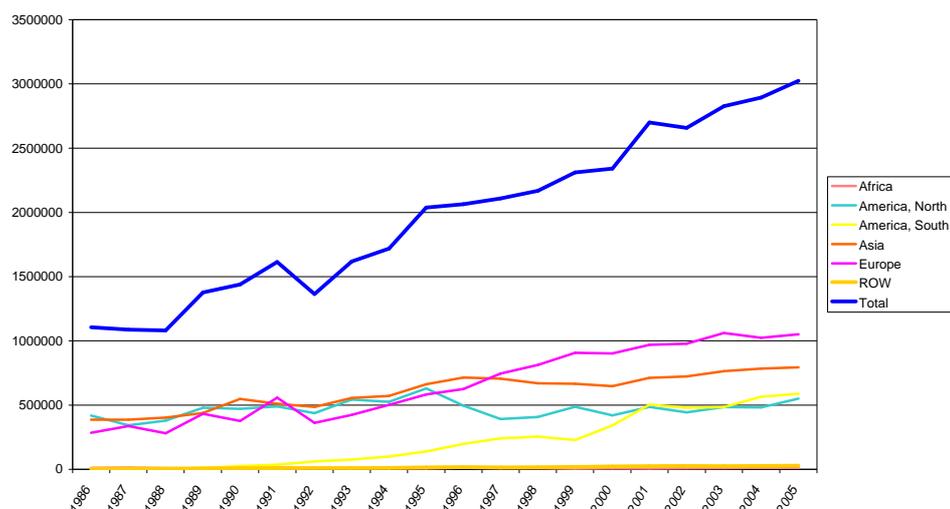
**World Marine Molluscs production**



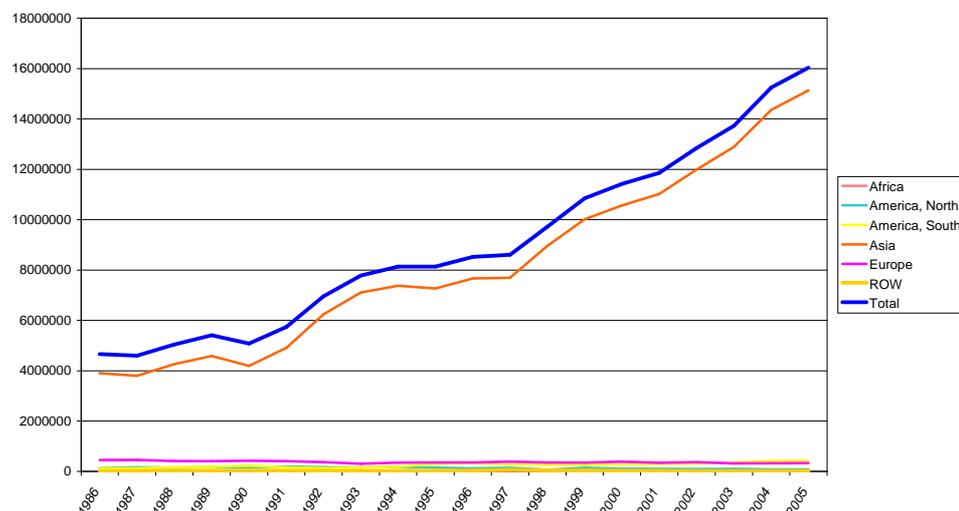
**World Marine Mammals production**



World Marine Diadrome fish production



World Marine Aquatic plant production



Food fish consumption

Region	Total consumption (million metric tons)			Annual growth rate (%)
	1973	1985	1997	1985-1997
China	4.9	8.7	33.2	11.8
Southeast Asia	5.4	7.9	11.3	3.1
India	1.8	2.8	4.5	4.3
Latin America	2.1	3.6	3.8	0.6
Sub-Saharan Africa	2.6	3.7	3.7	0
United States	2.9	4.5	5.4	1.5
Japan	7.6	7.4	7.9	0.5
Developing world	20.4	32.5	63.2	5.7
Developed world	25	29.4	28.1	-0.4
World	45.4	61.9	91.3	3.3

**Developing Countries**

- Important source of animal protein, accounting for 20% in low income food deficit countries vs. 13% in industrialized countries
- Growth in food fish consumption, with increased share from 45% in 1973 to 70% in 1997
- China dominates aggregate consumption of fisheries products, from 11% in 1973 to 36% in 1997
- Sub-Saharan Africa – stagnant *per capita* fish consumption for the past 30 years

**Developed Countries**

- Aggregate consumption level declined since 1985 as a consequence of lower *per capita* consumption in the former Eastern Bloc countries

Region	Total use (thousand metric tons)			Annual growth rate (%)
	1973	1985	1997	1985-1997
China	112	554	1,573	9.1
Southeast Asia	135	238	728	9.8
India	17	32	25	-2.0
Latin America	483	672	451	-3.3
Sub-Saharan Africa	15	12	14	1.6
United States	334	463	267	-4.5
Japan	828	1,052	731	-3.0
Developing world	877	1,821	3,148	4.7
Developed world	3,637	4,273	2,982	-2.9
World	4,514	6,094	6,133	0.1

*Feed fish demand*

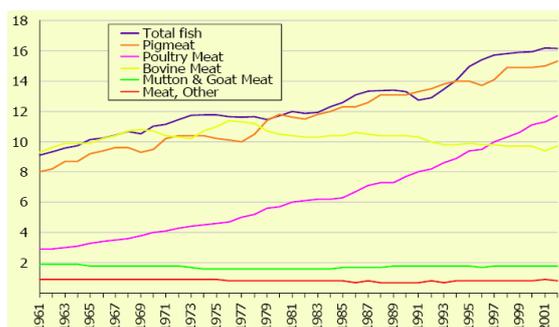
Fishmeal and fish oil – derived from wild-caught fisheries used for feeding terrestrial livestock and farmed fish. Demand is determined by demand for livestock and fish, influenced by feed conversion efficiency, relative prices of competing feeds, outlook for competing sectors that also consume fishmeal and fish oil. Demand for fishmeal and fish oil has increased significantly in China and Southeast Asia with rapidly growing

poultry, pig and aquaculture sectors. Demand in other regions has declined with substitution of maize and soybean for fishmeal

*World Fisheries Utilization (million tonnes)*

	2000	2001	2002	2003	2004	2005
Human consumption	97.0	100.2	100.5	103.3	105.6	108.0
Non-food uses	34.0	30.8	33.1	29.7	34.7	33.4
Population (Billions)	6.1	6.1	6.2	6.3	6.4	6.5
Per capita food fish supply (kg)	16.0	16.3	16.1	16.4	16.6	16.7

*World: per capita consumption of fish and meat kg/capita*



**Analysis**

*Supply:*

- Between the 1950s and 2004, fish production from fisheries and aquaculture increased from 20 million tonnes to some 140 million tonnes. At this moment production from fisheries is stable. Growth is realised in aquaculture product. The growth over the past 20 years is mainly due to increased production in China, especially aquaculture production.

- In terms of capture fish production, about half comes from Africa. Most regions have stable production. European production of fish product shows a steady decline.
- Crustacean and mollusc production is developing rapidly mainly though production in Asia; most other regions show a stable production.
- Marine mammal production is basically production from North America; production in the EU has declined since the 1980s.
- Production of marine aquatic plants has increased by 350% since the 1980s, production basically taking place in Asia.

*Demand:*

Food

The main trend is an increase in consumption of fish *per capita*.

Feed Fishmeal and fish oil – derived from wild-caught fisheries used for feeding terrestrial livestock and farmed fish- demand is expected to increase

## Hypotheses (2020)

**1. Endless Demand:** The demand for fish and fish products will increase worldwide in the next two decades due to

- a growth in the world's population
- increase in the wealth of (parts of) the population
- increased possibilities to meet demand (standardization of the product) next to increased possibilities of aquaculture production
- there will be a shift in demand from North America and EU towards Asia, especially India and China.

The demand for fish and fish products will increase worldwide in the next few decades, but this demand cannot be met because the resources available both for capture fisheries and for feed for the aquaculture industry are limiting. Due to overfishing, stocks worldwide will collapse and diseases and lack of fish oil and fishmeal will hamper further aquaculture development. Fish prices will increase sharply, leaving available fish only for niche markets such as Japan.

**2. The Other Market:** Main production increase from marine living resources will not come from (shell) fish but from other organisms such as sponges, seaweeds, and algae . Three mainstays of production are:

- Biomaterial production (*inter alia* energy)
- Feed and ingredients
- Pharmaceuticals and nutraceuticals

These new forms of production compete for available space and productivity of water bodies.

## Sources

- The state of World Fisheries and Aquaculture 2006 , FAO, Rome 2007
- Production and Trade The Role of Aquaculture Fish Supply Jochen Nierentz Senior Officer FAO Globefish, May 2007
- FAO - Fisheries and Aquaculture Information and Statistics Service - 05/07/2007
- IFPRI, Fish 2020; Fish to 2020: Supply and Demand in Changing Global Markets Siwa Msangi Mark W. Rosegrant Environment and Production Technology Division IFPRI
- Trade The Role of Aquaculture Fish Supply Jochen Nierentz Senior Officer FAO Globefish, May 2007
- Source © FAO - Fisheries and Aquaculture Information and Statistics Service - 05/07/2007
- IFPRI, Fish 2020; Fish to 2020: Supply and Demand in Changing Global Markets Siwa Msangi Mark W. Rosegrant Environment and Production Technology Division IFPRI
- Production and Trade The Role of Aquaculture Fish Supply Jochen Nierentz Senior Officer FAO Globefish, May 2007

## SEAFOOD MARKETS AND ECONOMICS

### C6 EU trade within world trade in fish and fish products

#### Driver Definition

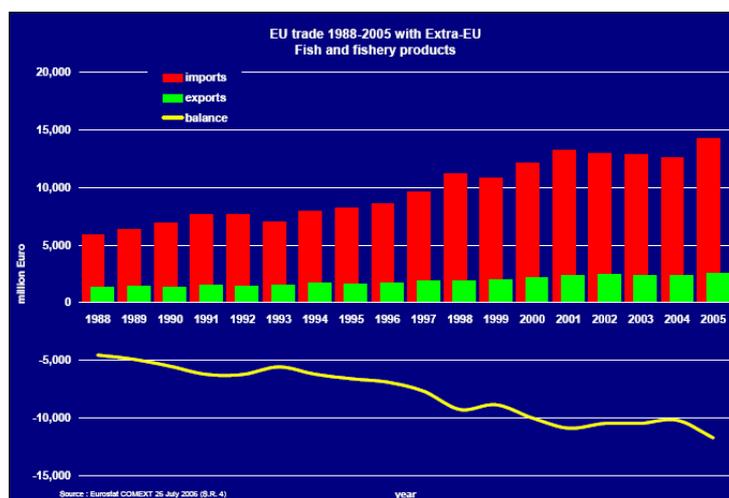
Imports and exports from the EU and within the EU as part of global movements in fish and fish products in terms of total quantity and quality of fish and fish products (by product).

#### Relevant Indicators

- Global trade flows in fish and fish products
- EU trade flows in fish and fish products in tonnes, value and species, with the question of quality definition in terms of species category

#### Developments over the past 20 years

The EU is increasingly dependent on imports of fish and fishery products to meet its needs. In 2005, the EU25 imported in excess of €14 billion worth of fish and fishery products, with exports amounting to €2.5 billion. As a result, the EU's trade deficit in fish and fishery products continued to widen and reached a new record of €11.7 billion. Most imports go to Spain (20%), followed by the United Kingdom (13%) and Denmark (11%). Overall, 55% of imports came from 10 countries, with Norway accounting for the largest share (17%) followed by Iceland (8%) and China (6%). The most significant imported products in value terms were fish fillets (€3.3 billion), crustaceans (€2.4 billion), and fresh or chilled fish excluding fillets (€2 billion). The main export items were frozen fish (€879 million), prepared and preserved fish (€307 million) and fresh or chilled fish excluding fillets (€305 million). Japan was the most important export market, with a value of €292 million.





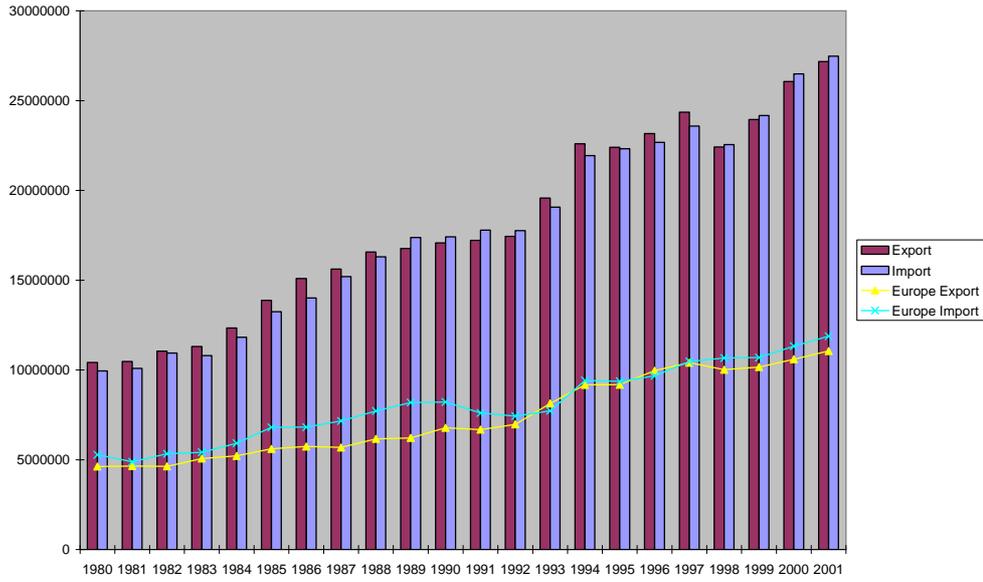
May 2006

**FACT SHEET: The international fish trade and world fisheries**  
United Nations Food and Agriculture Organization (FAO)

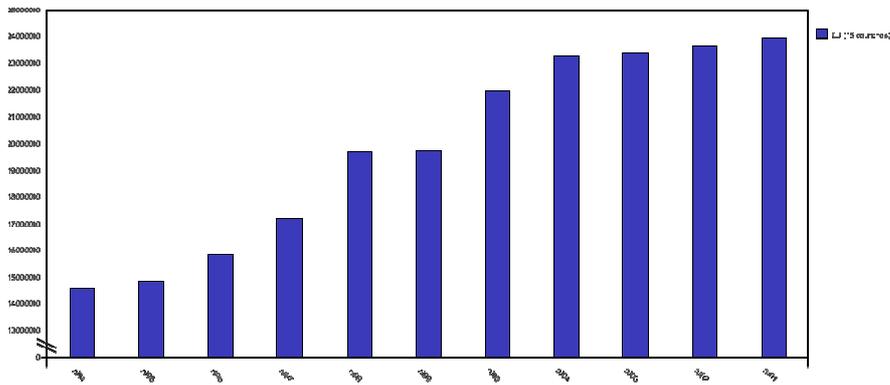
**THE GLOBAL FISH TRADE\***

<b>Amount of fish traded internationally</b>	A large share of all fish production enters international marketing channels, with about 38% (live weight equivalent) exported in 2004.										
<b>Value of fish exports</b>	In 2004, total world exports of fish and fish products reached a record value of US\$71.5 billion, a 51% increase from 1994.										
<b>Value of fish imports</b>	World fish imports rose 25.4% from 2000 to 2004, reaching the new record of more than US\$75 billion in 2004. Developed countries accounted for about 81% of the total value of imports.										
<b>Top exporting countries</b>	<table border="0"> <tr> <td>China (exports valued at US\$6.6 billion)</td> <td>Canada (US\$3.5 billion)</td> </tr> <tr> <td>Norway (US\$4.1 billion)</td> <td>Spain (US\$2.6 billion)</td> </tr> <tr> <td>Thailand (US\$4.0 billion)</td> <td>Chile (US\$2.5 billion)</td> </tr> <tr> <td>The United States (US\$3.9 billion)</td> <td>Netherlands (US\$2.5 billion)</td> </tr> <tr> <td>Denmark (US\$3.6 billion)</td> <td>Viet Nam (US\$2.4 billion).</td> </tr> </table>	China (exports valued at US\$6.6 billion)	Canada (US\$3.5 billion)	Norway (US\$4.1 billion)	Spain (US\$2.6 billion)	Thailand (US\$4.0 billion)	Chile (US\$2.5 billion)	The United States (US\$3.9 billion)	Netherlands (US\$2.5 billion)	Denmark (US\$3.6 billion)	Viet Nam (US\$2.4 billion).
China (exports valued at US\$6.6 billion)	Canada (US\$3.5 billion)										
Norway (US\$4.1 billion)	Spain (US\$2.6 billion)										
Thailand (US\$4.0 billion)	Chile (US\$2.5 billion)										
The United States (US\$3.9 billion)	Netherlands (US\$2.5 billion)										
Denmark (US\$3.6 billion)	Viet Nam (US\$2.4 billion).										
<b>Top importing countries</b>	<table border="0"> <tr> <td>Japan (US\$14.6 billion worth of imports)</td> <td>Italy (US\$3.9 billion)</td> </tr> <tr> <td>United States (US\$12 billion)</td> <td>United Kingdom (US\$2.8 billion)</td> </tr> <tr> <td>Spain (US\$5.2 billion)</td> <td>Germany (US\$2.8 billion).</td> </tr> <tr> <td>France (US\$4.2 billion)</td> <td></td> </tr> </table>	Japan (US\$14.6 billion worth of imports)	Italy (US\$3.9 billion)	United States (US\$12 billion)	United Kingdom (US\$2.8 billion)	Spain (US\$5.2 billion)	Germany (US\$2.8 billion).	France (US\$4.2 billion)			
Japan (US\$14.6 billion worth of imports)	Italy (US\$3.9 billion)										
United States (US\$12 billion)	United Kingdom (US\$2.8 billion)										
Spain (US\$5.2 billion)	Germany (US\$2.8 billion).										
France (US\$4.2 billion)											
<b>Imports to Europe</b>	In 2004, the original European community countries (EC-15) continued to expand their dependency on imports for their fish supply, reaching US\$28.3 billion (+44% since 2000 and +10% since 2003). Yet 46% of these imports had an intra-EU-15 origin.										
<b>Exports from Europe</b>	In 2004, EU-15 exports of fish and fishery products were valued at US\$17.1 billion, representing a growth of 51% since 2000. About 80% of these exports were destined to other EU-15 countries. (The significant increase of the EU-15 imports and exports are also due to the marked appreciation of the European currencies against the US dollar.)										
<b>Top commodities</b>	Shrimp continues to be the most important commodity traded in value terms, accounting for 16.5% of the total value of internationally traded fish products in 2004. The other main groups of exported species were groundfish (10.2%: e.g. hake, cod, haddock and Alaska pollock), tuna (8.7%) and salmon (8.5%). In 2004, fishmeal represented around 3.3% of the value of exports and fish oil less than 1%.										
<b>Developing countries and fish trade</b>	The share of developing countries in total fishery exports was 48% by value and 57% by quantity in 2004. The fishery net exports of developing countries (i.e. the total value of their exports less the total value of their imports) showed a continuing rising trend in the last decades, growing from US\$4.6 billion in 1984 to US\$16.0 in 1994 to US\$20.4 billion in 2004. These figures were significantly higher than those for other agricultural commodities such as rice, coffee and tea.										

\*All figures for 2004

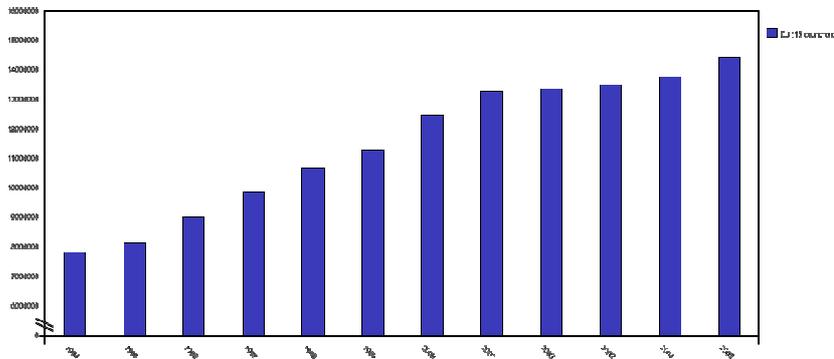


Trade in fishery products - Imports  
1000 e.u.



Source: E.u.scar

Trade in fishery products - exports  
1000 e.u.

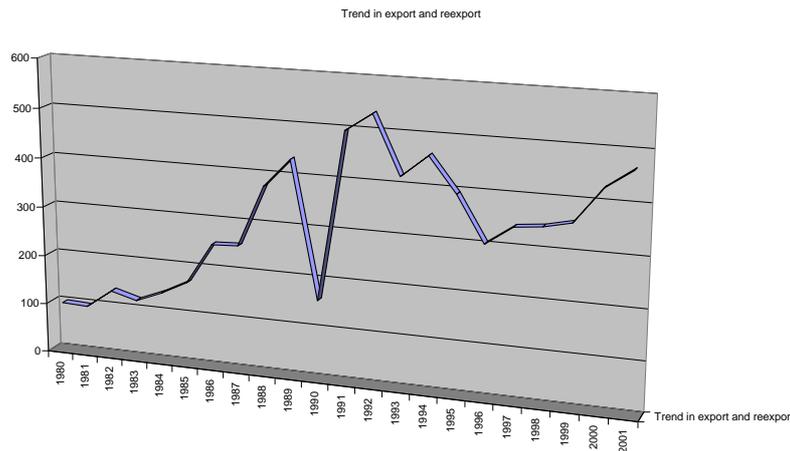


Source: E.u.scar

**Analysis:**

Over the past 20 years, flows of fish around the world have increased. In part this can be attributed to an increase in fish consumption in Western Europe and America which has been met by increased fish production and trade elsewhere (also by an increase in fish products from aquaculture;). Also, due to an increase in *per capita* income, China, for example, has risen rapidly as a fish importer, using fish for the purposes of direct human consumption.

In addition, world trade flows in fish have increased as progressively more raw fish is exported for processing, after which the final consumer product or half-product is re-exported. In the figure below we can see, taking 1980 as base year that by 2001, export and re-export has increased by some 400%.



The part Europe is playing in the entire trade of fish has remained rather stable over the years. Between 40 and 50% of both exports and imports go to and from the EU.

**Hypotheses (2020)**

- 1. World Free Trade:** Increasingly, produce is being traded without restriction. The concepts of export and import become more fluid as the issues of primary production, processing and consumption become less related. In addition, production focuses more on processed products, so trade is increasingly dominated by 'white fish blocks' and 'fish fillets'
- 2. Import Armageddon:** The production increase in Europe will not be sufficient to meet increased European demand. Increasingly, European fish consumption will depend on imports. However, the world market will have to meet increased consumer demand, especially from growing economies such as India, China and Vietnam.
- 3. Limited Trade:** Due to increased local demand, gradually more fish is being consumed locally (nationally) and less fish is available on the international market. EU governments try to safeguard national fish consumption. As a result, a net flow of fish remains from the Low Income Countries to the High Income Countries

**Sources**

- World trade stats © FAO - Fisheries and Aquaculture Information and Statistics Service - 17/07/2007
- FACT SHEET: The international fish trade and world fisheries United Nations Food and Agriculture Organization (FAO) May 2006
- EU Trade Document 133509
- EUROSTAT

## SEAFOOD MARKETS AND ECONOMICS

### C7 COSTS AND EARNINGS OF FISHERIES

#### Driver Definition

The driver refers to all cost types related to fishing operations. Those include flexible/operational, fixed and investment costs). In addition the driver refers to the economic performance of the activity of fishing within the European nations and at an overall EU level.

#### Relevant Indicators

- Relative share of the different costs of fisheries
- Evolution of fuel rates
- Salary rates for the crews of fishing vessels compared with average wages in European countries
- Relevant Indicators of economic performance

The economic and financial performance of fishing operations is generally assessed with the help of two relevant Indicators. To assess the economic performance of a fishing vessel, as in the case of other economic enterprises, the ratio between net cash flow and total earnings (NCF/TE) is used. This ratio is a general indicator of economic profitability/viability of enterprises, because it shows the amount of total earnings required by a certain type of fishing vessel in order to generate a given net profit.

The financial performance is assessed with the help of the rate of return on investment (ROI). The ratio shows how much money needs to be invested in a fishing enterprise to generate a certain net profit.

#### Developments over the past 20 years

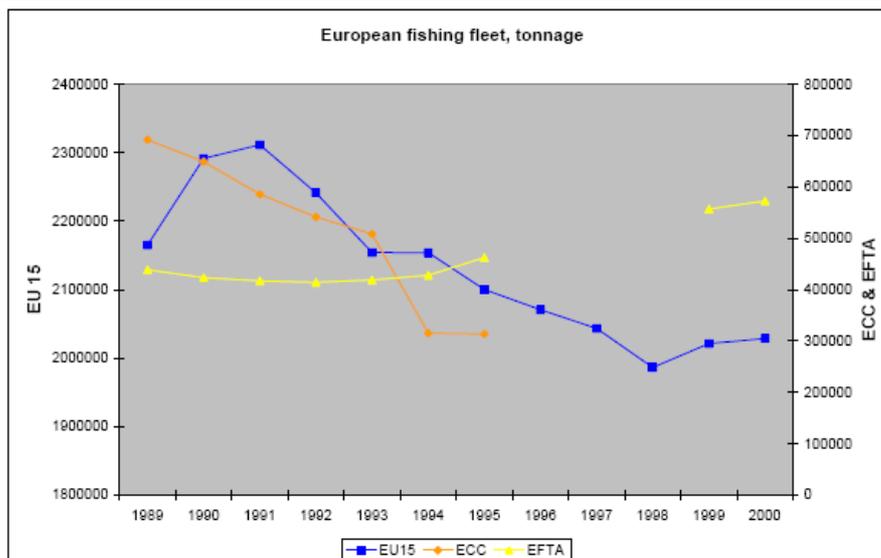
Fisheries development over the past 20 years can be characterized by several periods of relative success and of years that were less successful. If we consider the results of the fishing fleets as reported in the Economic Performance of Selected European Fishing Fleets series over the period 1999–2006. then we can list the following issues:

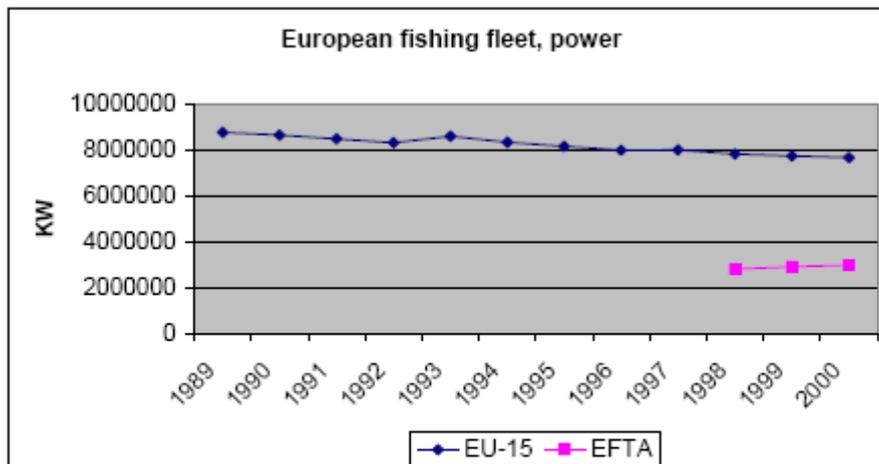
- There is no 'across the board' development: in periods where some fleet segments are in decline, others are performing in a stable manner
- Costs and earnings differ between fleet segments, sp cost structures differ
- Whereas some fleets are on the decline, other fleets are developing
- However, in general terms,
  - The total number of vessels is gradually declining
  - Employment, both in active fishing and in processing and ancillary industry, is gradually dropping
  - Whereas total number and tonnage is decreasing, overall engine capacity is not.
- For fuel-intensive fisheries, the oil price increase over the past 20 years has had an effect on profitability. However, where the latest fuel price increase has had a very negative effects on results in, for example, the beam trawl fisheries, pelagic freezer trawlers seem far less affected by the development.
- Increases in fishing costs are not totally transferable to consumer prices
- Primary producers take a relatively small share of the final consumer price
- In some specialist fisheries, quota reductions (with a lack of alternative income sources) has depressed fishery results .

**AER 1999** The report presents economic results for 1998 in 46 fleet segments, representing about 4045% of the total fishery sector of EU, Norway and Iceland. Coverage by country varies between 1% for Greece and 100% for Italy, Iceland and Sweden. European fishing fleets employ about 280 000 people on board, of whom 252 000 are in the EU. The value of total production amounted to EUR 9.8 bln (EUR 7.8 bln). Average gross value added per fisher is estimated at about EUR 26 000, of which the major part is disposable income. Still, a number of segments show average crew share below EUR 10 000 per man. 36 of 46 segments have achieved satisfactory to good economic performance over the period 1996-98. Results of only 6 segments faced structural losses over that period. In 1998, compared with 1996/97, 23 segments improved their performance, while 17 faced some degree of deterioration. The relatively good economic performance can be largely ascribed to three causes: reduction of the size of the segments and in some cases higher fish prices and low fuel costs.

**AER 2002** The report presents economic results for 2001 of 75 fleet segments, representing 50-60% of the total fishery sector of Europe in terms of value and volume of landings and employment. Coverage by country varies between 3-4% for Greece and 100% for Italy and other countries. Fishing fleets of the 20 countries discussed employ about 246 000 people on board. The value of total production amounted to EUR 9.8 bln. Average gross value added per fisher amounts to about EUR 36 000, of which the major part is disposable income. Some of the segments show average crew share below EUR 10 000 per man. In the EU alone, some 216 000 fishers produced in 2001 approximately EUR 7.6 bln worth of fish. Compared with the year 2000, the value of production remained approximately constant, but employment has decreased by about 5%. This implies improving results and higher incomes. This conclusion is broadly supported by the evidence on 75 specific segments of fishing fleets for which data have been collected. About 57 segments have achieved satisfactory to good economic performance over the period 1999-2001. These segments represent about 44% of the economic value of the surveyed fleets in terms of value of landings, and 33% of employment. Results of 12 only segments faced structural losses over that period. In 2001, compared with 1999-2000, 35 segments further improved their performance, while 26 faced some degree of deterioration.

**AER 2005** The report presents economic results for 2004 of 69 fleet segments, representing about 55-60% of the total fishery sector of the EU in terms of value and volume of landings and over 40% of employment. Coverage by country varies between 3-4% for Greece and 100% for Italy and other countries. In the EU some 186 000 fishers produced in 2004 approximately EUR 7.1 bln worth of fish. Compared with the year 2000, the nominal value of production decreased by approximately 8-9%. The inflation over the period amounted to 9%, so the real value of landings decreased from 2000 by some 19%. Employment in the fisheries of the EU-15 decreased in the same period by about 50 000 jobs, i.e. 21%. Of the 69 specific segments on which data are presented, the short-term performance of 39 segments deteriorated from the situation in 2002/2003. These 39 segments represented 73% of the total production value and 71% of crew of the surveyed fleets. Only 11 segments, with 11% of the production value (8% of employment), managed to improve their short-term results. In longer term perspective (2002-2004) 33 segments (65% of the production value and 66% of employment) still operate at or above the break-even level, i.e. they are able to cover all their costs, incl. depreciation and interest on capital. In terms of the report their performance is classified as strong or reasonable. Average value of fish landings per fisher in the surveyed fleets in the EU-15 amounted to EUR 58 000. Consequently, the production value per fisher in fisheries not covered by the report can be estimated at some EUR 34 000. The value of production per man in the surveyed fleets of the new Member States amounts to EUR 14 500. This difference in productivity can at least partly be explained by higher capital intensity in the EU-15 countries; there are 51 kW/man in the EU-15 and 33 kW/man in Poland and the three Baltic republics.





NB: EFTA countries: Norway and Iceland

ECC countries. ECC stands for European Union candidate countries: Bulgaria, Cyprus, Malta, Poland, Romania, and Slovenia. (Estonia, Latvia and Lithuania were not included in the graphs due to limited time series).

Sources: Eurostat 2001, FAO1998, Fisheries DG, 1999, data compiled by ETC Water.

### Subsidies in fisheries

In recent years there has been a growing interest in the widespread use of subsidies in the fisheries sector. According to the World Bank, global fishing subsidies vary between \$14 and \$20 billion, which would approximate to 20–25% of turnover in the sector. The OECD and APEC consider them somewhat smaller at just over \$12 billion, or 17% of turnover. An 1999 OECD study estimated that the amount of subsidies was just short of \$6 billion and broken down as follows: EC\$1.2 billion, US \$1.1 billion, Japan \$2.5 billion, Canada \$0.5 billion, Korea \$0.4 billion.

Many fishery managers see sustainability of fisheries and aquaculture as being undermined when governments grant subsidies. It is a commonly held belief that subsidies distort the conditions of trade in fish and fish products, favouring nations that provide subsidies over those that do not. Also, it is said that subsidies speed up the development of overcapacity and consequently threaten the continued wellbeing of wild fish stocks. However, little factual information on effects is available; few in-depth studies having been carried out. Some of the controversy is no more than an extension of the differences in the manner in which countries use subsidies as a tool in their respective macro-economic policies. Notwithstanding, the controversy over the importance and usefulness of subsidies in fisheries is fuelled also by the fact that there is no universally accepted definition of exactly what government actions (or inactions) can to be considered as subsidies.

The term subsidies can be broadly applied to a wide range of government interventions, or to the absence of correcting interventions, that reduce costs and/or increase the revenues of producing and marketing of fish and fish products in the short-, medium- or long-term. "Government interventions" include financial transfers or the provision of goods or services at a cost below market price. "The absence of correcting interventions" includes failure by government to impose measures that correct for external costs associated with fishing.

In general, where the incentive for fishers remains one of catching available fish before others are able to do so, most subsidies appear to cause effort and fleet capacity to expand more than they would otherwise have done, which increases the pressure to overfish. Further, overfishing leads ultimately to falling catches of fish through stock depletion, and perhaps even to stock collapse. Elimination of subsidies in badly managed fisheries is therefore highly desirable for reasons of conservation. However, in conditions where perfect control of effort prevails, subsidies will probably result in increased profits rather than in increased fishing effort.

The causal link between subsidies and overfishing should not be taken for granted. Overfishing and subsidies may both be symptoms of poor management of the fisheries rather than there necessarily being a causal link between them. A subsidy may also have a positive impact on the aquatic ecosystem, reduce overcapacity (e.g. a well-designed vessel decommissioning programme) and may enhance the sustainability of the resource, depending on the purpose for which it is granted, the circumstances in which it is given, and whether unintended impacts have been avoided.

### **Subsidies to the EU fishing sector**

In Europe, support to the fisheries sector started in order to help fishers restart their work after World War II. As the European Union was created and the Common Fisheries Policy (CFP) took form, the structural support to the Member States were mostly used for modernisation, one of the most important parts of the CFP. The aim of the support was to make the EU fishing fleet more competitive.

Since then the support has been broadened and it now constitutes a great deal of the fisheries industry as well as the aquaculture industry. Already in 1992, the community fishing fleet was restructured, because modernisation and incremental growth of the fishing fleet led to a strong decline in many of Europe's fish stocks. One of the aims of the restructuring was to control overcapacity. The EU therefore started to give economic compensation for decommissioning fishing companies and for reconstructing vessels to be used for purposes outside of fishing, or for the scrapping of vessels. New types of structural support were introduced, such as support for the development of more selective gear or more environmentally sound fishing methods. Support for the improvement of sanitary conditions and the handling of seafood onboard the fishing vessels was also introduced. However, the EU continued supporting modernisation and building new vessels in order to make the fishing fleet more competitive.

Within the EU today, there are essentially two types of support: structural support and national aid. Structural support is essentially money distributed by the EU to facilitate the production of commodities and to organise the production. Structural support exists among sectors such as agriculture too, and the support is given to produce a long-term effect. Since January 1994, the structural support for fisheries and aquaculture has fallen within the framework of the community structural funds.

EU has four structural funds channelling economic support to the fishing sector. The Financial Instrument For Fisheries Guidance (FIFG), which has been replaced by the European Fisheries Fund (EFF) in 2007 is the most important structural fund. The FIFG, which ran from 2000 to 2006 distributed EUR 545 million per year, or a total amount of EUR 3 746 million. The EFF, which was adopted in July 2006, will distribute a total of 3.8 billion during the next programming period of 2007-2013. During 1997 it is estimated that the EU alone subsidised the fishing sector to the tune of EUR 824 million. Additional money is available under the Community financial measures for the implementation of the Common Fisheries Policy and in the area of the Law of the Sea, also known as the "2nd instrument", the European Regional Development Fund (ERUF), and the European Social Fund (ESF).

National or state aid is "aid to facilitate the development of certain economic activities or certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest". Examples of such aid are financial transfers, loans at reduced interest rates, interest subsidies, and financial incentives to companies. The rules for such aid are controlled under the Commission Regulation for *de minimis* 1860/2004, which is currently being debated, and the Commission guidelines for national Regional Aid (98/C7406), which will be replaced by a new set of guidelines (2006/C 54/08) for the programme period of 2007-2013.

The reform of the CFP in 2002 meant great improvements in structural support. There was a decision to end common support for modernising vessels beginning in 2004. At the same time support for modernising fishing vessels was only distributed on the condition that they would increase fishing capacity. The reform also included an end to subsidies for exporting overcapacity, through so-called joint ventures, as well as increased subsidies for scrapping

vessels. However, the creation of new fishing opportunities for the EU fishing fleet is still one of the highest priorities within the CFP. Negotiations of third country agreements therefore continue, the costs of which are generally paid by the EU.

A new proposal for the EFF was advanced by the Commission in 2004, based on the reform of 2002. The EFF was adopted in July 2006, and includes a number of new, broad support structures for sustainable development in coastal communities with limited opportunities for alternative employment, as well as support for increased protection of fish stocks and the marine environment. However, it does contain some parts that could allow further increases in fishing capacity, such as opportunities for vessel modernisation, support for recruitment of young fishers, and support for engine replacement.

## Hypotheses (2020)

1. **Down the drain:** Costs continue to increase while fish prices remain stable: with little fishing opportunities more fleets face negative development, leading to scrapping of vessels, capital moving out of the sector. Unemployment in fishing communities, both direct and indirect in processing and ancillary industry, increases.

2. **A Healthy Mean and Lean:** Through sector initiative and government support, fleet capacity is brought in line with fishing opportunities. Excess capital is removed from the sector, both reducing fishing pressure and increasing profitability. A fishing sector, smaller than before but economically healthy, produces a highly valued and high value fish product for the European Market.

## Sources

- [http://www.oceansatlas.com/world\\_fisheries\\_and\\_aquaculture/html/issues/govern/subsi/default.htm](http://www.oceansatlas.com/world_fisheries_and_aquaculture/html/issues/govern/subsi/default.htm)
- AER, 1999, 2002, 2005
- <http://www.fishsec.org/>
- [http://jpn.cec.eu.int/home/news\\_en\\_newsobj581.php](http://jpn.cec.eu.int/home/news_en_newsobj581.php)

## **SOCIAL DYNAMIC**

## SOCIAL DYNAMIC

### D1 Recreational fisheries

#### Driver Definition

There is a confusing array of definitions in the literature pertaining to recreational fishing and its constituent parts and related sectors. Most confusing is the interchangeable use of the terms subsistence fishing, recreational fishing, marine recreational fishing, leisure fishing, sports fishing, angling, and recreational angling.

A common theme represented in many definitions of “recreational fishing” relates to a description of the sector in terms of what it does not constitute. For example, the European Commission defines ‘recreational and game fisheries’ as “*all fishing activities not conducted for commercial fishing purposes*” (CEC, 2001). Other definitions use linked concepts to define recreational fishing as an activity that “*does not include sale of catch*” (Roberts *et al.*, 2001), or as an activity “*not deemed commercial fishing*” (EAA, 2004). However, the definition used in the NMFS ‘Marine Recreational Fishery Statistics Survey’ introduces a notion that part of a recreational fishery catch could be sold for financial gain, “*If part or all of the catch was sold, the monetary returns constituted an insignificant part of the person’s income*” (Witzig, 2004).

Some definitions of ‘recreational fishing’ go further and introduce a notion of the types of gears and methods with which recreational fishing can be undertaken (EAA, 2004; Witzig, 2004), whereas others focus on the motivations for the activity, e.g. “*Harvesting fish for personal use, fun, and challenge*” (Roberts *et al.*, no date) and “*Fishing primarily ..... for pleasure, amusement, relaxation, or home consumption*” (Witzig, 2004).

#### Relevant Indicators

- Number and character of licences
- Money spent
- Number of boats
- Magnitude and profile of participants in sector
- Economic importance

#### Developments over the past 20 years

Recreational fishing appears to be a growing activity within many European Member States (Pawson *et al.*, 2007), and concerns have been raised about its influence on commercial fish stocks. Correspondingly, there is a growing body of regulation at the national level governing marine recreational fishing, albeit exerting far less control than is evident for recreational fishing within inland waters.

Total expenditure on recreational fishing across Europe is believed to exceed €25 billion a year (Dillon, 2004). By comparison, the 1998 value of commercial landings in the 15 EU member states was estimated at €20 billion (Pawson *et al.*, 2007). In its report on the problems encountered by inshore fishers (A6-0141/2006), the European Parliament’s Committee on Fisheries noted that there is increasing tension between inshore fishers, who fish for a livelihood, and recreational fisheries that are competing in the same physical space of the same coastal areas for the same fish, and suggest that this issue needs to be addressed.

Recreational fisheries may interact with commercial fishing in many ways. For example, they may contribute a substantial source of mortality for some species (sea bass: Dunn *et al.*, 1989, 1995; Pickett and Pawson, 1994) that is seldom accounted for in stock assessments (ICES, 2004). Recreational fisheries also interact with commercial fisheries through

competition for fishing space, and when unlicensed “recreational” or “hobby” fishers compete with commercial pot or net fisheries both for the resource and by supplying low-priced fish to markets<sup>24</sup>. Further, at a political level, sport anglers and commercial fishers can make conflicting claims over the conservation needs of fish stocks, because they tend to have differing requirements either in terms of fish availability or size structure. On the positive side, alternative employment opportunities for commercial fishing vessels are provided through chartering by sport angling parties.

Recreational fishing is an important leisure activity in all the Scandinavian countries. It is estimated that almost 25% of recreational fishers in Europe are Nordic, and their expenditure in connection with this hobby is considerable (Pawson *et al.*, 2007).

Table 1. Demography of marine recreational sector (number of fishers, gender and age), by EU country (from Pawson *et al.*, 2007)

Country	Number of marine recreational fishers	Type of activity	Gender (% male)	Average age (years)	Data source
Denmark	267 000	All marine	79*	40*	Toivonen <i>et al.</i> (2000)
Sweden	817 000	All marine	71*	41*	Toivonen <i>et al.</i> (2000)
Finland	292 000	All marine	65*	42*	Toivonen <i>et al.</i> (2000)
Germany	818 400 87 800	Marine & all-rounders <i>Salmonid anglers</i>	94*	41*	Arlinghaus (2004)
The Netherlands	450 000 <sup>1</sup>	All marine	94	n/a	Smit <i>et al.</i> (2004)
Ireland	41 000 67 300 47 400	Overseas anglers Domestic anglers <i>Salmonid river anglers</i>	n/a	n/a	Institute of Technology (1997) Indecon (2003)
England & Wales	1 100 000 <sup>2</sup> 800 000 (241 000) (600 000) (361 000)	Marine angling <i>Salmonid anglers</i> (Local anglers in SW) (Visiting anglers in SW) (English sea bass anglers)	97	46 <sup>3</sup>	Crabtree <i>et al.</i> (2004) Spurgeon <i>et al.</i> (2001) Cappell and Lawrence (2005) Pickett <i>et al.</i> (1995)
Scotland	n/a <sup>4</sup>	<i>Salmonid river anglers</i>			
France	>4 000 000 <sup>5</sup> (900 000)	All marine (Sea bass anglers)	(79)	(35-49)	Morizur <i>et al.</i> (2005)
Portugal	n/a n/a	(Lisbon area) (Tagus estuary)	(99) (n/a)	(20-50) (51)	Do Vale (2003) Lopes (2004)
Spain	(93,000)	(From boat)	(Majority)	(50)	Gordoa <i>et al.</i> (2004a)
France	n/a	(Tuna fishing)	(Majority)	(55)	Gordoa <i>et al.</i> (2004a)
Italy	(1,500,000) n/a	(From boat) (Tuna fishing)	(>99%) (Majority)	(30-60) <sup>6</sup> (50)	Anagnopoulos <i>et al.</i> (1998) Gordoa <i>et al.</i> (2004a)
Greece	(96,075)	(From boat)	(99) <sup>7</sup>	(50% retired) <sup>8</sup>	Anagnopoulos <i>et al.</i> (1998)

Notes: \* Denotes average age of marine and freshwater fishers combined.

( ) Denotes values within a subset of the total MRF population.

1. Over the age of 15 years.
2. Around 1.1 million households in England and Wales contained 1 adult sea angler, so it was estimated that there were at least 1.1m adult sea anglers. It was further estimated that there may be a further 0.34 million children participating.
3. Own estimate based on Crabtree *et al.* (2004).
4. Number of angler days for salmon and sea trout was estimated at 545,000.
5. The source of this estimate is unclear.
6. 60% of fishers were 30-60 years old, with the modal age range (32%) being 30-40 years.
7. Majority of Greek respondents were male, although 5% of membership of club's interviewed were female.
8. 50% of those interviewed were retired, but 75% of club members were 31-60 years old.

<sup>24</sup> Though, by definition, fishers who sell their product on the market are not truly engaged in recreational fishing, but illegal, unregulated and unreported (IUU) commercial fishing

### Magnitude and profile of participants in sector

National-level data relating to the marine recreational fisheries activity (specifically number of fishers) are generally not collated regularly by government departments or national bodies (Pawson *et al.*, 2004). The magnitude of the marine recreational fisheries sector in various European Union countries, for which data were readily accessible, is shown in Table 1.

There appear to be at least 9.5 million marine recreational fishers in Europe, based on information for a variety of years ranging from 1997-2005 depending on the source data. However, this is likely to be a significant underestimate of true numbers because national figures were not readily available for Belgium, Cyprus, Estonia, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia or Slovenia, and figures for a subsegment of the national sector (those fishing from boats) were only available for Greece, Italy and Spain (Pawson *et al.*, 2007).

### Economic importance: non-market benefits of recreational fishing

Although a considerable amount of research is available relating to the non-market benefits of freshwater fishing, there is a paucity of similar information for the marine recreational fishery experience in Europe. The only national-level study that estimated the non-market benefits of all marine recreational angling activity was undertaken in England and Wales by Crabtree *et al.* (2004). The total annual value of consumer surplus associated with all recreational sea angling in England and Wales in 2003 was estimated to be between €163 and 1054 million. In 1992, the consumer surplus associated with the recreational fishery for sea bass alone – a subset of total recreational sea angling activity - was estimated to be €30 million (CVM: Dunn *et al.*, 1995). Toivonen *et al.* (2000) estimated similar values for marine and freshwater recreational fishing activities combined, and estimated the total economic value in Denmark to be between € 255 and 287 million depending on the method used to derive the estimates: €163-167 million in Finland and € 260–270 million in Sweden.

### Hypotheses (2020)

In several of the existing scenario exercises for the marine environment, recreational fisheries have been considered (notably Pope, 1989; MEA, 2005; Pinnegar *et al.*, 2006). The future importance of recreational fisheries will be dependent upon the prevailing socio-political climate and the emphasis that society places on leisure versus environmental protection, animal welfare or food production.

Several authors have anticipated that Europeans will enjoy greater leisure time in the future and therefore that we might expect an expansion of sport fisheries. Others have anticipated a situation whereby recreational fishers will be governed by the same rules as commercial fishers, i.e. their access to sites and fish resources will be greatly restricted.

In recent years politicians have started to pay greater attention to recreational fisheries because of the large number of citizens who participate, but also because more is becoming understood about the economic scale of the activity. This increase in political profile might be expected to continue in the future, as recreational fishing organisations and associations become better coordinated and gain a 'louder voice'.

One important caveat which must be considered when thinking about possible futures is that opportunities for recreational fishers may be influenced by climate change, because many species that are popular among sport fishers (e.g. cod, tuna, salmon) are known to have experienced shifts in their distribution or migration routes in recent years, such that they are no longer resident in certain areas. By contrast other 'sport' fish such as sea bass may become more prevalent as the climate warms.

1. **The oceans as a 'play-ground'**: Increased leisure time, and a focus on social wellbeing throughout Europe encourages a great expansion of recreational fisheries. Many commercial fishers convert their boats to accommodate tourists, and stocks are managed such that some fish reach sizes and numbers that are attractive to recreational fishers. Certain stocks/species are given over to 'sport fisheries' only.

2. **‘Pay to play’:** The increased prevalence of free markets, ‘individual transferable quotas’ and spatial planning in the oceans allows recreational fishing organisations to use their substantial financial resources to ‘buy out’ fish resources or zones of sea bed, so restricting access by commercial fleets. On the negative side, environmental groups also ‘buy out’ zones of the ocean and limit access by both recreational and commercial fisheries.

3. **‘Sport squeezed out’:** National and international concerns regarding food security are heightened. The oceans are seen primarily as a place of food production, so recreational fisheries are largely squeezed out. Fish stocks continue to decline. Stocks of large fish (e.g. salmon, seabass, tuna, cod, turbot) that are favoured by sport fishers largely disappear.

4. **‘Welfare worries’** Concerns regarding animal welfare come to the fore, and public opinion swings away from pastimes that involve the pursuit and capture of wild animals. Stronger legislative controls are imposed on recreational fisheries, and fewer Europeans participate.

## Sources

- Commission of the European Communities (CEC). (2001). Fisheries Control in Member States – Belgium. Brussels: Commission Staff Working Paper, Commission of the European Communities. SEC (2001) 1799.
- Crabtree, B., Willis, K., Powe, N., Carman, P., Rowe, D., MacDonald, D. and Usher-Benwell, Y. (2004). *Research into the economic contribution of sea angling*. Final report to UK Department for Environment Food and Rural Affairs, March 2004, 71 pp. plus 7 annexes.
- Dillon, B. 2004. *A bioeconomic review of recreational angling for Bass (Dicentrarchus labrax)*. Scarborough Centre for Coastal Studies, University of Hull.
- Dunn M. R., Potten, S.D., Radford, A.F., and Whitmarsh D. 1989. An economic appraisal of the fishery for bass in England and Wales. Report to MAFF, Cemare, Portsmouth.
- Dunn, M. R., Potten, S. D., Whitmarsh, D. (1995). *Further economic evaluation of the bass fishery in England and Wales 1992/93*. CEMARE Research Report R30, CEMARE, University of Portsmouth, UK.
- EAA (2004). Recreational Angling – Definition. A definition on Recreational Angling agreed by the European Anglers Alliance at the General Assembly 2004 in Dinant, Belgium. <http://www.eaa-europe.org/web/Frames/PFPositions/PositionList-EN.htm>
- 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.
- Pawson MG, Tingley D, Padda G, & Glenn H (2007) EU contract FISH/2004/011 on “Sport Fisheries” (or Marine Recreational Fisheries) in the EU. Final Report, Centre for Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft UK. 211pp.
- 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.
- Pickett, G. D. and Pawson, M. G. (1994). "Sea Bass, Biology, exploitation and management." Chapman and Hall, Fish and Fisheries Series 12: 358pp.
- Pope, J. (1989) Fisheries research and management for the North Sea; the next hundred years. *Dana*, 8: 33-43.
- Roberts, K. J., Horst, J.W., Roussel, J.E, and Shephard, J.A. (1991). Understanding Fisheries Management. A Manual for understanding the Federal Fisheries Management Process, Including Analysis of the 1996 Sustainable Fisheries Act. Appendix 2: Definition. NOAA.
- Toivonen, A., Appelblad, H., Bengtsson, B., Geertz-Hansen, P., Guðbergsson, G., Kristofersson, D., Kyrkjebø, Navrud, S., Roth, E., Tuunainen, P. and Weissglas, G. (2000). *Economic value of recreational fisheries in Nordic countries*. TemaNord 2000:604. Nordic Council of Ministers, Copenhagen, 71pp.
- Witzig, J.F. (1997) Marine Recreational Fishery Statistics Survey Procedures Manual. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Office of Research and Environmental Information. Section 3.3.1.2 <http://www.recfin.org/procman/index.html>

## SOCIAL DYNAMIC

### D2 Public perception of fisheries/aquaculture (communication)

#### Driver Definition

The public perception of fisheries and aquaculture can be defined as the way in which society at large perceives the activities of fish production. In this, it is obvious that there might be several different groups<sup>25</sup> in society that have a different perception or opinion about the way fisheries and aquaculture are conducted. Also, there might be differing opinions depending on the role an actor plays: for example people as consumers might have a different opinion towards a product (e.g. they might prefer a large quantity at a low price) than when they act as citizens (when they may prefer all production to be sustainable in ecological, economic and societal terms).

The whole issue of public perception has to do with the extent to which public opinion:

1. drives the regulatory system;
2. is part of and is answerable to the principles of governance;
3. is a stakeholder in the discourse.

#### Relevant Indicators

Using the “A, B and C” of public perception and attitudes, does each attitude have one or more of the following components?

A: affective (liking, a feeling for)

B: behavioural (how one behaves towards the object in question)

C: cognitive (what are one’s beliefs/thoughts about the object in question)

And also,

- what is the influence of public opinion on the rules and regulations governing fisheries and aquaculture activities?
- What are the real public perceptions of fisheries and aquaculture

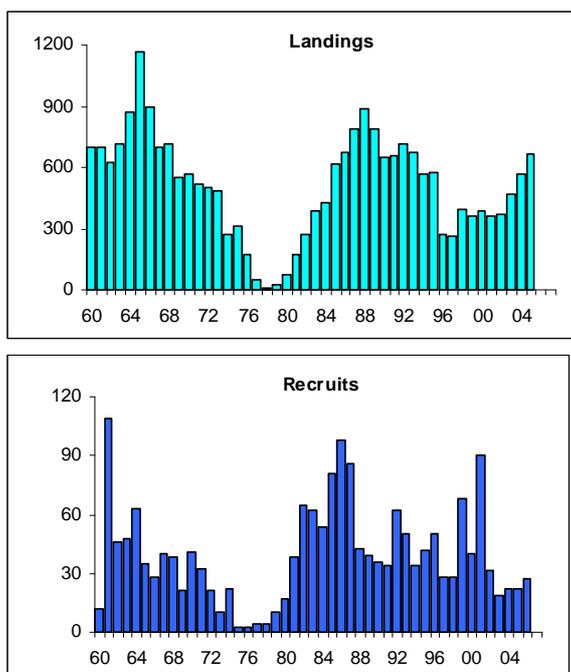
There are many relevant indicators one can use, including: opinion surveys; lists and descriptions of community actions in defending or (in direct contrast) protesting against fisheries/aquaculture; information on the actions of NGOs for and against fisheries and/or aquaculture; the demands (to national and EU levels) of coastal communities for access to or association with fisheries and aquaculture activities in their immediate vicinity.

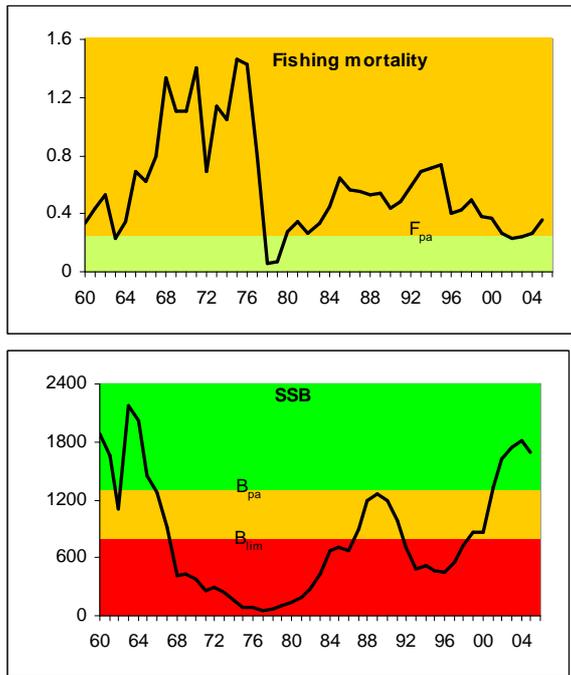
<sup>25</sup> To be more precise in this context one should use the term category, because in the sociological definition of a group there are a number of people with shared attributes who are aware and know each other and acknowledge membership of a group. Social categories group people according to a set of criteria, but the members of each category are not necessarily aware of each other’s existence, nor do they necessarily subscribe to all attributes and opinions of the whole group.

## Developments over the past 20 years

Wild fisheries historically dominated the production of marine protein both for human consumption and for the production of fishmeal for feed production for agriculture and aquaculture. As the availability of wild stocks of fish and shellfish diminished aquaculture developed and with it the demand for fishmeal. This increased use of especially stocks of small pelagic fish and forage species such as sandeels, led to calls for (and hence research into) alternative feed sources for aquaculture.

It is these dynamics that drive the whole issue of public perceptions of seafood harvesting, whether natural or by culture. It is likely that, even 20 years ago, the general public's perception of fishing and its effect on the marine environment was reasonably positive, i.e. that fishing was not really a problem because the seas were large and their stocks almost inexhaustible, although overfishing and its effects on the associated ecosystems had already been noted and documented early in the 20<sup>th</sup> century. For the United Kingdom and the important North Sea fishing grounds in particular, Michael Graham wrote about the problem extensively in an authoritative volume published in 1956. The Figure below, for North Sea herring, shows what scientists such as Michael Graham inferred (he did not have access to the technology we have access to these days) and scientists now know to be the case. The public, of course, only became aware of the problem with herring when there was a scarcity in the mid 1990s (top left), but scientists now know that the problem had already started earlier, when recruitment (of young fish) had progressively declined (top right) whereas fishing on the stock had not (bottom left). Of course, one needs spawners (measured as SSB, spawning-stock biomass, bottom right) to produce young fish, so the plot on the bottom right clearly shows that we were somewhat lucky that herring recovered from its virtual crash and is now in a much more favourable position. The public, of course, remain blissfully unaware of the interacting dynamics and simply know that herring from the North Sea is abundant again now (top left). Scientists, however, try to raise public awareness of the health of fish stocks by way of a simple traffic-light approach, so the bottom right panel shows the real stock dynamics in bands of red, amber and green, green being reasonably safe, red in danger, and amber where care is needed. Despite the subjectivity in determining the levels where red, amber and green are appropriate, this method does have value in disseminating information in a clear manner, something that needs to be done better in future.





North Sea herring stock dynamics (source: ICES Advisory Committee on Fisheries Management reports)

During the past 20 years, and even earlier, once problems of storage (frozen or otherwise) had been solved, virtually the whole population of Europe has had access to quality, affordable (as well as luxury) fish and shellfish produce, and whole generations, inland- and coast-dwelling, have grown up in the knowledge that fish product is a part of one's diet that is readily available to them, even though, as shown graphically above, occasional fluctuations in availability can occur. Most of the production has been in the form of large volume, reasonably low price, fish such as herring, and some countries have kept prices low (while other drivers such as fuel and manpower costs have escalated) through a system of subsidies (including for fishing boat construction).

The past 20 years has also, of course, seen public perception of fish as a healthy foodstuff soar, as better education and health awareness, as well as enhanced communication means have allowed the general public access to information that earlier generations could never accumulate.

Now, despite burgeoning aquaculture of some species (e.g. salmon), and subsidization and rationalization of the fish catching and production process, fish and shellfish prices have risen to the extent that fish has become almost a luxury product. The awareness of its healthy properties has still led the general public to source it. Knowledge of the finite nature of marine resources has at last filtered through to much of the population, perhaps driven by NGO pressures and knowledge of why the prices are rising and certain products are becoming scarcer.

Communication to the general public of adequate information about fisheries and aquaculture and how they are prosecuted has not yet reached the stage in the first world, even in schools and the educational system, where a large percentage of the population has been able develop its own feelings towards the two industries. In much of the third world, populations in inland areas know little about seafood, and coast-dwellers probably know only that it is becoming more difficult as time passes to make a living on or extract enough to eat from the sea. The shifting baseline syndrome, whereby successive generations base their perceptions of "pristine status" or "ideal status" on only the situation regarding fish stocks known to its preceding generation, is becoming more and more obvious to those concerned with the sea and its contents. Therefore, scientific knowledge plots such as historical "traffic light" displays (as shown above) for all the stocks of fish in which humankind is interested assume great

importance. The downside of this, of course, is that such displays are based on single-species/stock dynamics, and do not provide information on the dynamics of whole ecosystems, including the fish, which is what the world fisheries resource managers are increasingly being asked to supply. Regrettably, we are still many years away from being able to inform the public in a similar manner about those dynamics!

## **Hypotheses (2020)**

1. **The Conservationist:** Views of the environmental lobby will dominate and the general public will restrict themselves virtually only to using seafood harvested and produced sustainably and in an environmentally friendly manner
2. **The Ruthless Exploitationist:** The world will be so short of protein that the public will demand that everything within the sea be used to support man's requirement for nourishment
3. **The Fisherman:** The views of fishers about the state of stocks (in public generally more positive than reality) will dominate perceptions
4. **The Politician:** Political expedience and currency will lead to public uncertainty about what is the real situation.

## **Sources**

- Wikipedia
- Ferguson 2005, Social Psychology.
- Graham, M. 1956. Sea Fisheries: their Investigation in the United Kingdom. Edward Arnold Publishers, London.
- ICES Advisory Committee for Fisheries Management reports

## SOCIAL DYNAMIC

### D3 Activities in Coastal Areas (including employment for fishers in other sectors)

#### Driver Definition

Next to activities directly related to fisheries and aquaculture it is important to have knowledge about other opportunities for seagoing and coastal activities, in particular geographical areas. Fisheries and aquaculture are an opportunity (for income, self esteem, a position in society) just as there might be other (job) opportunities. Therefore, the driver is defined as job opportunities in coastal areas, including job opportunities in fisheries and aquaculture and processing.

#### Relevant Indicators

- the number of jobs at the coast created annually
- diversification of employment
- annual figures of migration into coastal areas
- employment share by activity in coastal areas of the EU, including geographic spread
- levels of unemployment by area in coastal areas of the EU
- availability of opportunities for employment in activities other than fishing and aquaculture by coastal area
- the economics of activities other than fishing, and the general attitude of fisherfolk and coastal communities towards these other activities
- the number of jobs in fisheries and aquaculture

#### Developments over the past 20 years

In the EU, most of the fishing communities have been getting smaller with time as quotas and fleets have become progressively reduced and jobs in fishing and associated industries have become scarcer. Associated with this in some countries has been migration to the coast in search of a better quality of life than may exist inland, a feature of many countries around the world, not just in Europe. In all cases, though, coastal populations at worst have at least stayed at the same levels.

Fishing has traditionally been associated with many coastal communities, and in many cases in even very advanced countries, whole communities depend on the fishing industry for their very existence. Families often pass down knowledge of fishing and the resources from generation to generation. Of course, in some areas of the European coast, there are not many opportunities for employment other than fishing unless local and national governments intervene (perhaps associated with forced relocation of citizens and industry away from crowded urban areas inland) and/or if other medium or small (rarely large) enterprises voluntarily decide to relocate their operations close to the sea; such interventions or relocations are the exception rather than the rule.

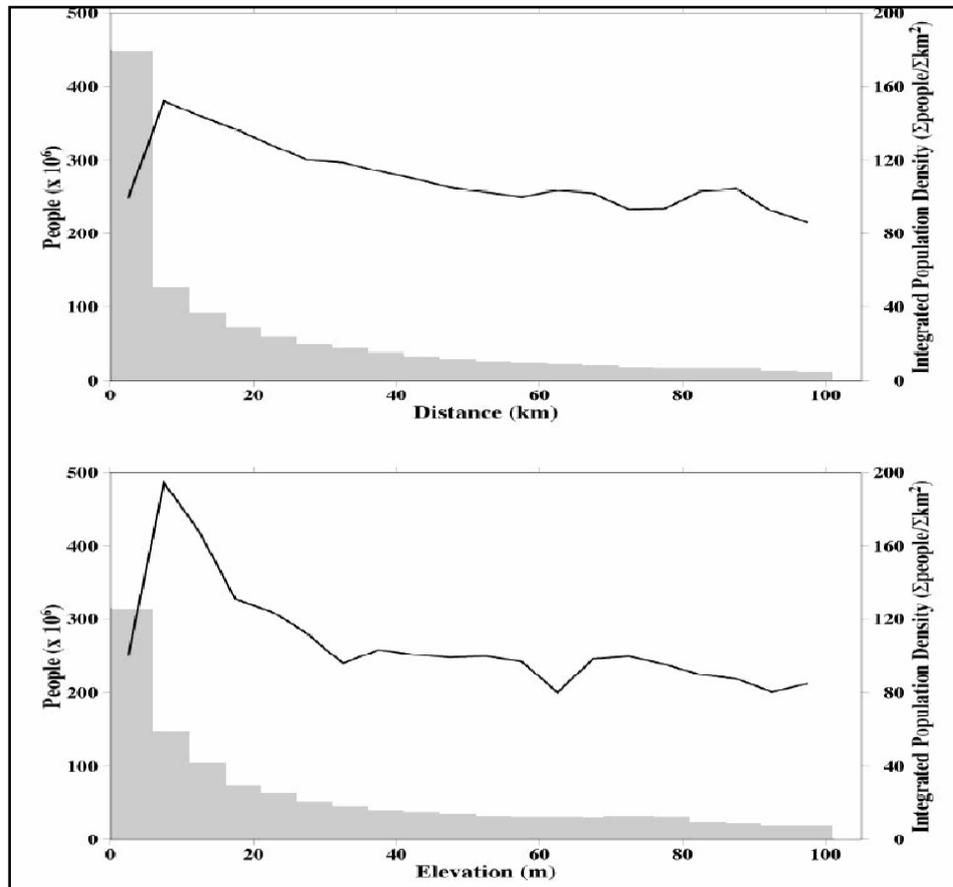
Certainly in the past 20 years, few new job opportunities have been created at the coast, although some enterprising ex-fishers and fishing industry support workers have found ways of making a living in a manner that until the downturn in the fishing industry they did not consider. Small-scale or in certain cases even large-scale aquaculture has developed and in some cases outstripped the income from wild fisheries in certain areas suitable for such activity, generally those that are less exposed to the elements but where local conditions (e.g. plankton productivity for shellfish; flushing capacity for both finfish and shellfish culture) are suitable for it. Also, some processing plants of large national and multinational companies

have retained or even expanded their presence in coastal communities, processing vegetables and meats on lines previously devoted only to fish or shellfish, and/or bringing in fish and shellfish from other landing areas to supplement their processing activities as local supplies of marine produce were interrupted or halted. In some areas too, immigration from new EU states has produced a coastal workforce more willing to handle the menial tasks of fish and shellfish processing and farming than long-resident locals, many of whom have moved elsewhere to seek work which they find more acceptable, changing the cultural make-up of some coastal communities and sometimes causing the coastal population to burgeon.

Overall though, world populations have always been proportionally larger close to the coast (see figure below). The dynamics are changing now, however, probably more noticeably than at any other time of anthropogenic existence.

An increasing pressure on the coastal zone derives from a lack of opportunities inland. In addition of late as a result of climate change, more and more people may be taking the decision to migrate to “desirable” coasts from inland and elsewhere. Nevertheless:

- coasts are experiencing the adverse consequences of hazards related to climate and sea level;
- coasts are being exposed to increasing risks as a consequence of many compounding climate-change factors;
- the impact of climate change on coasts is exacerbated by increasing human-induced pressures;
- coastal adaptation in developing countries will be more challenging than in developed countries, such as in Europe, because of constraints on adaptive capacity.
- adaptation costs for vulnerable coastlines are much less than the costs of inaction;
- the unavoidability of sea-level rise even in the long-term conflicts with human development patterns and trends.



*The dynamics of coastal population densities, by distance and elevation (from Nicholls, 2007).*

Fishing has traditionally been associated with coastal communities, and in many cases in even very advanced countries, whole communities depend on the fishing industry for their very existence, and families often pass down knowledge of fishing and the resources from generation to generation. Of course, in some areas of the European coast, there are not many opportunities for employment other than fishing unless local and national governments intervene (perhaps associated with forced relocation of citizens and industry away from crowded urban areas inland) and/or if other medium or small (rarely large) enterprises voluntarily decide to relocate their operations close to the sea; such interventions or relocations are the exception rather than the rule. Certainly in the past 20 years, few new job opportunities have been created at the coast, although some enterprising ex-fishers and fishing industry support workers have found ways of making a living in a manner that until the downturn in the fishing industry they did not consider. Small-scale or in certain cases even large-scale aquaculture has developed and in some cases outstripped the income from wild fisheries in certain areas suitable for such activity, generally those that are less exposed to the elements but where local conditions (e.g. plankton productivity for shellfish; flushing capacity for both finfish and shellfish culture) are suitable for it. Also, some processing plants of large national and multinational companies have retained or even expanded their presence in coastal communities, processing vegetables and meats on lines previously devoted only to fish or shellfish, and/or bringing in fish and shellfish from other landing areas to supplement their processing activities as local supplies of marine produce were interrupted or halted. In some areas too, immigration from new EU states has produced a coastal workforce more willing to handle the menial tasks of fish and shellfish processing and farming than long-resident locals, many of whom have moved elsewhere to seek work to which they are more amenable, changing the cultural make-up of some coastal communities and sometimes causing the coastal population to burgeon.

The coastline of many European countries has long been a favoured holiday and tourist destination, particularly in summer, so jobs have also been created in that sector to support tourist expectations, perhaps seasonally, but often lucratively within the accommodation, entertainment and catering industries. This sector too has drawn on the families and even breadwinners of migrants from elsewhere to support it. The upshot has been that, although coastal unemployment in many areas initially tended to burgeon as the traditional (wild) fishing industry shrank, the uptake of opportunities in other sectors and general entrepreneurship turned the unemployment trend around and many also started to diversify and take on different types of seasonal employment where it was provided. The same has also happened, of course, to some of the diehards who remained in the fishing industry, providing themselves a living no longer in a single fishery, but taking advantage of fishing stock availability/abundance across several fishing sectors. Therefore, although many fishers actively avoid any form of employment other than that to which they have traditionally been drawn, and sometimes show a disdainful attitude to those who leave the industry, far more coast-dwellers and ex-fishers have realized that their only hope for continued life near the sea is to diversify their activity to benefit from seasonal opportunities in other sectors. Some, of course, retain their boats and use those to support tourism activities in season.

In summary, although human populations tend to concentrate at the coast, fishing and lately aquaculture have not been the sole employment opportunities; many other activities have been and are becoming even more important. Therefore, the dynamics of coastal activities are changing, and future challenges will be to encourage an even greater diversity of activities than traditional for the coast to burgeon and to exist in harmony side by side.

## Hypotheses (2020)

1. **The Fishing Fantasist:** Some coastal communities and ex-fishers and fishing industry employees refuse to believe that their traditional way of life has a limited or different future, and coastal communities become poorer and older as their youth move away for greener horizons.
2. **The Realist:** Coastal communities and their inhabitants find ways to diversify employment and to attract tourists, and support and actively encourage new industries such as energy (windfarms, tidal, nuclear) and aquaculture to come their way. The community thrives.
3. **The Marine Entrepreneur** The individual or group who go out of his/their way to actively find new outlets for their energies, promoting the benefit to health of the sea and becoming businesspeople themselves. With a degree of luck, the community thrives.

## Sources

- Nicholls, R. J. 2007. The threat to coastal populations and ecosystems. In Climate change impacts, adaptation and vulnerability. A meeting to present and discuss the results of the Intergovernmental Panel on Climate Change Working Group II, Fourth Assessment, 18/19 September 2007. WMO/UNEP. Available at <http://www.rgs.org/NR/rdonlyres/E6426EAE-9895-481B-B97C-EBA01467AE5/0/IPCCRNicholls18Sept2007.pdf>

## SOCIAL DYNAMIC

### D4 Competing Use Of Seashore (energy, leisure activities, urbanization)

#### Driver Definition

The seashore and coast has a spatial footprint that encompasses manifold, often competing, uses, e.g. fishing, aquaculture, tourism, energy use, marine transport, waste disposal.

#### Relevant Indicators

- different usage components acting or not in harmony,
- the extent of well managed coastal environment throughout Europe,
- conflicts between competing users

#### Developments over the past 20 years



*Population densities in Europe (from Nicholls, 2007). Note the dominance of densities at the coast.*

The coastlines and coastal environments of Europe are generally well or in some case over-populated (see Figure above). Some have traditionally been popular destinations for tourists, and ports have historically been crucial to the economies and the populations/consumers of European states and of the region as a whole, with shipping and small-boat recreation in many areas being highly visible. Therefore, a well-managed coastline shared amicably between all users is critical to a country's well-being. Now, with populations in many European countries having burgeoned and pressures from manifold coastal industries and users beginning to conflict, the need for robust but fair management of what has become in some cases a scarce resource has risen.

Fishing from boats, of course, is a long-standing coastal activity, and manifold regulations now apply to the boats and to the industries supporting them. However, there is already conflict between different sectors of the commercial fishing industry, and tensions often arise too between artisanal or recreational fishers and outright commercial fishers. Therefore, there is as much competition between sectors of the fishing industry as there is between fishers and other users. The same applies to other sectors. There is managed competition for space in European waters between those wishing to erect coastal or offshore windfarms and the fishing fraternity. Some oil and/or gas extraction facilities or their pipelines ashore cause yet further competition, and many energy plants (e.g. power stations, nuclear or otherwise) are sited next to the sea. With burgeoning populations and traditional fishing now no longer able to meet the demand for fish and shellfish, intensive aquaculture is also now taking over large expanses of suitable coastline, affecting onshore space availability and subtidal habitat and space, further adding to the pressure on coasts. Further, the need to dispose of waste, through rivers or directly into the sea, has rocketed with the human population explosion and increasing industrialization, though regulations governing such discharges and minimizing impacts on the environment and potentially on human health have to a large extent and in most coastal European countries kept pace with man's need for a healthy coastal environment.

Coastal tourism would not remain such a dynamic and lucrative industry for European nations if waste discharges, simple spatial pressures, growing urbanization, or simply the construction of (often large or imposing) structures increased further and negatively impacted the quality of the environment that drew the tourists to the coast in the first place. In most countries, though, it must be emphasized that fishing and tourism are two coastal sectors that can exist amicably and symbiotically, each to some extent benefiting from the other. It is, however, the expansion of the other sectors that has caused the competition for space and resource to escalate. Therefore, although rigorous formal environmental impact assessments can mitigate some of the industrial impact competition, the limited spatial footprint in many countries is the simple driver for often litigious competition between sectors. And no-one then really cares who was there first (in many cases it was the fishers!).

Not all European countries have the same pressures or competition for coastal space and access to it. In countries with relatively small human populations and long coastlines that are accessed from the land generally only with difficulty, such as Norway, the competitive coastal situation is not as critical as in countries with large populations and shorter coastlines that are more easily accessed, such as the Netherlands and Greece. The dynamics of the differing competitive industries also differs in European countries as a whole or even in some cases along different parts of the coast of individual countries, depending on climate, relative health of fish resources, exposure to the elements, and sometimes on the political strength some sectors can muster and bring to the table. One must not overlook too the power of environmental lobbyists supporting, for instance, wetlands for migratory or non-migratory birds, protected areas for shore and subtidal life, and the maintenance of ecclesiastical, archaeological or historically important sites around the coasts, some of which have not been in their current position for very long.

Every side of the competitive argument has valid and strong reasons why it should have preferential treatment in terms of access to the spatial footprint that is the coast. Sensitivities between sectors tend to be high, and although most can muster considerable financial muscle in delivering the background data and information to support their own case, sometimes unsighted to competitors until the last possible moment, decisions do still tend to be made on

political grounds, and sometimes “he who speaks loudest (or with most financial muscle) gets his way”.

Overall, though, the key to best governance is to maintain good management of the coast and not to let development in one sector take place at the expense of others. The past 20 years have witnessed many pressure points around the coasts of Europe, and the situation is unlikely to change in the foreseeable future, at least not until some of the competitors for scarce space drop out of the equation, as fishing has to some extent in certain areas as wild stocks have diminished.

## **Hypotheses (2020)**

1. **Free for all:** Unfettered access to scarce coastal resources by anyone who has the financial muscle to outflank potential rivals. Coastal quality of life will diminish along with aspects of our heritage and parts of the ecosystem. Future options are virtually closed.
2. **Big Brother:** Decisions on access will be made with due regard to others’ interests and needs, and will be bureaucratic though fair, and dominated by environmentally friendly options. Future options will be preserved and quality of life will be maintained only to the extent that the coast as a resource can sustain.
3. **The Mafia:** Decisions on access will be made with some regard to others’ interests and needs, but will be bureaucratic and dominated by the power of money. Only limited future options will be preserved, and future quality of life cannot be assured.
4. **Collaborative control:** Coastal users will themselves rise to the challenge of helping to ensure fair and equitable access to scarce coastal and subtidal space by forming a network of collaborative (all interest) advisory councils, and the State listens to them. Options are preserved, coastal quality of life remains good, and some potentially damaging users are kept out.

## **Sources**

- Larcombe, P., Morris, D. J., and O’Brien, C. M. 2008. In recognition of inevitable uncertainties: from fisheries management to managing marine resources. *In Advances in Marine Science: 50 years on from Beverton and Holt*. Ed. by A. Payne, J. Cotter and T. Potter. Blackwell, Oxford
- Nicholls, R. J. 2007. The threat to coastal populations and ecosystems. In *Climate change impacts, adaptation and vulnerability. A meeting to present and discuss the results of the Intergovernmental Panel on Climate Change Working Group II, Fourth Assessment*, 18/19 September 2007. WMO/UNEP. Available at <http://www.rgs.org/NR/rdonlyres/E6426EAE-9895-481B-B97C-CEBA01467AE5/0/IPCCRNicholls18Sept2007.pdf>

**SOCIAL DYNAMIC**

**D5 Fisherfolk attitude towards the future (including education, training, tradition and the attractiveness of the career)**

**Driver Definition**

Next to the perception of the future of fisheries and aquaculture activities by the people engaged in these activities, it is also important to note the attitude these people have towards this future. In principle this focuses on a 2-by-2 matrix involving a positive future for current activities and a less rosy future offset against a positive attitude towards possible developments or a negative opinion about any future developments:

		<i>Future</i>	
		Positive development of activities	Stressed development of activities
Attitude	Optimistic	++	Depressed development
	Pessimistic	Depressed development	--

Few fishers acknowledge publicly that fish stocks are in bad health, and fisher optimism is common. Set against this backdrop is the culture of overfishing, that “if I don’t catch what’s there, someone else will”, or that “all will come right in the end because the sea is infinite in its productivity”, or “its not my problem that there is overfishing, it is country XX that caused it”. These views can be driven by the tradition or in some cases the poverty of coastal communities who have nothing else than fishing to which to turn for their very existence.

**Relevant Indicators**

Attitude of fish folk towards the possibilities for continuation of current activities in the future.

- Perception of future business opportunities
- Perception of risk
- Perception of future fishing opportunities
- Investment in fishing operation
- Number of young people leaving the local community for employment/staying for employment
- New entrants to the fishing business
- ICES and GFCM indicators of target stock health and landings trajectories
- socio-economic indicators
- information on coastal community impoverishment (through demographic statistics)

**Developments over the past 20 years**

It is rare to find active fishers whose attitude towards the future of fishing is less than positive, at least when confronted as a group. As a group they tend to advocate that management of fisheries would be best left to them, and even that the parlous situation of some stocks would not have come about if they had been left to manage them alone. Individually though, i.e. in one-on-one interviews, some fishers occasionally acknowledge the gravity of the current

situation in many fisheries and the fact that catches and catch rates have been declining for years, and continue to do so. However, some still temper their comments with asides such as “potential catches and catch rates are now as we haven’t seen for years; it’s the absence of quota that causes us problems”. It is these comments that lead one to believe that the fishing industry and fishers generally want to be left alone to manage and harvest their stocks with minimal interference and that fishers really believe that the situation would be far better if that situation was to become practice.

In a recent exercise that surveyed fishery managers across Europe, however, the outcome was revealing. These “managers” were not all active fishers, but they did include some who were involved in general management of fisheries on a day to day basis, as well as a good number of people who were involved in managing fisheries from a scientific or national/regional strategic perspective. The survey was not specifically to determine attitudes towards fishing and its future, but rather to tease out the real drivers for (improved) fisheries management. Nevertheless, some of the results are revealing in terms of attitude and perception, so are worth documenting here. The most obvious result was that there was no commonality of belief in what was the current situation. For instance, 12 of the 15 countries that responded did not rate fishing as a high priority economically or politically for their country, whereas the remaining three considered fishing to be important in both aspects. Further, about half of the responding countries rated environmental concerns as crucial drivers for improving fisheries management, whereas the rest assigned higher priority to socio-economic factors (i.e. related to fishers specifically), especially stability, and in contrast to the those that considered environmental concerns first, considered the fishing industry to have an important influence on policy in their country and in Europe generally.

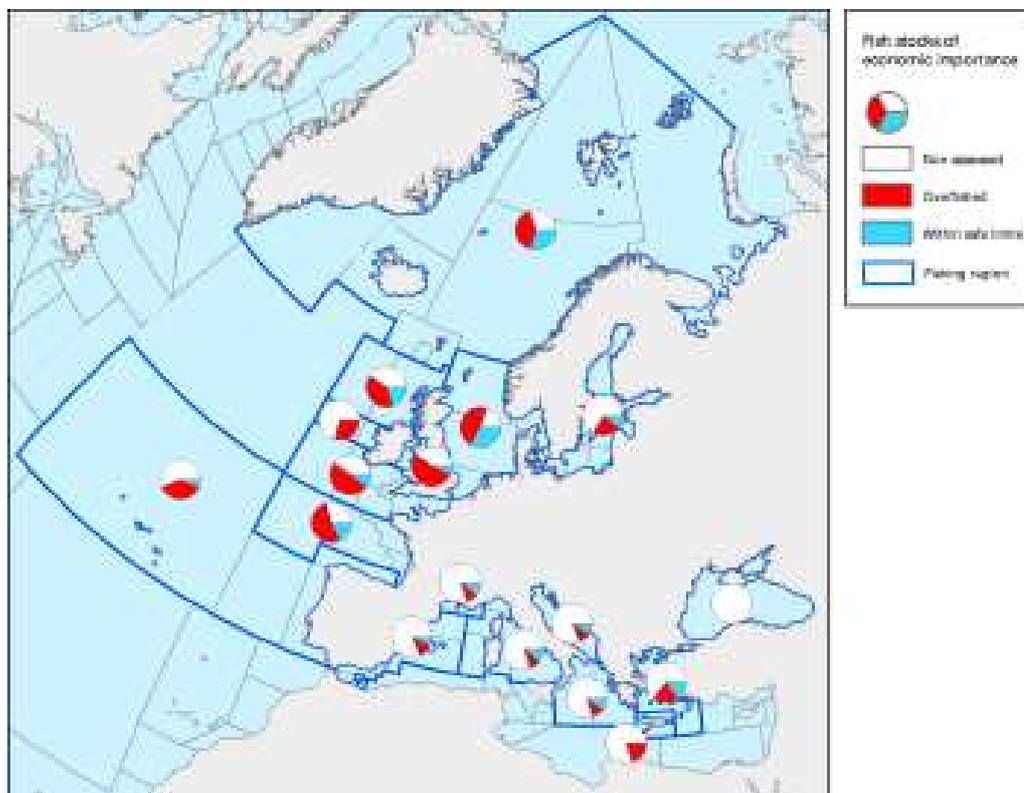
Just as with the general public, the survey respondents had changed their belief on how fisheries should be managed away from single-species quota management towards supporting a more holistic ecosystem approach, but although they stressed that such an approach towards fishing in future would be beneficial, few seemingly understood exactly what it meant. Some specifically said that it was poorly defined. Moreover, although survey respondents stressed that (socio-)economics should be more prominent in fisheries advice and management, and that more and better information would be sought on the subject, most still considered the traditional advice based on biology to be more important and politically acceptable than economic input. Overall, and not surprisingly, all felt that current fleet capacity in the fishing industry was too large and supported the idea of decommissioning, and just over half rated effort limitation as a high priority. By contrast, support for the variety of technical measures currently employed was mixed, and this was underscored by comments that fishers, the fishing industry and the general public likely did not understand either the basis for scientific advice or the advice itself. Thus, better collaboration between the fishing industry and the scientific advisory community was strongly supported.

The last statement is revealing. Clearly, fishers and their managers, at least those surveyed, have started to move away from their position of attacking the science as the Achilles heel of fisheries management, and towards the Europe-wide advocacy for all sides, including environmental lobbyists, to meet (in formal Regional Advisory Councils, RACs) and to find common ways of improving the partnership approach to fisheries management. Partnerships between scientists and industry in managing fisheries and making the most of what is in the sea while it is available are not new. They started, generally in an attempt to maximize the benefits from catching small pelagic fish, at least forty years ago. Recently, of course, formal partnerships have sprung up around the world, including in Europe (e.g. the Netherlands, the United Kingdom), North America (Canada and the US), Australasia and Southern Africa. Credibility on all sides has been enhanced from virtually all these programmes and partnerships, although the funding model through which each is operated has been variable (i.e. who pays for it, and to whom do the benefits of fish and financial profit accrue?).

The outcome of all these initiatives has been that there has been a step change in the relationships between those involved in managing or advising on fisheries and fishers themselves. Honesty about the reality of the situation for fisheries seems to have spread, and it seems to be more widely acknowledged now that the future for fisheries is not bright unless this partnership approach towards data-collecting and sharing is maintained. Regrettably,

however, the situation in terms of attitudes on the ground, at fishing harbours and in fishing communities still has some way to go to being unanimous, cordial and positive. The habit of many fishers of assigning blame for currently reduced quotas on everyone except themselves and their predecessors is still commonplace and will take many more years of partnership approaches to ameliorate. Nevertheless, attitudes are gradually changing, and the future is likely no longer as bleak as it was 20 years ago when stocks were increasingly being acknowledged as overfished.

The bottom line, however, is that Europe's fish stocks are not in a healthy state, as shown by the Figure below for 2004. If anything, matters have worsened since 2004 as more stocks have been subjected to rigorous assessment (moved from white colour) and found to be overfished (red). Of course, whether fishers all really believe the statements in this Figure is questionable. Some do, without question, but as stated above, attitudes as a group can be hard, and it is only when there is a complete crash of a stock (e.g. cod off Newfoundland, Canada) that acknowledgement of the accuracy of such statements is generally acknowledged, even if the source of blame for the situation is not.



*Commercial fish stocks outside safe biological limits, 2004*

## Hypotheses (2020)

1. **Fisher self-management:** Only fishers know what is in the sea and how best to manage stocks for future generations. The attitude of fishers and their communities is publicly optimistic, whereas everyone else knows the future is bleak.
2. **Partnership:** All players acknowledge the value of the partnership approach to fishing and fisheries management and acknowledge the reality of the current situation to be generally poor, but are willing to work towards improving it.
3. **Bureaucracy:** The CEC and national governments take control because they know the situation with fisheries management is out of control. Attitudes in fishing communities harden and the situation worsens with time.

## Sources

- Armstrong, M.J, Payne, A.I.L., Cotter, A.J.R. 2008. Contributions of the fishing industry to research through partnerships. *In* Advances in Marine Science: 50 years on from Beverton and Holt. Blackwell, Oxford
- CEC, 2005. Commercial fish stocks outside safe biological limits, 2004. Available at [http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007132227/IAssessment1116498234748/view\\_content](http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007132227/IAssessment1116498234748/view_content)
- Marifish 2006 Report D1.4a Drivers for Fisheries Management

## SOCIAL DYNAMIC

### D6 Social capital (skills and expertise)

#### Driver Definition

Social capital is composed of all knowledge, expertise and skills available and/or mobilisable in society. It includes cultural and traditional skills. Social capital can be defined as down to people, their capacity levels, institutions, cultural cohesion, education, information, skills, and knowledge and the networks of relationships among persons, firms, and institutions in a society, together with associated norms of behavior, trust, cooperation that enable a society to function effectively..

#### Relevant Indicators

- Interactive knowledge networks; information networks,
- Level of education
- Number of organisations and memberships in civic organizations
- access to services

#### Developments over the past 20 years

Fishing is a livelihood that has a massive cultural and traditional community base. In other words, fishing skills and knowledge tend to be passed down through generations of the same family or even through whole communities from generation to generation. That, of course, is what makes fishing such a tightly constrained society, one in which it has proven difficult, for instance, to convince fishers that cutbacks in effort and catches have to be made when catch rates and real numbers of fish available decline. Many fishers still believe that “the sea and its resources are infinite” and that in time catch rates will increase again and fishing will once more become a highly profitable activity. The same traditional and cultural or community base means that finding a way into an industry/activity can be as difficult as leaving it. Those wishing to invest in the fishing industry often find unwillingness of those they approach even to consider allowing them to invest or participate in the activity. They tend to be seen as outsiders who they don’t really want to incorporate into their fishing “society”.

Traditionally, information and/or knowledge of fishing, good fishing areas and seasons, and optimum gear usage are passed down only through personal relationships. The so-called “black book” so often thought to be a skipper’s most important piece of information on where, when and how to fish, is jealously guarded even from an operating company or owner for whom the fishing skipper works, and seldom do scientists or decision-makers get to see one, even briefly. That is why logbook information of any nature handed to regulatory authorities in terms of licence conditions is generally provided on the explicit understanding that detail is not to be passed on to anyone and is to be used collated on large spatial scales only.

The fishing community itself is a very close one, and the information they have to feed into the management process is ignored generally at the cost of good management. However, the knowledge often remains, as said above, in the realm of individuals or groups of fishers, and is rarely open to perusal broadly. As a group in a room, they tend to speak as one voice, although there are often several diverse opinions held about fish and fisheries management. Recently, there has been a strong move to bring fishers into the management process, so that their knowledge and skills can be part of the process. This has happened regionally through the Regional Advisory Councils (RACs) established by the EU, and nationally through partnership programmes such as those running in the Netherlands and the United Kingdom, among others (Armstrong *et al.*, 2008). The outputs from such partnerships are generally

available on institutional websites, such as that displayed over the page ([http://www.cefas.co.uk/data/fisheries-science-partnership-\(fsp\).aspx](http://www.cefas.co.uk/data/fisheries-science-partnership-(fsp).aspx)), but is extremely rare to have information on traditional fish knowledge, such as known only to fishers, so easily available.

## ***Fisheries Science Partnership (FSP)***



### ***Background***

The Government announced in January 2003 a package of funding for the industry which included £1 million in 2003/2004 for fishermen and scientists to work in partnership. Following the announcement, the NFFO and Cefas cooperated intensively to develop a programme to improve knowledge of our fish stocks. A further £1m was provided for projects in 2004/2005.

The Government agreed a further £1m each year for 2005/2006, 2006/2007 and 2007/2008. The management for the programme for 2005-2008 is given below.

### ***Objectives***

The objectives of the programme are to build relationships between UK fishermen and scientists and to involve fishermen in the co-commissioning of science.

To achieve these objectives, the programme will:

1. provide information from commercial fishing catches on key stocks to supplement data sources traditionally used in ICES assessments;
2. investigate concerns raised by fishermen on scientific assessments or on stocks not currently assessed;
3. investigate innovative scientific methods and or more selective/environmentally friendly fishing methods; and,
4. support the work of Regional Advisory Councils.

### ***Scope***

Fishing vessels able to implement the projects in the programme will be eligible. The programme will mainly support projects in fisheries within UK waters.

### ***Deliverables***

The key deliverables for the programme are a set of projects which meet the objectives set out above. The projects will address priorities identified by the fishing industry and Regional Advisory Councils, and will be scientifically robust and valuable.

*The UK's Fisheries science partnership website on the Cefas, UK site ([http://www.cefas.co.uk/data/fisheries-science-partnership-\(fsp\).aspx](http://www.cefas.co.uk/data/fisheries-science-partnership-(fsp).aspx)).*

Over the years too, there has been a gradual escalation in the number of private agencies and consultants working in the fishing community and generating extra knowledge and information, of use in fishing sustainably, and in managing fisheries optimally. Again, much of their output is available, generally after some time has elapsed, in the public domain in the form of reports and or web-based documents, but it still adds to the social capital available in the domain of fisheries.

Overall, the social capital available in fisheries is massive and broad, across nations and the region, but national pride generally precludes the sharing of such capital regionally. Indeed, as has been shown, and despite many initiatives having been undertaken to broaden the knowledge base and to share information even within countries and fisheries, the target of generating a commonly available currency in the form of knowledge available to all, still remains elusive.

## Hypotheses (2020)

1. **What's mine's my own!** The fishing community continues to refuse to share knowledge and information broadly, and accusations of deceitful data and misuse of data abound
2. **The benefactor approach!** Fishers realize that their only way of being treated seriously is if they share the boundless knowledge they have of the sea and all it contains. The result: workable and credible scientific advice and better management, leading to recovered stocks.
3. **We don't believe you anyway!** Fishers share their knowledge and social capital across national and regional boundaries, but political prudence dictates that such information is treated as untrustworthy, so fisheries management carries on in the way it has for a century, and ultimately fails and stocks collapse.
4. **Capital loss:** Due to a lack of fishing opportunities over time both economic and social capital are eroded. Even if new fishing opportunities arise the ability to make use of them has expired.

## Sources

- Armstrong, M. J. Payne, A. I. L., and Cotter, A. J. R. 2008. Contributions of the fishing industry to research through partnerships. *In Advances in Fisheries Science. 50 years on from Beverton and Holt*, pp. 63–84. Blackwell, Oxford, UK.
- Callois ,Jean-Marc and Francis Aubert, 2005. Towards Relevant Indicators of social capital for regional development issues.
- The World Bank Group, 2003. Integrated Questionnaire for the Measurement of Social Capital, Social Capital Thematic Group.

# ECOSYSTEMS

## ECOSYSTEMS

### E1 Pollutants and contaminants (inc. nutrients)

#### Driver definition

Pollution can act on wild stocks by modifying vital characteristics such as fecundity, growth, migration and larval survival. Pollution can reduce surfaces available for aquaculture as well as modify culture productivity. Effects can be ranked from short (a few days to a few months) to long term (years, decades).

Pollution resulting from rearing facilities and their management can include the output from fish cages, pools and ponds (faeces, excess food, medications), and from shellfish facilities (faeces, siltation)

#### Overview on pollutants and contaminants and Relevant Indicators

Chemical contaminants can be classified into different families:

*Metals*: the most toxic metals for the environment are mercury, cadmium, lead, zinc, copper, nickel and silver. Sources of metals are anthropogenic (mines, paints, batteries, etc), but can also be natural (mercury). Metals are included in some monitoring nets. The contamination by some, but not all, metals has been decreasing over the past 20 years or so.

*Hydrocarbons* from oil production and consumption, incomplete combustion of organic material: polycyclic aromatic hydrocarbons (PAH) are among the most worrying for the aquatic environment, e.g. PAH Ideno 123-cd pyrene concentration in oysters and mussels. The trend is generally increasing, and PAHs can generate tumours or disturb reproductive physiology in fish.

*Pesticides and herbicides* are found in agricultural runoff but are also used in road and railroad maintenance; *biocides* are used in maritime activities, chlorine for cleaning fouling in power plant pipes, tributyltin (TBT) in hull antifouling paints.

*Synthetic organic substances* such as PCBs are commonly used organochlorines, or substances resulting from incomplete combustion of organochlorine during waste incineration, such as dioxin and furans. Dioxin is found in wild fish after bioaccumulation through the food chain. Effects on animals (including fish in the wild) are known for a few substances only, such as endocrine perturbations in aquatic animals.

*Radioactive elements*: man-made inputs come from testing nuclear weapons, nuclear reprocessing activities and accidents like the one at Chernobyl.

*Nutrients and eutrophication*: human activities are important sources of additional nutrients in estuaries and coastal waters: agricultural and urban runoff, industrial waste, marine fish farming. Increasing inputs have consequences such as an increase in the incidence of unwanted events, e.g. algal blooms, red tides, plankton and fish mortalities. Relevant Indicators can be in the number of HAB events for the different phycotoxins produced (diarrheic, amnesic and paralytic poisoning).

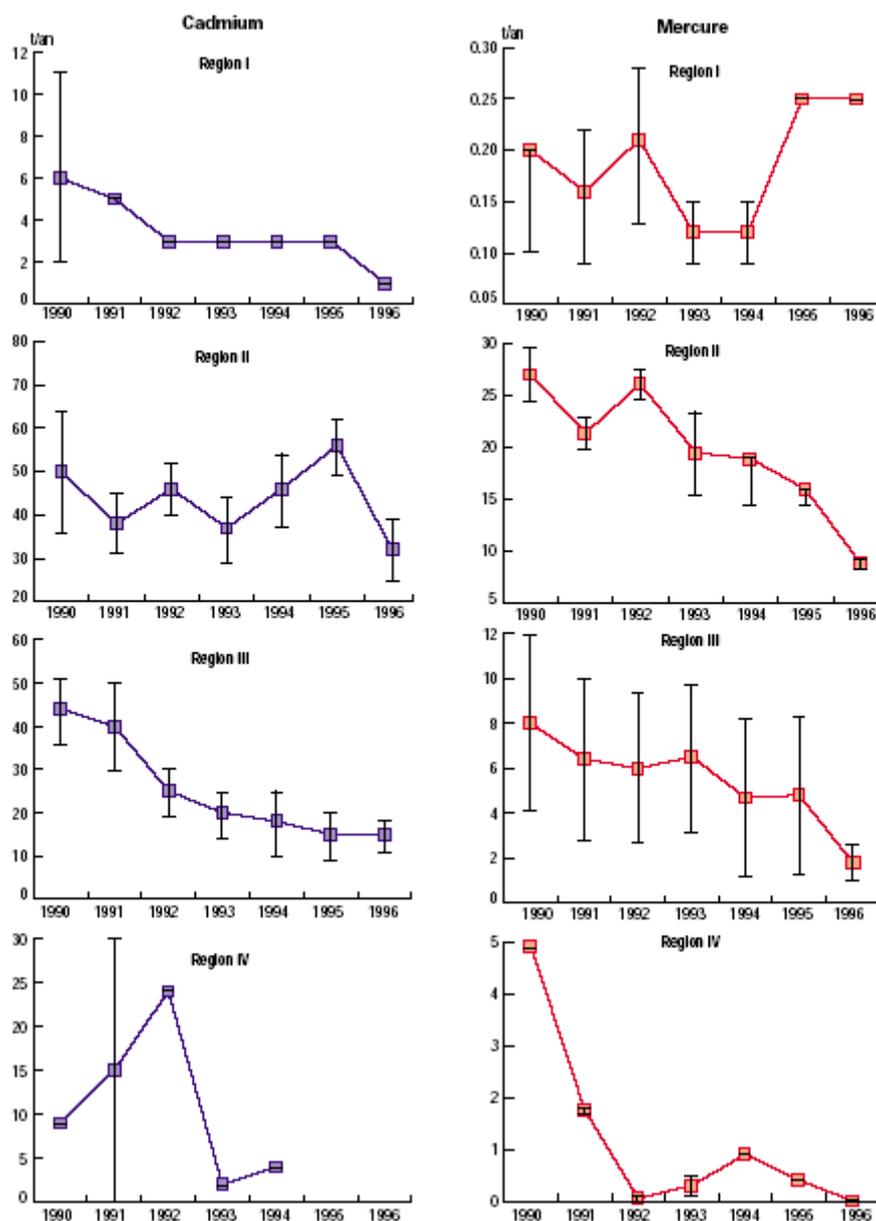
#### Developments over the past 20 years

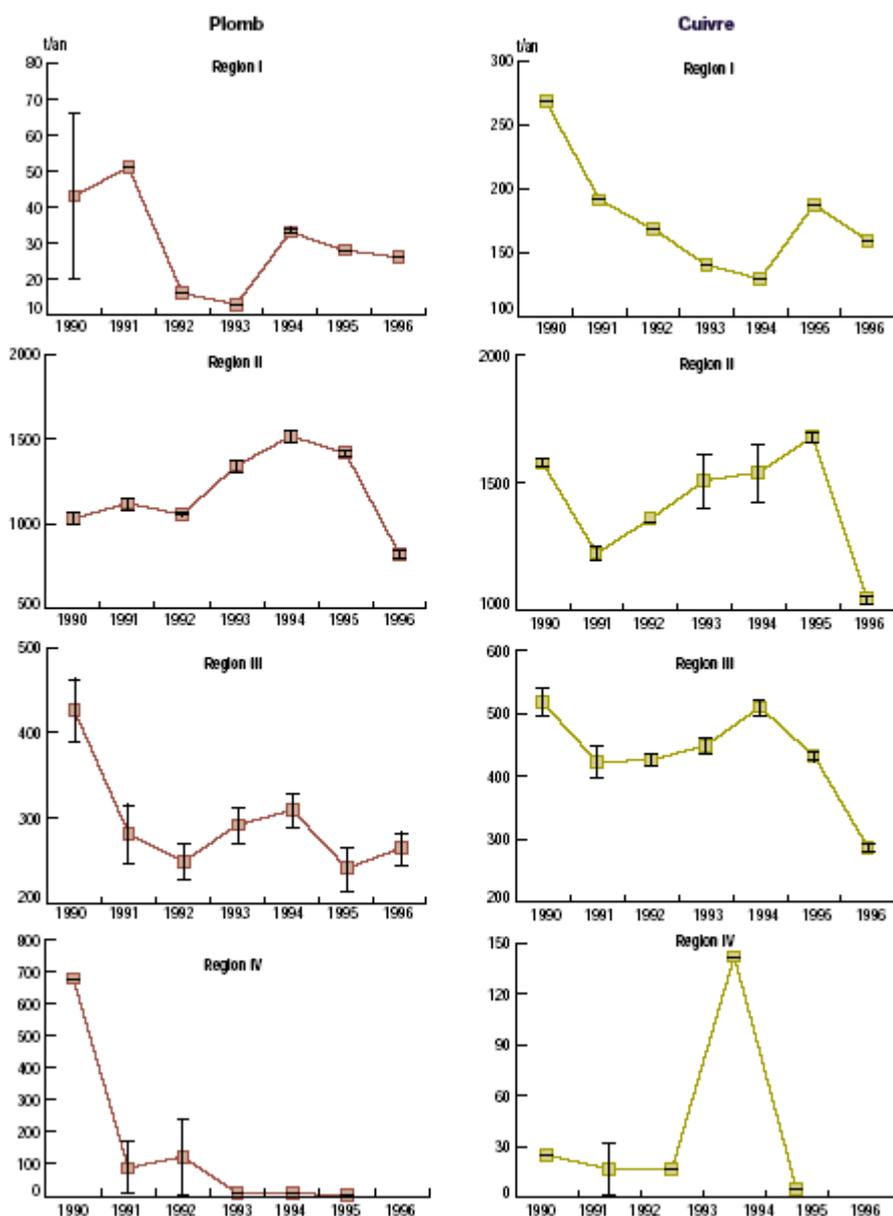
##### Chronic pollution

###### *Metals and PAH*

Origin: mostly from river discharge in coastal waters. The general decrease in direct contributions since 1990 results from better control of point discharges, but diffuse discharges are possibly increasing (OSPAR 2000: Sanitary balance 2000, London 108 +vii p.; ICES 2003 Environmental Status of the European Seas, Report same, 76 p.). PAHs can be chronic

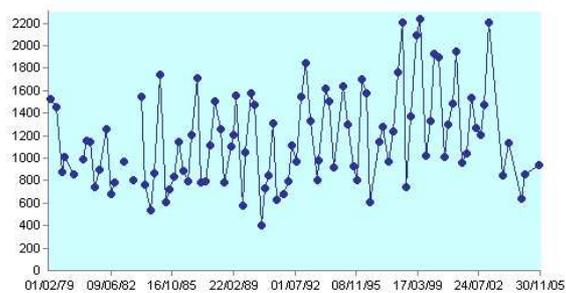
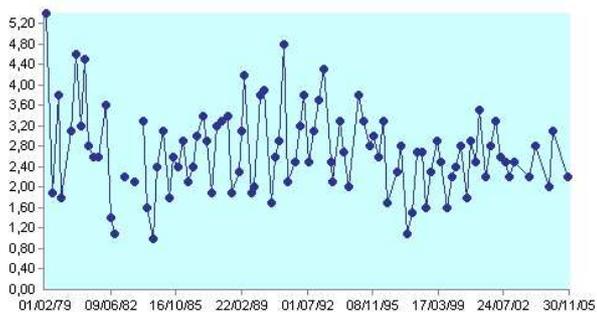
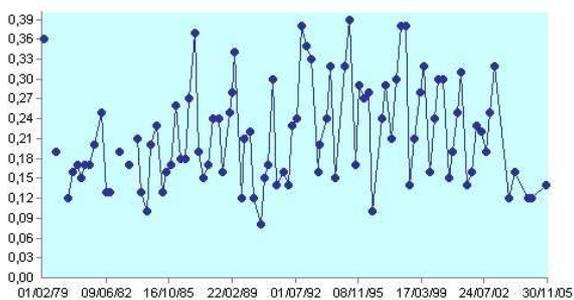
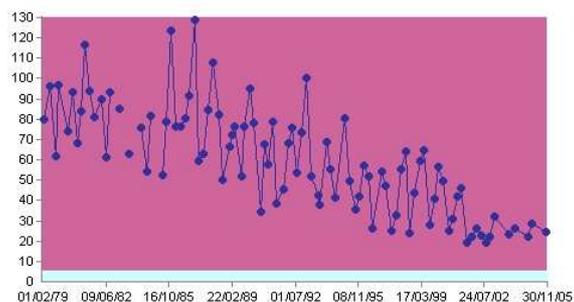
Figure 4.2 Tendances des apports directs et fluxiaux de cadmium, mercure, plomb et cuivre. Les données de la Région I ne concernent que les sous-régions mer de Norvège et mer de Barents.





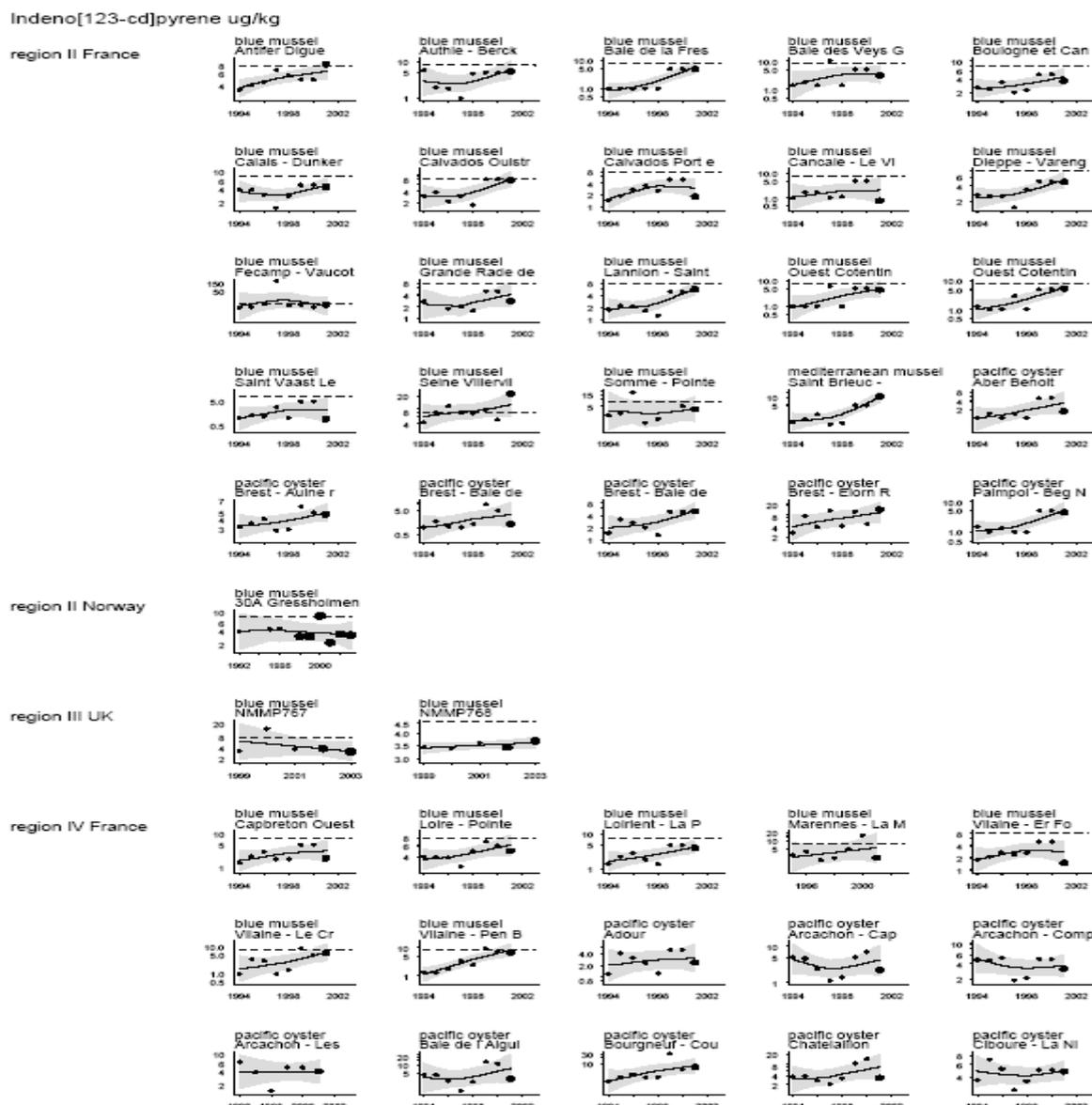
Trends for direct riverine inputs of cadmium, mercury, lead and copper in the OSPAR Regions.

Regions: I: Arctic Waters; II: Greater North Sea; III: Celtic Seas; IV: Bay of Biscay and Iberian Coasts.



Cadmium, mercury, lead and copper concentration in oysters (mg/kg dry weight) from 1979 to 2005 in the Gironde estuary, France

Source: <http://www.ifremer.fr/envlit/documentation/index.htm>



Indeno [123-cd]pyrene as indicator of level of chronic Hydrocarbon PAH contamination  
 Source: Assessment of Co-ordinated Environmental Monitoring Programme (CMPEMP) data, OSPAR 2005

**Accidental pollution: oil and chemical spills**

In 50 years (1952-2002) the total volume of goods transported by sea has multiplied sixfold. At the same time, hydrocarbon transportation has multiplied tenfold. Nevertheless, major oil spills have decreased since the 1970s due to increase in legislation, security and ship structure quality. Yet chronic oil pollution still exists because washing tanks and ballasts is still the norm in many parts of the world

There are about 37 million known chemical substances, and the European market has 100,000, of which 5000 are dangerous. Of these, 2000 are transported by sea, so chemical spills represent a permanent risk in places where maritime traffic is high. Enhanced security rules at sea and in ship construction are expected to reduce the risk of accidental pollution.



**Aquaculture density and management: Number of farms, cages, ponds; surfaces and density, carrying capacity; small-scale flood measurements**

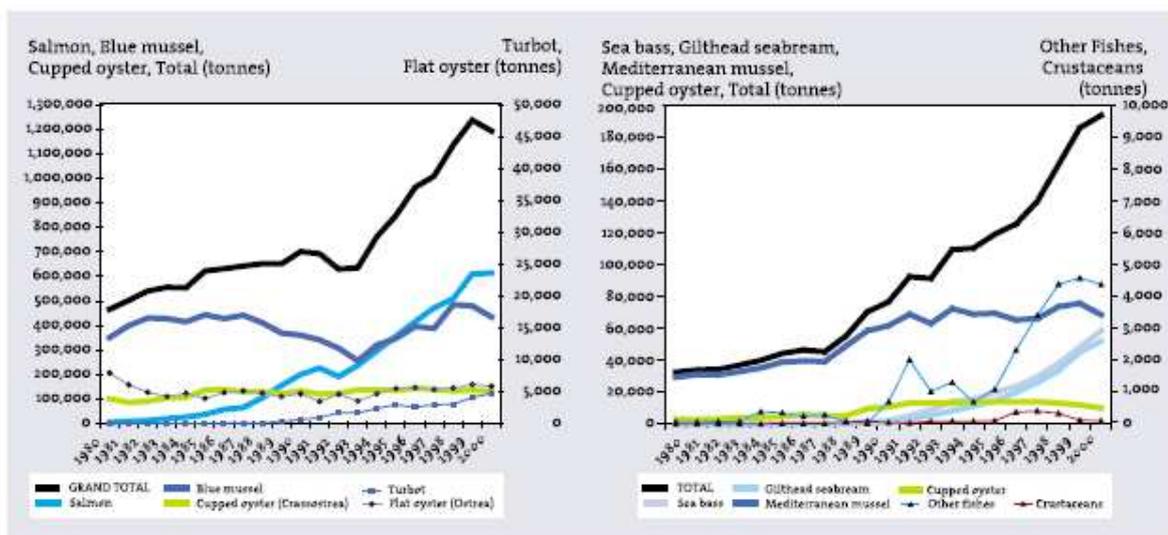


Figure 3.8.1. Aquaculture in the Northeast Atlantic and the Baltic Sea.

Figure 3.8.2. Aquaculture in the Mediterranean and Black Seas.

(Source: FAO Fishstat+ Database).

(Source: FAO Fishstat+ Database).

20 years of marine aquaculture in Europe, source FAO / ICES 2003 Environmental Status of the European Seas

**Hypotheses 2020**

**1. Economy over environment:** Individual interest wins social and environmental goals. Inputs from industry and mining decrease owing to a reduction of activity, but increased runoff from individual uses such as dangerous organic substances may impact fish physiology. Green petrol results in increased input of fertilisers, pesticides and other contaminants, with resulting increased coastal and estuarine eutrophication, and perhaps Harmful Algal Blooms. Shipping regulation is weak, and frequent accidents generate chronic hydrocarbon pollution. There is global deterioration of coastal waters, increase of human hazards due to wild fish consumption and/or living in coastal areas (e.g. diarrhoea, allergies). The consequences for fish and shellfish are a general decrease in quality and increasing mistrust from consumers.

**2. Localised stewardship:** Some green pieces in a black puzzle. Local practices allow inputs and runoff to decrease dramatically so that, combined with locally integrated coastal area management, some coastal seas increase in quality. These areas appear as oases in a world dominated by local/regional regulations, but without efficient coordination. These oases produce high quality products from fisheries and aquaculture, labelled organic production for consumers. Such areas remain fragile due to the permeability of enclosures. Other problems with global effects such as ballast release and shipping accidents are not solved.

**3. Global stewardship:** International cooperation towards global sustainability. Inputs and runoff have decreased dramatically in all rivers and coastal waters, and eutrophication has decreased through organic agriculture, reasonable use of medicines by consumers, and highly efficient waste treatments. Global governance results in a coordinated net of Marine Protected Areas. HAB phenomena have been explained and reduced and can be predicted. Clean and productive coastal and estuarine areas are available for developing aquaculture. International regulation is highly efficient, reducing shipping accidents substantially.

## ECOSYSTEMS

### E2 Recruitment

#### Driver Definition

It is well known that changes in fish populations are primarily driven by variability in recruitment. Recruitment can be defined as the number of fish surviving to enter a fishery or to some life history stage such as settlement or maturity. The inability to predict recruitment has hindered the development of both single and multispecies fish assessment forecast models. This inability to predict recruitment stems from the complexity of the process, which is affected by the number of offspring produced as well as the overall effect of density-independent and -dependent processes on all pre-recruit stages.

Density-independent factors include temperature and food conditions experienced by pre-recruits; Density-dependent processes include: Competition for food or refuge with conspecifics or offspring of other species

Mortality rates during the pre-recruit stage are very high. This means that a population of faster-growing individuals will experience lesser cumulative mortality than a slower-growing one. Recruitment is currently forecast from analytical relationships between spawning-stock biomass and recruitment. In most cases, these relationships are derived by fitting a simple mathematical model to a time-series of historical data.

#### Relevant Indicators

- Recruitment indices from ICES stock assessments (more than 150 fish stocks)
- Recruitment indices surveys of eggs and larvae

#### Developments over the past 20 years

Some of the least convincing results produced by fisheries biologists are those that attempt to relate the number of new recruits (juveniles) to the size of the parental spawning stock. Intuitively one would expect a reasonable correlation; that is, the larger the number of reproductive adults in the stock, the larger the number of resulting offspring. However, variation in recruitment is often considerable. From time to time, the population structure of commercial species shows particularly strong year classes, which persist in catches over several years. Strong recruitment occurs periodically when favourable aspects of the environment coincide. One confounding factor is that recruitment is often separated from the spawning event by a long period, in some cases several years. This period usually includes a planktonic phase, during which eggs and larvae are exposed to highly variable environmental and hydrological conditions, as well as high rates of juvenile mortality (due to predation and starvation). This often means that apparent relationships between the number of juveniles recruiting into a population and the concurrent adult spawning population are greatly obscured or obliterated altogether.

Data have been used to fit all manner of imaginative 'stock-recruit' relationships. The most widely applied are those proposed of Beverton and Holt in 1957 and Ricker (1954, 1975). However, more often than not, the observed data appear as a 'cloud' of scattered points, and any fit to the data seems somewhat subjective (Figure 1). Clearly we would not expect any recruitment of juveniles if the adult stock is reduced to zero, so the relationship can be anchored through the 'origin'. However many stock assessment scientists do not feel confident enough to force a particular relationship through the rest of the 'cloud' so they elect

simply to use a long-term average of observed recruitment when running models into the future. Most ICES working groups have chosen to use a long-term geometric mean of observed recruitment because these are less sensitive to extreme outliers than an arithmetic mean.

Fishers and scientists have known for more than 100 years that the status of fish stocks can be greatly influenced by prevailing weather conditions (Hjort 1914; Cushing 1982). In the case of cod, there is a well established relationship between recruitment and sea temperature (O'Brien *et al.*, 2000; Clarke *et al.*, 2003; Beaugrand *et al.*, 2003). At the northern extremes, warming leads to enhancement of recruitment, whereas in the North Sea, close to the southern limits of the range, warm conditions lead to weaker-than-expected year classes, and vice-versa.

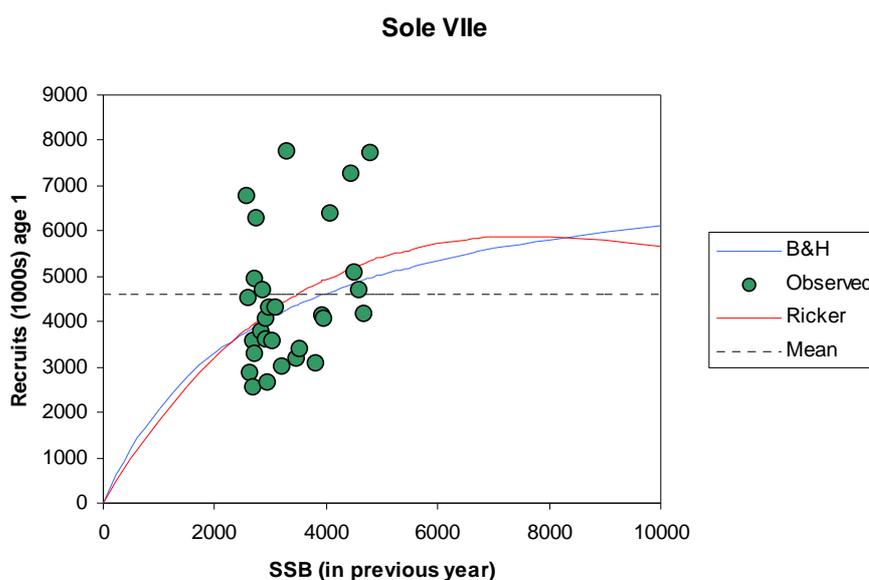
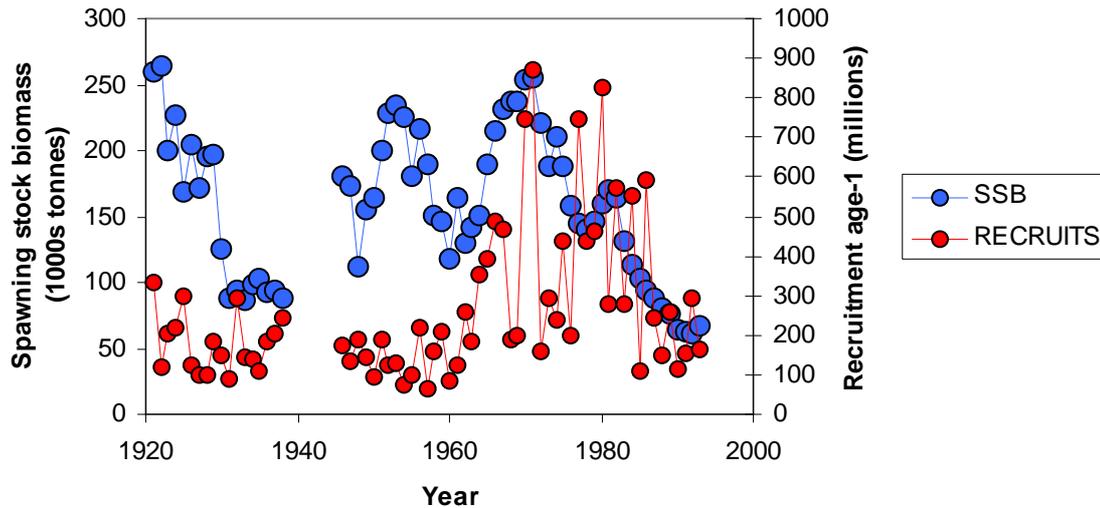


Figure 1. Stock –recruit relationships and long-term (1969-2003) arithmetic mean for sole in area VIIe (western Channel).

During the late 1960s and early 1970s, cold conditions were correlated with a sequence of positive recruitment deviations in cod, haddock and whiting in the North Sea (Brander and Mohn, 2004), a phenomenon which has come to be known as the ‘gadoid outburst’ (Heath and Brander, 2001) when recruitment increased to hitherto unseen levels (Figure 2). However, more recently, a warming climate has prevailed and year-class strength has been weaker than average. This in turn has led to a decline in the level of fishing mortality that can be sustained by the stock.

Although there has been a demonstrable correlation between recruitment deviations of cod and temperature, this does not necessarily imply that temperature *per se* is the causative factor. Other aspects of the ecosystems inhabited by cod have changed in concert with temperature, and these could be responsible. In particular, the composition of the plankton on which cod larvae feed has changed. The year-class size of marine fish is greatly influenced by the timing of spawning and the resulting match-mismatch with their prey and predators (Cushing, 1990).

Nash and Dickey-Collas (2005) reported a positive relationship between abundance of herring early larvae and winter bottom temperature in the North Sea. They concluded that the relationship probably reflected a direct physiological effect of temperature on growth and development rates. However, greater abundance of juvenile herring was associated with colder temperatures, possibly reflecting greater *Calanus* copepod abundance, which was itself inversely correlated with winter bottom temperatures.



**Figure 2.** Recruitment and spawning-stock biomass of North Sea cod from 1920-1995 (after Pope and Macer 1996).

### Hypotheses (2020)

Drinkwater (2005) reviewed the possible impacts of future climate change on cod and used temperature-recruitment relationships from Planque and Frédou (1999) together with outputs from Global Circulation Models (GCMs) to predict possible responses of cod stocks throughout the North Atlantic to future temperature and hydrodynamic changes. According to this study, stocks in the Celtic and Irish Sea are expected to disappear altogether by 2100, whereas those in the southern North Sea and Georges Bank will decline. Cod will likely spread north along the coasts of Greenland and Labrador, occupying larger areas of the Barents Sea, and may even extend onto some of the continental shelves of the Arctic Ocean.

Clark *et al.* (2003) used projections of future North Sea surface temperatures and estimated the likely impact of future climate change on the reproductive capacity of the North Sea cod stock, assuming that the current high level of mortality inflicted by the fishing industry continues. Output from the model suggested that even a relatively modest level of climate change ( $+0.005^{\circ}\text{C y}^{-1}$ ), will result in a more rapid decline in fish biomass and juvenile recruitment. Scenarios with higher rates of temperature increase resulted in faster rates of decline in the cod population.

**1. Back to the future:** In line with the current practice of most ICES stock assessment groups, future recruitment for all fish species lies somewhere around the geometric mean of the ‘observed’ recruitment over the past 20–30 years.

**2. In hot water** (depends on Driver A1): Marine waters throughout Europe warm appreciably and this greatly influences fish recruitment patterns. Cold-water species (such as cod and herring) retract northwards where they experience better recruitment, but they suffer poorer recruitment in regions such as the North Sea. Southerly species (such as sardine, seabass and red mullet) experience better conditions for recruitment farther north and biomasses in the North Sea, Irish Sea and Channel increase accordingly.

**3. No parents, no children:** Owing to heavy overexploitation, adult fish are reduced to very low numbers such that reproduction is seriously impaired (the Allee effect). Recruitment success in many commercial fish stocks is reduced and populations decline accordingly. Some non-target species experience improved recruitment prospects owing to reduced competition among larvae for food, and fewer predators.

**4. Let the spawners survive:** Management takes account of changing environmental conditions, such that a sufficient number of adult fish survive to reach maturity (including

some large “megaspawners”). This results in a sustained level of recruitment even in years when environmental conditions are poor. A well developed age-structure buffers against extreme recruitment variability. Essential spawning habitats and spawning aggregations of adults are protected.

## Sources

- Beaugrand G, Brander KM, Lindley JA, Souissi S & Reid PC (2003) Plankton effect on cod recruitment in the North Sea. *Nature*, 661-664.
- Beverton, R. J. H., & Holt, S. J. 1957. On the dynamics of exploited fish populations. *Fishery Invest., Lond., Ser. 2*, 19: 533 pp.
- Brander KM & Mohn R (2004) Effect of the North Atlantic Oscillation on the recruitment of Atlantic cod (*Gadus morhua*). *Canadian Journal of Fisheries & Aquatic Sciences*, 61: 1558-1564.
- Clarke RA, Fox CJ, Viner D, Livermore M (2003) North Sea cod and climate change – modelling the effects of temperature on population dynamics. *Global Change Biology*, 9: 1669-1680.
- Cushing DH (1982) *Climate and Fisheries*. Academic Press.
- Cushing D (1990) Plankton production and year-class strength in fish populations: an update of the match/mismatch hypothesis. *Advances in Marine Biology* 26: 249-293.
- Drinkwater KF (2005) The response of Atlantic cod (*Gadus morhua*) to future climate change. *ICES Journal of Marine Science*, 62: 1327-1337.
- Heath MR & Brander K (2001) Workshop on Gadoid Stocks in the North Sea during the 1960s and 1970s. The Fourth ICES/GLOBEC Backward-Facing Workshop, 1999. ICES Cooperative Research Report, 244. 53pp.
- Hjort J (1914) Fluctuations in the great fisheries of Northern Europe viewed in the light of biological research. *Rapp. P.-V. Réun. Cons. Int. Explor. Mer* 20: 1-228.
- Nash RDM & Dickey-Collas M (2005) The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (*Clupea harengus* L.). *Fisheries Oceanogr*, 14: 279-291.
- Planque B & Frédou T (1999). Temperature and the recruitment of Atlantic cod (*Gadus morhua*). *Canadian Journal of Fisheries and Aquatic Sciences*, 56: 2069-2077.
- O'Brien CM, Fox CJ, Planque B & Casey J (2000) Climate variability and North Sea cod. *Nature*, 404: 142.
- Pope JG, Macer CT (1996) An evaluation of the stock structure of North Sea cod, haddock, and whiting since 1920, together with a consideration of the impacts of fisheries and predation effects on their biomass and recruitment. *ICES J Mar Sci* 53:1157-1169.
- Ricker, W. E. 1954. Stock and recruitment. *J. Fish. Res. Bd. Can.*, 11: 559-623.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd Can.*, (191): 382 pp.

# ECOSYSTEMS

## E3 Invasive Species

### Driver Definition

Invasive species are introduced artificially by man. Species (plants and animals) can be introduced in an ecosystem, intentionally (for cultivation, for aquarium) or unintentionally (non-visible but associated with voluntary introduced species) or transported from a distant area within ballasts or cargo. They become invasive when favourable conditions allow them to replace one or more “native species”. Results on fish production sometime positive, often negative.

Invasion Vectors and Types of Organisms Transported	
 <p><b>Ships</b></p> <ul style="list-style-type: none"> <li>Planktonic and nektonic organisms in ballast water</li> <li>Attached and free-living fouling organisms on hull, on rudder, on propeller and propeller shaft, in seawater systems, sea chests, in ballast tanks, and in ballasted cargo holds</li> <li>Organisms associated with anchors, anchor chains, and anchor chain lockers</li> <li>Organisms associated with cargo, such as logs that have been floated for loading</li> </ul>	 <p><b>Fisheries, Including Marine Aquaculture (Mariculture)</b></p> <ul style="list-style-type: none"> <li>Transplantation or holding of shellfish, such as oysters, mussels, clams, crabs, lobsters, and other organisms; fish; or seaweed (algae) in the open sea for growth or freshening (rejuvenation); and other organisms associated with dunnage and containers</li> <li>Intentional release of shellfish, fish, and seaweed (algae) species, either as part of an official governmental introduction attempt, or as an illegal private release</li> <li>Stock enhancement, often ongoing, as well as accidentally transported associated organisms</li> <li>Movement of live seafood intended for sale but then released into the wild</li> <li>Processing of fresh or frozen seafood and subsequent discharge of waste materials to environment, which may include associated living or encysted organisms</li> <li>Movement of live bait subsequently released into the wild</li> <li>Discarding of packing materials—such as seaweed and associated organisms—used with live bait and seafood</li> <li>Movement, relocation, or drifting of fisheries gear, such as nets, floats, traps, trawls, and dredges</li> <li>Release of organisms as forage food for other species</li> <li>Organisms transported intentionally or accidentally in “live well” water, vessel scuppers, or other deck basins</li> <li>Release of transgenic stocks—genetically modified organisms (GMOs)</li> <li>Movement of algae and associated organisms as substrate for fish egg deposition</li> </ul>
 <p><b>Drilling Platforms</b></p> <ul style="list-style-type: none"> <li>Attached and free-living fouling organisms</li> <li>Planktonic and nektonic organisms in ballast water</li> </ul>	
 <p><b>Dry Docks</b></p> <ul style="list-style-type: none"> <li>Attached and free-living fouling organisms</li> <li>Planktonic and nektonic organisms in ballast water</li> </ul>	
 <p><b>Navigation Buoys and Marina Floats</b></p> <ul style="list-style-type: none"> <li>Attached and free-living fouling organisms</li> </ul>	
 <p><b>Amphibious Planes, Seaplanes</b></p> <ul style="list-style-type: none"> <li>Attached and free-living fouling organisms</li> <li>Organisms in pontoon water</li> </ul>	
 <p><b>Canals</b></p> <ul style="list-style-type: none"> <li>Movement of species through sea level, lock, or irrigation canals</li> </ul>	
 <p><b>Public Aquaria</b></p> <ul style="list-style-type: none"> <li>Accidental or intentional release of organisms on display</li> <li>Accidental or intentional release of organisms accidentally transported with target display species</li> </ul>	
 <p><b>Research</b></p> <ul style="list-style-type: none"> <li>Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in research (intentional or accidental escape)</li> <li>Organisms associated with research and sampling equipment, including SCUBA and other diving or swimming gear</li> </ul>	
 <p><b>Floating Marine Debris</b></p> <ul style="list-style-type: none"> <li>Transport of species on human-generated debris, such as floating nets and plastic detritus</li> </ul>	
 <p><b>Recreational Equipment</b></p> <ul style="list-style-type: none"> <li>Movement of small recreational craft, snorkeling and SCUBA gear, fins, wetsuits, jet skis, and similar materials</li> </ul>	
	 <p><b>Aquarium Pet Industry</b></p> <ul style="list-style-type: none"> <li>Movement and release of invertebrates, fish, seaweeds (algae) and seagrasses used in the aquarium industry (intentional or accidental escape)</li> </ul>
	 <p><b>Restoration</b></p> <ul style="list-style-type: none"> <li>Movement of marsh, dune, or seagrasses as well as associated organisms</li> <li>Reestablishment of locally extinct or decimated populations of native species, and accidentally transported associated organisms</li> </ul>
	 <p><b>Education</b></p> <ul style="list-style-type: none"> <li>Release of species from schools, colleges, and universities following classroom use</li> </ul>

Common marine bioinvasion vectors; J. T. Carlton, Pew Ocean Commission, 2001

## Relevant Indicators

Areas affected by invasive species

For concerned taxa, population density, area, diversity, population dynamics and variables (fecundity, age at reproduction, etc.), legislation.

Non-indigenous species inventory impacting fish production (and directives and regulations),

An example of mapping an invasive limpet distribution in the Bay of Saint Brieuc (France) can be found at: Distribution of *Crepidula fornicata* in the bay of Saint Brieuc, West Channel, France

<http://www.ifremer.fr/delec/projets/habitats/crepidule/actions>

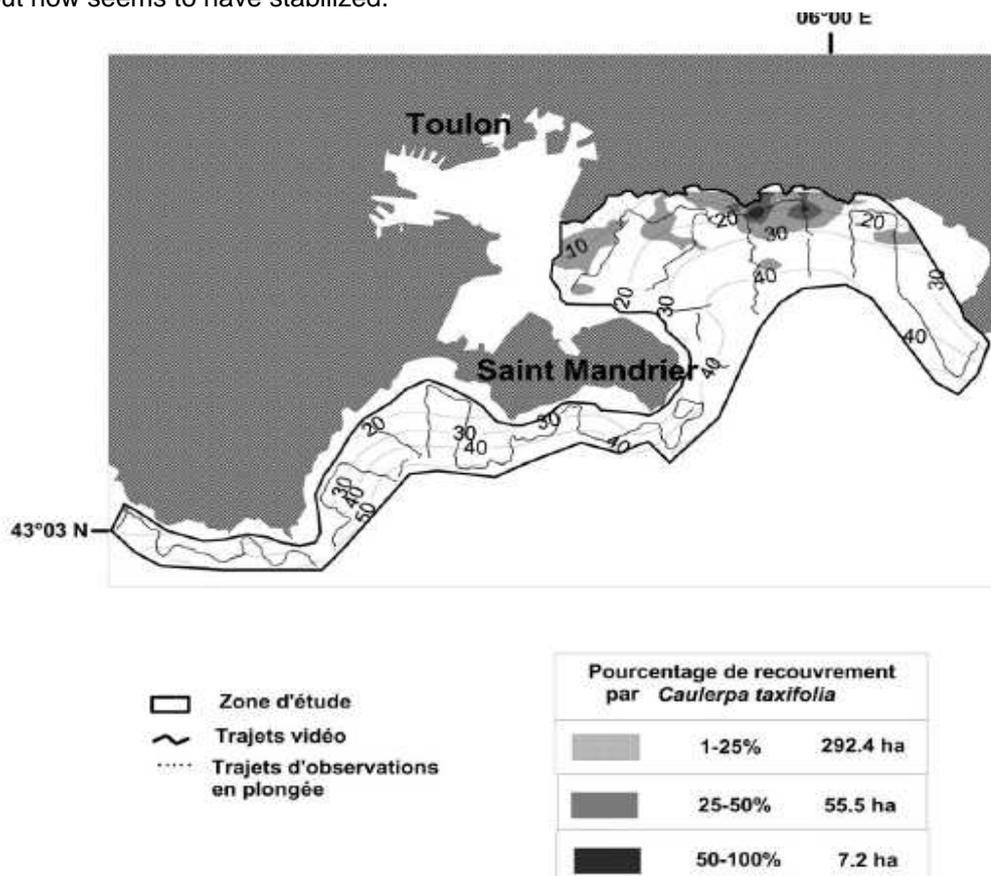
## Developments over the past 20 years

### Algae

*Sargassum muticum*: uncontrolled introduction in Europe from Indo-Pacific when introducing oysters (e.g. *Crassostrea gigas*) in the 1970s; first appeared in the Mediterranean (Thau lagoon, France), but now also appears in Venice (Adriatic), Brittany (Atlantic).

*Undaria pinnatifida*: uncontrolled introduction in Europe from Indo-Pacific area when introducing oysters (e.g. *Crassostrea gigas*) in the 1970s; first appeared in the Mediterranean (Thau lagoon, France). Voluntarily introduced into Brittany for culture (1990, Ussant island) without success, but has since appeared in several places.

*Caulerpa taxifolia*: tropical species introduced with the aquarium trade and accidentally released into the Mediterranean 1984. Covered some 8000 m<sup>2</sup> in 1989, 45 million m<sup>2</sup> in 1997, but now seems to have stabilized.

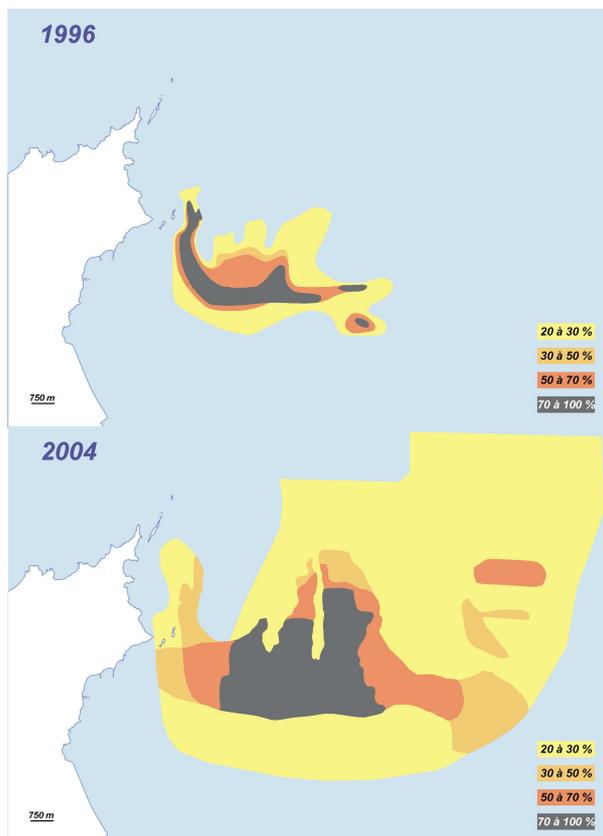


Percentage coverage of *Caulerpa taxifolia* in the bay of Toulon, (France, Mediterranean), 2003 Source: Belsher et al. (2003)

## Molluscs

*Rapana venosa*, a gastropod predator of molluscs (oysters, mussels), originally from Asia. Appeared in the Black Sea in 1940, Adriatic (1975) Aegean Sea (1980), UK (1992 Dogger Bank), France (1997, Brittany), USA (1998 Chesapeake Bay).

*Crepidula fornicata*, gastropod, competitor with man for oysters, scallops: uncontrolled introduction with oysters from North America in the 19th century, then appeared at different places in Europe when transferring oysters. Largest biomasses in France (250 000 t in Bay of St Brieuc, 100 000 t in Bay of Cancale); seems to be still expanding (by 6000+ t per year in Bay of St Brieuc).



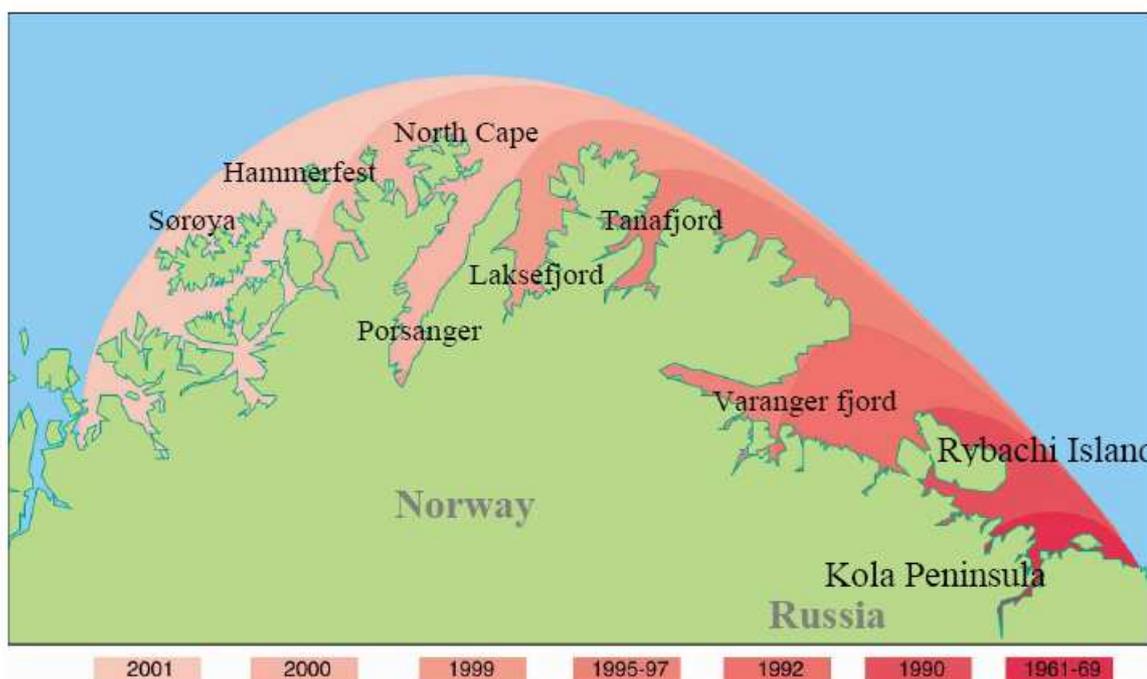
Proliferation of *Crepidula fornicata* <http://www.ifremer.fr/delec/projets/habitats/crepidule/actions> after Blanchard, 2007

*Crassostrea gigas*: introduced for cultivation in Europe (France) from Asian waters after complete destruction of previously introduced *C. angulata* by disease. The species could become invasive because it reproduces naturally, and at an increasing rate in several places (Brittany, Netherlands), creating extensive stocks that can compete with broodstock and other wild filter-feeding species (ICES, 2004).

## Crustaceans

Red king crab *Paralithodes camtschaticus*

Species intentionally introduced from west Kamchatka into the east Barents Sea in the 1960, in order to create a “new” fishing resource. Now (2000) extends towards the western Barents Sea and to the Norwegian southern Barents sea and Northwest Cape. One potential effect of red king crab expansion is a reduction in the scallop (*Chlamys islandica*) population (Jørgensen and Primicerio, 2007).



Generalised distribution and spread of the red king crab *Paralithodes camtschaticus* from its release region in the Barents Sea. L.L. Jørgensen, J. Sundet IMR, 2006

### Fish<sup>26</sup>

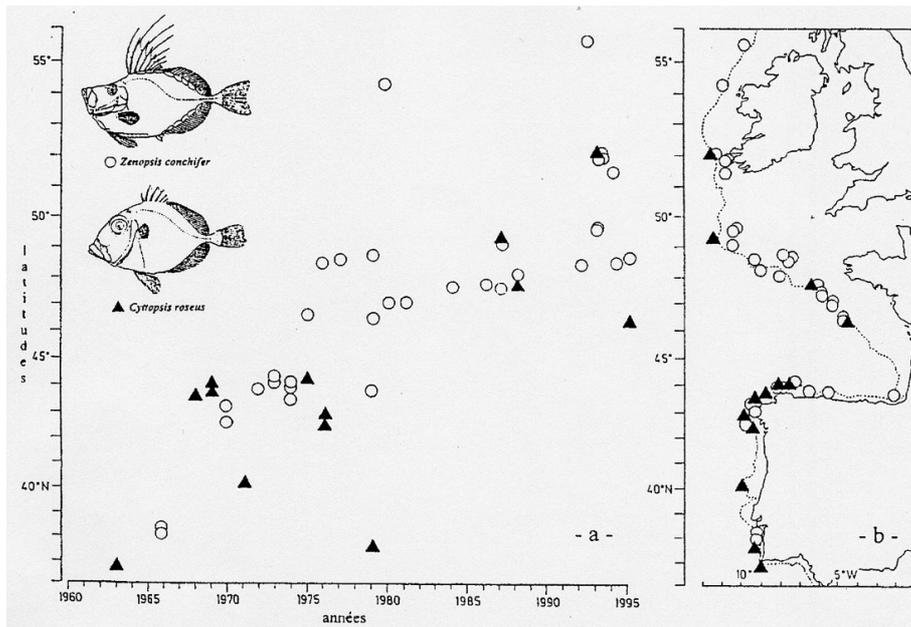
Fish as invasive species are mainly known in fresh water, after intentional introductions into lakes, ponds and rivers for “restocking” or creating a resource. Also from intentional or accidentally escapements from aquariums.

Invasive fish are rare in the sea except in terms of escapements from aquaculture (see E4). Pacific salmon *Oncorhynchus mykiss* were first introduced into Europe at the end of the 19<sup>th</sup> century, and *O. gorbuscha* in 1960 (NOBANIS Network: <http://www.nobanis.org>). The populations of these two species seems to have stabilised at a low level (i.e. they are not truly invasive). Changes in coastal and freshwater ecosystems could change reproductive capacity.

One example of a “soft invasion” is given by Lessepsian migration, so-called Lessepsian species (not only fish) coming from the Red Sea and Indian Ocean to the Mediterranean through the Suez Canal (built by Ferdinand de Lesseps, and opened in 1869). Examples of *Upeneus moluccensis* (Mullidae), *Siganus rivulatus* and *S. luridus* (Siganidae) are given in the literature as species coming from the Red Sea that developed commercial stocks in the eastern Mediterranean (Saad 2001); no significant genetic difference observed, so clearly they entered the Mediterranean through the Suez Canal.

Global warming can also modify the distribution of fish, which is then referred to as an “invasive process”. Quéro *et al.* (1998) observed this for two tropical (non-commercial) fish species along the Atlantic coast of Europe.

<sup>26</sup> (see also E4: Escapement)



Latitudinal distribution of *Zenopsis conchifer* and *Cyttopsis roseus* as observed during scientific cruises between 1960 and 1995 (after Quéro *et al.*, 1998).

## Hypotheses (2020)

**1. Alien attacks:** Aquaculture growth tries to offset the reduced production from wild fisheries; introductions of many species (finfish and shellfish) result in increased invasions of alien species, with a concomitant negative impact on wild stocks. Oysters are so numerous that they become pests, filtering phytoplankton production to the detriment of other commercial stocks. Ballast-water transport increases due to the opening of new routes (e.g. the Northwest Passage). Invasive species increase in number, phylum and quantity. There are some positive effects as commercial harvesting becomes possible on “new stocks”, but generally ecosystems are badly disturbed and do not stabilize by 2020. Huge “ecological therapy” exercise needed to restore sustainability.

**2. Green pieces in a black (red?) puzzle:** Intentional introduction of species has succeeded at several locations along the European coast; farmers are able to contain the introductions. However, some other intentional introductions fail; coastal waters result in a patchwork of productive aquaculture and fisheries and unproductive ecosystems where fishing and/or cultivation are not possible as a consequence of the unexpected “new” species. There is no stable equilibrium between different areas and economic sustainability cannot be attained. Unintentional introductions remain a risk as regulations on ballasts, transfers, etc. are not efficient.

**3. Sea is a kitchen garden:** Intentional introduction of species has succeeded around Europe; objectives of “restocking” and high density cultivation are achieved. In that way, “new” local and sedentary stocks are highly productive: scallops, clams, lobsters and crabs, seaweeds. Effects on ecosystems are monitored and controlled by means of “artificialized” environments (e.g: artificial reefs). Shipping regulations prevent dissemination of larvae by ballast water.

## Sources

- Bariche M. 2003. Biologie et écologie de deux espèces lessepsiennes (*Siganus rivulatus* et *Siganus luridus*, Téléostéens Siganidae) sur les côtes du Liban. *Cybiurn* 2003, 27 (1) : 52.
- Belsher T. et al, 2003. Acquisition de données sur l'expansion de *Caulerpa taxifolia* et *Caulerpa racemosa* en rade d'Hyères et en rade de Toulon (France). *Oceanol. Acta* 26 (2003) 161-166.
- Blanchard, Ifremer, 2007. Prolifération de la Crépidule *Crepidula fornicata* <http://www.ifremer.fr/delec/projets/habitats/crepidule/actions>
- Camus P. 2001. Un bien discret et redoutable prédateur de coquillages *Rapana venosa*. *La Vigie* 26, 3-9. <http://www.ifremer.fr/envlit/documentation/documents/htm>
- Carlton J. T. 2001. Introduced species in U.S. coastal waters. Environmental impact and management priorities. Pew Oceans Commission, Arlington, Virginia; 30pp.
- Hassan M., F. Bonhomme, 2005. No reduction in neutral variability of mitochondrial and nuclear genes for a Lessepsian migrant, *Upeneus moluccensis*. *J. Fish Biol.*, 2005 66 (3) 865-870.
- ICES 2004. Report of the working group on marine shellfish culture (WGMASC), Portland (Main) USA, 13-15 may 2004.
- Jørgensen L.L., J. Sundet IMR, 2006 Generalised distribution and spread of the red king crab *Paralithodes camtschaticus* from its release region in the Barents Sea.
- Jørgensen L. L., R. Primicerio 2007. Impact scenario for the invasive red king crab *Paralithodes camtschaticus* (Tilesius, 1815) (Reptantia, Lithodidae) on Norwegian, native, epibenthic prey. *Hydrobiologia* (2007) 590: 47-54.
- NOBANIS Network: <http://www.nobanis.org>
- Quéro J. C.M. H. du Buit, J. J. Vayne, 1998. Les observations de poissons tropicaux et le réchauffement dans les eaux de l'Atlantique européen. *Oceanol. Acta* 21 345-351
- Saad A. 2001. Cycle de reproduction et fécondité chez *Upeneus moluccensis* dans les eaux de Syrie (Méditerranée Orientale). *Lebanese Science Journal* 2001 (2,1)

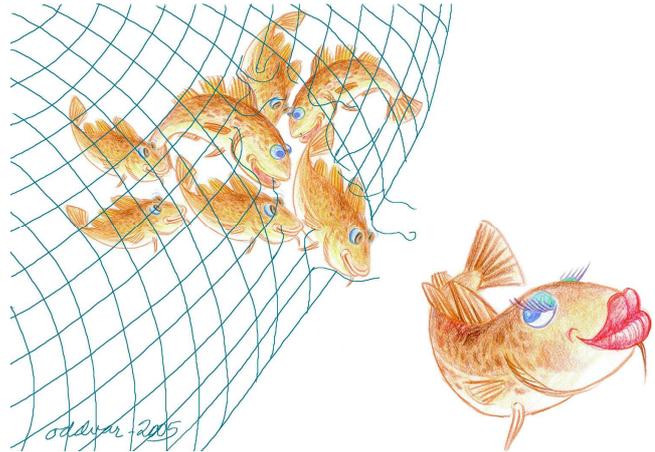
## ECOSYSTEMS

### E4 Escapement (inc. GMO, parasites)

#### Driver Definition

Escapement of farmed livestock contributes to the spreading of diseases and parasites, it is a source of genetic pollution, it has ecological effects, and is also a source of economic loss.

The Ecosystem Approach to Aquaculture (EAA) is among the initiatives addressing the potentially negative effects of farmed organisms, such as genetic contamination when alien species interbreed with local strains or species, or when disease is transmitted when alien species bring in new pathogens (FAO 2006).



#### Relevant Indicators

- Escapement as measured by
- Numbers of incidences of escape
  - Quantity of escaped livestock
  - Number of wild stocks affected by escaped livestock
  - Economic loss
  - Incidents of disease spread, including parasites

#### Developments over the past 20 years

The *ecosystem impacts of escapement* of farmed fish has been on the agenda for 20 years, becoming increasingly well covered. It was the theme of a Nasco/ICES conference in the UK in 1997: "Interactions between salmon culture and wild stocks of Atlantic salmon: scientific and management issues". From then on, research on the effects of escapement has evolved in three directions:

- genetic effects
- ecological effects
- the spread of diseases

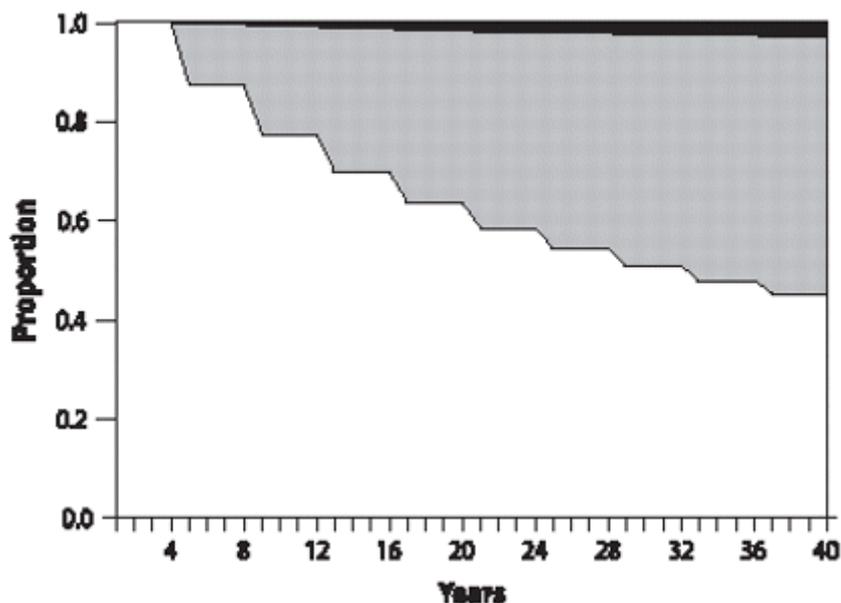
The *genetic diversity* of salmon, in and between rivers, is well documented (Ståhl 1987). The introduction of non-local fish has the potential to alter local populations genetically, reduce local adaptability and influence the character and survival of the population (Hindar *et al.* 1991). There are two key questions regarding the genetic effects of escapement, namely

- 1) how much genetic variation is lost in the domestication of salmon?
- 2) how will the traits and survival of wild salmon be affected if they are crossed with (the traits of ) a domesticated salmon?

Whether or not an escaped salmon finds its way into a river depends on the time of the year it escapes. In winter, escapees may stay in fjords for months, whereas younger fish (smolt) go

where wild salmon go: seeking food in the open sea, then finding their way up a river. As it was not spawned wild in a river, its choice of river is arbitrary.

Studies show that farmed salmon might outcrowd wild salmon in a river, reducing both the productivity of wild salmon and genetic diversity (Skilbrei *et al.* 2003). Simulations have been made of the effect of escaped salmon reproducing in a river populated by wild salmon. If the wild population received 20% escaped farmed salmon each year, the population of salmon would behave as shown below: <http://icesjms.oxfordjournals.org/content/vol63/issue7/images/large/63-7-1234-f01.jpeg>



(White = Wild; Grey = hybrid; Black = feral farmed fish (natural-born farmed fish).)

**Figure 1** Development of a salmon population receiving 20% escaped farmed salmon during ten generations (approximately 40 years). After Hindar *et al.* (2006)

The *ecological effects* of escapement are seen both in rivers and on the high seas. In rivers, there might be competition for spawning grounds, disruption of egg laying or eggs already deposited and competition between offspring from wild and escaped salmon. On the high seas there might be competition for food as well as predation. Successful spawning from escaped salmon has been registered (Carr *et al.* 1997), and although escaped salmon seem to have less successful reproduction in the wild, they will still compete for food and space in the river. Farmed salmon tend to have more but smaller eggs. From smaller eggs come smaller larvae, which might lose out to wild salmon larvae in the initial competition for food.

The population of wild Atlantic salmon is believed to have been reduced by 80% over the past 30 years<sup>27</sup>. In some countries the species is already extinct, and in Norway it has disappeared from 60 rivers.

*Diseases and parasites* might be introduced and spread by escaped salmon. *Gyrodactylus salaris* is an example of an introduced disease, while sea louse infestation is part of a burgeoning parasite problem as the farming industry, and with it the number of escapees,

<sup>27</sup> According to sources in the Norwegian Police, Department of Economic Crime, who consider escapement to be an environmental crime that should be met with fines of significant amounts.

grows. Sea lice affect the smolt as it enters salt water. They do not survive on grown salmon entering a river, because they can only live in saline water.

**The size of the matter**

The escapement of farmed salmon is shown in the graph below:

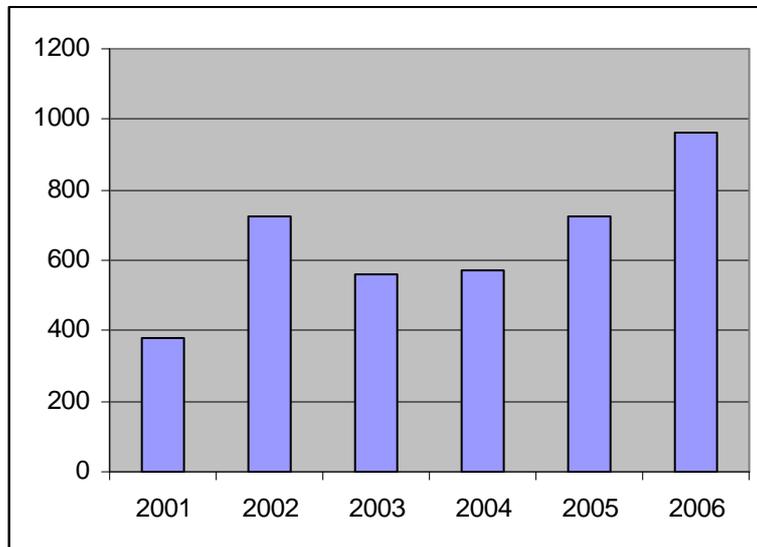


Figure 1 Escapement of salmon and rainbow trout 2001–2006. Source: Fisheries Directorate of Norway.

If the number of fish harvested each year is 200 million, a million escapees means that 0.5% of the stock escape each year. However, knowing that the spawning stock of wild salmon is about 600 000, this number is put into a different perspective. As escapees are not distributed evenly along the coast, but tend to happen in a few and rather significant incidences, escapement and the escapees might be a huge problem in rivers close to the sites from which the escapement occurred.

Even though escapement is considered to be the most important environmental issue associated with salmon farming, and has therefore been the subject of both research and regulation, the problem has obviously not approached a solution over the past few years.

**Hypotheses (2020)**

- 1. Wild salmon collapse:** Even with efforts to hinder escapement, the increase in farming activity means that escapement is widespread. The spread of disease and parasites leads to the collapse of wild salmon stocks.
- 2. Land-locked salmon:** To avoid genetic pollution and the spread of diseases, salmon farming is only allowed in contained systems ashore. Higher costs decimate the market for farmed salmon.
- 3. Sterile salmon:** The sterility of all farmed organisms reduces the consequences of escapement.
- 4. New-tech:** Strict regulations on the form and functioning of sea pens leads to the development of escape-safe pens. It is costly, but it works. Escapement is reduced by 90% in seven years.

## Sources

- Carr, J. W., et al. (1997). "The occurrence and spawning of cultured Atlantic Salmon (*Salmo salar*) in a Canadian river." *ICES Journal of Marine Science* 54: 1064-1073.
- FAO (2006). *The state of world fisheries and aquaculture*. Rome, FAO: 164.
- Hindar, K., et al. (1991). "Genetic effects of cultured fish on natural fish populations." *Canadian Journal of Fisheries and Aquatic Sciences* 48: 945-957.
- Kjetil Hindar,\*, Ian A. Fleming, Philip McGinnity and Ola Diserud (2006): Genetic and ecological effects of salmon farming on wild salmon: modelling from experimental results. *ICES Journal of Marine Science*, 63(7):1234-1247.
- Skilbrei, O., Ø. Skaala, et al. (2003). Rømming av laks og regnbueørret - konsekvenser på ville bestander. *Fisken og Havet*, nummer 11. Bergen, Havforskingsinstituttet, IMR.
- Ståhl, G. (1987). Genetic population structure of Atlantic Salmon. *Population genetics and Fishery Management*. N. Ryman and F. Utter. Seattle, University of Washington Press.

## ECOSYSTEMS

### E5 Impact of gears on habitat and organisms

#### Driver Definition

This driver focuses on the negative impact of fishing gears. In particular the impact on: (a) the various marine habitats (in the case of EU fleets, mostly benthic); (b) the structure of marine communities; and (c) the endangered species.

In recent times, there has been a growing appreciation of the wider and more subtle effects that fishing pressure can exert on the marine ecosystem. These wider ecosystem effects of fishing activities have been projected to new prominence, both through scientific activity and media publicity, such that they are widely considered to be crucial considerations in any future management plans. It is important to understand what is meant by the 'ecosystem effects' of fishing (Jennings and Kaiser, 1998).

This can be summarized as:

- (i) The effects of fishing on predator-prey relationships, which can lead to shifts in community structure (known as alternative stable states).
- (ii) Fishing can alter the population size and body-size composition of species leading to a fauna composed of primarily small individuals (this can include the whole spectrum of organisms, from worms to whales).
- (iii) Fishing can lead to genetic selection for different body and reproductive traits and can extirpate distinct local stocks.
- (iv) Fishing can affect populations of non-target species (e.g. cetaceans, birds, reptiles and elasmobranch fish) as a result of accidental bycatch or ghost fishing.
- (v) Fishing can reduce habitat complexity and perturb seabed (benthic) communities.

#### Relevant Indicators

- State of stocks of key and protected (e.g. IUCN red list) marine species.
- Degree of destruction of habitats, e.g. deep-water coral reefs, maerl beds.
- Biodiversity indices.

#### Developments over the past 20 years

Most seabed (demersal) fishing activity is undertaken in shallow seas on the continental shelf at depths <100 m. However, deep-water fishing is an increasingly important sector of the industry and notably occurs around seamounts at depths >1000 m.

The short-term effects of fishing on seabed biota are well documented in recent studies (for reviews, see Jennings and Kaiser, 1998; Kaiser and De Groot, 2000). Collie *et al.* (2000) found that the magnitude of the immediate response (i.e. change in abundance or biomass) of organisms to fishing disturbance varied significantly according to the type of fishing gear used, the habitat in which the study was undertaken, and among different taxa. Those authors undertook a regression-tree analysis that perhaps provides the first quantitative basis for predicting the relative impacts of fishing under different situations. Following the tree from its root to the branches, we can make predictions, for example, about how a particular taxon would be affected initially by disturbance from a particular fishing gear in a particular habitat. Therefore, trawling would reduce anthozoa (anemones, soft corals, sea ferns) by 68%, whereas asteroid starfish would only be reduced by 21%. Similarly, repeated (chronic) dredging is predicted to lead to 93% reductions of Anthozoa, Malacostraca (shrimps and

prawns), Ophiuroidea (brittlestars) and Polychaeta (bristle worms), whereas a single (acute) dredge event is predicted to lead to a 76% reduction.

Towed bottom fishing gears (trawls, dredges, drags, hydraulic devices) are used to catch species that live in, on or in association with the seabed. Such gear is designed to catch bottom-dwelling species, so it is intended to remain in close contact with the seabed. The impact of passing trawl gear over the seabed can be summarized as follows:

- Disturbance of the upper layers of the seabed causing short-term re-suspension of sediments, re-mineralization of nutrients and contaminants, and re-sorting of sediment particles.
- Direct removal, damage, displacement or death of a proportion of the animals and plants living in or on the seabed.
- A short-term attraction of carrion consumers into the path of the fishing gear.
- The alteration of habitat structure (e.g. flattening of wave forms, removal of rock, removal of structural organisms).

Hall-Spencer and Moore (2000) examined the effects of fishing disturbance on maerl beds. Maerl beds consist of highly dichotomous calcareous algae. This forms a complex substratum with a high degree of three-dimensional complexity. Not surprisingly, the associated assemblages have great diversity and many of the associated species are large-bodied and slow-growing. Hall-Spencer and Moore (2000) showed that four years after initial scallop-dredging disturbance, certain fauna, such as the nest-building bivalve *Limaria hians*, had still not recolonized trawl tracks. Similarly, work by Sainsbury *et al.* (1987, 1999) suggests that recovery rates may exceed 15 years for sponge and coral habitats off the western coast of Australia.

The same forces that fishing gears apply to the substrata also affect organisms living on and within them. The resulting effect can range from none (Kaiser *et al.* 1999) to displacement or injury (Kaiser 1996, Robinson and Richardson 1998), including mortality, depending on the vulnerability of the organism and the characteristics of the encountered gear component. Types of injuries include abrasion, laceration and breakage of shells and skeletons (exo- or endo-). Mobile epifauna may be able to avoid the gear, depending on the speed of approach and their sensory abilities, whereas sessile species may be more vulnerable (Hall-Spencer *et al.* 1999).

Changes in the composition of infaunal (Tuck *et al.* 1998) and epifaunal (Kaiser *et al.* 1998, McConnaughey *et al.* 2000, Prena *et al.* 1999) communities have been indicated. Significant changes in the abundance of individual species, either through displacement or mortality, could affect foodweb dynamics. Several studies have indicated that scavenger population may benefit from injured or discarded organisms (Ramsay *et al.* 1996, 1998, Kaiser and Ramsay 1997). Loss or reduction of sheltering structures and organisms may affect both predator-prey interactions and the energetic needs of individuals (Sainsbury 1987, Auster *et al.* 1996, McConnaughey *et al.* 2000).

Another category of fishing gear effect is the entrapment and eventual mortality of organisms from encounters with lost gear, so-called "ghost fishing". This is mainly an issue with gears left on the seafloor, so-called 'passive gears' such as pots, gillnets and traps, though active gear can also become derelict when separated from the towing vessel.

Most fishing operations trap organisms that are not the primary fishing target, which are commonly referred to as the bycatch. It may include small individuals of the target species, or other species with little or no commercial value. The problem is widespread, with a global estimate of approximately 20 million metric tonnes (Alverson *et al.* 1994), representing about one-quarter of the total world catch. Shrimp fisheries tend to generate the largest quantities of bycatch, and fisheries for small pelagics the least. Bycatch rates in mixed demersal and large pelagic fisheries are intermediate. Bycatch arises because fishing gears have imperfect selection properties, but the problem is made worse by economic pressures resulting from overexploitation. This leads to inefficient use of resources and changes in the abundance of both target and non-target species. Some bycatch species, including certain fish, reptiles,

birds and mammals, may well be threatened with extinction. Raised public awareness means that these conservation issues increasingly influence fishery management.

Although some large, densely schooling species, such as herring, capelin and mackerel, allow a fisher to target a single species, most fish occur in mixed assemblages, many members of which are at risk of capture during the passage of the gear. Not all discarded fish die. Some species, notably certain flatfish, dogfish and sculpins/cottids can survive the fish capture process quite well (Berghahn *et al.* 1992), but this is not the norm. For example, Hill and Wassenberg (1990) found that only 1–2% of fish survived, though as many as 50% of the crustaceans survived.

Turtles may be taken in almost all types of fishing gear. In many instances, they may be released unharmed or taken as food. Shrimp trawls have been identified as a major source of turtle mortality in the USA (Magnuson *et al.* 1990), and their threatened or endangered status precipitated the use of turtle excluding devices (TEDs) in fishing gear. In at least one case, loggerhead turtles, the mortality attributable to fishing was sufficient to prevent stock recovery. However, the use of excluding devices is increasing and should mitigate the problem. Turtle bycatch is also a significant problem for distant-water longline fleets, which are also known to impart significant losses on oceanic shark populations. A recent, global estimate of the effect of fisheries on marine turtles suggests that some 260 000 loggerheads and 50 000 leatherbacks are captured incidentally by longlines each year, many of which die as a consequence (Lewison *et al.* 2004).

Tasker *et al.* (2000) review the impact of fishing on marine birds. Both driftnets and longlines have caused mortalities among albatrosses and petrels, particularly in the Southern Ocean and North Pacific, though the use of driftnets has declined. Some albatrosses have very low reproductive rates, and even very small incidental mortalities are sufficient to threaten species with extinction. By contrast, another important effect of fishing is the increased availability of food to scavenging species, notably gulls. The production of discards and offal by fishing vessels makes hitherto inaccessible food obtainable to these species, and is linked to population increases in a number of seabirds.

Of the marine mammals taken as bycatch, dolphins and porpoises tend to attract the greatest public attention. Most incidental catch is associated with driftnets and gillnets, but tuna purse-seines are also involved. Incidental mortalities in excess of ~2% per year are often quoted as not sustainable for populations of small cetacean (Perrin *et al.* 1994). In contrast, typical fishing mortality rates for target fish species are well in excess of 10%, and it is not unusual to observe rates >50%. This indicates that a very small additional mortality for cetaceans attributable to fishing is enough to endanger their populations.

There are a wide variety of modifications to fishing gear that can be made to improve selectivity and hence mitigate the problem of bycatch. These are often referred to as technical measures. For trawls, which are one of the least selective gears, the principle is essentially to provide larger holes for the unwanted element of the catch to escape. The most obvious way to do this is to increase the mesh size, but the main drawback is that the conventional diamond mesh of nets may close under tension. Alternatives to mesh size increases are the insertion of panels made with square mesh. Such panels are less susceptible to mesh closure and may be effective for roundfish if located appropriately in the net. They are less effective for flatfish owing to the shape of the mesh opening.

A device that has attracted increasing attention is the rigid grid, placed somewhere in the codend of a trawl. The grid acts as a sorting device, filtering larger organisms and diverting them to another part of the gear. Such devices allow either the small organisms to be retained while the larger ones escape, or vice versa. These devices are used in some shrimp fisheries in Arctic waters to allow the fish component of the catch to escape. The same principle is applied in turtle excluding devices, as in shrimp fisheries in the USA.

Grids offer a partial means of separating species, but this is primarily based on size. It is possible to sort species by exploiting their particular behaviour. This is done in separator trawls, where a horizontal panel in the net divides those species that try to escape by

swimming upwards from those that try to escape by swimming downwards. In the Northeast Atlantic, this device can be used to separate haddock from cod.

Static gears, such as gillnets and lines, offer different challenges. Gillnets and driftnets may entrap mammals, such as dolphins, because they cannot be seen easily or echolocated by the mammal. Devices can be attached to these to make the gear acoustically visible, and hence warn the animal of its presence so that avoiding action can be taken. For lines, selectivity can be achieved through choice of hook size, shape and bait. Perhaps the highest profile concern is the ensnaring of seabirds such as albatrosses. Brothers *et al.* (FAO, 1999b) describe various devices, including setting lines at night when birds are absent, causing the lines to sink more quickly, or trailing streamers that discourage birds from attacking the bait.

## Hypotheses (2020)

**1. The Norwegian example:** As has been the case in Norway for many years, discarding is disallowed throughout Europe, and all bycaught non-target animals must be brought to port for monitoring purposes and to be rendered into fishmeal (so reducing the demand for industrial fisheries). Bycaught individuals of commercial species (undersized animals) are considered against quotas. Habitat damage is not considered.

**2. Compulsory mitigation:** The use of bycatch mitigation devices, such as separator panels, square meshes and acoustic deterrent devices become commonplace and required by law in certain fisheries. New trawl gears are introduced, employing jets of water, electronic currents, etc to act as bycatch mitigators. Fishing gears are generally less damaging to habitats and to non-target populations.

**3. No worries:** Food production takes precedence over environmental concerns. Few technical restrictions are placed on fisheries, with the exception of mesh-size regulations to sustain important commercial stocks.

**4. Burden of proof:** As with other activities in the marine environment, vessel owners are legally obliged to prove (by means of an Environmental Impact Analysis) that their particular fishing activities will not damage important habitats or compromise populations of non-target species, before being granted quota to fish. This effectively eliminates fishing in sensitive habitats such as maerl beds and deep-sea coral reefs. It also encourages the uptake of less damaging gears.

## Sources

- Cook, R. (2001) The magnitude and impact of bycatch mortality by fishing gear. Supporting material prepared for the FAO conference on "Responsible Fisheries in the Marine Environment", Reykjavik, Iceland, October 2001.
- FAO. 1994. A global assessment of fisheries by-catch and discards. Prepared by D.L. Alverson, M.H. Freeberg, S.A. Murawski and J.G. Pope. *FAO Fisheries Technical Paper*, no. 339. 233 pp.
- Kaiser M.J., Collie J.S., Hall S.J., Jennings S., Poiner I.R. (2001) Impacts of fishing gear on marine benthic habitats. Supporting material prepared for the FAO conference on "Responsible Fisheries in the Marine Environment", Reykjavik, Iceland, October 2001.
- Rose C, Carr A., Ferro D., Fonteyne R., MacMullen P. (2001) Using gear technology to understand and reduce unintended effects of fishing on the seabed and associated communities: background and potential directions. Supporting material prepared for the FAO conference on "Responsible Fisheries in the Marine Environment", Reykjavik, Iceland, October 2001.

# PRODUCTION

## PRODUCTION

### F1 Marine “ingredients”, by-products, and bio prospecting

#### Driver Definition

A large number of by-products<sup>28</sup> of fishery and aquaculture is currently available on the market and extensive research is conducted to increase this number. The by-products are derived from fish and shrimp waste (muscle, bones, peel, viscera) after processing for manufacturing fillets for human consumption, from algae, from invertebrates (sea cucumber and urchin and more and more invertebrates) and from bacteria. The by-products are for alimentation (human and animals), cosmetic, pharmacy, energy. They are : proteins (surimi for example), peptides, collagen, gelatine, omega 3 fatty acids, phospholipids, antioxidants, carotenoid pigments, calcium, enzymes, carraghenan, chitin, chitosan, vitamin, pharmaceutical molecules with antimicrobial, antifungal, antitumor, antibiotic, hemolytic, immunomodulatory properties and energy (from microalgae lipids). Marine microalgae, sponges, crustaceans, echinoderms, molluscs, cyanobacteria, and other invertebrates are (potential) sources for novel substances including anticancer and anti-hiv drugs and other therapeutics.

Bioprospecting<sup>29</sup> for novel compounds from marine sources represents an enormous potential to develop high-value pharmaceutical, nutraceutical and agrochemical products based on bioactive compounds found in the marine environment.

#### Relevant Indicators

- Number of molecules extracted from fish waste which is related to the research effort which will be invested
- value of these molecules,
- use of fishery discard
- Identified substances
- Patented substances
- (number of) Commercialized substances
- Commercial value of substances

#### Developments over the past 20 years

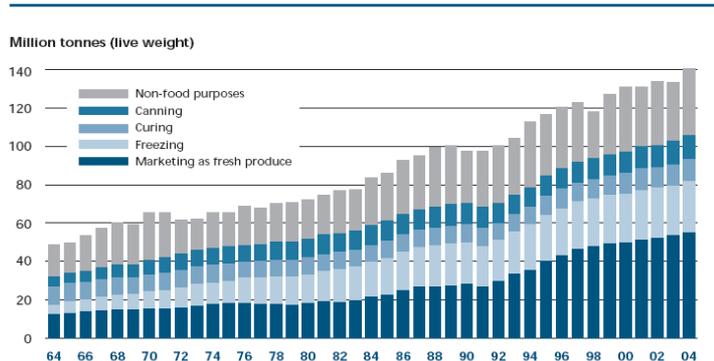
The oceans are the largest ecosystems on earth with immense biodiversity already known and thousands of new species being discovered as marine scientific research intensifies. Novel marine biodiversity is concentrated most specifically in four areas or *hot spots*: coral and temperate reefs, seamounts, hydrothermal vents and abyssal slopes and plains. These concentrations of biodiversity are largely untouched, despite being highly sought after by scientists, governments and companies that have speculated about the immeasurable pharmaceutical potential of novel structures (Green 2003). The screening and development of chemicals of marine origin have largely been based on organisms from tropical waters and the potential in cold water regions is far from fully explored (Anonymous 2006).

<sup>28</sup> A by-product is a secondary or incidental product deriving from a manufacturing process or chemical reaction, and is not the primary product or service being produced. A by-product can be useful and marketable, or it can have severe ecological consequences.

<sup>29</sup> Bioprospecting is the collecting and testing of biological samples (plants, animals, micro-organisms) and the collecting of indigenous knowledge to help in discovering and exploiting genetic or biochemical resources. Bioprospecting has primarily economic purposes (e.g., new drugs, crops)

In 2004, about 75 percent (105.6 million tonnes) of estimated world fish production was used for direct human consumption. The remaining 25 percent was destined for other products, in particular the manufacture of fishmeal and oil (Figure 1). In 2004, the bulk of the fishery products used for other purposes than direct human consumption came from natural stocks of small pelagics. Most of these fishery products were used as raw material for the production of animal feed and other products. Ninety percent of world fish production (excluding China) destined for non-direct human consumption was reduced to fishmeal/oil; the remaining 10 percent was largely utilized as direct feed in aquaculture and for fur animals (and the remaining for marine ingredients).

Utilization of world fisheries production (breakdown by quantity), 1964–2004



particular the manufacture of fishmeal and oil (Figure 1). In 2004, the bulk of the fishery products used for other purposes than direct human consumption came from natural stocks of small pelagics. Most of these fishery products were used as raw material for the

production of animal feed and other products. Ninety percent of world fish production (excluding China) destined for non-direct human consumption was reduced to fishmeal/oil; the remaining 10 percent was largely utilized as direct feed in aquaculture and for fur animals (and the remaining for marine ingredients).

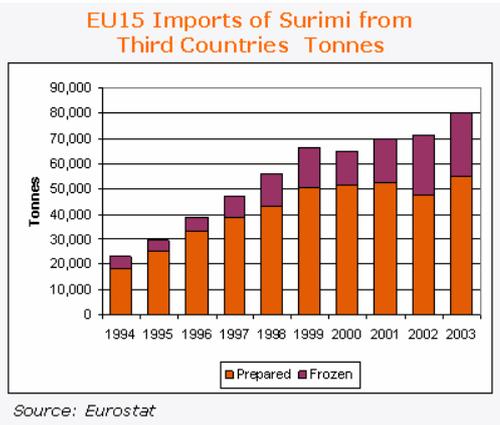
A relatively small number of marine plants, animals, and microbes have already yielded more than 12,000 novel chemicals (Anonymous 2006). According to Sahu *et al.* (2007) about 10,000 metabolites have been isolated from different marine organisms. Among them, 37% has been isolated from sponges, 21% from coelenterates, 18% from microorganisms, 9% from algae, 6% from echinoderms, 5% from tunicates, 2% from molluscs and 1% from bryozoans.

**Specific products**

*Surimi*

Many species and types of fish that were previously considered to be by-catch are now included in a broader range of target species. Evidence strongly suggests increased utilization of by-catch in many fisheries such as increased at-sea processing by factory vessels producing surimi (For example, Argentina, Chile, Northeast and Northwest Pacific) and related products (Kelleher 2005).

Global surimi production is estimated to be between 550 000 and 600 000 tonnes, with approximately half of the volume based on Alaska pollock. Other species used for surimi production include the threadfin bream (itoyori), atka mackerel, hoki, blue whiting and cod. The largest surimi producers are the USA, Thailand and Japan, while the main markets are Japan (400 000 MT) and Republic of Korea (100 000 MT), that are also the largest importers, although the USA and some EU countries, such as France, also consume substantial quantities EU15 imports of surimi products increased from 23 000 tonnes in 1994 to 80 000 tonnes in 2003 (FISHINFO 2005) as shown in figure 2.



The groundfish caught in the Gulf of Alaska and Bering Sea-Aleutian Islands fisheries, are used in a variety of ways. The range of product forms ranges from «high unit value» products (roe, individually frozen fish filets) to industrial products (oils and meals) and baits. New product forms continue to emerge in response to market opportunities. Indeed many products that are economically important to the US industry today, such as surimi, were not regarded as important (Queirolo *et al.* 1995).

*Extraction of collagen from calcified tissues*

Collagen and collagen peptides (subunits) are widely used in such areas as food, cosmetics, pharmaceuticals, glue, and photography (Pattentstorm 2007). The principal raw materials

currently used as sources for generating collagen commercially are bovine/porcine skins and bones. However, in the light of bovine spongiform encephalopathy and foot-and-mouth disease, the use of collagen derived from cattle and pigs has been called into question. Fish skins and bones are high in collagen, as are the exoskeletons (shells) of crustaceans. The processing of fin fish and shellfish generates a great deal of waste that contains high collagen levels and could be used.

#### *Cod sperm for use in cosmetics and chocolate*

A Norwegian biotech company claims a booming business in providing cod sperm for use in cosmetics and chocolate (Aftenposten 2007). Maritex, among the world's largest producers of cod liver oil, said it aimed to produce seven tons of processed cod sperm in 2002 for the international makeup market. The sperm is used to bind water in body lotions and make-up. Processed cod sperm sells for around \$200 a kilo, depending on its purity.

#### **Chitin**

Chitin and its derivatives have attracted the interest of many researchers and industries in the last 30 years owing to their antimicrobial activity, biocompatibility and biodegradability. They also interact strongly with pesticides and metal ions in aqueous solutions. Thus, they are potentially useful for applications in medicine, pharmacy and agriculture and also as biosorbent materials for the uptake of metal ions from polluted water and analytical applications. The most important raw materials for the extraction of chitin are the refuses of the sea-food industry, mainly the shells of crabs and shrimps. Indeed, huge amounts of shells of crabs and shrimps are issued from the fishery industries and they are used to extract the  $\alpha$ -chitin, the most common polymorph commercially available (Lavall *et al.* 2007).

#### **Fish oils**

Fish oils are used in the manufacture of edible fats, soaps and paints, for leather dressing and lineoleum manufacture, and also fish stearin (Fishbase 2007). Fish oil is also recommended for a healthy diet because it contains the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), precursors to eicosanoids that reduce inflammation throughout the body.

#### **Cosmetics**

A number of ingredients extracted from marine organisms are used for hair colour shining, protecting the hair fibres, preventing static and enhancing natural colour. Other ingredients are claimed to firm the skin, have anti-ageing purposes, contain soothing and calming agents and slow down skin ageing (from Cosmeticsbusiness 2007).

#### **Medicine**

Pharmaceutical drugs currently have annual sales exceeding \$200 billion. It has been estimated that over 25% of the drugs sold in the developed world and 75% in the less developed countries (LDCs) are based on chemicals made by organisms (Pearce and Puroshothamon 1995).

Over the past quarter-century, more than 10,000 compounds have been reported from marine-derived organisms. These compounds encompass a wide variety of chemical structures including acetogenins, polyketides, terpenes, alkaloids, peptides and many compounds of mixed biosynthesis. Marine-sourced material (e.g. from sea water and marine sediments) has a higher chance of a successful commercial 'hit' because of its mega-diversity (using the assumption: samples x biodiversity x assays = probability of a hit). The USA National Cancer Institute (NCI) was one of the first organisations to begin systematic large scale collection of marine invertebrates and in the mid-1980s formal collection programs were initiated to protect access to the original material (Newman *et al.* 2003).

The development of drugs from marine organisms can be highly profitable. E.g. the extraction of arabinosides from the sponge, *Tethya crypta*, has led to more than \$50 million annual sales in derived antiviral medicines (Anonymous 2006). A list of pharmaceuticals originating from the sea either commercialised or being tested is provided in table 1.

Regarding new drugs from the years 1982-2002, it is obvious that natural products are important (Figure 3), even though products from both marine and terrestrial organisms are presented.

**Anti-fouling**

After the ban of TBT-based products, marine paint companies are urged to find an appropriate substitute to prevent biofouling on ship hulls. Biocides commonly used in antifouling paints to replace TBT have caused many doubts about their environmental effects. An alternative is offered by the development of antifouling coatings in which the active ingredients are compounds naturally occurring in marine organisms. Many recent studies confirm a potential for novel active ingredients in antifouling preparations from crude extracts of marine algae (e.g. extracts from *Ceramium botryocarpum*) (Bazes *et al.* 2005).

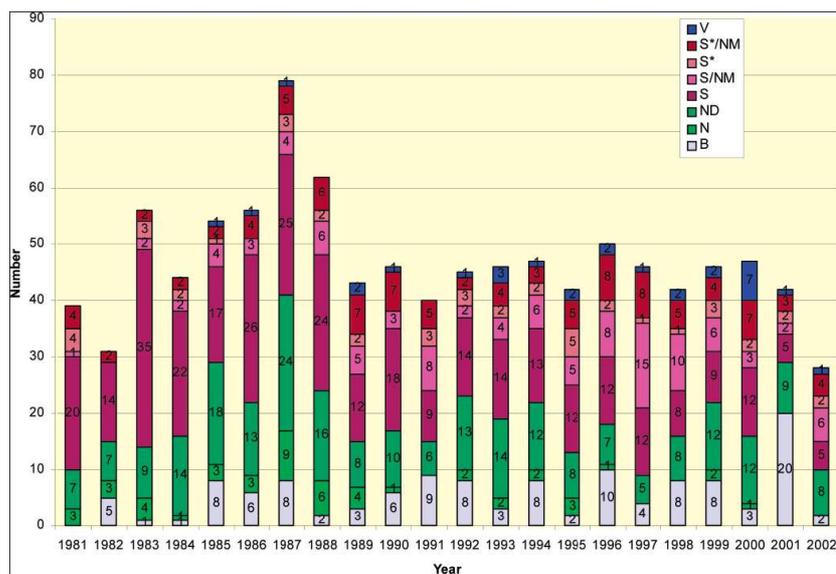
**Table 23.1 The Bounty of the Sea**

This table highlights some of the chemicals and biological materials isolated from marine organisms that are in use or being developed.

Application	Original Source	Status
<b>Pharmaceuticals</b>		
Anti-viral drugs (herpes infections)	Sponge, <i>Cryptotethya crypta</i>	Commercially available
Anti-cancer drug (non-Hodgkin's lymphoma)	Sponge, <i>Cryptotethya crypta</i>	Commercially available
Anti-cancer drug	Bryozoan, <i>Bugula neritina</i>	Phase II clinical trials
Anti-cancer drug (mitotic inhibitor)	Sea hare, <i>Dolabella auricularia</i>	Phase I clinical trials
Anti-cancer drug (tumor-cell DNA disruptor)	Ascidian, <i>Ecteinascidia turbinata</i>	Phase III clinical trials
Anti-cancer drug	Ascidian, <i>Aplidium albicans</i>	Advanced preclinical trials
Anti-cancer drug	Gastropod, <i>Elysia rubefescens</i>	Advanced preclinical trials
Anti-cancer drug (microtubule stabilizer)	Sponge, <i>Discodermia dissoluta</i>	Phase I clinical trials
Anti-cancer drug	Sponge, <i>Lissodendoryx sp.</i>	Advanced preclinical trials
Anti-cancer drug	Actinomycete, <i>Micromonospora marina</i>	Advanced preclinical trials
Anti-cancer drug (G2 checkpoint inhibitor)	Ascidian, <i>Didemnum granulatum</i>	In development
Anti-cancer drug	Sponge, <i>Jaspis sp.</i>	In development
Anti-inflammatory agent	Marine fungus	In development
Anti-fungal agent	Sponge, <i>Trachycladus</i>	In development
Anti-tuberculosis agent	Gorgonian, <i>Pseudopterogorgia</i>	In development
Anti-HIV agent	Ascidian	In development
Anti-malarial agent	Sponge, <i>Cymbastela</i>	In development
Anti-dengue virus agent	Marine crinoid	In development
<b>Molecular Probes</b>		
Phosphatase inhibitor	Dinoflagellate	Commercially available
Phospholipase A2 inhibitor	Sponge, <i>Luffariella variabilis</i>	Commercially available
Bioluminescent calcium indicator	Bioluminescent jellyfish, <i>Aequora victoria</i>	Commercially available
Reporter gene	Bioluminescent jellyfish, <i>Aequora victoria</i>	Commercially available
<b>Medical Devices</b>		
Orthopedic and cosmetic surgical implants	Coral, mollusk, echinoderm skeletons	Commercially available
<b>Diagnostics</b>		
Detection of endotoxins (LPS)	Horseshoe crab	Commercially available
<b>Enzymes</b>		
Polymerase chain-reaction enzyme	Deep-sea hydrothermal vent bacterium	Commercially available
<b>Nutritional Supplements</b>		
Polyunsaturated fatty acids used in food additives	Microalgae	Commercially available
<b>Pigments</b>		
Conjugated antibodies used in basic research and diagnostics	Red algae	Commercially available
<b>Cosmetic Additives</b>		
Cosmetic (anti-inflammatory)	Gorgonian, <i>Pseudopterogorgia elisabethae</i>	Commercially available

Source data combined from:

Pomponi, S. A. "The Bioprocess-technological Potential of the Sea." *Journal of Biotechnology* 70 (1999): 5-13.  
 Pomponi, S. A. "The Oceans and Human Health: The Discovery and Development of Marine-derived Drugs." *Oceanography* 14 (2001): 78-87.  
 National Institutes of Health, National Cancer Institute, Natural Products Branch, Frederick, MD.  
 Jordan, M.J., and L. Wilson. "Mining the Ocean's Pharmacological Riches: A Lesson from Taxol and Vinca Alkaloids." In *Marine Biotechnology in the 21st Century*. Washington, DC: National Academy Press, 2001.



**Figure 3. All new chemical entities organized by source/year (from Newman et al. 2003 )**

“B”: Biological; usually a large (>45 residues) peptide or protein either isolated from an organism/cell line or produced by biotechnological means in a surrogate host. “N”: Natural product. “ND”: Derived from a natural product and is usually a semi synthetic modification. “S”: Totally synthetic drug, often found by random screening/modification of an existing agent. “S\*”: Made by total synthesis, but the pharmacophore is/was from a natural product. “V”: Vaccine. (For amplification as to the rationales used for categorizing using the above subdivisions, the reader should consult the original review.1) One subcategory is used. “NM”: Natural Product Mimic (see rationale and examples below).

## Hypotheses (2020)

1. **Chase for organic products:** Increasing use of marine ingredients. New substances are discovered. Further resources are exploited.
2. **Chemistry wins:** Development of new synthetic products makes unnecessary the use of marine molecules. Demand for surimi products remains rather stable.
3. **Aquaculture helps:** Several substances and molecules are supplied through large – scale aquaculture of different marine organisms. No need for intensive exploitation of natural resources.

## Sources

- Aftenposten (2007): Boom for cod sperm cosmetics, available at: <http://www.aftenposten.no/english/local/article275951.ece>
- Anonymous (2004): An ocean blueprint for the 21st century, Final Report, U.S. Commission on Ocean Policy, Washington DC, available at : <http://www.oceancommission.gov>
- Anonymous (2006): Exploitation of Marine Living Resources – Global Opportunities for Norwegian Expertise, Report from a working group appointed by The Royal Norwegian Society of Sciences and Letters (DKNVS) and Norwegian Academy of Technological Sciences (NTVA), 48 pp.
- Bazes A.; Fay F.; Vallee-Rehel K.; Quemener E.; Braud J.-P.; Bourgougnon N. (2005): Development of friendly antifouling coatings from marine algae, Oceans 2005 – Europe Volume 1, 20-23 June 2005, Vol. 1: 190 – 195,
- Cosmeticsbusiness (2007): Marine ingredients worth their salt, available at:<http://www.cosmeticsbusiness.com/story.asp?sectioncode=1&storycode=1653&c=1>
- FAO (2006): The state of world fisheries and aquaculture, FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, available at : <http://www.fao.org/docrep/009/A0699e/A0699e00.htm>
- Fishbase (2007): Term : fish oils, available at: <http://64.95.130.5/Glossary/Glossary.cfm?TermEnglish=Fish%20oils>
- FISHINFO (2005): FISH INFOnetwork Market Report, Published in January 2005, available at :<http://www.eurofish.dk/indexSub.php?id=1928&easysitestatid=252338999>
- Green J. (2003): Bioprospecting in the high seas, Summary, In: (Shotton R., ed) Workshop on Marine Bioprospecting Synopsis, Deep Sea 2003: Conference on the Governance and Management of Deep-sea Fisheries, Part 2: Conference poster papers and workshop papers, Queenstown, New Zealand 1–5 December 2003, Dunedin New Zealand, 27–29 November 2003, available at: <http://www.fao.org/docrep/009/a0337e/A0337E15.htm>
- Kelleher K. (2005): Discards in the World's Marine Fisheries, An Update, FAO FISHERIES TECHNICAL PAPER 470, Food and Agriculture Organisation of the United Nations, Rome
- Lavall R. L., Assis O. B. G., Campana-Filho S. P. (2007):  $\beta$ -Chitin from the pens of *Loligo* sp.: Extraction and characterization, *Bioresource Technology*, 98, 13: 2465-2472
- Newman D. J., Cragg G. M., Snader K. M. (2003) : Natural Products as Sources of New Drugs over the Period 1981-2002. *J. Nat. Prod.* (Review) 66(7):1022-1037
- Pattenstorm (2007): Extraction of collagen from calcified tissues, US Patent Issued on September 19 2006, available at: <http://www.patentstorm.us/patents/7109300-description.html>
- Pearce D.W. and Puroshothamon S. 1995. The economic value of plant-based pharmaceuticals. In: Swanson T. (ed.), *Intellectual Property Rights and Biodiversity Conservation*. Cambridge University Press, Cambridge, UK, pp. 127–138
- Queirolo L. E., Fritz L. W., Livingston P. A., Loefflad L. F., Colpo D. A., de Reynier Y. L. (1995): Bycatch, Utilization, and Discards in the Commercial Groundfish Fisheries of the Gulf of Alaska, Eastern Bering Sea and Aleutian Islands, NOAA Technical Memorandum NMFS-AFSC-58, US Department of Commerce, November 1995, 148 pp.
- Rausser G.C. and Small A.A. 2000. Valuing research leads: bioprospecting and the conservation of genetic resources. *Journal of Political Economy* 108: 173–206.
- Sahu M. K., Sivakumar K., Kannan L. (2007): Marine realm: A treasure house for bioprospecting, *Asian Journal of Microbiology, Biotechnology and Environmental Sciences* 9 (1), pp. 191-196

## PRODUCTION

### F2 Fleet structure, size and technology (including selectivity, discards)

#### Driver Definition

Fishing fleets are of varying size, structure and use different gears. As technology is forever advancing, fleet size and capacity are an ever-changing parameters. The number of fishing vessels and/or the gross tonnage can provide just a rough indication on the fishing capacity of a given fleet.

The driver refers also to technological improvements of fishing gears and vessel equipment that could allow exploitation of new fishery resources, increase productivity and decrease catches of unwanted species.

Following FAO discards is considered the portion of the total catch which is dumped or thrown overboard at sea. This concerns catches of non-commercial species and non-marketable individuals of commercial ones. Recent FAO estimates indicate that, in terms of weight, discards represent about 8% of the global catches; past discard rates, however, were considered to be much higher (around 25%).

#### Relevant Indicators

- Fleet structure
- Number of vessels and total tonnage by fishery/gear type
- Evolution of discard catch rates and state of stocks of key and protected (e.g. IUCN red list) marine species
- Expansion of fishery grounds
- Discards

#### Developments over the past 20 years

##### Fleet structure and capacity<sup>30</sup>

The majority (81%) of EU fishing vessels have a length of less than 12 metres and only 4% are larger than 24 metres in length. Only in Belgium and the Netherlands are the smaller vessels not in the majority. In the remaining Member States vessels of less than 12 metres in length make up of over two thirds of the fleet; in Finland and Greece even over 90% of the total. The median age of EU fishing vessels in 2002 was 22.3 years. The median age was greatest in Denmark and Spain (25.0 years each) closely followed by Italy (24.8 years), Portugal (24.7 years) and Ireland (24.4 years). The youngest fleets were found in Belgium (median age 16.7 years), followed by France (17.2 years) and Finland (17.5 years).

Power and tonnage are the main factors determining the fishing capacity of a fleet and hence provides a proxy for the pressure on the fish stocks. Excess power is considered to be one of the major factors of over capacity resulting in overfishing. Despite the drop in fishing fleet capacity experienced by the EU fleet in the past 15 years the chronic overcapacity persists, undermining conservation measures. The Multi-Annual Guidance Programmes (MAGPs) have been proven inadequate and in the reformed CFP (January 2003) have been replaced by a simpler entry/exit regime. Advances in technology and design mean that newer vessels exert more fishing pressure than older vessels of equivalent tonnage and power; hence despite the drop of fleet capacity, fish resources remain seriously depleted and unsustainably managed.

---

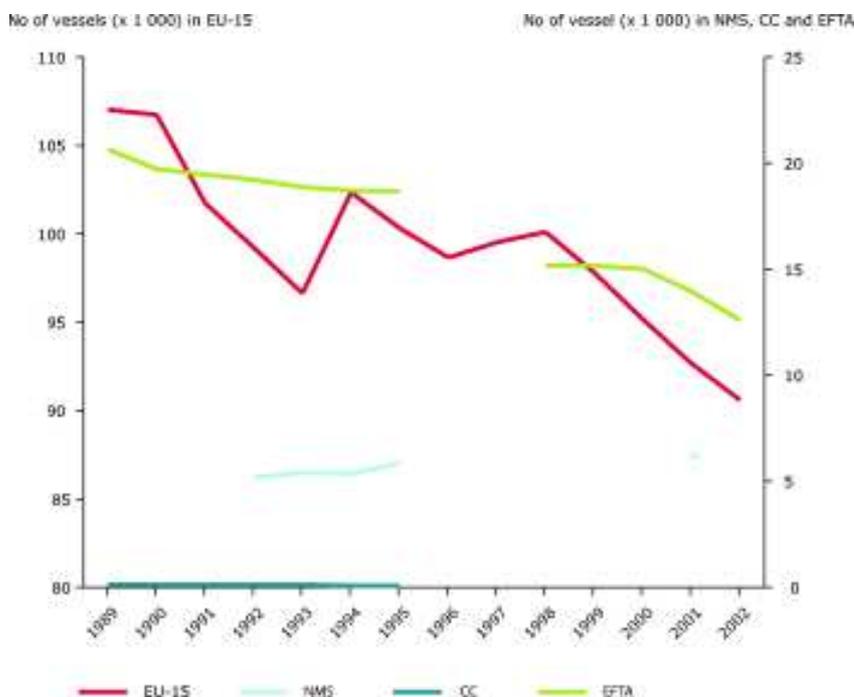
<sup>30</sup>also see Driver B3

Over the 1989-2004 period the EU fishing fleet capacity followed a downward trend, with reductions of 23 % in power, 15 % in tonnage and 23 % in numbers. Similarly the NMS (New Member States) fleet decreased by 80 % in tonnage and 5 % in number. However, the EFTA fleet (Iceland and Norway) increased in terms of tonnage (by 34%) and power (by 33%) despite the drop in numbers by 52% over the same period. Trends are shown in Figures 1-3 and for the period 1989-2004 are summarized in Figure 4. During the 2000-2005 period the fleet was in constant decline and details are shown in Table 1.

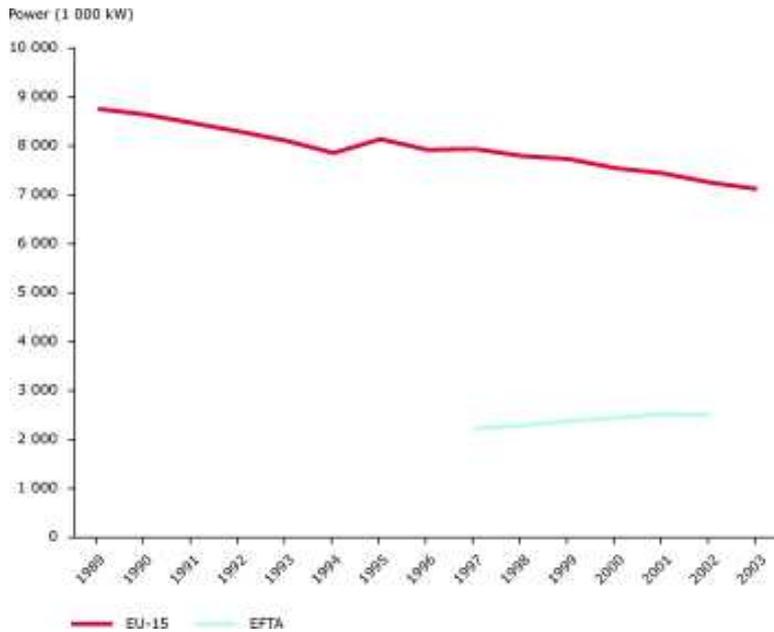
**Table 1:** EU-25 fishing fleet in 2000 and 2005

Country	Total number		Total tonnage		Total power (kW)		% variation between 2000 and 2005		
	2000	2005	2000	2005	2000	2005	Number	Tonnage	Power
BE	127	121	23 054	22 686	63 502	65 643	-4.7	-1.6	3.4
DK	4 139	3 274	107 471	91 961	393 373	326 368	-20.9	-14.4	-17.0
DE	2 315	2 121	71 168	64 075	167 744	159 299	-8.4	-10.0	-5.0
EL	19 962	18 275	107 407	93 012	623 043	536 942	-8.5	-13.4	-13.8
ES	16 678	13 691	521 838	487 397	1 332 708	1 124 323	-17.9	-6.6	-15.6
FR	8 181	7 859	224 077	215 116	1 108 229	1 070 040	-3.9	-4.0	-3.4
IE	1 615	1 411	68 282	87 753	211 894	215 961	-12.6	28.5	1.9
IT	17 369	14 459	232 467	213 231	1 394 483	1 226 763	-16.8	-8.3	-12.0
NL	1 101	830	212 466	171 988	522 305	401 508	-24.6	-19.1	-23.1
PT	10 692	9 955	117 313	108 697	397 326	384 292	-6.9	-7.3	-3.3
FI	3 663	3 267	20 819	17 126	197 703	171 634	-10.8	-17.7	-13.2
SE	2 016	1 640	51 394	44 778	244 610	221 908	-18.7	-12.9	-9.3
UK	7 643	6 774	265 145	218 713	974 901	882 326	-11.4	-17.5	-9.5
<b>EU-15</b>	<b>95 501</b>	<b>83 677</b>	<b>2 022 901</b>	<b>1 836 533</b>	<b>7 631 821</b>	<b>6 787 007</b>	<b>-12.4</b>	<b>-9.2</b>	<b>-11.1</b>
EE	:	1 045	:	24 216	:	61 987	:	:	:
CY	:	887	:	9 121	:	47 380	:	:	:
LV	:	928	:	38 541	:	66 194	:	:	:
LT	:	272	:	64 404	:	70 651	:	:	:
MT	:	1 421	:	19 006	:	102 112	:	:	:
PL	:	974	:	30 260	:	105 347	:	:	:
SI	:	169	:	1 060	:	10 966	:	:	:
<b>EU-25</b>	:	<b>89 373</b>	:	<b>2 023 141</b>	:	<b>7 251 644</b>	:	:	:

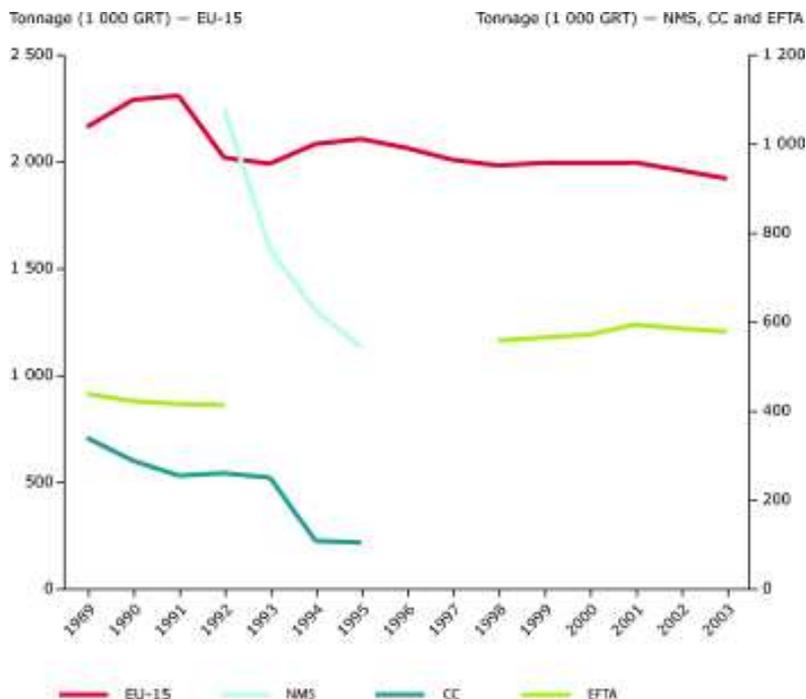
Source: EUROSTAT



**Figure 1:** European Fishing Fleet Capacity: Number of vessels, 2003 (from European Environment Agency, <http://themes.eea.europa.eu/>). **Note:** Data availability: Number of vessels 1989-2002 for EU-15; 1989-1992 & 1998-2002 for EFTA; 1989-1995 & 2001 for EU-10; 1992-1995 & 2001 for AC countries. Legend: Countries have been grouped into the following categories: EU-15 (Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom), EFTA (Iceland and Norway), EU-10 (new member states: Estonia, Cyprus, Lithuania, Latvia, Malta, Poland, and Slovenia), CC (accession countries: Bulgaria and Romania).

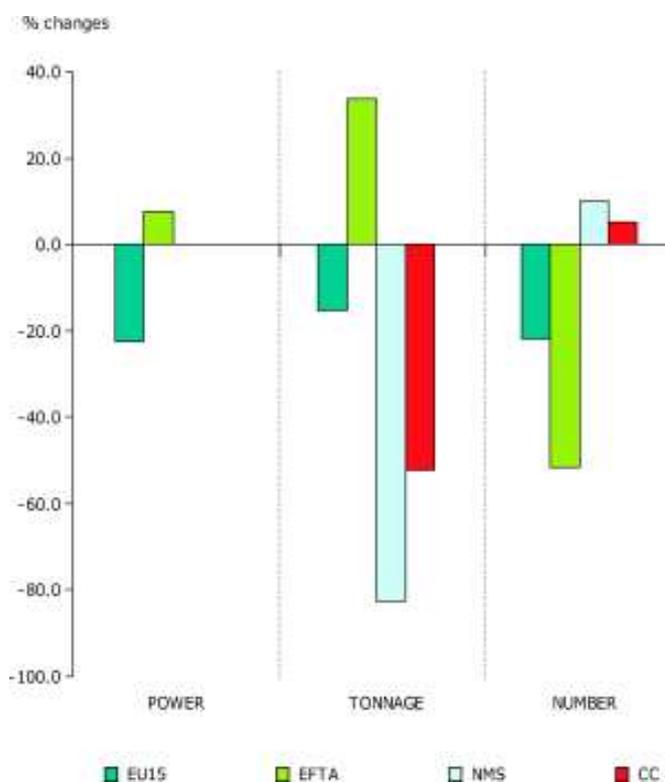


**Figure 2:** European Fishing Fleet Capacity: Engine Power. (from European Environment Agency, <http://themes.eea.europa.eu/>). **Note:** Data availability: 1989-2003 for EU-15; 1997-2002 for EFTA countries, no data for EU-10 and AC countries. Legend: Countries have been grouped into the following categories: EU-15 (Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom), EFTA (Iceland and Norway).



**Figure 3:** European Fishing Fleet Capacity: Tonnage. (from European Environment Agency, <http://themes.eea.europa.eu/>) . **Note:** Data availability: 1989-2003 for EU-15; 1989-1992 & 1998-2003 for EFTA; 1989-1995 for EC; 1992-1995 for BS countries. Legend: Countries have been grouped into the following categories: EU-15 (Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, United Kingdom), EFTA (Iceland and Norway), NMS (New Member States), CC (Central and Eastern European Countries).

Sweden, United Kingdom), EFTA (Iceland and Norway), EU-10 (new member states: Estonia, Cyprus, Lithuania, Latvia, Malta, Poland, and Slovenia), AC (accession countries: Bulgaria and Romania).



**Figure 4:** Changes of European fishing fleet capacity: 1989-2004. (from European Environment Agency, <http://themes.eea.europa.eu/>).

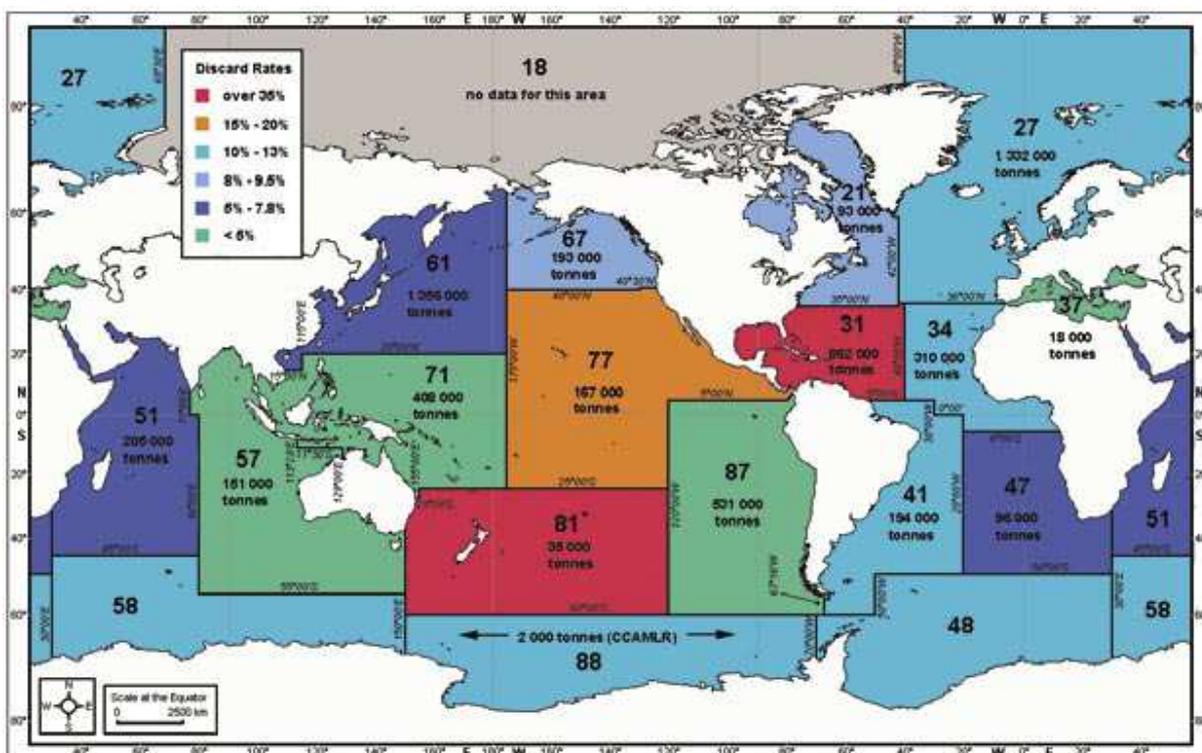
**Discards and by-catches**

On average, a total of 110 million tonnes of marine animals are removed annually from the world seas through the various fishing operations. Those include not only the commonly targeted commercial species but also those that are caught although they are not targeted (by-catches). Certain by-catch individuals are kept to be marketed but most often they are thrown back dead (discards) as they include low economical value species, endangered protected species, undersized fish of valuable commercial species or they are simply surplus to the fishing operation’s quotas. The United Nations Food and Agriculture Organisation (FAO) reports that discards represent, in terms of biomass, as much as 8-25% of the total world catches. In several cases, discards influence the assessment of stock status and dynamics, affecting the fisheries management of both target and by-catch species (Tserpes et. al. 2006). The redirection of large amounts of energy into marine ecosystems through discards can lead to community structure changes, especially in scavenger species (Jennings et al., 2001).

A great number of species is included in the discards, many of which are fish and sharks. The impact of fishery is bigger on discarded species that cannot survive (e.g. species with swim-bladders). In addition, by-catches of protected species, such as marine mammals and sea-turtles, occur in several fisheries, especially the gillnet ones.

In geographical terms, the Northeast Atlantic (1.4 million tonnes), the Northwest Pacific (1.3 million tonnes) and the Western Central Atlantic (0.8 million tonnes) generate the highest discards (Figure 5). Trawl fisheries and shrimp fisheries account for 55 and 27 percent of the recorded discards respectively.

No coherent time series of discard rates is available at the global level. However, from case studies of a wide range of fisheries, it is apparent that the global level of discards has decreased in recent years (Table 2). This is a result of by-catch reduction through improvements on gear selectivity and adoption of mitigation measures, as well as due to increased by-catch utilization (i.e. through production of byproducts for example as ingredients). The continuous development of technologies and enforcement of measures for by-catch reduction and incidental catch mitigation continue to offset possible further restrictions and declines in these fisheries.



**Figure 5:** Recorded discards by FAO statistical area. \*Note: the high discard rate in FAO Area 81 is a data artifact (from FAO, 2005).

**Table 2:** Development of discard estimates (tonnes), 1994–2004 (from FAO, 2005).

FAO area	FAO Fisheries Technical Paper No. 339 (Alverson Table 5)	FAO Fisheries Report No. 547/SOFIA 1998 (approx.) <sup>1</sup>	FAO Fisheries Report No. 407, 2004
Arctic Sea	18		0
Northwest Atlantic	21	685 949	92 926
Northeast Atlantic	27	3 671 346	1 408 931
West Central Atlantic	31	1 600 897	831 808
East Central Atlantic	34	594 232	309 718
Mediterranean/Black Sea	37	564 613	17 954
Southwest Atlantic	41	802 884	197 618
Southeast Atlantic	47	277 730	120 283
West Indian Ocean	51	1 471 274	205 428
East Indian Ocean	57	802 189	151 190
Northwest Pacific	61	9 131 752	1 355 822
Northeast Pacific	67	924 783	192 829
West Central Pacific	71	2 776 726	407 826
East Central Pacific	77	767 444	167 351
Southwest Pacific	81	293 394	35 475
Southeast Pacific	87	2 601 640	530 582
Multiple area	31, 77		27 335
Multiple area	67, 77		150 161
Multiple area	71, 77		2 138
Global shark fin			206 815
<b>Tunas, bonitos, billfish</b>			
Atlantic and Mediterranean (ICCAT area) (21, 27, 31, 34, 41, 48)			159 466
Indian Ocean (IOTC area) (51, 57)			139 465
Pacific E. Central (IATTC area) (67, 77, 87)			56 508
Pacific SW and W. Central (SPC area) (71, 81)			162 068
<b>Subtotal tuna</b>			<b>517 507</b>
<b>Antarctic</b>			
Atlantic, Antarctic	35 119	35 119	
Indian Ocean, Antarctic	10 018	10 018	
Pacific, Antarctic	109	109	
<b>Subtotal Antarctic CCAMLR (48, 58, 88)</b>			<b>2 079</b>
<b>Global estimate of discards</b>	<b>27 012 099</b>	<b>19 185 303</b>	<b>6 931 776</b>

### *Expansion of fishing grounds/activities*

As fishing fleets expanded through the late 1980s and as fish-finding and harvesting technologies became more efficient, the world's fishers have systematically gone after their catch at greater depths and in more remote waters. In Europe, recent examples of expansion/development of new profitable fisheries with high capitalization and technology include French and Spanish tuna seiners, German pelagic trawlers, and Norwegian combination vessels equipped for pelagic trawling and purse seining.

An important part of the European fishing fleet depends on access to non-EU fish resources, either in waters under the jurisdiction of third countries, with which the EU has signed Fisheries Agreements, or in international waters. Competition for decreasing resources is fiercer every day, making it increasingly difficult for the EU to conclude bilateral fisheries agreements which would grant its fleets access to the surplus fish resources in third country waters. Moreover, the EU distant water fishing fleets are becoming less and less competitive vis-à-vis the fleets of new emerging fishing nations which are operating at lower costs.

## Hypotheses (2020)

1. **The same old story:** Fleet size and nominal capacity keeps going down, but not the effective effort. Technological improvements help, to a certain extent, in reducing unwanted catch and improving fishing efficiency. No major changes in fishing grounds.
2. **What a wonderful world:** No need to reduce capacity. Innovative technology allows access to new promising fishing grounds and all catches are utilized (no discards).
3. **Bad news:** Existing fishing grounds are exhausted, no access to new ones. Fleet size is reducing dramatically. Technology unable to provide substantial help.

## Sources

- European Commission – Eurostat (<http://epp.eurostat.ec.europa.eu>)
- European Environment Agency (<http://themes.eea.europa.eu/>)
- FAO, 2005. Discards in the World's Marine Fisheries: An Update. *FAO Fisheries Technical paper 470*.
- Jennings, S., K.J. Warr, S.P.R. Greenstreet, and A.J.R. Cotter, Spatial and temporal patterns in North Sea fishing effort. In: M.J. Kaiser, and S.B. de Groot (Eds) *Effects of fishing on non-target species and habitats*. Oxford: Blackwell Science (2000) pp. 3–14.
- Tserpes G., P. Peristeraki, and J. R. Nielsen, 2006. Ecological Side-Effects of Fishing from the Fisheries Management Perspective. In: "The Knowledge Base for Fisheries Management". Eds. L. Motos, D.C. Wilson. Elsevier, Oxford, *Developments in Aquaculture and Fisheries Science*, 36, pp. 454 (267-294).

## PRODUCTION

### F3 Stock Development (commercial stocks, potential commercial stocks, restocking,)

#### Driver Definition

The driver refers to:

- the state of the exploited fish stocks. FAO reports that 47% of the world's stocks are fully exploited, 18% over-exploited and 10% significantly depleted or recovering.
- under and/or non-exploited marine fishery resources. Those include commercial stocks difficult to access (e.g. deep water fishes), and stocks of species of low/no commercial value under the current consumer attributes (e.g. certain invasive species).
- Restocking. Based on the FAO definition, restocking is the practice of maintaining a stock by regular release of juveniles that are reared in aquaculture or introduced from other areas. So far, restocking experiments are focusing on commercial fish stocks.

#### Relevant Indicators

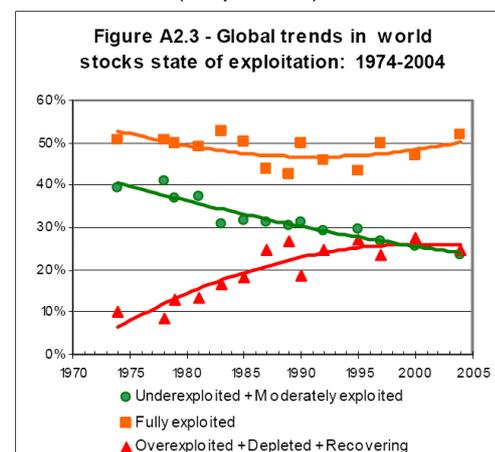
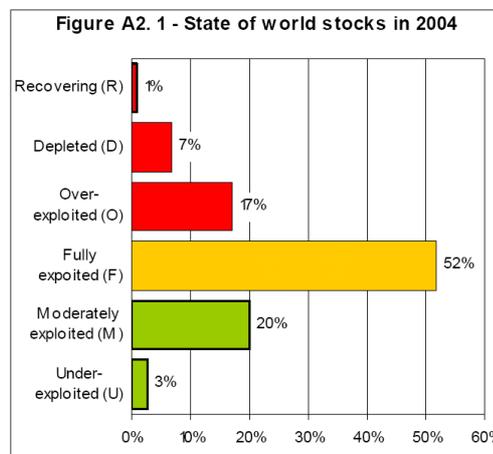
- Global trends on the state of commercial stocks
- Stocks of protected species
- Stocks of invasive species
- List of marketable species
- Deep water fishery production
- Recovery of depleted stocks through restocking practices
- Share of aquaculture activity for restocking

#### Developments over the past 20 years

##### Global trends on the state of commercial stocks

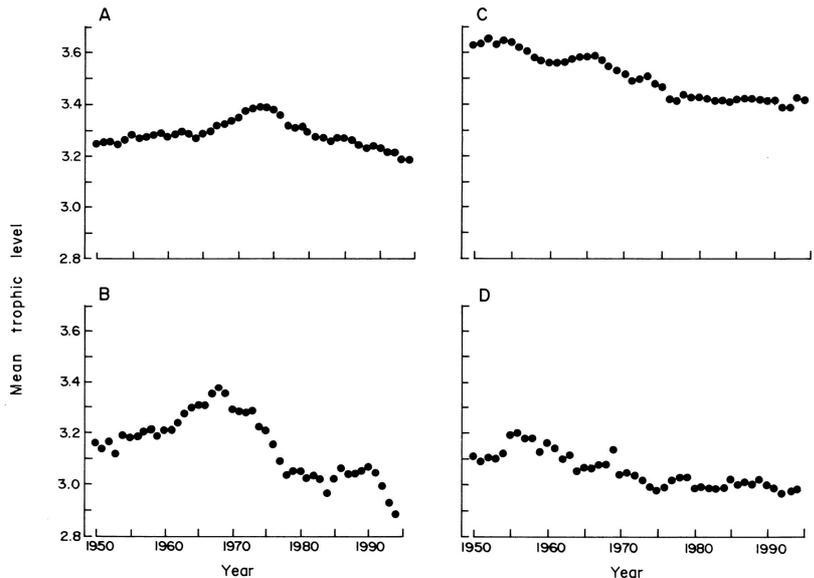
The global state of exploitation of the world marine fishery resources has been relatively stable over the past 10-15 years, even if changes have been reported for some fish stocks and specific areas. The proportions of overexploited and depleted stocks have remained unchanged in recent years, after the noticeable increasing trends observed in the 1970s and 1980s. It is estimated that in 2004, as in previous recent years, around one-quarter of the stock groups monitored by FAO were underexploited or moderately exploited (3 percent and 20 percent, respectively) and could perhaps produce more. About half of the stocks (52 percent) were fully exploited and therefore producing catches that were at or close to their maximum sustainable limits, with no room for further expansion. The other one-quarter were either overexploited, depleted or recovering from depletion (17 percent, 7 percent and 1 percent, respectively) and thus were yielding less than their maximum potential owing to excess fishing pressure exerted in the past, with no possibilities in the short or medium term of further expansion and with an increased risk of further declines and need for rebuilding (Figure 1).

Since FAO started monitoring the global state of stocks in 1974, there has been a consistent downward trend from almost 40 percent in 1974 to 23 percent in 2004 in the proportions of underexploited and moderately exploited stocks, which are those



offering some potential for expansion. At the same time, there has been an increasing trend in the proportion of overexploited and depleted stocks, from about 10 percent in the mid-1970s to around 25 percent in the early 1990s, where it has stabilized until the present, while the proportions of fully exploited stocks declined from slightly over 50 percent in 1974 to around 45 percent in the early 1990s, increasing to 52 percent in 2004 (Figure 2). However, many commercial fish stocks in European waters remain non-assessed. Of the assessed commercial stocks in the NE Atlantic, 22 to 53 % are outside safe biological limits (SBL). Of the assessed stocks in the Baltic Sea, the West Ireland Sea and the Irish Sea, 22, 29 and 53 %, respectively, are outside SBL. In the Mediterranean, the percentage of stocks outside SBL range from 10 to 20 %.

Pauly *et al.* (1998) state that the mean trophic level of the species groups reported in FAO

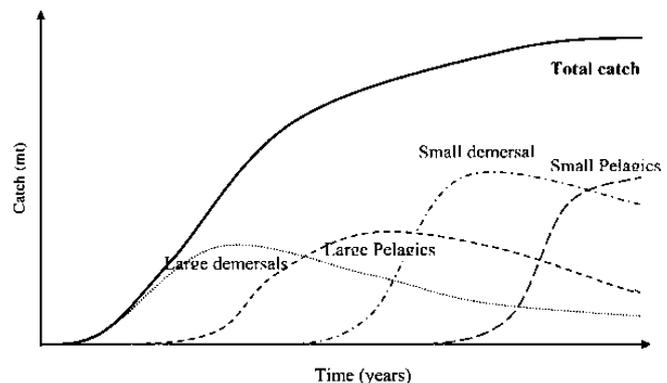


global fisheries statistics has been declining (Figure 3). This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish Pauly *et al.* (1998). As a result species composition and abundance are altered in an area (as well as the resulting catch). This effect is most pronounced in the Northern Hemisphere Pauly *et al.* (1998). Fishing down food webs leads at first to increasing catches, then to

a phase transition associated with declining catches (Figure 4 from Sugiyama *et al.* 2004).

**Figure 3:** Trends of mean trophic level of fisheries landings in northern temperate areas, 1950 to 1994. (A) North Pacific (FAO areas 61 and 67); (B) Northwest and Western Central Atlantic (FAO areas 21 and 31); (C) Northeast Atlantic (FAO area 27); and (D) Mediterranean (FAO area 37). From Pauly *et al.* 1998.

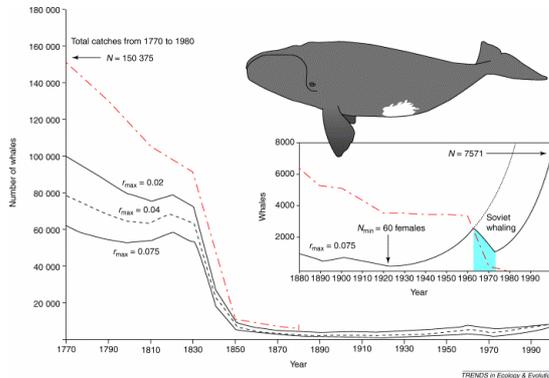
**Figure 4:** A hypothetical model of the impact of fishing on a marine ecosystem (Sugiyama *et al.* 2004)



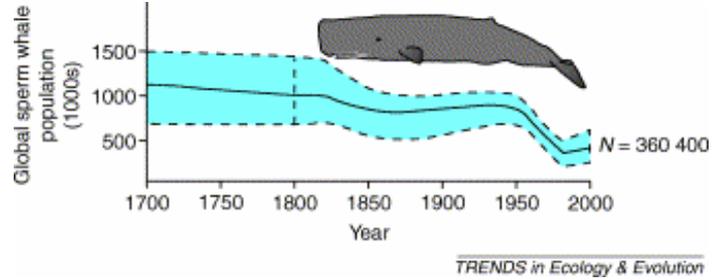
**Stocks of protected species**

*Whales*

According to the International Whaling Commission (2007) most whale populations of the world have been increasing in recent years.



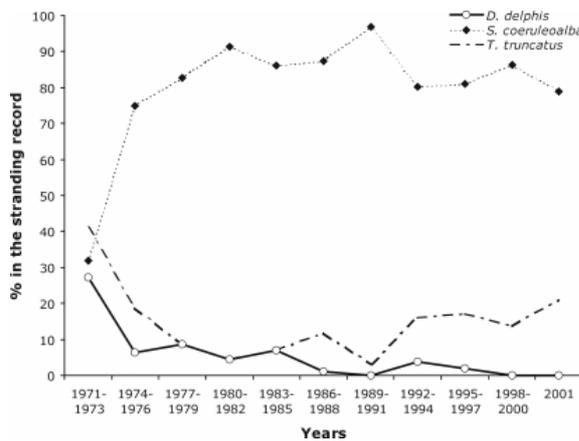
**Figure 5:** Historical reconstruction of the abundance of southern right whales from the start of whaling in 1770 to 1997. From Baker & Clapham (2004) citing Whitehead (2002) .



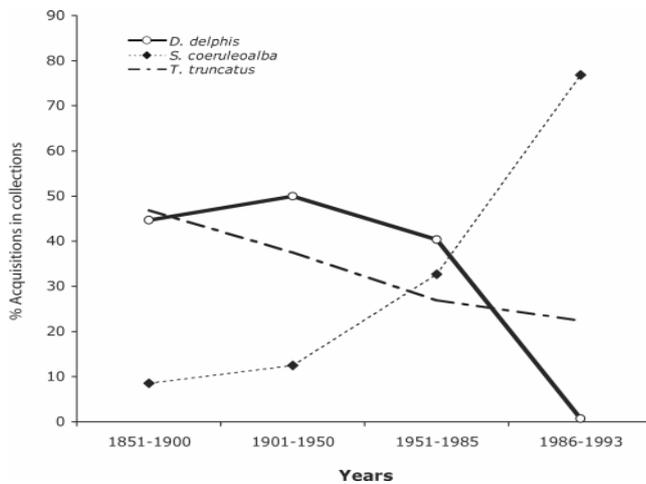
**Figure 6:** Estimated population trajectories for the global sperm whale population from 1700 to 1999. The solid line shows the trajectory based on the best estimate of current and historical abundance. From Baker & Clapham (2004) citing IWC (2001)

*Dolphins*

The common dolphin *Delphinus delphis* may have been one of the most abundant cetacean species in the Mediterranean basin until the early 20th century. Stranding data provide unambiguous evidence for declines of common dolphins in certain Mediterranean areas, and this decline in some areas (e.g. French coast) has been matched by a concurrent increase of striped dolphins, with the trajectories of the two species crossing in the early 1970s.



**Figure 7:** Strandings of dolphins along the Mediterranean coasts of France between 1971 and 2001 (see text for references). *Delphinus delphis* (n = 25), *Stenella coeruleoalba* (n = 700), *Tursiops truncatus* (n = 96). (from Bearzi et al. 2003)



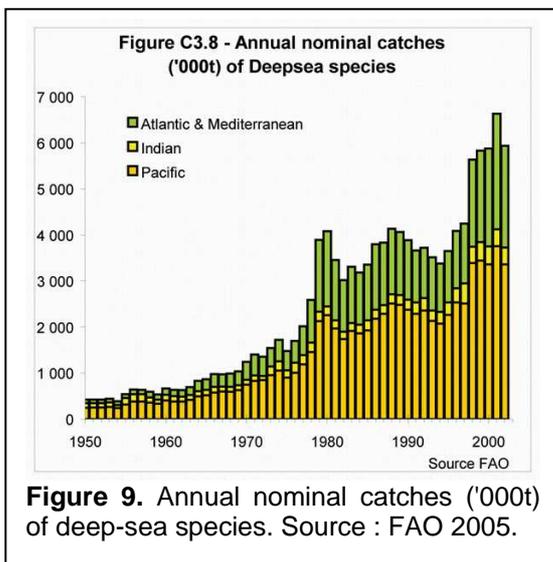
**Figure 8:** Acquisitions of cetacean specimens by museums and zoological collections in Italy between 1851 and 1993, based on Cagnolaro (1996). *Delphinus delphis* (n = 56), *Stenella coeruleoalba* (n = 243), *Tursiops truncatus* (n = 109). (from Bearzi *et al.* 2003)

**List of marketable species**

According to SAUP 2007 there is a variety of marketable species in Europe. A total of 83 taxa are listed as commercial in the Mediterranean. A number of 94 commercial taxa come from the Celtic-Biscay shelf, 80 originate from the Iberian coast, 124 from the FAO area of Northeast Atlantic, 76 from the North Sea, 28 from the Baltic Sea. 53 commercial taxa are identified in the Norwegian Shelf and 51 in the Iceland Shelf. 69 taxa were listed from the Faeroe Plateau and 46 from the Barents Sea.

**Deep water fishery production**

Until recently, the great depth of the deep-sea has made it difficult to exploit, and the existence of relatively more abundant resources in shallower seas have meant that there was little incentive to fish in such difficult-to-exploit regions.



Deep-sea fisheries are relatively loosely defined from a biological perspective. In general, deep-sea fisheries are defined as fisheries carried out in waters deeper than around 400-500 m (Koslow *et al.* 2000). Stock assessments for deep-sea stocks are mostly undertaken according to species in geographically defined areas. Prominent species often mentioned in relation to deep-sea fisheries include orange roughy, Greenland halibut, pelagic armourhead, Patagonian toothfish and blue grenadier. In brief, deep-sea species are generally characterized as having a slow growth rate, being long-lived and having low fecundity (Gordon 2001). They also tend to aggregate around ocean banks and seamounts. These characteristics mean that they are particularly vulnerable to overexploitation. Many deep-sea fisheries biologist has concluded that it is

not meaningful to talk about deepwater fisheries in terms of sustainable fisheries, because the growth rates of many of these species are very low, a characteristic that is compounded by their apparently episodic recruitment.

In such fisheries if the resource consisted of widely-separated age-classes that are fished to very low levels of abundance, stock recovery arising from good recruitment may only be possible in generation terms greater than those of humans. In general, management of deep sea resources is confounded by the difficulty of obtaining required data. Figure 9 represents the development of captures of the deep-sea species. Some of these species however can

also be captured in other fisheries and there is no possibility to determine which portion comes from deep-sea fishing. These statistics only reflect the amount of deep-sea species catches reported to FAO by member countries. No information is available to attribute the changes in 1979 and 1998 to an increase of actual catches or a better reporting (FIRMS 2005).

### Restocking through aquaculture

In recent decades, advances in rearing techniques have considerably increased the range of fish that can be cultivated and has provided a new impetus for stock enhancement programs worldwide (Jennings *et al.* 2001). Despite numerous restocking attempts, wild populations have shown few signs of recovery, and there are few data demonstrating that releases of hatchery-reared fish actually benefit wild stocks. It seems that the majority of release programmes fail because released individuals suffer higher mortality compared with wild fish of the same age (Salvanes & Braithwaite 2006).

Concerning specific cases: Salmon stock rebuilding is feasible and significant increases in wild stocks can be achieved over a short time frame provided the initial productivity is sufficiently high (Maoiléidigh *et al.* 2003). *Diplodus sargus* and *Sparus aurata* restocking associated with artificial reefs may be used as an additional tool within an integrated coastal management plan aimed at the enhancement of locally important artisanal fisheries (Santos *et al.* 2006). In Kaneohe Bay, Hawaii, hatchery-reared *Mugil cephalus* accounted for 75% of the nursery population in nursery areas. The success of this programme was attributed to thorough pilot studies that identified the best release size, sites and season. The hatchery release of molluscs is complicated by considerations of the minimum density required to permit effective fertilisation at spawning (Jennings *et al.* 2001). Restocking flatfish populations such as turbot through releases is a viable option. Future work should focus on optimizing such releases in terms of finding ideal habitats, reducing the hatchery costs and improving post-release survival of the released individuals (Støttrup *et al.*, 2002). Despite relatively large variation in environmental conditions, in cod production and in fishing mortality along the Norwegian coast, results indicate that, under the conditions experienced during the 1980s and 1990s, releases of juvenile cod did not significantly increase cod production and catches (Svasand *et al.* 2000).

In response to the rapid decline in fish numbers, hatcheries breed, rear and release billions of fish annually. It has been estimated (Welcomme & Bartly 1998) that well over 300 species worldwide are involved and every country contributes to some extent. Of these 300 or so species 290+ are freshwater (Welcomme 1992); therefore, marine re-stocking is still relatively uncommon (Brown & Day 2002). The amount spent annually on rearing and releasing hatchery fish is yet to be estimated, but there is little doubt that the total annual bill runs into billions of dollars. The number of hatchery-reared Atlantic salmon released every year, for example, is well over 5 billion (Brown & Day 2002). Mussels produced by cultivation can be used in restocking programmes (ICES 2006).

### Hypotheses (2020)

1. **No change:** No major changes regarding stock status. Most stocks stay fully or overexploited.
2. **Back to the future:** Management measures/actions, environmental changes and restocking practices help recovery of most stocks to the levels of early 70's.
3. **Terminator:** Collapse of most commercial stocks with no possibility for recovery.
4. **Changes in fish empires:** Stocks of large predators (tunas, cod, etc) are collapsed. Modest changes in the rest of the stocks.

## Sources

- Baker C. S., Clapham P. J. (2004): Modelling the past and future of whales and whaling, *Trends in Ecology and Evolution*, 19, 7: 365-371
- Bearzi G., Reeves R. R., Notarbartolo-Di-Sciara G., Politi E., Canadas A., Frantzis A., Mussi B. (2003): Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea, *Mammal Review*, 33, 3-4: 224-252
- Broderick A. C., Glen F., Godley B. J., Hays G. C. (2002): Estimating the number of green and loggerhead turtles nesting annually in the Mediterranean. *Oryx*, 36, 3: 227-236.
- Brown C., Day R. L. (2002): The future of stock enhancements: Lessons for hatchery practice from conservation biology, *Fish and Fisheries*, 3, 2: 79-94.
- Koslow, A.J., Boehlert, G.W., Gordon, J.D.M., Haedrich, R.L., Lorange, P. & Parin, N. 2000.
- Continental slope and deep-sea fisheries: implications for a fragile ecosystem. *ICES J. Mar. Sci.* 57:548-557.
- Cagnolaro L. (1996): Profilo sistematico e tipologico delle raccolte di cetacei attuali dei musei italiani, *Supplemento Museologia Scientifica*, 13: 193-212.
- FIRMS (2005): Review of the state of world marine fishery resources, Deep sea marine resources - Global, 2005, Fishery Resources Monitoring System, available at: <http://firms.fao.org/figis/website/FIRMSRetrieveAction.do?dom=resource&fid=13336>
- FAO (2006): Review of the state of world marine fishery resources. *FAO Fisheries Technical Paper* 457.
- FO (2006): The state of world fisheries and aquaculture, FAO Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Rome, available at : <http://www.fao.org/docrep/009/A0699e/A0699e00.htm>
- ICES (2006): Mariculture Committee (MCC) Resolutions 2006, available at: <http://www.ices.dk/iceswork/recs/2006%20Resolutions/MCC/MCC%20Draft%20ToRs%202006.pdf>
- IWC (2001): Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison, *Journal of Cetacean Research Management*, 2: 1-61
- IWC (2007): Whale Population Estimates, The International Whaling Commission's most recent information on estimated abundance, International Whaling Commission, available at: <http://www.iwcoffice.org/conservation/estimate.htm>
- Jennings S., Kaiser M. J., Reynolds J. D. (2001) : Marine Fisheries Ecology, Blackwell Science, Oxford, 417 pp.
- Maoláidigh N. Ó, Legault C., Amiro P., Erkinaro J., Chaput G. (2003): Long and Short Term Recovery Trajectories from Stock Rebuilding Programmes for North Atlantic and Baltic Salmon Stocks. International Council for the Exploration of the Sea Theme Session U, *ICES ASC 2003*, Effectiveness of Stock Recovery Plan in Fishery Management, CM 2003/U:09
- Pauly D., Christensen V., Dalsgaard J., Froese R., Torres F. Jr. (1998): Fishing Down Marine Food Webs, *Science*, 279, 5352: 860 - 863
- Salvanes A.G.V. and Braithwaite V.A. (2006): The need to understand the behaviour of fish reared for mariculture or restocking, *ICES Journal of Marine Science*, 63, 2: 346-354
- Santos M.N., Lino P.G., Pousão-Ferreira P., Monteiro C.C. (2006) : Preliminary results of hatchery-reared seabreams released at artificial reefs off the algarve coast (Southern Portugal): A pilot study, *Bulletin of Marine Science*, 78, 1: 177-184
- SAUP (2007): Fisheries and Biodiversity Information by area: Large Marine Ecosystems, The Sea Around Us Project, available at: <http://www.seaaroundus.org/lme/lme.aspx>
- Støttrup J. G., Sparrevohn C. R., Modin J., Lehmann K. (2002): The use of releases of reared fish to enhance natural populations. A case study on turbot *Psetta maxima* (Linné, 1758), *Fisheries Research*, 59: 161-180
- Sugiyama S., Staples D. & Funge-Smith S. (2004): Status and potential of fisheries and aquaculture in Asia and the Pacific, ASIA-PACIFIC FISHERY COMMISSION, RAP Publication 2004/25
- Svasand T., Kristiansen T.S., Pedersen T., Salvanes A.G.V., Engelsen R., Naevdal G., Nodtvedt, M. (2000): The enhancement of cod stocks, *Fish and Fisheries*, 1: 173- 205.
- Welcomme R. L. and Bartly D. M. (1998) An evaluation of present techniques for the enhancement of fisheries. *FAO Fisheries Technical Paper* #374. Department of Internal Development of the United Nations.
- Whitehead H. (2002): Estimates of the current global population size and historical trajectory for sperm whales. *Marine Ecology Progress Series*, 242: 295-304

## PRODUCTION

### F4 Fish feed development and availability

#### Driver Definition

Farmed fish in Europe are fed compound diets, (where in the rest of the world (ROW) a part of farmed fish is fed based on natural primary production and productivity). Compound diets for fish are presently composed of fish meal (around 30%), fish oil (around 10%), and vegetable ingredients. The trend is a decrease in the use of fish meal and fish oil for fish feed, and an increase in vegetable ingredients.

All fish species farmed in Europe are fed with the same products (but in slightly different proportions).

ROW (mainly Asia) increases its demand in fish oil and meal for fish farming.

The development of fish aquaculture will depend on the possibility to feed the fish without or with very low levels of fish meal and fish oil.

#### Relevant Indicators

- Development of the volumes (Metric tonnes) of fish feed needed par year in EU and ROW.
- Percentage of fish meal and fish oil in the feed.
- Feed conversion rate by fish.
- Possibility of creating fish strains able to growth without fish oil and fish meal (selection or GMO)
- Acceptance of the consumer for fish fed vegetable diets (it might depend of fish nutritional quality when fed with vegetables, if these vegetables are genetically modified or not and of consumer information: tags and labelling in social services subsystem)?

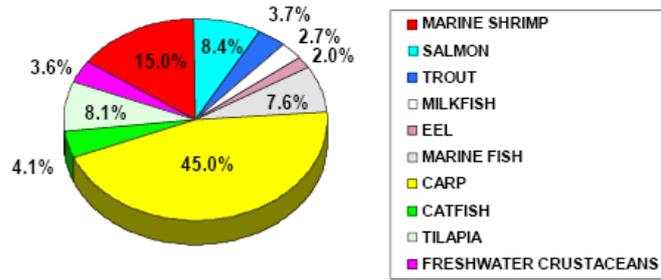
#### Developments over the past 20 years

##### Feed for aquaculture

Aquaculture contribution to total world fish production amounted to 55 million tonnes in 2003 (i.e. 37% of the total fish production), including about 30 million tonnes finfish and crustaceans, 23 million tonnes constituted by fed finfish and crustaceans, and 7 million tonnes by filter feeders in extensive systems. This production is highly dependent on marine capture fisheries for providing fishmeal, fish oil and trash fish (trash fish mainly in developing countries). It is estimated that in 2003, the aquaculture sector consumed almost 3 million tonnes fishmeal and 0.8 million tonnes of fish oil or the equivalent of 18 million tonnes of pelagics, plus 5 to 6 million tonnes of trash fish as direct source for farmed fish.

100% of the production of farmed salmon and trout depends on feed supply. On the opposite, only half of the carp production was based on feeding. Yet even with half of the carp production not relying on compound feed, still carps consume 45% of the total compound diets (fig 1). But this percentage showed almost a 10 fold increase during the last 12 years, the supply of feed leading to higher production compared to extensive rearing, based on natural productivity.

**Estimated global compound aquafeed production in 2003 for major farmed species**  
(values expressed as percentage of total aquafeed production, dry as-fed basis)

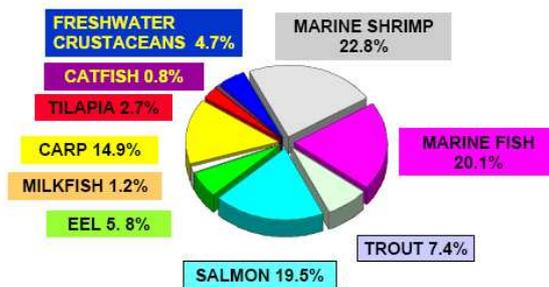


Total estimated compound aquafeed production in 2003–19.5 million

**Fish oil and fishmeal in feeds**

Feeds for marine carnivorous species such as salmon, trout, eel and shrimp, include fish meal and fish oil at high levels; for carp, tilapias, milkfish and catfish are fed with diets including around 5% fish meal and 1% fish oil (fig 2a, 2b).

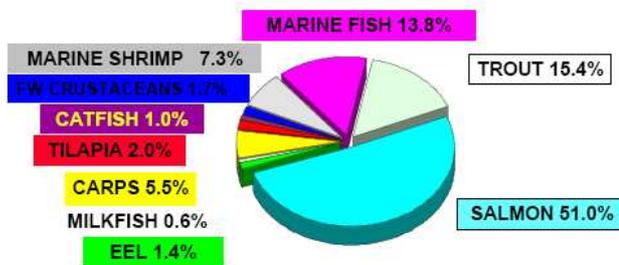
Estimated global use of fishmeal (percentage of dry as-fed basis) within compound aquafeeds in 2003 by major species



Total estimated fishmeal used in aquafeeds was 2.936 million tonnes or 53.2% of total reported world fishmeal production of 5.52 million tonnes in 2003 (FAO, 2005a)

fig 2a (Tacon et al., 2006)

Estimated global use of fish oil (percentage of dry as-fed basis) within compound aquafeeds in 2003 by major cultivated species



Total estimated fish oil used in aquafeeds in 2003 was 802 000 tonnes or 86.8% of total reported world fish oil production of 924 426 tonnes in 2003 (FAO, 2005a)

Fig 2b (Tacon et al., 2006)

The food conversion ratio (gain of wet weight related to dry weight of diet ingested during the period) is between 1.2 (trout, salmon) and 1.8 (shrimp, carp).

*Part of world fish meal and fish oil used for aquaculture feeds*

Farmed fish production uses only 3 to 4 % of the total feed production for farmed animals but almost 50% of the total fish meal resources and 80% of the total fish oil resources (fig 3).

**Reported global fishmeal and fish oil usage in 2002 (Pike, 2005)**

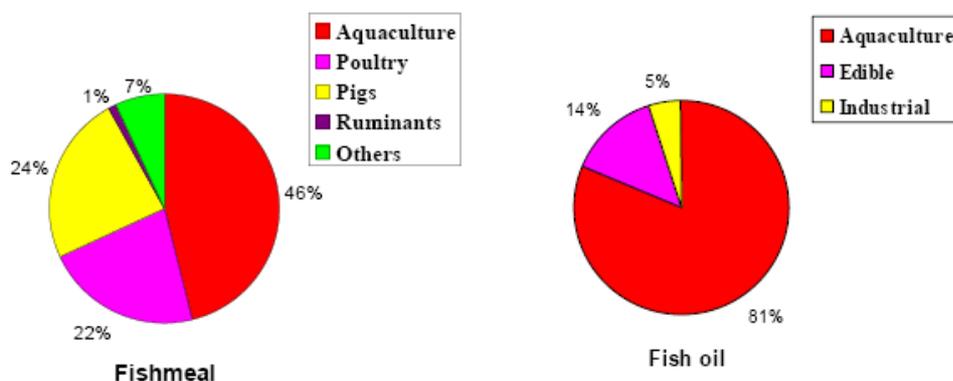


Fig 3 (Tacon et al., 2006)

Fi

**Recent Developments**

Table 1- Use (thousand tonnes) of fishmeal and fish oil (dry) in compound aquafeeds 1992-2003, in the world, per groups of species.

Species-group		1992	1998	2003
Shrimp	Fishmeal	232	486	670
	Fish oil	28	35	58
Marine finfish	Fishmeal	180	420	590
	Fish oil	36	112	110
Salmon	Fishmeal	201	485	573
	Fish oil	60	265	409
Trout	Fishmeal	142	219	216
	Fish oil	47	123	126
Eel	Fishmeal	72	113	171
	Fish oil	18	21	11
Milkfish	Fishmeal	19	27	36
	Fish oil	9	8	5
Feeding carp	Fishmeal	51	362	438
	Fish oil	26	60	44
Tilapia	Fishmeal	29	72	79
	Fish oil	0	7	16
Catfish	Fishmeal	23	50	24
	Fish oil	9	6	8
<b>Total</b>	<b>Fishmeal</b>	<b>963</b>	<b>2256</b>	<b>2936</b>
	<b>Fish oil</b>	<b>234</b>	<b>649</b>	<b>802</b>

Source: Tacon et al., 2006

We observe a 3 to 4 fold increase in the use of fishmeal and fish oil for aquaculture from 1992 to 2003, with mainly an increase of fishmeal and fish oil in carp feeding. It can be pointed out that a reduction of using fish meal and fish oil in feed started between 2003 and 2005.

**Species used for fishmeal and fish oil and consequences**

The main pelagic fish species caught for reduction in fishmeal and fish oil in 2003 were Peruvian anchovy: 6.2 million tonnes; Blue whiting 2.4 million tonnes; Japanese anchovy 2.1 million tonnes and Atlantic herring 2 million tons.

The large majority of the current fish for feed species are of potential food-grade quality and could be used for direct human consumption. Current pelagic fish consumption trends within many developing countries show that these small pelagic fish constitute a popular low cost food.

The increased demand for and use of low value fish or “trash fish” by farmers for the culture of high value carnivorous finfish/crustacean species feeding has resulted in increased trash fish prices within some countries, which in turn may result in decreased availability of affordable low cost fish for direct consumption by the rural poor (Edwards et al, 2004).

Moreover, some stocks of pelagics are over-exploited and will not resist to the present exploitation rate. Pelagics constitute food for predators and the repercussion of pelagic exploitation on predators is poorly known.

*Replacement of fishmeal and fish oil by other ingredients*

Researchers and feed manufacturers have made considerable efforts to find replacements for fishmeal and fish oil in compound aquafeeds. The meal mainly bring protein, i.e. amino acids. Vegetables have the same 20 amino acids as animals, but in different proportions. So vegetable protein can be used as protein sources, but expensive treatment is sometimes essential to remove anti-nutritional factors they contain. Oil is more problematic: fish need long chain unsaturated fatty acids (EPA and DHA) which are only synthesized by microalgae and are concentrated in the marine food chain. Total replacement of fish oil by vegetable oil in the feed of some species cannot be successfully achieved for the moment.

Main terrestrial plant used as ingredient in fish feed are Canola (oil and meal), Coconut oil, Corn gluten meal, Linseed oil, Lupin meal, Olive oil, Pea meal, Rapeseed oil and meal, Soybean oil and meal, Sunflower oil and Wheat gluten.

According to FAO (2004), the total production of plant oilseed cakes and meals was in 2003 over 200 million tonnes and plant oil 105 million tonnes (compared to the 7 million tonnes production of fish meal and oil). Up to now, use of vegetable sources didn't lead to a lower price for aquafeed, and price of vegetable sources is increasing.

Terrestrial animal by-products, such as tallows, bone meal, feather meal and blood meal are used in Asia and Africa, but were forbidden for animal feed industry in Europe after the outbreak of mad cow disease.

It is expected that an increasing part of world fishmeal and fish oil will be reserved for aquaculture feeds in the future (Fig.4).

**Estimated global use of fishmeal and fish oil in 2012 (Pike, 2005)**

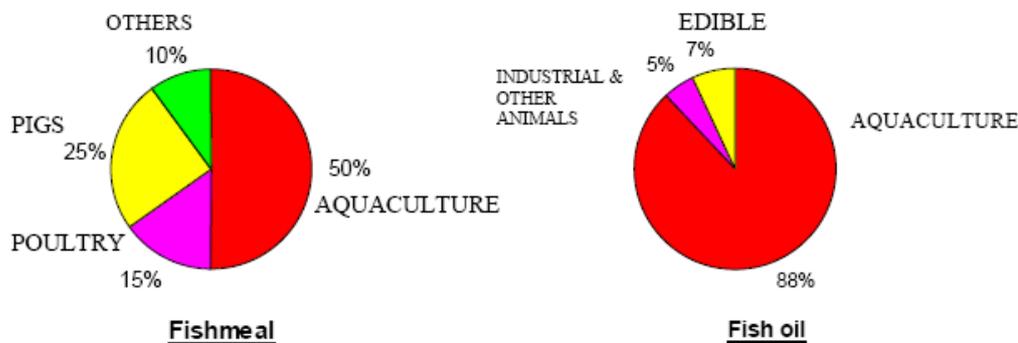


Fig.4 (Tacon et al., 2006)

Nevertheless, fish oil availability would be limiting for aquaculture development. Availability of alternative ingredients is essential. Data in table 2 forecast an increase of farmed fish production and feed production, without increase of fish meal and fish oil use, taking into account

- a slight reduction in food conversion ratio (due to higher digestibility of feed and better rearing management practices)
- the availability of convenient substitutive ingredients

Table 2. Estimated global use (thousand tonnes ) for fishmeal and fish oil, until 2012 (Tacon et al, 2006)

	Total feed species production	Total aquafeed production	Total estimated fishmeal use	Total estimated fish oil use	Equivalent pelagics used
2003	18 617	19 474	2 936	802	18 690
2005	21 031	20 958	2666	551	16 089
2010	27 939	27 744	2478	534	15 060
2012	31 747	31 747	2577	664	16 209

## Hypotheses (2020)

1. **Science will solve the problem:** Science will find solutions to solve the problem of limited fishmeal and fish oil resources. Unlimited quantities of substitutive ingredients for fish feed will be found (vegetable, algae) and/or GM fish able to synthesize omega 3 fatty acids, selected strains will be manufactured.
2. **Fish for food :** All the fish, including small pelagics (and manufacture waste), will be used directly for human consumption, or indirectly after transformation (i.e. surimi). Only herbivorous species, without or with low fish meal and fish oil requirements, such as carp and tilapia will be reared. Herbivorous European species will be promoted and herbivorous non native species will be introduced.
3. **Fish for feed :** All the available world resources in fish meal and fish oil will be dedicated to aquafeed production (other farmed animals don't really need marine ingredients). Production of all species, including marine finfish, salmon and shrimp will be supported up to 2020.
4. **Other marine resources:** "New" marine resources, with convenient omega 3 profiles, will be exploited for providing feed for marine farmed fish: mesopelagic fish, krill in Antarctica, or other invertebrates of lower trophic levels.

## Sources

- Tacon A.G.J., Hasan M.R., Subasinghe R.P., 2006. Use of fishery resources as feed inputs for aquaculture development: trends and policy implications. FAO Fisheries circular, N° 1018, Rome, 99 p.
- Pike I.H., 2005. Eco-efficiency in aquaculture: global catch of wild fish used in aquaculture. Int. Aquafeed, 8, 38-40.
- FAO 2004. FAO statistical database, FAOSTAT: Agricultural data- crops (may 2004).
- FAO 2006. The state of world fisheries and aquaculture 2006. FAO fishery department, 162 p., Rome.
- Edwards P., Tuan LA, Allan GL., 2004. A survey of marine trashfish and fish meal as aquaculture feed ingredients in Vietnam. ACIAR Working paper 57, 56 p.
- Naylor RL. et al., 2000. Effect of aquaculture on the world fish supplies. Nature 405: 1017-1024.

## PRODUCTION

### F5 Aquaculture hardware technologies

#### Driver Definition

Fish aquaculture technology is developing in two main directions, mainly aiming to limit induced pollution: land based recirculation systems and cages, including off shore cages. For molluscs, deep water systems are being developed to avoid coastal pollution.

Escapement is one of the major problems of fish farming, (more because the genetic pollution induced by escapees than for income diminution). Cages will be improved to limit escapees.

Automatization of food distribution and fish weighing will be developed in order to reduce production costs.

#### Relevant Indicators

- Volume (and capacity) of off shore cages in Europe, volume (and capacity) of land based recirculation systems.
- Evolution of labour costs by production unit
- Number of patent for aquaculture hardware technologies

#### Developments over the past 20 years

In Europe the main techniques used to produce farmed fish are: extensive aquaculture, land based ponds, land based recirculation systems and cages.

##### *Extensive aquaculture and land based ponds*

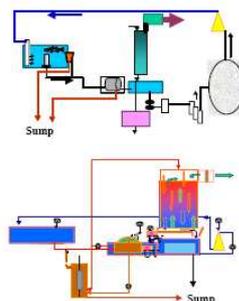
Extensive aquaculture is still used in Europe but production with this technique is decreasing. Still extensive fish farming can be found in Italy mainly for mullet production, in Spain for seabream and seabass, in Portugal for sole. The extensive production is relatively low-tech with low energy input. A rather eco-friendly practices, however with low yields. Integrated aquaculture systems, with the production of algae and animals of different trophic levels is tested (Hussenot, 2004). Land based ponds without recirculation systems are also used in Europe but no consistent technological improvements have been made last years.

##### *Land based recirculation systems*

In Europe, different fish species are produced in recirculation systems, such as turbot, seabass, African catfish and European eel. Recirculation systems involve a lot of specific equipments, including mechanical filters, UV reactors, biofilters, CO<sub>2</sub> stripping and oxygenation systems.

#### Fresh and seawater recirculation system

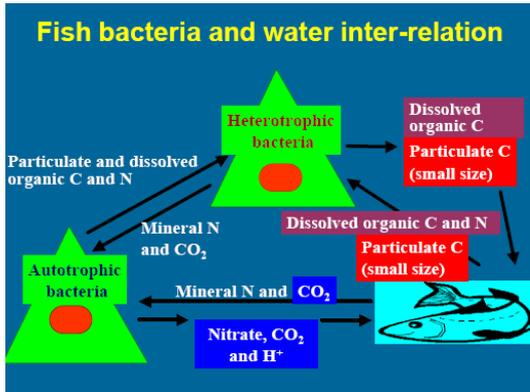
- Mechanical filter
- UV reactor
- Biofilter
- CO<sub>2</sub> stripping
- Oxygenation



Recirculation systems are based on water treatment by bacteria, transforming particulate organic matter in dissolved carbon and nitrogen.

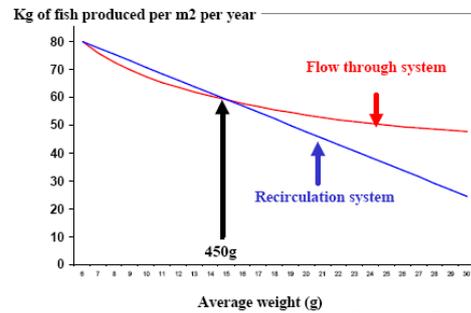
Nevertheless, the growth of fish, turbot as well as sea bass, is reduced in recirculation tanks compared to open system, when the fish can reach larger sizes (450g for turbot).

From Blancheton, EFARO 2002.



From Blancheton et al, EFARO 2004

### Turbot ongrowing in various systems



Courtesy of France Turbot

Substances from fish or from bacteria (growth inhibiting factors) accumulate in the system resulting in reduced growth. Currently research is on its way to better understand and to prevent the accumulation of this growth inhibiting factors. Nevertheless, recirculation systems represent a way for better fish management, improved controls, less diseases, but also a reduction of environmental impact, by reduced emission of phosphorus, nitrogen and organic matter.

### Cages<sup>31</sup>

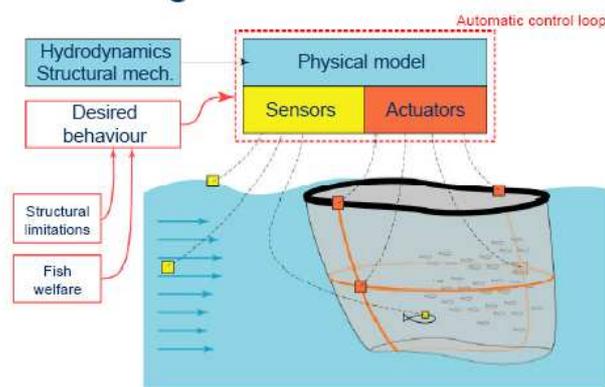
A large part of farmed fish in Europe is being produced in cages. Salmon, cod and halibut in northern Europe and seabass and seabream in southern Europe. Fish are reared in open sea net cages since the sixties, which allow a supply of good quality water. First cages were made of wood, then of polyethylene. Feed was distributed by hand at the beginning. Large farms with hinged steel cages, including feeding system with feed blowers and appetite controlled feeding are now used.

The circumference of a single cage increased from 70 m to 160 m diameter, the capacity from 20 tons to 1000 tons in one net cage, and several thousand tons per location. Production developed from 1 employee for every 600 tonnes produced to today 1 employee per 1000 tonnes.

Production cost decreased from about 5 euros/kg in 1999 to 2 euros/kg in 2004. Feeding costs make up 40 to 50% of the production costs, slaughtering and transportation 15%, equipment 5 to 10%, finance, insurance and administration 10%, salaries only 5 to 10%.

R&D is currently conducted to improve cage technology. The floating fish farm will be improved to withstand sea (strength, flexibility), to be operational (cost efficient), to ensure fish welfare (oxygen clean water) and to prevent environmental impacts (escape of fish, visual pollution).

### The intelligent structure



From Fredheim, EFARO 2004.

Research is especially geared at offshore fish farming, and submersible systems. The number of sheltered in shore locations for fish cages is rather limited next to arising conflicts in the coastal zone with other uses and users and visual pollution. Offshore development could allow increasing productivity, fish welfare and possibly increase the quality of the product. Up to now, there is no clear technological trend for offshore systems, and focus is more on cage design than on

operational aspects. Development is driven by private companies.

**Trends in innovation in hardware aquaculture technologies during the 28 past years**

Official document featuring the word “Aquaculture” resulted in 202 occurring patents<sup>32</sup>. The table below gives an overview by subject :

	2007-2004	2003- 2000	1999-1996	1995-1992	1991 -1981
<b>Cage technology including offshore</b>	17	3	9	0	0
<b>Recirculation systems</b>	9	8	12	2	5
<b>Water treatment</b>	19	19	5	3	2
<b>Feed manufacture and distribution</b>	7	11	5	2	1
<b>Aquaculture transport structures- Fish handling</b>	1	1		1	
<b>Shellfish structures</b>	3	1	1	1	
<b>Biotechnology</b>	26	9	11	6	1
<b>Total</b>	<b>82</b>	<b>52</b>	<b>44</b>	<b>15</b>	<b>9</b>

The overall trend over the past 25 years is an increase in patents relating to aquaculture. Next to the development of hard technology innovations in biotechnology for aquaculture is on the rise with the development of i.a. vaccines and active molecules to improve growth and fish health. Hardware development focus is on the development of technology related to water treatment, associated to land based systems i.a. for recirculation systems.

**Hypotheses (2020)**

1. **Boxes full of fish in the world ocean:** Technology for cages will be improved. Large offshore fish farms will develop everywhere in Europe, for salmon, cod, halibut, sea bass, seabream. Product of high quality will be obtained, with reasonable cost, due to reduced labour cost, thanks to automatization. Problem of fish escapment will be solved by adapted cage construction (or total sterility of farmed fish). Consumers will be enthusiastic for the fish reared in the sea.
2. **Marine fish become terrestrial:** Technology for cages will not develop so much. Problem of fish escapment will be not totally solved. Energy cost for offshore fish farming will be prohibitive. Land based recirculation systems, already develop in North Europe countries, will develop, allowing zero escapment and total control of organic pollution.
3. **Technological improvements in several directions:** In 2020, cage technology and recirculation system technology will have made progress. Both systems will cohabit, together with extensive traditional aquaculture, which will develop thanks to improvements in integrated aquaculture systems, involving several species in trophic chain.

**Sources**

- Blancheton JP, 2004. Recirculation systems towards closed systems. Diversification in Aquaculture, European Fisheries and Aquaculture Research organisations (EFARO), Budapest February 2004. EC MUTFISHARE Concerted Action.
- Fredheim A, 2004. Offshore fish farming construction- Diversification in Aquaculture, European Fisheries and Aquaculture Research organisations (EFARO), Budapest February 2004. EC MUTFISHARE Concerted Action.
- Hussenet J, 2004. Extensive aquaculture systems. Diversification in Aquaculture, European Fisheries and Aquaculture Research organisations (EFARO), Budapest February 2004. EC MUTFISHARE Concerted Action.
- “World Intellectual Property Organization” <http://www.wipo.int/patentscope/en/>

<sup>32</sup> Data concerning aquaculture technology patents from the “World Intellectual Property Organization” <http://www.wipo.int/patentscope/en/>

## PRODUCTION

### F6 Species Diversification Aquaculture

#### Driver Definition

Very few of Europe's native species of fish and shellfish are being used in aquaculture. As consumers ask for a more diversified offer of species and as knowledge on the fundamental laws in fish and shellfish reproduction and development is rapidly increasing, the number of "candidate" species for aquaculture increases.

Concerning non indigenous species, some have been voluntarily introduced in Europe, such as the oyster *Crassostrea gigas*, introduced from Japan, and numerous ornamental fish. Now, this introduction is controlled by European legislation.

Species diversification in the past focused mainly on fish and finfish. Today it also looks at other groups, such as echinoderms (holothurians, sea urchins) and cephalopods (octopus) for human consumption. In addition other marine species are cultivated for producing alimentary and cosmetic molecules (kelp) or pharmaceutical and chemical molecules (bacteria).

#### Relevant Indicators

- new farmed species during the last years
- species studied in laboratories
- demand of consumer for "new species", including ornamental fish

#### Developments over the past 20 years

##### Development of farmed species in the world during the 50 last years

According the aquaculture production data, in 1950, only 72 aquatic species (from 34 families) were used in aquaculture. In 2004, production was reported for 236 species (from 115 families). From 1950 to 1960, 0.3 species were added per year; this increased to one species per year for the 1960 to 1980 period. From 1980 to 1990: almost 10 species per year were added..

Asia and the pacific region lead in the number of species farmed; in 2004, 204 species. In Western and Eastern Europe in 2004 134 species were farmed species (table1).

Table 1.

Number of species in aquaculture with reported production in 2004 in FAO FISHSAT PLUS database by continent and major grouping

Continent	No. families	No. species
World	245	336
North America	22	38
Central and Eastern Europe	21	51
Western Europe	36	83
Latin America and the Caribbean	33	71
Sub-Saharan Africa	26	46
Asia and the Pacific region	86	204
Near East and North Africa	21	36

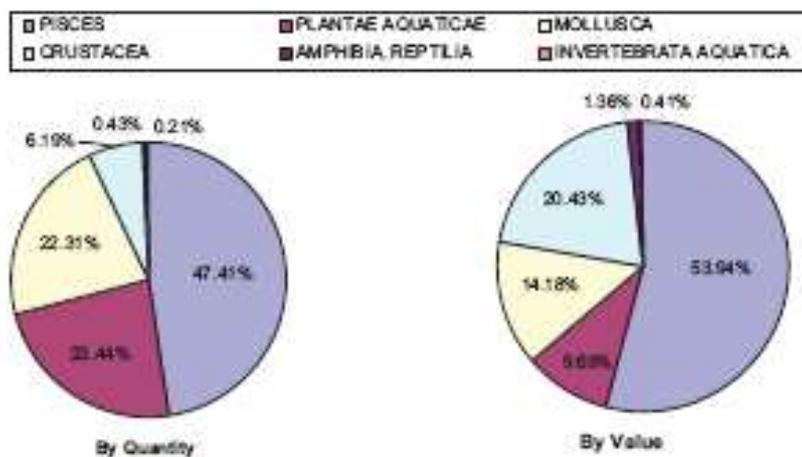
FAO, 2006

Fish is still the dominant group of species farmed. Considering quantity and total value, cyprinids emerge as the most important taxonomic group: 18,2 million tonnes and 13 billion Euros. Most of them are freshwater species. But the number of marine fish species in aquaculture is increasing. In Asia marine species are being considered as luxury species compared to freshwater species.

By volume, oysters are a distant second at 4.6 million tonnes, followed by laminaria (kelp) at 4.5 million tonnes. Crustacean represented by penaeid shrimp and grapsid crabs have a total value that are disproportionately high relative by their quantities. While the penaeid shrimps rank sixth by quantity, they rank second by value (Fig 1).

Fig 1

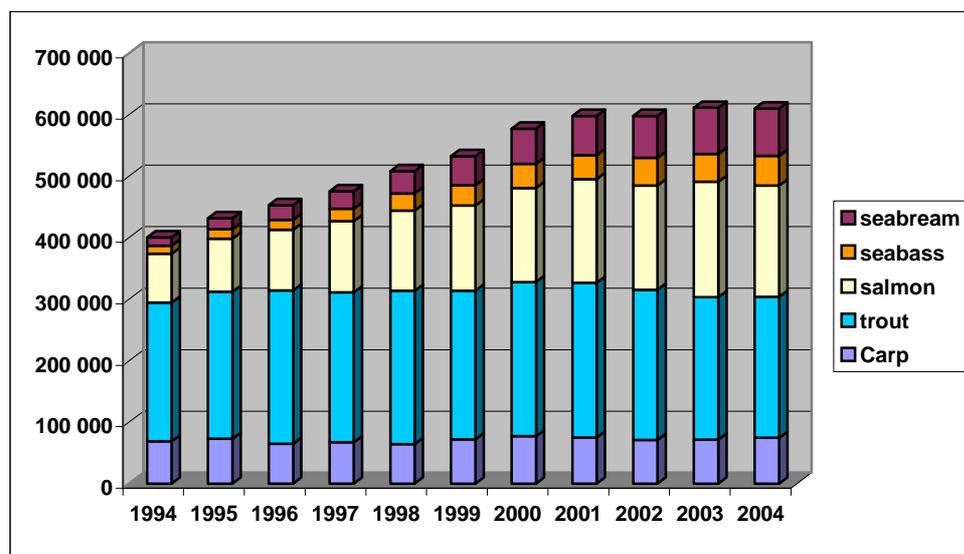
World aquaculture production by major taxonomic grouping in 2004



FAO 2006

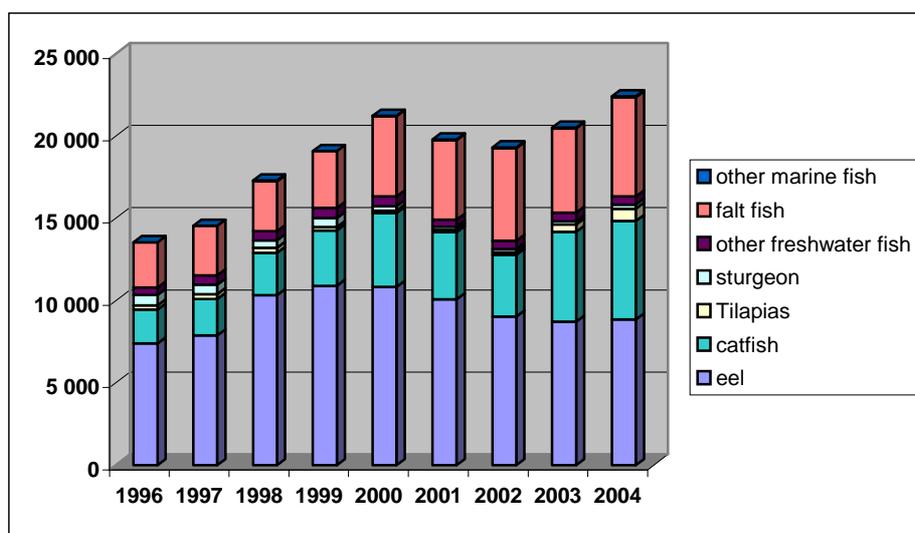
**Species diversification Europe recent years**

In Europe 5 species make up for 96% of farmed fish production. (fig 2). Trout (*Oncorhynchus mykiss*): being the largest with 36% of production, followed by Salmon (*Salmo salar*): 29%, Carp (*Cyprinus carpio*): 12%, Seabream (*Sparus aurata*): 12% and Seabass (*Dicentrarchus labrax*): 8%.



Production of the 5 main fish species in Europe for the last 10 years, in tonnes

The increase in production over the last ten years was due to an increase in production of salmon, seabass, seabream (Fig 2). Beside the 5 majors species, the production of other species is developing but not reaching the magnitude of the big 5: tilapia, sturgeon, flatfish, eels and cat fish (fig 3)



Production in Europe of the minor farmed fish species C. Hough, EFARO meeting

Among molluscs, Pacific oyster constitute the bulk of the European production. Mussels are also produced in substantial quantities, followed by flat oyster, scallops and abalone.

During a workshop of EFARO (2005) on species diversification, 33 “new” species were identified for the Mediterranean Sea: 32 fish and 1 cephalopod, among them sheepshead bream (*Puntazzo puntazzo*), meagre (*A. Regius*), Solea (*Solea senegalensis* and *solea solea*), amberjack (*Seriola dumerilii*), grouper (*Epinephelus marginatus*) (P. Divanach, 2005). Some of the species identified have good growth but a small market (meagre, amberjack), others have a strong market but some technical issues to be solved. Laboratories and private sector have started intensive research on reproduction and larval rearing of Tuna (*Thunnus thynnus*), sustained by EU funding. The reproduction and larval development in captivity will limit the overfishing of this species (juveniles are now also caught for the fattening industry).

New species also have been identified in North Europe: Cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), halibut (*Hippoglossus hippoglossus*), scallop (*Pecten maximus*), lobster (*Hommarus gammarus*), hake (*Merluccius merluccius*) (Torrissen, 2005). Reproduction and larval rearing of some species, like cod, have been established several decades ago. Today the challenges lie in the hatchery. Scientists before involved in salmon research, focus now their efforts on cod, halibut and scallop.

The point of view of the producers, conveyed by FEAP, is that diversification in Europe is a very expensive and very risky undertaking. It needs research on hatchery phase, on susceptibility to diseases and stress, and requires a better analysis of the market.

Production of ornamental fish is really an aquaculture activity, but many countries do not report statistics on this production and these species are not included in the FAO FISHSTAT Plus database. This product is generally traded by piece rather than by weight and the best way to estimate the importance is through the value of production. The ornamental fish industry is strongest in Pacific and Asia, and focuses on freshwater species. Marine ornamental culture is limited to a very few species.

**Introduced species**

Species introduction is not new in aquaculture, but with air transport and increased global trade, the rate of introduction increased over the last years worldwide. For some species,

such as Nile tilapia or Penaeid shrimp (*Penaeus vannamei*) current production in regions where the species has been newly introduced exceeds production in the native region.

In European aquaculture the introduction of alien species, such as Pacific Oyster and rainbow trout has been successful and profitable. Based on consumers demand it can be expected that European aquaculture will continue to introduce new species.

The EU is now editing rules related to the introduction of alien species, aimed at preventing negative biological interactions with native populations, including genetic modifications, and to prevent the propagation of invasive species. Introduction of alien species as new species for European aquaculture will not be forbidden, but be controlled.

## Hypotheses (2020)

1. **Something new from the East:** Diversification is expensive and risky. Low number of species will be farmed in Europe. "New" species will be imported from developing countries, mainly Asia, where production costs are lower and where aquaculture and diversification are traditional activities.
2. **Some expected new species:** Research will continue in laboratory and acquisition of knowledge on new species biology will accelerate. Most of the around 40 species on which research results and some success in production have been obtained will develop. New knowledge on reproduction, larval rearing and compound diet feeding in tuna will allow a sustainable production of this species.
3. **Introduction of alien fast growers:** Alien species will be introduced, especially fast growers, such as cobia or herbivorous (and fast grower) fish as Pangasius. This will complete or replace the production of native species (as did Pacific oyster).
4. **The big five dictatorship:** A large number of marine species will be successfully farmed in their native area in the world. But science will focus efforts (genetic, health) only on a small number of species, such as salmon, oyster, which will develop everywhere in the world. It is what happened with terrestrial animals.

## Sources

- FAO 2005. International mechanisms for the control and responsible use of alien species in aquatic ecosystems. Report of an Ad hoc Expert Consultation, Xishuangbanna, RP China, 198p
- FAO 2006. The state of world fisheries and aquaculture 2006. FAO fishery department, 162 p., Rome.
- Hong W. and Zhang Q., 2003. Review of captive bred species and fry production of marine fish in China. Aquaculture 227, 305-318.
- C. Hough, 2005. New species for European fish farming: the producer's point of view. EFARO (European Fisheries and Aquaculture Research Organisations). Aquaculture diversification, Budapest workshop, February 2005.
- P. Divanach, 2005. New species in Mediterranean Aquaculture. EFARO (European Fisheries and Aquaculture Research Organisations). Aquaculture diversification, Budapest workshop, February 2005.
- O. Torrissen, 2005. New species in aquaculture- Atlantic fishes. EFARO (European Fisheries and Aquaculture Research Organisations). Aquaculture diversification, Budapest workshop, February 2005.
- EU commission, 2006. Proposition de règlement du conseil relatif à l'utilisation des espèces exotiques et des espèces étrangères au milieu local. Bruxelles 4/4/2006. COM(2006) 154final.

## PRODUCTION

### F7 Breeding, selection and genome manipulation

#### Driver Definition

Nature's principle of "survival of the fittest" is through breeding programmes directed towards "survival of the most apt for farming". The selection by traits of individuals to breed on has been instrumental in increasing i.a. growth rate and survival.

Hybrids (crossbreeding of two species) or triploids (organisms with 3N chromosomes instead of 2N) of fish and shellfish can be generated in order to

- 1- increase the growth rate of a species.
- 2- prevent reproduction (this prevention being not totally successful)

For the moment triploid oysters and trout are being produced. The number of hybrids and (mainly) triploids is expected to increase during the coming years.

Experimental studies are conducted on Genetically Modified fish and shellfish. Among others, transgenesis with gene coding aimed at growth-hormone development produces positive results in salmon growth. Transgenesis to improve omega 3 levels and to improve disease resistance is currently being studied. If GMO will be allowed in fish and shellfish, this surely is expected to have its influence on aquaculture production.

#### Relevant Indicators

##### Breeding

- Choice of selection criteria : growth rate, survival rate, resistance to diseases, colour,

##### Polyploidy:

- Development of the number of hybrid and triploid species (Percentage of hybrid and triploid individuals related to non-hybrid and diploid individuals), Effect of triploids (and hybrid) on reproduction, growth and feed conversion rate

##### GMO

- Number of GMO species used in aquaculture
- GMO in feed
- GMO acceptance by consumers and by law
- Efficiency of transgenesis: effect of transgenesis for one gene on the characteristics not directly affected by this gene. Example: effect of growth hormone gene on feed conversion.
- Type of transgenesis allowed: affecting quantity of production (growth hormone) or quality of production (omega 3 level)

#### Developments over the past 20 years

##### Breeding

Breeding programmes exist for all major farmed carnivorous fish species. Salmon being the main species for which breeding programmes have been developed. The first selected parameter is growth, followed by fat in fillet and in viscera, flesh colour, disease resistance and delayed sexual maturation. Breeding programmes for growth improvements have been also developed for trout (Mambrini et al., 2006), seabass, seabream and tilapia. Genetic selection for growth improvement of farmed fish led to high growth gain, 10 to 20% per generation, without affecting genetic variability. Increased feed intake is generally correlated to this growth improvement. Improved feed efficiency is now a goal of most fish breeding programmes. Particularly the ability of fish to grow on plant-based diets, in the global aim of the reduction of fishmeal and fish oil resources use for aquaculture (Quinton, 2007).

### **Polyploidy , hybridisation and mono-sex populations**

Chromosome-set manipulation is a technique that can be used to produce so-called 'triploid' organisms that have three sets of chromosomes instead of the usual two. Triploids generally cannot reproduce and so it was initially thought that the energy that was not channelled into reproduction would go instead to an increased growth rate, but this has not in fact been proven to be the case. The advantage of triploids seems to lay rather in their functional sterility (although that does not reach 100%). For example, triploid oysters do not produce gonads and are therefore marketable at times of the year when mature oysters have an off-taste because of gamete production. (Devin Bartley, Inland Water Resources and Aquaculture Service<sup>33</sup>)

Oyster is one of the main aquatic species in which triploidy is used. Triploid oysters are sold in Europe as in USA mainly during summer. Triploidy is also applied in trout, salmon and seabass. In the wild, around 5% of oyster or trout are triploid. Triploid animals are not considered as Genetically Modified Organisms.

It appears that triploidy can induce skeletal deformity and other malformations affecting metabolism in fish (Sadler et al, 2001). Research is in progress to understand potential physiological differences between diploid and triploids, in oyster, fish or shrimp.

### **Hybridisation<sup>34</sup>**

Hybridisation is another simple genetic technology that has become easier with the development of artificial breeding techniques, such as the use of pituitary gland extract and other hormones to initiate gamete development and induce spawning . Various fish species have been crossbred over the years either for pure research purposes or as a matter of routine for aquaculture purposes. Hybrids of different tilapia species or different sturgeon species are now widespread:

- sturgeon *Huso huso* female x *Acipenser ruthenus* male, *Acipenser naccarii* x *A-baerii*, *Acipenser guldenstadti* x *A-beste*
- tilapia *Oreochromis niloticus* x *O. aureus*, *Oreochromis niloticus* x *O-mossambicus*

but a lot of other species are considered, such as:

- tiger muskellunge - a hybrid between muskellunge and northern pike
- hybrid striped bass - cross between white bass and striped bass
- tiger trout - hybrid between brook trout and brown trout.

Hybrids generally grow faster than either parent, but some do not fare as well in regards to survival from egg through fry stage. Some are incapable of reproduction, which is often viewed as an advantage. Some are more fitting to certain types of habitat than one of the parents, and some may have better catchability (in terms of angling) than one of the parents.

### **Mono-sex populations**

Sex control, and the use of mono sex populations, is used for several fish species in aquaculture based on the existence of various sex-specific traits. For example, female sea bass, turbot and male tilapia show a better growth rate. Sturgeon females are producing eggs used for caviar. Sexual maturity occurs earlier in males than in females of salmonids and seabass. Therefore the use of female monosex populations will delay the occurrence of the negative effects of reproduction such as the decrease of growth rate, decrease of fillet quality and the resistance to pathogens. Tilapia species face overpopulation and dwarfism in case of precocious and asynchronous reproduction. Sex control can also be important for the management of hermaphrodite breeders (seabreams, groupers), because natural sex inversions can lead to a skewed sex ratio.

Production of a single sex population (female) is obtained by breeding of a female with a neomale. However, the production of neomales requires the use of hormones (17 $\alpha$ -methyltestosterone) under veterinary control. Alternative approaches, particularly more environmentally friendly, to produce male breeders will be of great interest to avoid hormone

<sup>33</sup> [http://www.oceansatlas.com/world\\_fisheries\\_and\\_aquaculture/html/tech/aqua/biotech/genbiotech.htm](http://www.oceansatlas.com/world_fisheries_and_aquaculture/html/tech/aqua/biotech/genbiotech.htm)

<sup>34</sup> based on [http://www.fish.state.pa.us/images/pages/ga/fish/hybrid\\_breeding.htm](http://www.fish.state.pa.us/images/pages/ga/fish/hybrid_breeding.htm)

use in the production process. It has been clearly demonstrated in tilapia, that environmental factors, especially temperature can strongly influence the sex differentiation. Temperature effects on sex differentiation have also been found for European seabass. Moreover, for both seabass and tilapia, genotype-temperature interactions have been demonstrated.

Nevertheless, in several fish species, the phenotypic sex cannot be identified and sex chromosomes are not sufficiently differentiated to be directly identified. We can observe ZZ neofemales of blue tilapia *O. aureus*, YY males of Nile tilapia *O. niloticus* or WW females of turbot. Indirect approaches such as progeny testing after hormonal sex reversal treatments have to be applied to produce homogametic breeders. Therefore, identification of the sex chromosomes/sexual genotypes in fish have huge potentials in future fish farming (Baroiller, personal communication).

### **Genetically Modified Organisms**

Since Zhu et al (1985) have reported the first success in transgenic production in goldfish, many aquatic species have been used to produce GMO. Among them, some are "model" species, with short life cycle used for studying gene function, some are species of commercial interest.

#### **Genes**

The most popular gene used in aquatic species is *growth hormone (GH)*, one of the first aims of transgenesis in animal production being growth enhancement. GH has been widely used in terrestrial species and since the gene sequence is retained GH genes of different species can be used for other species.

*Anti-freeze protein gene( AFP)* is also considered as an interesting gene, the protein preventing ice-crystal growth in farmed fish during cold winter and so damage in production. Research has focussed on production of AFP from winter flounder and introduced in Atlantic salmon.

Gene transfer has been also used to increase the resistance of fish to pathogens. This is *DNA vaccines*: a DNA sequence encoding virus, for example Infectious Hematopoietic Necrovirus has been injected to salmon. Similar studies have been undertaken for other fish diseases such as Haemorrhagic Septicaemia Virus. It seems desirable for the moment that such treated animals are "transient" GMOs rather than full GMOs.

Transgenesis has been applied also on pet fish: *fluorescent zebrafish* have been created by injecting genes of anemones (Nature 426, 2003). This "Glofish" is allowed onto the market in different states of the USA.

#### **Modified species**

The review of Beardmore and Porter (FAO 2003) reported 53 published studies on GMO in aquaculture on 13 species. Atlantic salmon: 8 studies, with GH and AFP genes, Tilapia: 10 studies with GH gene, Carp: 8 studies with GH gene, Trout, arctic char, seabass, seabream, catfish, pike, loach with GH, DNA vaccine, goldfish, medaka and zebrafish were used for more basic studies, for example to assess detection of expression of transgenesis.

#### **Benefits arising from the use of GMO in aquaculture**

Depending on the species, a growth enhancement of 3-5 to 10-30 times in GH transgenic fish compared to non modified individuals have been observed. These studies suggest that the potential benefit with GMO fish will be great, mainly by a better growth, disease resistance, and low temperature resistance.

One particularly interesting application of transgenesis in fish would be the introduction of a gene allowing production of omega 3 fatty acids by fish. This would solve in part the problem of the resources for feeding fish.

#### *Risk factors*

Fish growth can be enhanced through GH transgenesis. However, this growth enhancement is associated with higher food intake. Moreover, growth of wild animal, which is naturally slow,

is enhanced by GH transgenesis but domesticated fish, which pass through traditional methods of selection, don't show the same growth enhancement with transgenesis (Delvin et al 2001). Moreover, Delvin et al (1995) reported cranial deformities, lower jaw deformation and opercular overgrowth in and AFP transgenic salmon.

The risk for human health of GMO consumption is yet poorly understood. The large majority of dietary DNA is degraded by digestive enzymes, but the use of viruses as vector can represent some risk factor for cancer induction. Transgenic animals can produce some proteins or other molecules inducing allergies.

Also biodiversity risks must be considered. Escapes of transgenic fish would lead to the spread of transgenes onto natural populations. Research is conducted to develop sterility in transgenic fish.

In 2003, it was considered that many GMOs have been produced in both terrestrial and aquatic animal species, but "there is no hard evidence of commercial use" (FAO, 2003) .

## Hypotheses (2020)

1. **Bio-engineered fish:** Biotechnology will progress on fish, shrimp, shellfish. Through selection on growth and resistance to disease, in the span of several generations, new hybrids, triploids, all kinds of GM fish, with high growth, high food efficiency, able to produce Omega 3 fatty acids and resistance to diseases will be produced.
2. **All except GM fish:** Scientific progress on GMO will not be decisive. Whereas society did accept genetically modified vegetables, GM animals will not be accepted. As in terrestrial domestic animals, large breeding programmes will be successfully developed, triploidy will be accepted as a part of aquatic animals is triploids in the wild. Hybrids will be developed. Fish possibly will be fed with GM vegetables, to solve in part the problem of feeding resources for farmed fish, but development of GM fish will stop.
3. **Back to nature:** Society will reject all kinds of biological intervention on animals. Development of hybrids, triploid, GMO will stop, in fish as in other animals.

## Sources

- Beardmore JA and Porter JS, 2003. Genetically modified organisms and aquaculture. FAO Fisheries Circular N°989, 35 p.
- Delvin RH, Yesaki TY, Donaldson EM, Du JS, Shao JD, Hew CL, 1995. Production of germline Pacific salmonids with dramatically increased growth performance?. *Can J. Fisheries Aquat. Sci.*, 52: 1376-1384.
- Delvin R.H., Biagi CA, Yesaki TY, Smailus D and Byatt JC, 2001. Growth of domesticated transgenic fish. *Nature*, 409, 781-782.
- *Nature* 426, 2003. California gives red light to sale of transgenic goldfish. P 596.
- Mambrini M., Iabbé L., Randriamanantsoa F., Boujard T., 2006. Response of growth-selected brown trout (*Salmo trutta*) to challenging feeding conditions. *Aquaculture* 252: 429-440.
- Melamed P., Gong Z., Fletcher G and Hew CL, 2002. The potential impact of modern biology on fish aquaculture. *Aquaculture* 204, 255-269.
- Quinton CD, Kause A., Koskela J., Ritola O., 2007. Breeding salmonids for feed efficiency in current fishmeal and future plant-based diet environments. *Genetics selection evolution* 39.
- Sadler J., Pankhurst PM, King HR, 2001. High prevalence of skeletal deformity and reduced gill surface area in triploid Atlantic salmon (*Salmo salar*). *Aquaculture* 198, 369-386.
- Stokstad E., 2002. Engineered fish : friend or foe of the environment? *Science*, 297: 1797-1798.
- Zhu ZY, Li G, He L., Chen S., 1985. Novel gene transfer into fertilised eggs of the goldfish *Carasius auratus*. *J. Appl. Ichthyol.* 1: 31-34.

## PRODUCTION

### F8 Health of animals

#### Driver Definition

Some pathologies are known in farmed and wild fish and shellfish. Europe is endowed with vaccines or strategies to limit the propagation of these pathologies. But emerging pathologies are not easily foreseeable. An emerging pathology could kill off a stock of a species, as it was the case with flat oyster, destroyed by *Bonamia* and *Marteilla* pathologies. Pathologies can be transmitted to wild species, particularly if more and high density offshore farming further develops. The existence of vaccines against diseases in farmed seafood species is instrumental in securing survival, and thus for securing profitability.

#### Relevant Indicators

- Knowledge on the wild: occurrence, prevalence, areas affected (infected): existing network
- Pathologies emerging in fish and shellfish farming during the last years
- Relationship between environmental parameters (temperature, pollution) and observed pathologies
- Food conversion
- Growth rates
- Strategies used to limit the effect of the pathology
- Vaccine : diseases that are controlled by the use of vaccine ; diseases that might potentially be controlled by the use of vaccines
- Possibility to change the concerned species by another not sensitive to this pathology
- Costs for aquaculture business
- Effect of pathologies on markets and consumers (price, consumer reaction, substitution)

#### Developments over the past 20 years

##### Monitoring of diseases in wild marine fish stocks: the present status

Diseases of wild marine fish have been studied on a regular basis by ICES Member Countries for more than two decades. Many national programmes have increasingly evolved into integrated monitoring programmes, including studies on chemical contamination and on biological effects of contaminants, as part of national monitoring programmes aiming at an assessment of the health of the marine environment, in particular in relation to the impact of human activities (Lang, 2002).

Long-term programmes have largely focused on externally visible diseases and, only partly, parasites. Since the end of the 1980s, studies on liver anomalies (mainly neoplastic liver lesions (tumours and their pre-stages)) have increasingly been added. Studies are being conducted in a variety of fish species, including dab (*Limanda limanda*) (main target species for the North Sea and adjacent areas such as the English, Channel, Celtic Sea, Irish Sea and western Baltic Sea), flounder (*Platichthys flesus*) (in coastal/estuarine North Sea areas and in the entire Baltic Sea) and cod (*Gadus morhua*) (at present, mainly in the Baltic Sea). Used methodologies are easily adaptable for other species such as plaice (*Pleuronectes platessa*) and other flatfish species, whiting (*Merlangius merlangus*) and haddock (*Melanogrammus aeglefinus*). Methodologies and diagnostic criteria involved in the monitoring of contaminant specific liver nodules and liver histopathology have largely been developed based on studies with flatfish species, in Europe mainly dab and flounder, but can also be adapted to other flatfish species (e.g. plaice) or long rough dab (*Hippoglossoides platessoides*) and possibly

also to bottom-dwelling roundfish species, such as viviparous blenny (= eelpout) (*Zoarces viviparus*).

On an international level, fish disease data have been used for environmental assessments in the framework of the North Sea Task Force and its Quality Status, the OSPAR Quality Status Report 2000 and for the 3rd and 4th HELCOM assessments. Studies on externally visible diseases, liver nodules and liver histopathology are on the list of techniques for general and contaminant-specific biological effects monitoring as part of the OSPAR Co-ordinated Monitoring Programme.

### **Disease of wild stocks<sup>35</sup>**

New outbreaks of VHSV Genotype IV in freshwater fish in North America suggest a broader host range for this marine virus and may indicate a higher risk to fish population previously not affected. The outbreak in drum (*Aplodinotus grunniens*) in Canada was the first due to Genotype IV in freshwater fish. *Ichthyophonus* sp. is an increasing disease problem in several species of fishes in Pacific coastal North America due to its potential to cause epidemics. Early stages of *Lepeophtheirus salmonis* are commonly parasitic on threespined sticklebacks (*Gasterosteus aculeatus*) in British Columbia. The role of this host in the ecology of the parasite and its transmission to wild and farmed salmonids is not known.

A 27 year data set showed bacterial pathogens *Yersinia ruckeri* and *Aeromonas salmonicida* previously causing disease problems decreased significantly in the captive broodstock of sea run Atlantic salmon (*Salmo salar*) in Penobscot River, Maine, USA, since 1997. The prevalence of *Anisakis simplex* larvae infection in Baltic herring (*Clupea harengus*) steadily declined since 1997 the causes of which are unknown.

The prevalence of hyperpigmentation (aggregation of pigment cells in the skin) in North Sea dab (*Limanda limanda*) continued to show a significant increase. Heavily affected fish have a lower condition factor than unaffected fish. The causes of the condition are unknown. The impact of M74 previously causing high mortalities in offspring of wild Baltic salmon and sea trout has declined in Sweden and Finland.

### **Transmission from cultured fish to wild stocks**

The association of fish farms with disease emergence in wild fish stocks remains one of the most controversial and unresolved threats aquaculture poses to coastal ecosystems and fisheries. However, several reviews have already comprehensively assessed the available scientific literature on the potential for disease interchange between wild and farmed fish (Hastein and Lindstad 1991; Brackett 1991; McVicar et al. 1993; McVicar 1997a, b; Hedrick 1998; Reno 1998; Amos et al. 2000; Amos and Thomas 2002; Olivier 2002). Notably, none of these reviews has found irrevocable evidence that fish farming has contributed to detectable adverse changes in wild fish populations, yet the topic remains one of the most controversial in the media and scientific community (McVicar et al. 2006).

However, FAO (2007) reports that the spread of pathogens to wild stocks along with species transported or traded in aquaculture is a serious problem. Of particular concern is the introduction of exotic species on local pathogens in the new environment. For example, along with abalone that the California aquaculture industry imported from South Africa came a sabellid worm parasite that caused no problems in South Africa but has had devastating effects of abalone under culture in California; the impact on other Californian molluscs is unknown. In Norway in 1975 the monogenean parasite, *Gyrodactylus salaris* was found in wild Atlantic salmon parr, probably introduced from infected and resistant Atlantic salmon from Sweden. The causative agent of furunculosis, *Aeromonas salmonicida*, was also introduced to Norwegian salmonid farming through infected stocks of rainbow trout from Denmark in 1966. The pathogen spread to over five hundred fish farms and to 66 salmon streams by 1991. *A. salmonicida* has been found in seawater over 20km from infected farms indicating its potential for dispersal. The spread of both *Gyrodactylus* and *A. salmonicida* was probably facilitated by stocking programmes that inadvertently used infected fish.

---

<sup>35</sup> Based on ICES 2007

FAO (2007) also reports that researchers in Ireland demonstrated that 95% of the production of the nauplius I of the sea lice, *Lepeophtheirus salmonis*, originated from farmed salmon and speculated that the lice had contributed to the decline in both wild salmon and wild sea trout (*Salmo trutta*) fisheries. Also, disease agents introduced with exotic species or strains may be more pathogenic in their new environment where they may spread to atypical hosts or encounter a more favorable environment (such as a mariculture facility). Whirling disease in rainbow trout is caused by a non-pathogenic myxosporean in brown trout; *P. vannamei* is a carrier of IHHN (infectious hypodermal and haematopoietic necrosis virus) that can devastate *P. stylirostris*. The Taiwan, Province of China shrimp industry collapsed after the introduction of diseased animals, e.g. shrimp containing *Penaeus monodon*-type baculovirus and yellow head virus, and newly discovered viruses caused financial losses of over a billion US dollars in Asia in the early 1990's. Norwegian strains of Atlantic salmon are highly susceptible to the parasite *Gyrodactylus salar* to which Baltic strains of salmon are resistant. Norway has tried to reverse the impact of *Gyrodactylus salar* infection to their Atlantic salmon stocks by poisoning entire river systems. The European flat oyster, *Ostrea edulis*, once imported to the western USA became infected with the blood cell parasite *Bonamia* which was subsequently spread back to Europe where it caused the demise of the majority of the fishery.

In FAO (2007) it is also reported that pathogens can also impact native species by interacting with other species. The introduction of crayfish from North America to Europe also introduced the crayfish plague. North American species, such as *Pacifastacus leniusculus*, are resistant carriers that also out-compete native European crayfish due to higher reproductive rates; the plague gives the invaders an additional competitive advantage. Disease agents hitch-hiking in and among the shells of molluscs is another important method of disease transmission that has affected the aquaculture industry and coastal environments. The Pacific oyster's most significant adverse global impact has been in the spread of such organisms. The Japanese oyster drill *Ceratosstoma inornatum*, the oyster flatworm *Pseudostylochus ostreophagus*, and the copepod parasite *Mytilicola orientalis* were all inadvertently introduced with Pacific oyster. However, it has been stated that there have been no catastrophic diseases transported with Pacific oysters.

**Stranding**

Various reasons for stranding are documented worldwide (Gulland & Hall 2007). Such stranding reasons are entanglement in fishing gears (mainly nets), diseases and parasitism, exhaustion, biotoxins, ingestion of non-food items and traumatic injuries.

According to DEFRA (2000), from 359 post mortem examinations of marine mammals stranded or caught in commercial fisheries in England and Wales, a cause of mortality was established in 264 of the 326

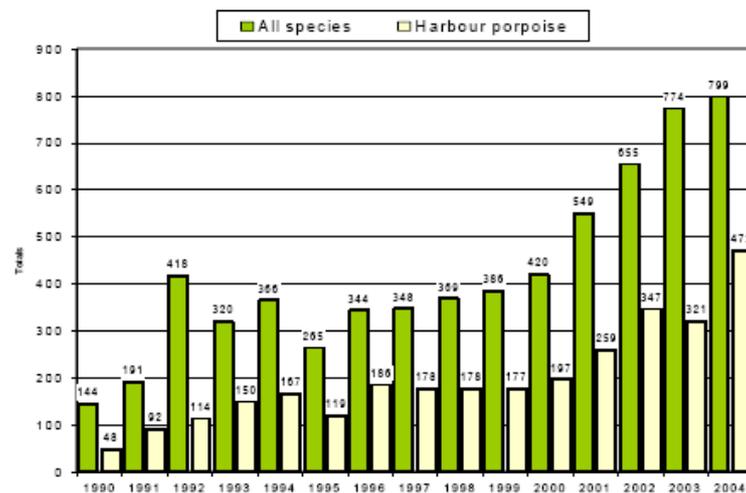


Figure 1. Total numbers of reported UK cetacean strandings etc., 1990 – 2004, compared with annual numbers of harbour porpoise. From DEFRA (2004)

of the 326 cetaceans examined (81%). While entanglement in fishing gear (by-catch) was the most frequent cause of mortality in cetacean species representing 45% of all cases where the cause of mortality could be established, infectious diseases were frequent causes of mortality in harbour porpoises (*Phocoena phocoena*)

specifically, accounting for the death of 26 harbour porpoises (of a total 215 carcasses) during the period of this report. The most common causes of infectious disease mortality in harbour porpoises were pneumonias (parasitic and bacterial) and generalised bacterial infections. Contamination by toxic pollutants may be implicated in these cases. Statistical analyses showed that tissue concentrations of PCBs and mercury were significantly higher in porpoises that died of infectious disease compared to healthy porpoises that were accidentally trapped in fishing nets. These results are in the direction predicted by the hypothesis that these industrial pollutants impair immune function in marine top predators. Infectious disease mortality was rarely recorded in strandings of other cetacean species.

The number of cetacean strandings reported has increased annually since 2000 reaching a high of 799 in 2004 (Figure 1) (DEFRA 2004). DEFRA (2004) discusses that the reasons for the strandings increase are not biological but are attributed to increased coastal vigilance for cetacean strandings. For that period the most common causes of mortality of 563 UK-stranded harbour porpoises examined at post mortem were attack from bottlenose dolphins (*Tursiops truncatus*) (n=128) and pneumonias due to combinations of parasitic, bacterial and fungal infections (n=102). Infectious diseases were much less frequent causes of death in other species.

Gulland & Hall (2007) report that a recent rise in the reporting of diseases in marine organisms has raised concerns that ocean health is deteriorating. By investigating the trends in disease reports over the past 40 years and exploring the changes in frequency of mass mortality events among marine mammals reported in the United States since 1978 they tried to determine whether or not there has been a recent deterioration in marine mammal health. Causes of mass mortality events have included biotoxins, viruses, bacteria, parasites, human interactions, oil spills and changes in oceanographic conditions.

List of diseases in wild and farmed aquatic animals reported by OIE (Office International des Epizooties)<sup>36</sup>.

<u>SECTION 2.1.</u>	DISEASES OF FISH
<u>CHAPTER 2.1.1.</u>	Epizootic haematopoietic necrosis
<u>CHAPTER 2.1.2.</u>	Infectious haematopoietic necrosis
<u>CHAPTER 2.1.3.</u>	<i>Oncorhynchus masou</i> virus disease (Salmonid herpesvirus type 2 disease)
<u>CHAPTER 2.1.4.</u>	Spring viraemia of carp
<u>CHAPTER 2.1.5.</u>	Viral haemorrhagic septicaemia
<u>CHAPTER 2.1.6.</u>	Channel catfish virus disease (Herpesvirus of <i>Ictaluridae</i> type 1)
<u>CHAPTER 2.1.7.</u>	Viral encephalopathy and retinopathy
<u>CHAPTER 2.1.8.</u>	Infectious pancreatic necrosis
<u>CHAPTER 2.1.9.</u>	Infectious salmon anaemia
<u>CHAPTER 2.1.10.</u>	Epizootic ulcerative syndrome
<u>CHAPTER 2.1.11.</u>	Bacterial kidney disease ( <i>Renibacterium salmoninarum</i> )
<u>CHAPTER 2.1.12.</u>	Enteric septicaemia of catfish ( <i>Edwardsiella ictaluri</i> )
<u>CHAPTER 2.1.13.</u>	Piscirickettsiosis ( <i>Piscirickettsia salmonis</i> )
<u>CHAPTER 2.1.14.</u>	Gyrodactylosis ( <i>Gyrodactylus salaris</i> )
<u>CHAPTER 2.1.15.</u>	Red sea bream iridoviral disease
<u>CHAPTER 2.1.16.</u>	White sturgeon iridoviral disease
<u>CHAPTER 2.1.17.</u>	Koi herpesvirus disease
<u>SECTION 2.2.</u>	DISEASES OF MOLLUSCS
<u>CHAPTER 2.2.1.</u>	Infection with <i>Bonamia ostreae</i>
<u>CHAPTER 2.2.2.</u>	Infection with <i>Bonamia exitiosa</i>
<u>CHAPTER 2.2.3.</u>	Infection with <i>Haplosporidium nelsoni</i>
<u>CHAPTER 2.2.4.</u>	Infection with <i>Marteilia refringens</i>
<u>CHAPTER 2.2.5.</u>	Infection with <i>Mikrocytos mackini</i>
<u>CHAPTER 2.2.6.</u>	Infection with <i>Perkinsus marinus</i>
<u>CHAPTER 2.2.7.</u>	Infection with <i>Perkinsus olseni</i>
<u>CHAPTER 2.2.8.</u>	Infection with <i>Xenohaliotis californiensis</i>
<u>SECTION 2.3.</u>	DISEASES OF CRUSTACEANS
<u>CHAPTER 2.3.1.</u>	Taura syndrome
<u>CHAPTER 2.3.2.</u>	White spot disease
<u>CHAPTER 2.3.3.</u>	Yellowhead disease
<u>CHAPTER 2.3.4.</u>	Tetrahedral baculovirus
<u>CHAPTER 2.3.5.</u>	Spherical baculovirus
<u>CHAPTER 2.3.6.</u>	Infectious hypodermal and haematopoietic necrosis
<u>CHAPTER 2.3.7.</u>	Crayfish plague ( <i>Aphanomyces astaci</i> )
<u>CHAPTER 2.3.8.</u>	Spawner-isolated mortality virus disease

### Emerging diseases and controls

Some diseases have been in existence for a long time. Others are considered as emerging diseases, such as Carp Koi Herpesvirus (KHV) which appeared in Israel in 1998 and is now widespread in the world due to fish transfers. Another emerging disease, a vibriosis (*Vibrio nigripulchritudo*) appeared for the first time in 1998 in the farmed shrimp in New Caledonia.

The reasons of a disease emergence are multiple:

- the pathogen agent develops new virulence factors via mutation processes
- biotic or abiotic parameters change in the ecosystem, for example temperature, making the system more favourable to certain pathogen agents
- depression of defence capacities in hosts
- anthropogenic factors: transfer of species for aquaculture, intensification in rearing

<sup>36</sup> [http://www.oie.int/eng/normes/fcode/en\\_sommaire.htm](http://www.oie.int/eng/normes/fcode/en_sommaire.htm)

Marine life is at growing risk from a range of diseases whose spread is being hastened by global warming, accelerated global transport and pollution. They cite a number of well-documented cases such as Crab-eater seals in Antarctica infected with distemper by sled-dogs, sardines in Australia infected with herpes virus caught from imported frozen pilchards, and sea-fans in the Caribbean killed by a soil-borne fungus. Climate variability and human activity appear to have played roles in epidemics by undermining host resistance and facilitating pathogen transmission. (Harvell, 1999, 2002).

62 cases of emergence, involving 43 pathogen agents, have been reported in 2002 and 2003 in aquatic animals in the world. Viruses are the most frequent cause (48%), followed by parasites 24%, bacteria 13% and mycoses (13%). Emerging diseases in aquatic animals are mostly reported in Europe and North America on salmonids (42%), and are more observed in farmed animals (65%) than in the wild. The latter can be explained by the fact that farmed animals are more closely monitored than wild animals.

Fish, shrimp and mollusc larvae are treated with antibiotics in case of disease. This can induce the emergency of bacteria resistant to antibiotics. Moreover, antibiotics are released in water and sediments. Currently the antibiotic treatments for aquatic animals decreases in Europe as everywhere in the world. Vaccines are developed for fish for specific pathogens. Molluscs, as opposed to fish, do not have a specific immune system, therefore the development of vaccines is impossible. The only way to control health in molluscs are health surveillance networks.

## Hypotheses (2020)

1. **World propagation of diseases:** Emerging diseases will develop more and more, with transfer of animals everywhere in the world. Bacteria resistant to antibiotics will develop. Technology in vaccines will not follow; time and money to develop vaccines will be insufficient. Moreover, vaccines are ineffective in shrimp and molluscs. This would lead to rarefaction or total extinction of some species.
2. **More and more healthy animals:** Transfer of species will be carefully conducted, with quarantine to avoid disease propagation. Alternative treatment to antibiotics, such as probiotics and antimicrobial peptides will be developed. Vaccine technology will develop for fish. Shellfish will be monitored through efficient networks.
3. **Too late...** : Transfers will be carefully controlled, efficient vaccines will be developed, rearing zones for molluscs will be monitored, but large quantity of antibiotics and xenobiotics (metals, organochlorine compounds, pesticides) will stay in the water in coastal zones and mainly in sediment, continuously inducing new pathologies.

## Sources

- Amos, K.H., and J. Thomas. 2002. Disease interactions between wild and cultured fish: observations and lessons learned in the Pacific Northwest. *Bull. Eur. Assn. Fish P.* 22: 95–102.
- Amos, K.H., J. Thomas, and B. Stewart. 2000. Pathogen transmission between wild and cultured salmonids: risk avoidance in Washington State, United States of America. p. 83–89. In C.J. Rodgers [ed.]. *Risk Analysis in Aquatic Animal Health. Proceedings of an International Conference.* World Organisation for Animal Health, Paris
- Brackett, J. 1991. Potential disease interactions of wild and farmed fish. *Bull. Aquac. Assoc. Canada* 91: 79–80.
- DEFRA (2000): Cetacean Strandings Investigation: England and Wales and Poseidon Database , Department for Environment, Food and Rural Affairs, *Final Report 1995 – 2000*, Executive Summary, available at:<http://www.defra.gov.uk/wildlife-countryside/resprog/findings/cetacean/execsumm.htm>
- FAO (2007): Impacts of aquaculture: biodiversity and alien species, available at:<http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=14853>
- Gulland F. M. D., Hall A. J. (2007): Is marine mammal health deteriorating? Trends in the global reporting of marine mammal disease, *EcoHealth*, 4, 2, 135-150
- Harvell, C.D., Kim, K., Burkholder, J.M., Colwell, R.R., Epstein, P.R., Grimes, D.J., Hofmann, E.E., Lipp, E.K., Osterhaus, A.D.M., Overstreet, R.M., Porter, J.W., Smith, G.W., Vasta, G.R. (1999) Emerging marine diseases – climate links and anthropogenic factors. *Science*, 285: 1505-1510.
- Harvell, C.D., Mitchell, C.E., Ward, J.R., Altizer, S., Dobson, A.P. Ostfield, R.S., Samuel, M.D. (2002) Climate warming and disease risks for terrestrial and marine biota. *Science*: 296: 2158-2162.
- Hastein, T., and T. Lindstad. 1991. Diseases in wild and cultured salmon: possible interactions. *Aquaculture*. 98: 277–288
- Hedrick, R.P. 1998. Relationship of the host, pathogen, and environment: implications for diseases of cultured and wild fish populations. *J. Aquat. Anim. Health* 10: 107–111
- ICES (2006) : Report of the ICES/BSRP Sea-going Workshop on Fish Disease Monitoring in the Baltic Sea (WKFDM), ICES WKFDM Report 2006, ICES Baltic Committee, ICES CM 2006/BCC:02, available at:<http://www.ices.dk/reports/BCC/2006/WKFDM06.pdf>
- ICES (2007): New disease trends in wild and cultured fish, molluscs and crustaceans, available at:<http://www.ices.dk/committe/acfm/comwork/report/2006/acme%20advice/new%20disease%20trends.pdf>
- Krkosek M., Lewis M. A., Morton A., Frazer L. N., Volpe J. P. (2006) : Epizootics of wild fish induced by farm fish, *Ecology Sustainability Science -BS*, Proceedings of the National Academy of Sciences of the United States of America, 103, 42, 15506-15510
- McVicar A.H., Olivier G., Traxler G.S., Jones S., Kieser D. MacKinnon A.-M. (2006) : Cultured and Wild Fish Disease Interactions in the Canadian Marine Environment, Fisheries and Oceans Canada, Can. Tech. Rep. Fish. Aquat. Sci. 2450: 139 p., available at:[http://www.dfo-mpo.gc.ca/science/environmental-environnement/sok\\_enviroeffects\\_aquaculture/volume\\_4/exec\\_mcvicar\\_e.htm](http://www.dfo-mpo.gc.ca/science/environmental-environnement/sok_enviroeffects_aquaculture/volume_4/exec_mcvicar_e.htm)
- McVicar, A.H. 1997a. Interactions of pathogens in aquaculture with wild fish populations. *Bull. Eur. Assoc. Fish Pathol.* 17: 197–200.
- McVicar, A.H. 1997b. Disease and parasite implications of the coexistence of wild and cultured Atlantic salmon populations. *ICES J. Mar. Sci.* 54: 1093–1103.
- McVicar, A.H., L.A. Sharp, A.F. Walker, and A.W. Pike. 1993. Diseases of wild sea trout in Scotland in relation to fish population decline. *Fish. Res.* 17: 175–185.
- OIE (Office International des Epizooties), World Organization for Animal Health (2007). Aquatic Animal Health Code. [http://www.oie.int/eng/normes/fcode/en\\_sommaire.htm](http://www.oie.int/eng/normes/fcode/en_sommaire.htm)
- Olivier G. (2002): Disease interactions between wild and cultured fish- Perspectives from the American Northeast (Atlantic Provinces), *Bulletin of the European Association of Fish Pathologists*, 22, 2: 103-109
- Reno, P.W. 1998. Factors involved in the dissemination of disease in fish populations. *J. Aquat. Anim. Health* 10: 160–171

## PRODUCTION

### F9 Resources available for catch-based aquaculture (tuna and eel ranching)

#### Driver Definition

Resource availability such as seed, food, and space for farming species whose reproduction we are not able to control (e.g. tuna, eel) is dependent on the harvesting of juveniles for on-growing. The supply of these species is therefore dependent on the availability of fingerlings. In, for example, tuna fisheries feed availability is a limiting factor. Also, for species such as cod, reproduction can be controlled and induced, but farming based on catches of fingerlings is currently more economical.

#### Relevant Indicators<sup>37</sup>

- Catches of fingerlings
- Reproductive rates (a good indicator, but difficult to measure)
- Spawning biomass and rate of recruitment

#### Developments over the past 20 years

Capture-based aquaculture (CBA) has been defined as the practice of collecting “seed” material – from early life stages to adults – from the wild, and its subsequent on-growing to marketable size in captivity, using aquaculture techniques.

By definition, CBA relies on the use of wild-caught “seed” (a term that covers fry, juveniles and, in some cases, larger fish) for stocking on-growing facilities such as tanks or cages. According to FAO (2004), this source of seed will be unsustainable in the short term and inadequate in the long term, because the catch per unit effort of seed – whether juveniles or adults – appears to be in decline. Nursery and adult habitats (e.g. mangrove, seagrass and coral) are increasingly being damaged by pollution, destructive fishing practices and other environmental impacts. Moreover, accurate information is not always available on the status of the resources. Overfishing of the target resources occurs frequently during normal fishing activities, but is exacerbated by the demand created by CBA. The collection of seed for CBA can also lead to mortalities in non-target species and the destruction and disturbance of habitats, and it can also generate discards, contributing further to the depletion of other resources. In addition, the transfer of seed to CBA farms is characterized by high rates of mortality (and therefore a wastage of resources) and conflicts with other resource users (e.g. the obstruction of waterways caused by the towing of cages containing bluefin tuna).

Capture-based aquaculture is a global activity but has specific characteristics that depend on geographic location and the species being cultured. The species groups used in capture-based aquaculture include molluscs (e.g. oysters, mussels, scallops), crustaceans (e.g. shrimps, crabs) and finfish (e.g. eels, grey mullets, milkfish, yellowtails, groupers, rabbitfish, tunas). The scale of such practices is difficult to quantify, but it is estimated that about 20% of aquaculture production comes from capture-based aquaculture.

Some examples of the species/groups harvested as wild juveniles and the various countries/regions where CBA is practiced is presented below:

<sup>37</sup> Note: Feed availability can be considered to be a second order indicator for this driver, but is defined in driver (F4)

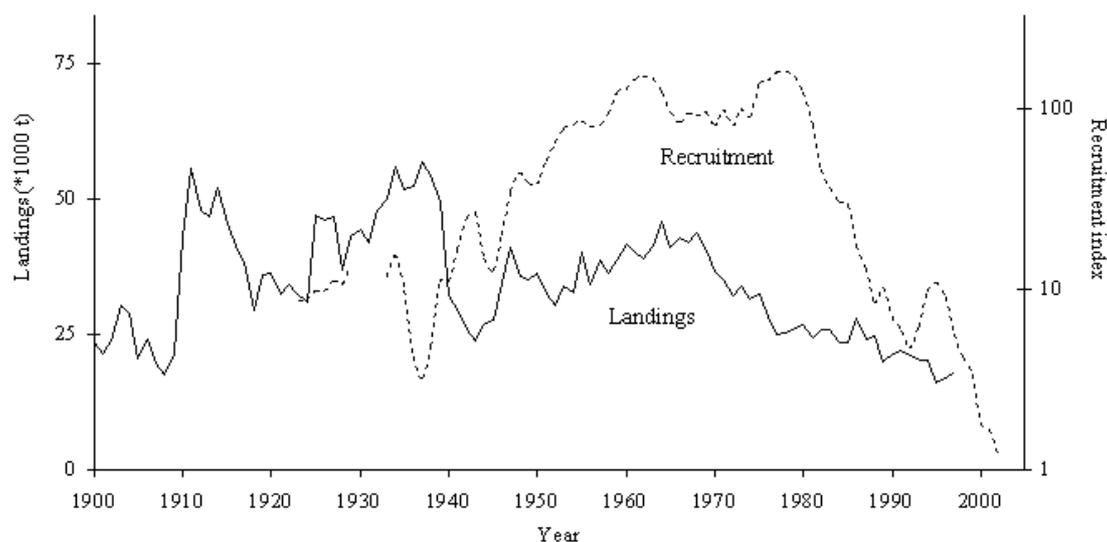
- shrimp (*Penaeidae*) in South America and South-East Asia;
- milkfish (*Chanos chanos*) in the Philippines, Sri Lanka, Pacific Islands and Indonesia;
- eels (*Anguilla* spp.) in Asia, Europe, Australia and North America, mainly in China, Japan, Taiwan, The Netherlands, Denmark and Italy;
- yellowtails (*Seriola* spp.), mainly in Japan, Taiwan, Viet Nam, Hong Kong, Italy, Spain, Australia and New Zealand;
- tunas (*Thunnus* spp.) in Australia, Japan, Canada, Spain, Mexico, Croatia, Italy, Malta, Morocco, Turkey, Greece, Cyprus;
- groupers (*Epinephelus* spp.), which is now widespread in Indonesia, Malaysia, Philippines, Taiwan, Thailand, Hong Kong, China and Viet Nam, and in other parts of the tropics, for example in southeastern USA and the Caribbean. Grouper culture is also ongoing in India, Sri Lanka, Saudi Arabia, Republic of Korea and Australia.

Here, we focus on eel and bluefin tuna ranching, which are the main species for which CBA is practiced in Europe.

### Eel ranching

European eels are found in virtually every coastal and inland water body around Europe and along the Mediterranean coasts of Africa and Asia. They also provide a vital source of income for more than 25000 fishers. In fact, no other fish stock within the ICES Area is as widespread or involves so many fishers (ICES 2007).

As artificial reproduction is currently not possible for eels, all aquaculture has to be based on the capture of glass eels. However, recruitment to the eel stock is estimated currently to be seriously decreasing, and reached an historical minimum in 2001 (Figure 1). ICES considers that the eel stock is almost certainly below what would be considered as safe biological limits and that the current fishery is unsustainable (ICES 2005). As the glass eel comprises the catch that will supply fish ranching, not only are the prospects unfavourable, but the potentially negative effects of this low recruitment on natural populations are worrying.



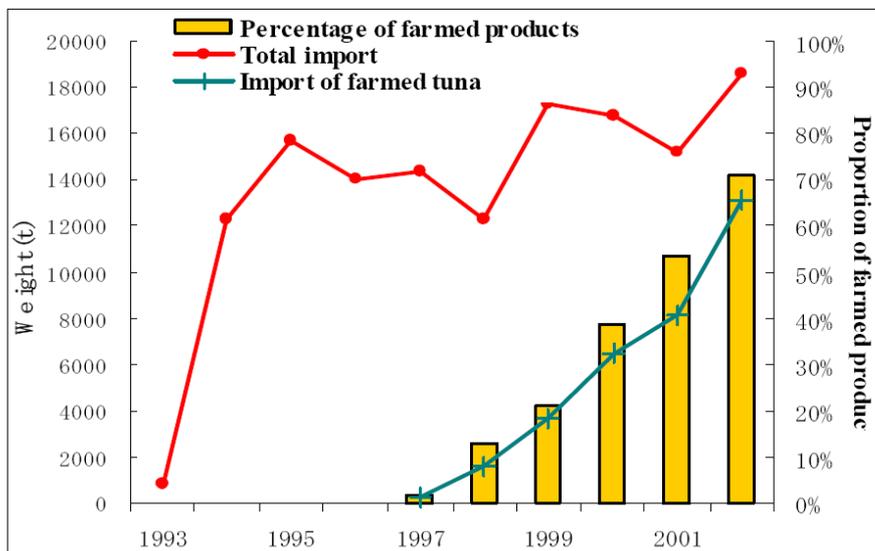
**Figure 1:** Estimated trends in recruitment and landings of the European eel Source: ICES 2007.

**Bluefin tuna farming**

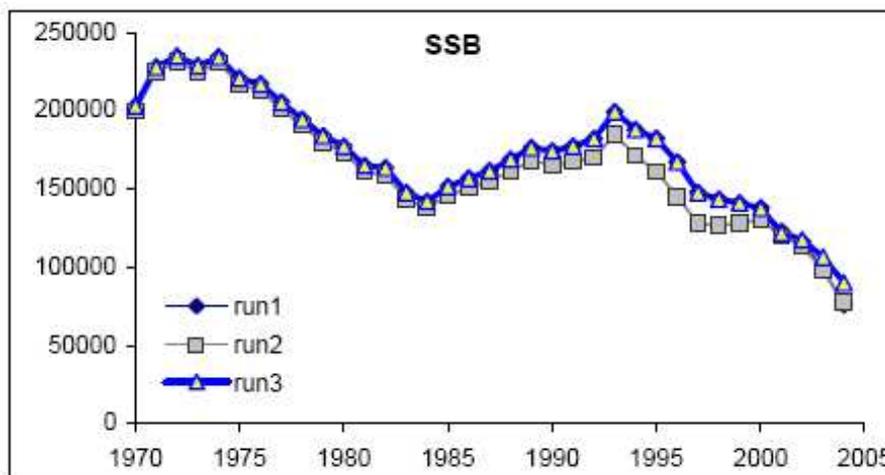
According to the term proposed by FAO, “tuna farming” involves the collection of wild fish, ranging from small to large specimens, and their rearing in floating cages for periods spanning from a few months up to 1–2 years.

In Europe, tuna farming has been practiced in the Mediterranean since the mid-1990s, and it is based on wild tuna caught alive by purse-seine. Currently, up to 80% of the tuna caught in the wild are destined for fattening/farming operations. Farm production is exported mainly to Japan (Figure 2).

The last assessment of the conservation status of the East Atlantic bluefin tuna stock (which includes the Mediterranean population) carried out by the Standing Committee on Research and Statistics (SCRS) of ICCAT in 2006 indicated that the spawning-stock biomass (SSB) had a declining trend which appeared to be more pronounced during the preceding four or five years (Figure 3). Therefore, unless fishing mortality is reduced significantly and tuna farming immediately and strictly regulated by the responsible management bodies, stock collapse in the near future is highly likely. Environmental organizations such as the WWF conclude that under the current circumstances, tuna farming in the Mediterranean is an unsustainable industry.



**Figure 2:** Comparison of Japanese imports of farmed and wild bluefin tuna from the Mediterranean (from Matsumoto, in press).



**Figure 3:** Spawning-stock biomass (SSB) estimates of Eastern Atlantic bluefin tuna based on three different model runs. Source: ICCAT, 2007.

## Hypotheses (2020)

- 1. Collapse:** Wild stocks of eel and bluefin tuna are reduced dramatically. Conditions are unfavorable for sea-ranching.
- 2. Miracle:** Jesus bless the fish! Bluefin tuna and eel stocks show signs of recovery.
- 3. Diversification:** Capture based aquaculture in Europe will be expanded to species groups, other than bluefin tuna and eel, for which wild stocks are in “healthy” condition.

## Sources

- ICCAT 2007, Bluefin Tuna East Executive Summary: SCI-018/2007
- ICES (2005): Widely distributed and migratory stocks, Special request on restocking of glass eel, available at :[http://www.ices.dk/committe/acfm/comwork/report/2005/may/Restocking\\_European\\_eel.pdf](http://www.ices.dk/committe/acfm/comwork/report/2005/may/Restocking_European_eel.pdf).
- ICES (2007): Eels close to collapse, available at:<http://www.ices.dk/marineworld/eel.asp>
- Ottolenghi, F.; Silvestri, C.; Giordano, P.; Lovatelli, A.; New, M.B. 2004. Capture-based aquaculture. The fattening of eels, groupers, tunas and yellowtails. Rome, FAO. 308p.

## PRODUCTION

### F10 Health risk of seafood

#### Driver Definition

Many studies, some including benefit/risk analyses, show that seafood is beneficial for human health. However, risks associated with different origins can affect the consumer:

*Chemical risks:* related to content of heavy metals (mainly methyl mercury), dioxins, pesticides, veterinary medicines

*Toxins:* mainly associated with toxic phytoplankton and concentrated in molluscs, such as oysters and mussels. This is potentially a serious risk, which can have fatal consequences for the consumer eating raw molluscs

*Bacteria:* such as *Salmonella* and *Listeria*; such problems are less frequent than toxins

*Allergy:* induced by some proteins (parvalbumine and tropomyosine) in seafood

#### Relevant Indicators

- The frequency of harmful algal blooms in coastal areas used for bivalve cultivation
- The occurrence of human pathology and death induced by seafood ingestion
- Concentration of different heavy metals, pesticides and other chemical molecules in the edible part of seafood, both farmed and wild

#### Developments over the past 20 years

There is evidence that fish (and shellfish) consumption benefits human health, and in particular the cardiovascular system. Indeed, fish (and shellfish) are rich in omega 3 fatty acids, whose role in cardiovascular disease prevention has been demonstrated. Moreover, fish and shellfish are an important source of minerals, especially iodine, selenium and calcium, and vitamins, especially vitamins A, D and B12. Ingestion of two portions of fish (130 g x 2) per week is recommended (EFSA Journal, 2005). Nevertheless, several risks have been identified as associated with eating seafood.

#### Chemical risks

##### *Heavy metals*

Metals are present in water from natural sources and as a result of anthropogenic activities such as industrial emissions. They accumulate in organisms in the food chain, and the concentration of elements such as arsenic, cadmium, lead and mercury can be higher in marine organisms (mainly predatory fish, such as tuna) than in other foods.

Fish is the main source of arsenic in the human diet, most in the form of arsenobetaine and arsenocholine. Nevertheless, arsenic in seafood is not considered to represent a significant health risk. *Cadmium* exerts a variety of toxic effects, including nephrotoxicity, osteoporosis, neurotoxicity, carcinogenicity and teratogenicity (EFSA, 2004d). The most notable effect of lead is retardation of neurobehavioural development in children. Overall, though, contamination by arsenic, lead and cadmium does not seemingly induce problems for human health in Europe.

The earth's crust rejects around 5 000 t of mercury per year into atmosphere, representing the main source of this metal in the environment. Methylmercury is the most toxic form and is easily absorbed and not excreted by live organisms, so is the dominant form of mercury in fish. The primary target of methylmercury is the nervous system, seen during the accidental exposures of Minamata and Niigata in Japan in the 1960s. However, neurological problems

related to chronic mercury intoxication from seafood ingestion have not been seen, though it is recommended for children and pregnant women to limit fish consumption and to avoid eating swordfish and marlin. The PTWI (Provisional tolerable weekly intake) was fixed at 1.6 µg/kg body weight per week (WHO, 2004).

**Table 5.28** Environmental chemical contaminants. Tolerances and critical limits in fish and fish products (EC, 2001a; FDA, 1998).

Substance	Maximum levels		Food commodity
	US (ppm)	EU (mg/kg wet weight)	
Arsenic	76-86		molluscs, crustaceans
Cadmium	3-4	0.05-1.0	fish, molluscs
Lead	1.5-1.7	0.2-1.0	fish, molluscs
Methyl mercury	1.0	1.0	all fish
PCB	2.0		all fish
DDT, TDE	5.0		all fish
Dieldrin	0.0		all fish
Dioxin		0.000004	

FAO, 2004

#### *Organochlorine compounds*

There are numerous organochlorine contaminants in the environment, and they belong to the class of chemicals referred to as persistent organic compounds (POPs). Most of these compounds are no longer in use and their levels in the environment are generally decreasing.

#### *Dioxins and furans*

There are 210 congeners, which are referred to generally as dioxins. They are produced by industrial processes such as incineration. Dioxins bioaccumulate and are concentrated in the fatty tissues of fish, as shown in the table below, and are suspected of inducing cancers. Nevertheless, dioxin contamination reduced by 60% between 2000 and 2005, thanks to controls introduced at incineration plants.

**Table 5.29** Dioxin amounts in common foods (Compilation of EU dioxin exposure and health data, October 1999)

Food commodity	Picogram TEQ/g fat	
	Min	Max
Milk products	0.5	3.8
Meat and meat products	0.1	16.7
Poultry	0.7	2.2
Fish	2.4	214.3
Eggs	1.2	4.6
Fat and oils	0.2	2.6
Bread and cereals	0.1	2.4

#### *Polychlorinated biphenyls (PCBs)*

(209 congeners) These are highly persistent, accumulated within food chains, and negatively affect nervous system development and neurotransmitter function.

#### *Brominated flame retardants*

(75 components) These persistent organic contaminants in the environment contaminate the food chain long after production has ceased.

#### *Hazardous air pollutants*

There are around 100 components known, some from natural sources but mostly from incomplete combustion of organic material. Bioaccumulation in fish is low, because fish can metabolize them.

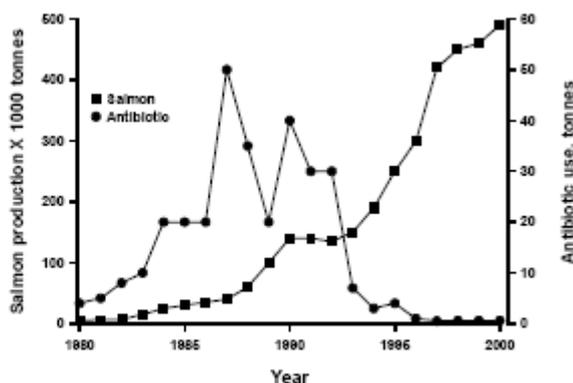
### Pesticides

There are 400–500 compounds known. Organochlorine insecticides are the most frequently detected pesticides in fish and shellfish, but their concentrations in fish and shellfish have decreased during the last 30 years (e.g. DDT concentration in mussels in Normandy decreased from 30µg/kg dry matter in 1970 to 3–5 in 2004). Exposure of the French population to pesticide residues through seafood products is not considered to present any risk at present (AFSSA, in press).

### Veterinary drugs

Antibiotics are commonly used in aquaculture to treat infections caused by a variety of bacterial pathogens of fish, used as in-feed medications. There are a wide range of antimicrobial agents used in aquaculture, and specified doses and withdrawal periods. The use of antibiotics in fish farming can lead to antibiotic residues in the flesh and the development of antimicrobial resistance in bacteria that may be transferred to consumers. Recently, however, the use of antibiotics has fallen dramatically in the salmon-farming industry in Norway, from about 50 t to < 1 t annually. This is the result of a successful scheme to develop vaccines for use against fish pathogens (FAO, 2004).

**Figure 5.17**  
Increase in production of farmed salmon and decrease in use of antibiotics in Norway from 1984 to 2000 (modified from Buchmann and Larsen (2001)).



FAO, 2004

Vaccines cannot be developed for farmed shrimp or molluscs, because invertebrates seem to have no specific immune system. The occurrence of antibiotic residues in cultured shrimp from Asia has led to rejection of product on export markets. The EU has introduced legislation requiring testing of all shipments of farmed shrimp from China, Vietnam and Indonesia for residues of chloramphenicol (EC, 2001b,c).

### Risks related to aquatic biotoxins

Natural toxins found in fish and (mainly) shellfish are produced by marine algae (phytoplankton). Molluscs are filter-feeders and can rapidly accumulate toxins from phytoplankton. Among the 4000 marine algae species, 70 can produce toxin. A bloom, such as a red tide, may contain up to 50 000 cells per ml, but concentrations as low as 200 cells per ml can make shellfish toxic. The consumption of these toxic shellfish by humans causes illness, with symptoms ranging from mild diarrhoea and vomiting to memory loss, paralysis and death.

Phycotoxins are increasingly responsible for human intoxication. There are a number of different seafood toxin syndromes, including paralytic shellfish poisoning (PSP), amnesic shellfish poisoning (ASP), diarrhetic shellfish poisoning (DSP), neurotoxic shellfish poisoning (NSP), and azaspiracid (VSP). Fish may also consume toxic algae and cause human disease (ciguatera). Puffer fish poisoning does not involve marine algae. Most of the algal toxins associated with seafood poisoning are heat stable and are not activated by cooking.

Many countries rely on biotoxin monitoring programmes to protect public health, and close harvesting areas when toxic algal blooms or toxic shellfish are detected. Monitoring programmes regularly detect high levels of toxins. Blooms of toxic algae have recently

become more prevalent (see driver E1), and may be due to coastal pollution. In developing countries, however, monitoring of harmful algal blooms is not routine and human fatality as a result of red tide toxins is becoming increasingly common. The toxins accumulate in the digestive gland of shellfish and do not affect the shellfish specifically. Toxicity then declines when the shellfish are exposed to clear water, but rates of depuration vary greatly by species.

**Table 5.26** Marine biotoxins and the associated poisonings.

The disease	Toxins	Occurrence
PSP-Paralytic shellfish poisoning	Saxitoxin	Worldwide
DSP-Diarrhetic shellfish poisoning	Okadaic acid dinophysis toxin	Worldwide
NSP-Neurotoxic shellfish poisoning	Brevetoxins	USA, Caribbean, New Zealand
ASP-Amnesic shellfish poisoning	Domoic acid	North America
Ciguatera fish poisoning	Ciguatoxin (CTX)	Tropical, subtropical
Puffer fish (tetrodotoxin) poisoning	Tetrodotoxin (TTX)	Japan, South Pacific

PSP is the most widespread form of shellfish poisoning and outbreaks worldwide are common. It is caused by a group of toxins produced by *Alexandria*, *Gymnodinium* and *Pyrodinium*. Blooms of toxic algae, and outbreaks of PSP, occur regularly throughout Europe and the EU.

DSP is due to *Dinophysis* and *Prorocentrum*, which are widespread. Thousands of cases of gastrointestinal disorders caused by DSP have been reported in Europe, Japan, Asia and America.

NSP is caused by *Gymnodinium* and limited currently to the USA and New Zealand. No human fatality due to NSP has been reported, but the toxin can cause massive fish kills.

ASP is produced by a diatom and is responsible for disorientation, confusion and memory loss (which can be permanent in survivors).

CFP or ciguatera fish poisoning. It has been estimated that 10 000–50 000 people a year suffer from this disease. It is caused by consumption of fish that have become toxic by feeding on toxic dinoflagellates or toxic herbivorous fish. Clinical symptoms are characterized by gastrointestinal, neurological and cardiovascular disturbances.

PF or puffer fish poisoning frequently occurs in Japan, with 500 cases in a 10-year period, with 6% fatality. The toxin is found mainly in the ovaries of the fish, and the muscle is normally free of the toxin.

The detection of natural toxins is mainly based on mouse bioassays, and analytical methods may be used to confirm presence of a toxic compound. The tolerances for natural dioxins have been established by FDA (1998) and other institutions. The primary preventative tool for intoxication with natural toxins is the monitoring of toxin levels in algae in the harvesting areas.

## Biological risks

### Bacteria

*Clostridium botulinum*: Most botulism outbreaks in northern and temperate regions are associated with fish (some are induced by meat). The disease can vary from a mild illness, nausea and vomiting to serious neurological symptoms and respiratory impairment), which may be fatal within 24 h. The toxin is one of the most potent of all poisons, but normal household cooking is sufficient to destroy it.

*Vibrio parahaemolyticus* is worldwide known as a source of gastroenteritis related to seafood. Infections of *Vibrio parahaemolyticus* are associated with the ingestion of raw fish and

shellfish. Outbreaks are generally during the warm months, and mainly in Japan, Asia and the USA. In Japan, *Vibrio parahaemolyticus* is responsible for 50–70% of the diseases related to seafood consumption. Several thousand cases of gastroenteritis caused by *Vibrio parahaemolyticus* are reported in Japan annually, and they constitute, as in the USA, a real problem of public health, as seafood consumption, and particularly of raw product, increases in those countries (AFSSA, in press).

Two other vibrios, *Vibrio vulnificus* and to a less extent *Vibrio cholerae*, are responsible for outbreaks of disease associated with shellfish consumption.

*Listeria monocytogenes* induces listeriosis, which is rare, transmitted by food, and mostly affects people with an impaired immune system. Listeriosis is caused by processed, industrialised food with an extended shelf life, such as smoked mussels or smoked salmon and trout.

**Table 5.10** European and Japanese gastroenteritis cases caused by *Vibrio parahaemolyticus* (EC, 2001; CAC, 2002)

Country	Period	Cases
UK and Wales	1995-1999	115
Northern Ireland	1997	44
Scotland	1994-1999	6
Spain	1995-1998	19
France	1995-1998	6
	1997	44 <sup>1</sup>
Sweden	1992-1997	350 <sup>2</sup>
Norway	1999	4
Denmark	1980-2000	2
Japan	1991-2000	64 000

1. Associated with seafood imported from Asia  
2. Associated with crayfish imported from China

### Viruses

The biggest outbreak of food-borne disease ever recorded was an outbreak of hepatitis A in Shanghai, in 1988, when more than 290 000 people were infected by eating clams affected by the hepatitis A virus (FAO, 2004).

To minimize the risk associated with bacteria and virus in shellfish, European countries have a monitoring programme for classifying the waters where shellfish are harvested. This classification is based on the number of *Escherichia coli* and *Salmonella* counted in sampled shellfish.

**Table 11.1** Classification of harvesting areas for shellfish in the EU. Microbiological examination of shellfish samples (EC, 1991).

Classification	Microbiological criteria (cfu /100 g shellfish)	Method
A No restriction. Shellfish acceptable for immediate consumption	<230 <i>E. coli</i> or <300 faecal coliforms no <i>Salmonella</i> in 25g	5 tubes 3 dilutions MPN-test
B Shellfish must be depurated or relayed until they meet category A standard	<4,600 <i>E. coli</i> or <6,000 faecal coliforms in 90% of samples	5 tubes 3 dilutions MPN-test
C Shellfish must be relayed over a long period (>2 months) until they meet category A standard	<60 000 faecal coliforms	5 tubes 3 dilutions MPN-test

FAO, 2004

### Parasites

More than 50 species of helminth parasites from fish and shellfish are known to cause disease in man, but most are rare and involve only slight injury. One of the most prevalent is Anisakis, which causes anisakiasis, and is caused by the consumption of raw or improperly

cooked seafood. Worms penetrate the gut wall causing abdominal pain. Anisakiasis is common in Europe, Japan and the USA.

*Histamine poisoning* is caused by ingestion of fish in which an amino acid, histidine, has been transformed (decarboxylation) into histamine during storage. Histamine poisoning follows the ingestion of spoiled scombrid fish such as tuna, skipjack, bonito and mackerel, but also from eating non-scombrid fish such as herring, marlin and mahi-mahi. Histamine poisoning in Europe is on the increase, and can even be induced by fish with low levels of histamine, so it is concluded that the proportion of persons sensitive to histamines is also on the increase.

*Allergic risks*

Parvalbumin, tropomyosine

**Occurrence of health problems due to seafood ingestion**

Exhaustive data on health problems associated with seafood ingestion are not available for the EU, but many studies provide precise and useful data. The table below shows, for example, that seafood was involved in 10% of food-borne health problems in the UK during an 8-year period.

**Table 4.5** Etiological agents of foodborne outbreaks in UK associated with seafood (Gillespie *et al.*, 2001).

Agent	No. of outbreaks 1992-1999							
	Total <sup>1</sup>	Food-borne	Seafood		Fish	Molluscs	Crustaceans	Other
			suspected	confirmed				
Scombrototoxin				47	47	0	0	0
DSP				1	0	1	0	0
Virus				26	0	21	3	2
<i>Salmonella</i>				14	7	1	4	2
<i>Campylobacter</i>				3	1	0	1	1
<i>S. aureus</i>				1	0	0	1	0
<i>B. cereus</i>				1	1	0	0	0
<i>C. perfringens</i>				3	1	0	1	1
Unknown				52	12	31	7	2
<b>Total</b>	<b>4 603</b>	<b>1 425</b>	<b>181</b>	<b>148</b>	<b>69</b>	<b>54</b>	<b>17</b>	<b>8</b>

<sup>1</sup> Total number of reported intestinal disease outbreaks

The number of seafood imports to the EU rejected before release to the markets increased between 1999 and 2002, mainly because of the increasing antibiotic contamination of products (shrimp) coming from Asia.

Alerts for contamination in fish, frogs, crustaceans and molluscs have been registered in Europe for the period June 1999 to June 2003. In all, 831 alerts were identified, corresponding to chloramphenicol or vibrio in shrimps, phycotoxins in mussels, salmonella in shrimps, fish, squid and octopus, listeria in smoked salmon, cadmium in squid and octopus, mercury in swordfish, and histamine in tuna.

**Table 4.7** Causes of rejection/detention of seafood imported into the EU during the period January 1999 – June 2002 (Ababouch and Gandini, unpublished)

Cause of detention/rejection	No. of rejections / detentions			
	1999	2000	2001	2002
Microbial	59	53	49	47
<i>V. parahaemolyticus</i>	13	10	19	14
<i>V. vulnificus</i>		2	1	3
<i>V. cholerae</i>	9	8	9	5
Other vibrios		1		
Enterobacteria	6	2	4	6
<i>S. aureus</i>	7	0		
<i>Listeria</i>		0		
<i>Salmonella</i>	20	18	10	12
Hepatitis	1	1		
Total plate count	1	8	4	7
Molds		1	1	
<i>Clostridium</i>		2	1	
Chemicals / residues	13	15	34	158
Biotoxins		1		1 <sup>1</sup>
Pesticides	2			
Mercury	4	4	9	8
Cadmium	5	2	3	4
Lead				2
Nitrofurans				39
Histamine	1	4	1	1
Chloramphenicol	1		16	86
Phenols				
Polycyclic Aromatic Hydrocarbons		4	3	7
Veterinary drug residues				4
Sulfites			2	2
Benzopyran				1
Malachite green				1
Antimicrobial agents				2
Parasites	1	13	11	7 <sup>2</sup>
Others	6	13	18	5
Labelling	3	7	8	2
Sanitary certificate	1	1	3	
Shelflife	1		2	
Interrupted cold chain	1	1		
Insects				1
Import prohibited		2	2	1
Mixing of fish species				1
Uncertified establishment		1		
packaging			2	
Not specified		1	1	
<b>Total</b>	<b>79</b>	<b>94</b>	<b>112</b>	<b>217</b>

1. DSP

2. One cestode

## Hypotheses (2020)

1. **Fortress Europe:** Europe will reinforce sanitary controls for imported seafood, mainly in terms of toxins, bacteria and viruses in molluscs, antibiotics in shrimps, and dioxins and mercury in fish. The precautionary principle will reach its maximum level, most seafood products from Asia and Africa will be not allowed on the EU market, owing to a fear of unknown new pollutants and emerging bacteria, viruses and toxins. Only seafood produced in Europe will be consumed there.
2. **Seafood as a healthy product** Dioxins and other organochlorine compounds will continue to decrease in world seafood products. Metal concentrations in seafood are currently not dangerous for human health, except methylmercury. Most mercury is from natural sources, and it will not increase. Sanitary controls on shellfish and in coastal waters will be reinforced to limit food poisoning by shellfish. Seafood will become safer.
3. **Russian roulette:** Red tide events will multiply throughout the world, with increased pollution and increased temperature inducing blooms of toxic phytoplankton. Shellfish will be unfit for human consumption because of their carrying phycotoxins, bacteria and viruses. Almost all areas in Europe will be classified in zone C. Use of antibiotics for shrimps in Asia will increase in response to pollution. New pollutants (metals, chemicals) will be assayed in fish. The availability of safe and healthy seafood will be limited, and eating fish will be like playing "Russian Roulette".

## Sources

- EC (European commission) 2001b. Commission decision 2001/699/EC concerning certain protective measures with regard to certain fishery and aquaculture products indented for human consumption and originating in China and Vietnam. Official Journal of the European communities L125, pp11-12.
- The EFSA (European Food Safety Authority) Journal, 2005. Opinion of the scientific panel on contaminants in the food chain on a request from European Parliament related to safety assessment of wild and farmed fish. Question N°EFSA-Q-2004-22. Adopted on June 2 005. N°236, 118p.
- AFSSA in press. Aspects nutritionnels et sanitaires des poisons, mollusques et crustacés.
- CAC (Codex Alimentarius Commission) 2002. Discussion Paper on risk management strategies for vibrio spp in seafood. Draft 2/28/02.CX/FH 03/5 Add 5. Food and Agriculture Organization, Rome, Italy.
- FDA (US Food and Drug Administration) 1998. Fish and fishery products Hazards and Control Guide. FDA, Center of Food safety and Applied Nutrition, Office of Seafood, Whashington DC, USA.
- Huss HH, Ababouch L, Gram L, 2004. Assessment and management of seafood safety and quality. FAO Fisheries Technical paper 444, 240p.
- WHO, 1988. joint FAO/WHO expert Committee on food additives (FEFCA). Safety Evaluation of Certain Food Additives and Contaminants. WHO additives series 24. World health Organization, Geneva, Switzerland.

# RESEARCH

## RESEARCH

### G1 Sources and allocation of funding for European marine research (including data collection, short term crisis)

#### Driver Definition

Several sources of funding for (marine) research can be identified:

- EU Framework Programme – Specific Programme “Cooperation”: consortia - support of EU policy;
- EU Framework Programme – Specific Programme “Idea”: individuals – basic research;
- National public expenditures: research in support of national policy;
- Private expenditures (philanthropic sources; commercial sources).

Such funding is organised through various procedures, e.g. via competitive, peer-reviewed responsive mode mechanisms. In some countries, specific thematic programmes have been created, with targeted funding, while still adopting the competitive peer-review selection.

Priorities in the policy agenda relating to research encompass all such things as general attention for marine and maritime research, specific fisheries and aquaculture research, attention for fundamental vs. applied research, ecology-driven vs. economic- and society-driven research.

Funding can be allocated according to:

- policy agenda (i.e. phasing out re. medium / long term priorities at national and EU level)
- extraordinary situations (i.e. short-term crisis – e.g. accidental pollution)

#### Relevant Indicators

- Evolution of expenditures on marine programmes and infrastructures at European and national levels;
- Respective allocation:
  - European vs. national;
  - public vs. private;
  - monitoring (including data collection) vs. research;
  - applied vs. basic research.
- Relative weight of fishery and aquaculture research funding in marine research and general research
- Private-led vs. public-led research in aquaculture (and perhaps too fisheries or fish processing research)

The involvement of the private sector in marine research (with specific reference to aquaculture) can be characterised by:

- Expenditure on private-led research;
- The number of private sector staff involved in marine research;
- The extent of involvement of the private sector in public-led research.

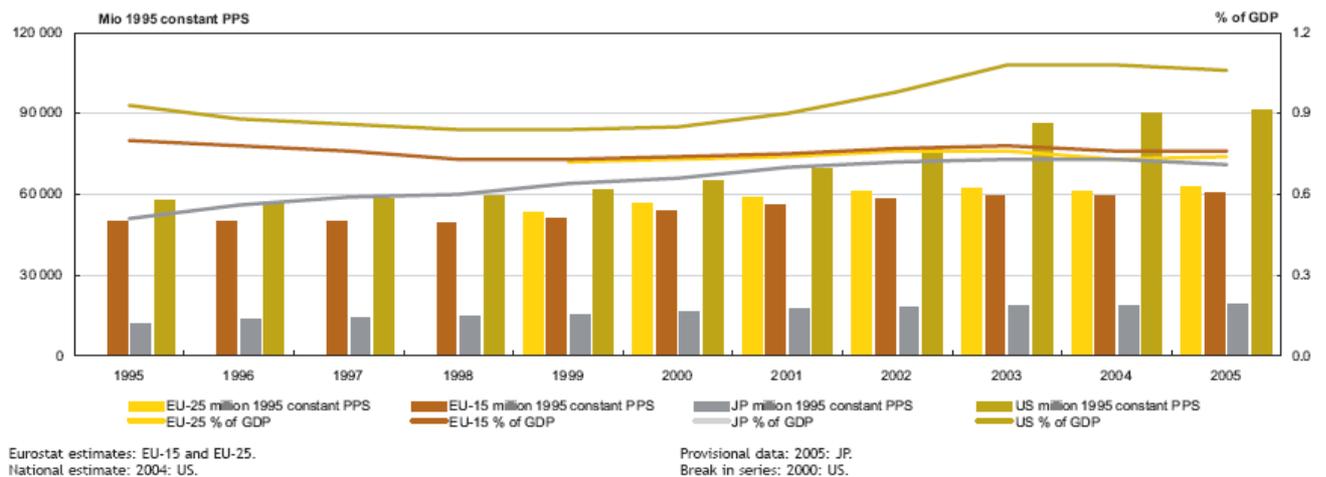
## Developments over the past 20 years

### National expenditures for research

R&D expenditure is a key indicator for tracing R&D development: the basic measure is intramural expenditure, in other words, all expenditure for R&D that is performed within a statistical unit or sector of the economy, whatever the source of the funds. Among the Relevant Indicators available, R&D intensity (which is defined as R&D expenditure relative to GDP) is the most frequently used for international comparisons of relative R&D effort.

Government budget appropriations or outlays for research and development (GBAORD) are the amount governments allocate towards R&D activities. Comparisons of GBAORD across countries give an impression of the relative importance attached to state-funded R&D. GBAORD statistics complement the *ex post* figures on government-financed gross expenditure on research and development (GERD) and, when broken down by socio-economic objective, underline the domains governments believe to be important for current and future policy action. Gross domestic expenditure on R&D (GERD) in the EU-25 was equivalent to 1.9% of GDP in 2005; this proportion rose to >3% in just two of the Member States, Finland and Sweden (where R&D expenditure made by the business enterprise sector was considerably higher than in any of the other Member States).

Figure 1.1 GBAORD in million 1995 constant PPS and as a percentage of GDP, EU, Japan and the United States – 1995 to 2005



Key Figures 2007 presents data and statistics on science, technology and innovation up to 2005, so pre-dating the recent initiatives and renewed commitments to the Lisbon Agenda targeted towards growth and jobs since 2005 revision. It shows however that these recent policy developments are now needed more than ever, for at least five reasons:

- The EU is part of a globalised world where knowledge is more evenly distributed than ever before. Great competition at this level requires the EU to adapt and make the ERA more attractive to the rest of the world. The Key Figures 2007 show that countries such as China already act as stiff competitors in the globalised knowledge-based economy.
- The report shows that EU R&D intensity has stagnated since the mid-1990s. In 2005, just 1.84% of GDP was spent on R&D in EU-27, and it still remains at a lower level than in the US, Japan or South Korea. Also, new emerging economies such as China are rapidly catching up. If current trends last, China will have caught up with the EU by 2009 in terms of R&D intensity. However, high-R&D-intensive EU Member States such as Austria, Germany, Finland and Denmark show that it is possible to maintain and increase R&D intensity above 2% and even above 3% of GDP.

- Over 85% of the R&D intensity gap between the EU and its main competitors is caused by differences in business sector R&D financing. The low level of private R&D expenditure in Europe compared with the US is mostly due to differences in industrial structure and to the smaller size of the high-tech industry in the EU.
- Regarding research excellence, although the EU is the world's largest producer of scientific knowledge, the impact of European science is lower than that of the US. Europe lags behind the US in all scientific disciplines in terms of citation impact scores and highly cited publications. Also, EU universities are very much under-represented at the top of a ranking based on bibliometric Relevant Indicators of the world's largest universities. In addition, the linkage between technology (patented inventions) and the science base is much weaker in the EU than in the US. Europe has a difficulty in breaking through in new high-tech industries.
- Even though private sector funds are a notable part of R&D, the public sector still has a major role to play. Public R&D funding in the EU must be sustained in order for private R&D activities to develop further and grow on a solid science base. The Key Figures 2007 reveal that high R&D intensity can be achieved when large contributions from the private sector go hand in hand with high levels of public funding. For those economies that are catching up, government funding of R&D is critical for creating and developing S&T capabilities.

*National expenditures for marine research*

Definitive figures on marine research budgets/expenditure are difficult to disaggregate, particularly from programmes that often have a broader "ecosystem" remit. In most cases, the data require interpretation and may include costs other than research (e.g. infrastructures).

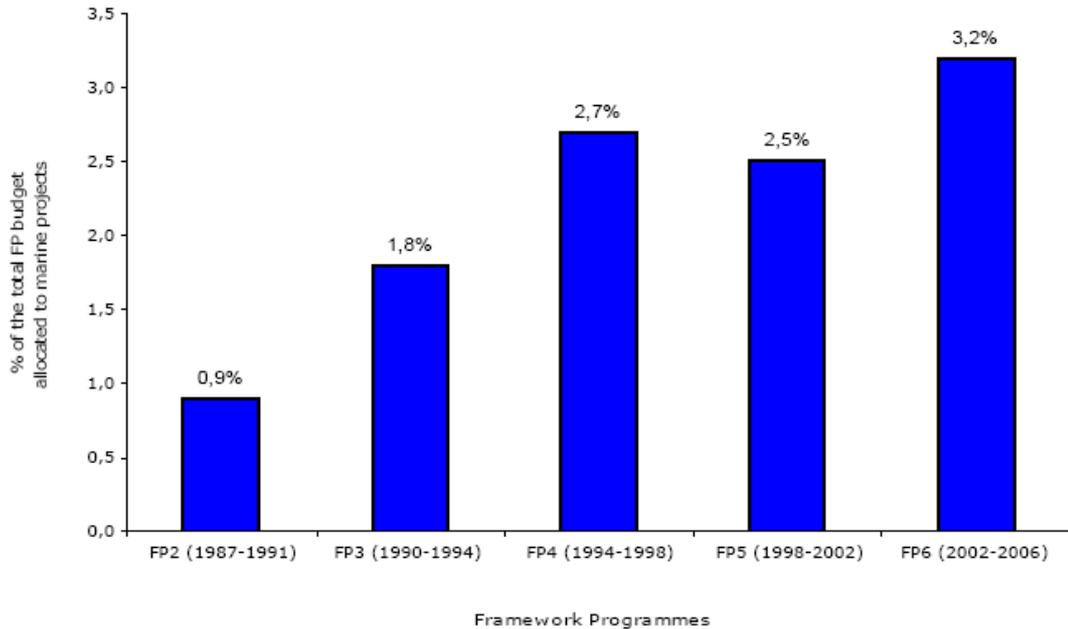
However, estimates do give national expenditure on marine programmes and infrastructure that accounts for approximately 95% of marine research funding in Europe.

We would draw the assumption that marine research expenditure follow the same pattern as for research expenditures as a whole, e.g.

- stagnating R&D intensity;
- lack of private investment in R&D.

*Development of the Framework Programme Budget Allocated to Marine Projects from 1987 to 2006*

The increasing budget allocated to dedicated European marine R&D programmes (MAST and FAIR) from 1987 to 1998 has been an efficient way to initiate a trend aiming to build a European marine research area. When these dedicated marine programmes (MAST and FAIR) disappeared after FP4, there was only a minor reduction in terms of the percentage of total funding allocated to FP5 marine projects, and it then increased again in FP6 where the marine research projects listed by EurOcean represent 3.2% (€572 695 056) of the FP6 budget (€17 883 000 000) (Figure 6 of the report, below).



**Figure 6** - Percentage of the total FP budget allocated to marine projects through the different Framework Programmes (FP2 to FP6).  
*Specific Marine Programmes in the FP's: FP2 – MAST I; FP3 – MAST II; FP4 – MAST III and FAIR. No specific programmes: FP5 and FP6.*  
*Source: EurOcean Last update: 16 October 2006*

The core of FP7 is the Cooperation Specific Programme, which will support research in a number of thematic areas corresponding to major fields of knowledge and technology where transnational cooperation can address European social, economic, environmental and industrial challenge.

Research relating to marine and maritime issues is integrated into all themes, but in particular into those on Food, Agriculture and Biotechnology; on Environment (including Climate Change) and on Transport (including Aeronautics). The implementation of FP7 foresees both a need to coordinate marine and maritime research across the relevant themes and the flexibility to respond to new policy needs as they arise. It was explicitly mentioned in the European Commission's FP7 proposal that "special attention will be paid to priority scientific areas which cut across themes such as marine science and technologies"; it was also reiterated in the European Commission's Blue Book on the Maritime Policy that joint cross-cutting calls under FP7 will be launched to promote an integrated approach and improve understanding of maritime affairs.

There has not been a tradition of strong collaboration at the level of programme development and funding. The suboptimal coordination between national funding bodies is recognised as a current weakness within the European Research Area (ERA), as funding bodies decide individually where, and on what priorities, research funds are spent. The ERA is a platform to regroup and intensify research efforts not only at a European level, but also at national and international levels. It is intended to guide and help coordinate Europe-wide research activities and innovation policy, so securing each Member State's economic and competitive future. Considerable benefits would be gained from working towards increased synergy among research and technology partnerships within the European Research Area (ERA). This is particularly critical for marine research which, operating within a spatial dimension beyond the jurisdiction of individual Member States, does not recognise national borders. Moreover, marine research deals with many issues that require the cooperation and commitment of several partners with different competencies and tools. Funds from the Framework Programme, particularly through the ERA-NET instrument (designed to step up

the coordination and cooperation of research activities carried out at national and/ or regional level), provide an opportunity to mobilise and coordinate marine research carried out nationally by different Member States, supporting the development of the ERA, while facilitating the coordination of national efforts.

### *Comments*

An EU increase in expenditure on marine, fisheries and aquaculture related research can be expected under FP7 following the past/current trend (previous FPs). However, because marine sciences, as well as Scientific Support to Policy (i.e. CFP) will not be addressed under a specific framework but under generic themes instead, we question whether the competition with other topics could turn out tougher...

Data are not specific in terms of the split between marine-, fisheries- and aquaculture-related research.

Therefore, while identifying a budget increase (both at EU and national level), one has still to question to where this increase goes: research or associated costs (e.g. infrastructure).

## **Hypotheses (2020)**

**1. European Union acts as a facilitator for marine research:** Marine budget is stable (both at EU and MS level), but national marine programmes are better coordinated, mainly thanks to European incentives (i.e. ERA-NETs – FP scheme). Funds used in a more efficient way for research relating to marine, maritime, fisheries, aquaculture matters, fragmentation, duplication are reduced, the marine component of the European Research Area is strengthened. The EU is seen as a facilitator

**2. The EU acts as an integrator for marine research:** The way FP7 addressed marine science and technologies was so successful that these priorities fell out of the Member States' research agenda. It results in disengagement from Member States regarding related matters, the latter fully relying on community efforts to explore how research can better contribute to knowledge creation and innovation. As a consequence, national marine budgets decrease, but the FP budget increase cannot compensate for the loss of national funding.

**3. EU and Member States act as “Terminator” for marine research:** A drastic cut in budget for marine research at all levels in 2020. The policy agenda shifts towards another major issue (e.g. energy supply).

**4. EU and Member States act as “Stimulator” for marine research:** A drastic increase in budgets for marine research at all levels in 2020. The policy agenda shifts towards the marine environment because of climate change (for example).

## **Sources**

- Marine Science and Technology Projects Funded under the 6th Framework Programme of the European Commission - A Statistical Overview - by Rita Santos, Telmo Carvalho and Laurent d'Ozouville, 2006.
- A Preliminary Description of MarinERA Member State Marine Research Funding Programmes and Implementation Procedures, MarinERA Technical Report 1 (May 2006)
- Key Figures 2007 on Science, Technology and Innovation – Towards a European Knowledge Area, DG RTD, June 2007.

## RESEARCH

### G2 Organisation of European Marine Research

#### Driver Definition

The European Union identified the development of the European Research Area (ERA) at the core of its Lisbon Strategy (launched in 2000 by EU Heads of Government) to make Europe "... the most competitive knowledge-based economy in the world by 2010."

Governance of the European Research Area and its marine component exploit existing synergies among institutes and university partnerships, shared investments and stakeholder involvement, networking of data centres, reciprocal opening of national programmes, regional cooperation (e.g. dealing with regional seas), instruments of the Framework Programmes (e.g. mobility programmes, Networks of Excellence [NoEs], ERA-NETs) and multilateral arrangements for access to marine facilities (e.g. the barter arrangements of the Ocean Facilities Exchange Group - OFEG).

#### Relevant Indicators

- Diversity of partners (size, public/private research, institutional positioning) and their associations;
- Marine related EU funded projects (numbers, budget, etc.)

#### Developments over the past 20 years

An estimated 94% of European marine research is funded and supported by national institutes and agencies. Although collaboration across national borders exists at the researcher level, and is also evident at the level of institutional networks (e.g. EFARO, EuroGOOS, Marine Board-ESF), there has not been a tradition of strong collaboration at the level of programme development and funding. The sub-optimal cooperation between national funding bodies is recognised as a current weakness within the European Research Area (ERA), as funding bodies decide individually where, and on what priorities, research funds are spent.

##### *Marine European Research Area*

The ERA is a platform to regroup and intensify research efforts not only at a European level, but also at national and international levels. It is intended to guide and to help coordinate Europe-wide research activities and innovation policy, so securing each Member State's economic and competitive future. Considerable benefits would be gained from working towards increased synergy among research and technology partnerships within the European Research Area (ERA). This is particularly critical for marine research, which, operating within a spatial dimension beyond the jurisdiction of individual Member States, does not recognise national borders. Moreover, marine research deals with many issues that require the cooperation and commitment of several partners with different competencies and tools. Funds from the Framework Programme, particularly through the ERA-NET instrument (designed to step up the coordination and cooperation of research activities carried out at national and/ or regional level), provide an opportunity to mobilise and coordinate marine research carried out nationally by different Member States, supporting the development of the ERA.

To strengthen the marine component of the European Research Area (ERA), the benefits resultant from synergies among institutes and university partnerships, shared investments, networking of data centres, opening of national programmes, regional cooperation (e.g. dealing with regional seas), instruments of the Sixth and Seventh Framework Programme (e.g. mobility programmes, Networks of Excellence [NoEs], ERA-NETs and ESF

EUROCORES), and multilateral arrangements for access to marine facilities (e.g. the barter arrangements of the Ocean Facilities Exchange Group – OFEG) should be fully exploited. Governance of the European Research Area will have to take into account the diversity of partners, whether from public or private research, both in size and institutional positioning. Concern has been expressed that despite the funding of approximately 242 marine related projects in the Sixth Framework Programme, coordination between these initiatives was not optimal. Working towards improved coherence of marine research activities will require:

- (i) enhanced partnership between marine research institutes;
- (ii) fostering of greater capability in marine technology across the marine sector;
- (iii) support for long-term observation and national facilities on appropriate timescales;  
and
- (iv) strengthened commitment towards supporting long-term oceanographic data centres.

#### *EU Framework Programme*

The Seventh Framework Programme (FP7; 2007–2013, budget €50.5 billion) provides a timely opportunity to secure the European Marine Research Area, reducing fragmentation and enhancing coherence. Integration and coordination of marine science across all scientific themes and areas of the Framework Programme is necessary to maximise the benefits for marine research, which will in turn enhance support to policy, in particular the developing European Maritime Policy. The challenge will be to establish an appropriate method to improve the coordination of marine science and technology topics across the relevant thematic areas and between marine research funding programmes of Member States.

Under the Specific Programme “Cooperation”, research support is provided to international *collaborative* projects across the EU and beyond, in 10 thematic areas, corresponding to major fields in science and research (budget 2007–2013, €32 billion).

The Specific Programme “Ideas” hosts all those activities implemented by the European Research Council (ERC) which aims at developing high level frontier research at a European level, building on excellence in Europe and raising its profile at an international level (budget 2007-2013, €7.4 billion).

In FP6, the activities under the heading “Scientific Support to Policy” used to underpin the formulation and implementation of Community policies; in particular the common agricultural policy (CAP), the Common fisheries policies (CFP), environment, energy, transport, health, development aid, consumer protection, etc. Under FP7, with a larger role for DGRTD in devising the research agenda, the SSP policy instrument as such no longer exists.

#### *Marine Institutional Networks – research funders, researcher managers*

Europe will benefit from increased interaction between the existing mature networks of marine institutes and agencies including EFARO (European Fisheries and Aquaculture Research Organisations), EuroGOOS (European Global Ocean Observing System), ICES (International Council for the Exploration of the Sea) and the Marine Board–ESF. These networks should elaborate perspectives on marine science and technology, support and convene regular joint scientific fora, and promote synergies between their membership, towards strengthening the voice of marine scientists in the European Research Area. In moving towards enhanced partnership of their activities, they can together better serve the development of European policies and foresight initiatives in marine science.

#### *Multi-decadal funding*

At a European level, commitment to multi-decadal funding (beyond the current three- to six-year funding cycle of national programmes and EU Framework Programmes) to secure both sustained observations and research is essential for many issues, including measuring climate variability and its impacts. Multi-decadal funding is also required for the development of systems such as early warning systems for natural hazards and for operational oceanography. A portion of research funding should be allocated to support these long-term objectives, which will build strong foundations for a well-coordinated marine science community.

### *Scientific and Industrial Partnerships*

Europe should widen its support for integrated marine science by providing incentives for scientific and industrial partnerships. The goal should be to maximise the manufacture, application and exchange of novel technologies within Europe and to maximise European industrial competitiveness, for the benefit of both marine research and society. Academic researchers must be encouraged to develop industrial links (e.g. through the use of instruments such as Technology Platforms and Joint Technology Initiatives). This should concern large groups, such as the petroleum industry and maritime transport, and Small and Medium Sized Enterprises (SMEs). Partnerships could include Public Private Partnerships (PPPs, i.e. the collaboration between private industry and governmental agencies).

## **Hypotheses (2020)**

**1. More cooperative research but not more competitive:** In 2020 duplication, fragmentation within the ERA has been reduced. Research funds are now used in a more efficient way among Member States, but they have not been increased to reach the 3% of GDP objective set in line with the Lisbon agenda and the creation of a European Research Area. The cooperative trend has reduced competitiveness in research.

**2. Continued shift from basic to applied research at EU level:** In 2020 research is supported and strengthened to address European social, economic, environmental, public health and industrial challenges, to serve the public good, and to support developing countries. This evolution could be considered as appropriate from a societal point of view, but questionable from other perspectives.

**3. Back to basic – a shift from applied to basic research at an EU level:** EU provides a strengthened support to basic research, and the European Council of Research (ERC) – the pan-European funding body supporting investigator-driven frontier research – becomes the key element of the Framework programme. Support to applied research and specific industries is provided at national level.

## Sources

- Decision of the European Parliament and the Council concerning the 7th framework programme of the European Community for research, technological development and demonstration activities (2007-2013) - COM(2006) 364 final
- Navigating the Future III (Marine Board Position Paper 9, November 2006)

## RESEARCH

### G3 Access to Infrastructure

#### Driver Definition

The term Research Infrastructures (RI) refers to facilities and resources that provide essential services to the research community in both academic and/or industrial domains. Research infrastructures may be single-sited (single resource at a single location), distributed (a network of distributed resources, including infrastructures based on Grid-type architectures), or virtual (the service being provided electronically).

In the marine field, sub-categories of infrastructure include

- Research vessels
- Underwater vehicles
- Satellites
- Marine institutes
- Monitoring networks
- Testing facilities
- Large databases
- Biological databases
- Data facilities
- Libraries and repositories

“Infrastructure” also includes databases: long-term constituted series of datasets such as tables of catch/effort/landings by statistical rectangle, Continuous Plankton Recorder time-series, satellite records (SST, water colour), scientific surveys (EU campaigns in the North Sea, Bay of Biscay)

#### Relevant Indicators

- Capacities (number of vessels, instruments, etc.)
- (Trans-) national access to RI (agreements, barter groups)
- Age, renewal
- Involvement in infrastructure-related FP initiatives (Integrated Infrastructure Initiative – I3, ERA-NETs)
- Marine-related ESFRI (European Strategy Forum for Research Infrastructures) opportunities.

For databases,

- The series themselves associated with quality evaluation; a list of missing series and needs. A list of relevant indicators can be elaborated from series

#### Developments over the past 20 years

Marine science requires a large variety of specialised and expensive infrastructure, including research vessels, satellites, observing networks, data centres, and computing and experimental facilities. The specialised infrastructure necessary to support marine research represents an estimated 50% of investment in marine research. The level of infrastructure available to marine research influences its competitiveness and performance; well-developed

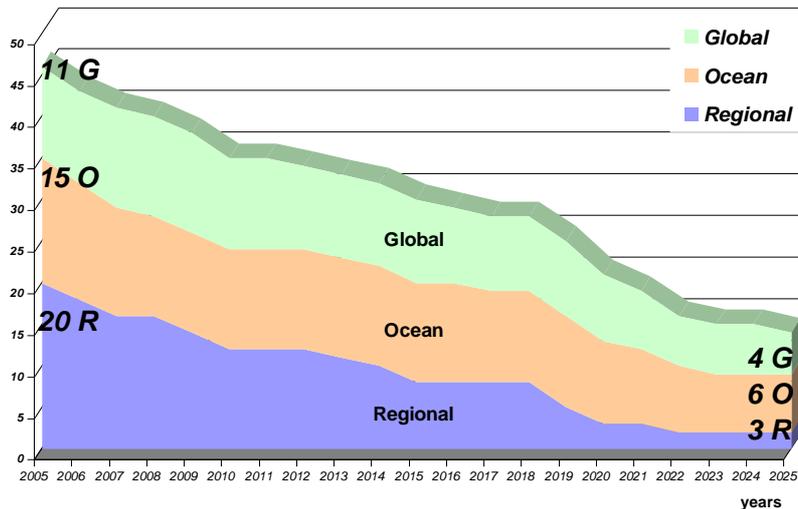
infrastructure supports the acquisition of enhanced knowledge and understanding of the oceans.

**Oceanographic Research Vessel fleet**

Availability of an oceanographic fleet and associated marine equipment (e.g. underwater platforms), is essential for research at sea. The oceanographic research fleet requires a large range of multipurpose research vessels of different size (e.g. global, ocean, regional):

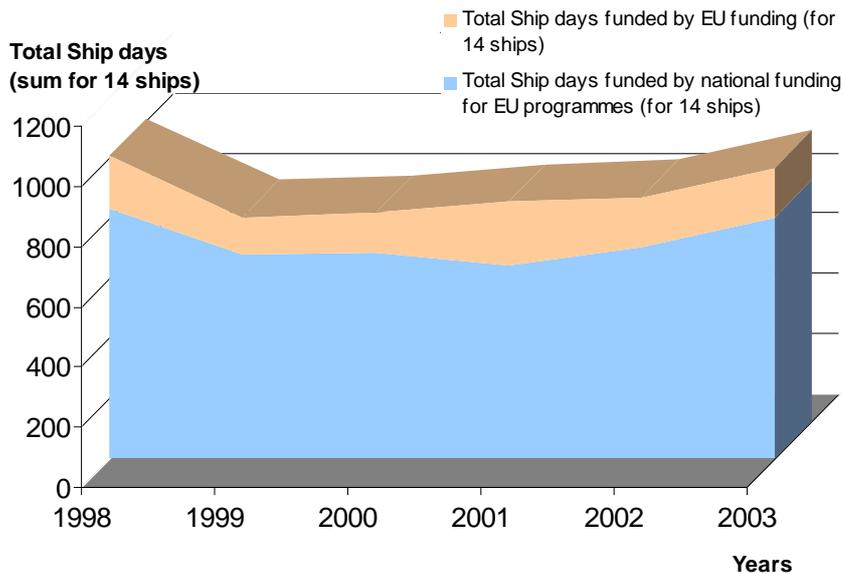
- Global vessels are large (>65 m) and currently operate on an at least a multi-ocean scale, e.g. RV L'Atalante, RV Discovery, RV Meteor;
- Ocean vessels are large enough (>55 m) to operate on an ocean scale, e.g. RV Le Suroit, RV Pelagia, RV Poseidon;
- Regional vessels currently operate generally on a European regional scale, e.g. RV Alkor (Baltic Sea), RV Celtic Voyager (Celtic Seas), RV Bilim (Eastern Mediterranean, Black Seas).

Research vessels require ongoing investment to upgrade their capabilities and to ensure that they maintain their status as state-of-the-art facilities. The regional fleet (vessel length <35 m) in particular is ageing rapidly and it is necessary that decisions are made now to ensure the capacity of European regional class vessels in the future. Without planned new builds, in 20 years the fleet will be reduced by 70% (see Figure 1).



**Figure 1:** Development of the European Academic Research Fleet (Marine Board Position Paper 10 – European Ocean Research Fleets)

Some European countries spend a large part of their funds for ships time to facilitate EU Framework Programme funded research projects.



**Figure 2:** Influence of EU Framework Programme funding on ship-time usage: >80% national funding vs. <20% EU Framework Programme funding.

*Existing partnerships*

Tools for collaboration and coordination already exist and have demonstrated that pooling resources facilitates an improved and more flexible use of specialised infrastructure for the benefit of the scientific community.

- Exchange of ship time or equipment or instruments – the barter system. The Ocean Facilities Exchange Group (OFEG) consists of six European institutions and Ministries (Ifremer/France, NERC/UK, BMBF/Germany, NIOZ/Netherlands, IMR/Norway, CSIC-UTM/Spain). It runs a system that announces opportunities such as vessels’ bartering time and offers of use of large equipment. The agreement, signed in 1996, has been based on an equivalent point by day.
- Shared investments and running costs. In the past, investments were shared in some few cases on the basis of bi- or multilateral international agreements. One of the reasons was that the costs of investment appeared too high for a single country, and/or the resulting annual running costs were too high compared with the expected annual use. Another reason, more political, was to foster cooperation between two counterpart scientific institutions or to address sensible societal challenges together.
- Chartering within Europe. For funding agencies or users who do not need vessel/equipment time on an annual basis, running costs can be reduced to an optimal level by chartering available time.
- Joint projects/programmes. Within joint projects, joint cruises and use of equipment without exchange of money or barter values are quite common. The funding agencies recognise that marine science, although funded nationally, is best performed in an international context.

*European Fisheries Research Fleet*

EFARO organised a workshop on the European Fisheries RV fleet in Tunis in January 2004. At that workshop, it was stated that 94 RVs are active in European fisheries research.

It was estimated that 50% of the cost of fisheries research is related to the exploitation of the RV fleet. There is scattered unutilised RV time available (caused by lack of funding or inappropriate planning); some countries require more RV time than they have access to.

Shared use of RVs is not a common practice; only few countries (e.g. France and Spain) have bilateral agreements. However, most of the fisheries research surveys are internationally coordinated. There is also a common practice of sharing survey equipment. However, commitments to monitor remote regions result in non-productive steaming time. Fleet managers see the possibility to manage their medium-size vessels more efficiently by setting up a regional coordination organisation (Baltic Sea, North Sea/Atlantics, Mediterranean Sea West, Mediterranean Sea East). The largest vessels could best be used at European level.

The fisheries RV fleet is relatively old. Two-thirds (62 RVs) are >20 years old, and 25 of those are >30 years old. Half the RV fleet is longer than 30 m (48 RVs). The younger segment (<20 years: 30 RVs) is relatively larger than the older segment: 16 young RVs are >50 m. Renewal of the fleet is stagnating. Fleet managers indicate a need for building approximately 25 new vessels within the next five years. The best utilisation of public funds would be to explore the co-utilisation of modern, multi-purpose vessels specialised in certain sea conditions.

#### *Experimental facilities*

Marine infrastructure includes experimental facilities of various type, including hydraulic basins for testing and calibrating instruments (for both research and industry), and aquaculture or ecosystem experimental facilities. A European strategy to optimise the capacity for experimental facilities is necessary; this would include improving some existing major facilities, with improved control of their experimental parameters and the use of various new measuring devices, allowing, for example, the determination of ecosystem parameters. In addition, facilitating open access to European scientists would enhance the benefit from existing specialised infrastructure. To create such a network and develop a dynamic of interactions, the launch of a forum of specialised operators of experimental facilities would be appropriate.

#### *Satellite Observing Systems*

Europe's efforts in developing oceanographic monitoring from space should be continued, in particular with regard to research satellites for observing parameters such as sea-ice thickness, sea surface salinity, pigment mapping, and directional wave spectra. In addition, operational satellites for observing the ocean in the framework of Global Monitoring for Environment and Security (GMES) should be implemented, dealing particularly with ocean currents, wind stress, precise sea surface height, temperature and chlorophyll pigments. Satellite observations need to be as continuous as possible, with overlap between successive missions, and coincident with the collection of appropriate *in situ* observations.

Inclusion of data and products from GMES into data centres, including real-time observations and output from numerical models, is needed. Since summer 2006, the major European institutes involved in operational oceanography have started a near real-time exchange of *in situ* data from various observing platforms. It is a collaborative effort between the different regional Global Ocean Observing Systems (GOOS) set up in Europe (BOOS, NOOS, IBI-ROOS, MOON, MedGOOS, BlackSea-GOOS). The exchange is carried out through regional and thematic data centres under the coordination of EuroGOOS and constitutes a major step towards the implementation of GOOS as well as an important European contribution to the marine component of GEO. Efforts such as these should be elaborated and supported.

#### *High-end computing facilities*

To address many of the major ocean research issues, high-end computing facilities (i.e. computers operating at the current highest operational rate possible, coupled with techniques for parallel computing) are required. Such facilities should have associated data storage, processing, visualisation and retrieval systems. Support for the implementation of high-end computing facilities in Europe for ocean and climate numerical modelling, comparable with those already in existence in Japan and the USA, is required. Furthermore, facilitating reciprocal access by European scientists to non-European computing facilities should be supported.

### *Data management*

Data centres are essential as an infrastructure facility in support of marine research, particularly in view of the cost and relative scarcity of observational data. Although marine research requires the deployment of an increased range of observatories to inform our knowledge of the ocean, a wealth of marine environmental data exists, which needs to be harnessed, quality controlled, assessed and made available.

Europe has a wealth of oceanographic data thanks to different bodies, such as:

- International Council for Exploration of the Seas (ICES), with its more than 100 years of data collection (gathering biological, physical, fisheries data);
- National Oceanographic Data Centres (NODCs) – and different datatypes from all disciplines;
- Regional projects focused on specific datatype;
- European part of global project e.g. EuroGOOS, prospective Euro-Argo.

Until the end of the 20<sup>th</sup> century, data management raised several problems regarding:

- Clear overview of data holdings
- Easy or uniform access to data
- Inter-operability: data have different formats, quality, etc. which impairs interdisciplinary research and cross-discipline use of data

Progress has been made in networking data centres in Europe. Today the community works towards the creation of an infrastructure to deliver data to marine and maritime related stakeholders in Europe. In that context, SeaDataNet (FP6 I3 project, 2006-2011) represents a pan-European infrastructure for Ocean and Marine Data Management. This project aims:

- *to develop and operate in a routine mode* an efficient data management system for ocean observing and forecasting programmes, able to handle the diversity and large volume of data collected via the Pan-European oceanographic fleet and the new observation systems,
- *to provide timely, coherent and integrated access* to the most comprehensive, long time-series of *in situ* and satellite marine data with emphasis on the Northeast Atlantic and its regional seas,
- *to secure long-term data archives*,
- *to avoid unnecessary redevelopment of new data management systems* for each new project and decrease or optimise the overall costs of data management;

#### 1. European approach to policy-making on research infrastructures in Europe

So far, there has been no recent EU-funded or co-funded investment known. However, plans have been made among Member States to jointly consider plans for the building of new research infrastructure. Marine research infrastructure priorities are currently considered as key elements of the European Strategy Forum on Research Infrastructure's roadmap (ESFRI = incubator for international negotiations about concrete initiatives, re. infrastructures):

- EURO-ARGO: as a future European component of the ARGO *in situ* global ocean observing system, EURO-ARGO would result in the development of some 250 buoys per year as well as the operation of the CORIOLIS data centre. First open access foreseen for 2010.
- AURORA BOREALIS: AURORA BOREALIS would be a multipurpose research icebreaker with drilling capability in up to 4000 m water depth with seafloor penetration up to 1 km. First open access foreseen for 2010.
- European Multidisciplinary Seafloor Observatory - EMSO: EMSO is intended to be a network of sea-floor observatories to be deployed on specific sites offshore of the European coastline. It would allow long-term monitoring of ocean environmental processes. First open access foreseen for 2011.
- LIFE WATCH: LIFE WATCH would construct and bring into operation the facilities, hardware, software and governance structures for research on the protection,

management and sustainable use of biodiversity. First open access foreseen for 2014.

The implementation of the roadmap is also supported by the European Commission, which provides catalytic and leveraging support for the preparatory phase leading to the construction of new research infrastructures (or major upgrades of existing ones). The preparatory phase aims at bringing the projects to the level of legal and financial maturity required to implement the project.

## Hypotheses (2020)

**1. Improved cooperation:** Europe managed to establish a consolidated structure to provide easy and free access to all European Marine Observation and Data Network (EMODNet) data and to ensure long-term, sustained funding to build the data legacy and let data really 'remain'. All marine research and observation programmes include a detailed, long-term and comprehensive data management plan. This effort is further elaborated and supported in the long term, in particular to address issues of data control, inter-operability and accessibility.

Scientists complied with the strategic requirement to advise national agencies and the European Commission on specifications for new research vessels, in order to maximise vessel use on a pan-European scale, to improve inter-operability and reciprocal access. Fisheries RVs are used for oceanographic surveys and vice versa. Co-utilisation of modern, multi-purpose vessels specialised in certain sea conditions have been fostered. The OFEG approach is to be extended to include more regional and thematic bartering systems.

**2. Poor cooperation:** Efforts to evolve harmonised data collection and data management failed at European level. Bi- and multilateral agreements no longer exist re. sharing investments and running costs of fleet and equipment. The OFEG bartering approach failed. Fragmentation and duplication rule access to research infrastructures.

**3. Privatization:** Key infrastructure facilities are privatized and leased back to institutions. Data are marketed and sold.

## Sources

### Publications:

- Navigating the Future III (Marine Board Position Paper 9, November 2006)
- European Ocean Research Fleet - Towards a Common Strategy and Enhanced Use (Marine Board position paper 10, April 2007)

### Presentations:

- Taco de Bruin (NIOZ), "Sustained data management in support of the study of ocean sustainability and global change" - presentation (Lisbon, 08/10/07)

### Websites:

- Cordis website - <http://cordis.europa.eu/infrastructures/home.html>
- EurOcean website - [http://www.eurocean.org/categories.php?category\\_no=12](http://www.eurocean.org/categories.php?category_no=12)
- MarinERA website - <http://www.marinera.net/marine/index.html>

## RESEARCH

### G4 Research Training and Management

#### Driver Definition

Policies for Education and Training form an important part of the EU's Lisbon strategy because the development of scientific and technological knowledge and literacy is a fundamental requirement in a competitive knowledge-based society. The aim of these policies is for all future citizens to acquire a basic understanding of science and technology subjects (including marine related ones) and to make studies and careers in these fields attractive for more young people, both for their own development as citizens and for the improvement of the position of Europe in a competitive global economy.

Research management refers to relationships among researchers, their employers and funders. These interactions define the conditions of employment as well as the conditions of funding and/or salaries for researchers, and the development of their career:

##### *Researchers*

Researchers are "*Professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned.*" (Frascati definition - OECD, 2002).

##### *Employers*

Researchers' employers are all those public or private institutions that employ researchers on a contractual basis or who host them under other types of contracts or arrangements. The latter refers particularly to institutions of higher education, faculty departments, laboratories, foundations or private bodies where researchers either undergo their research training or carry out their research activities on the basis of funding provided by a third party.

##### *Funders*

The term "Funders" refers to the bodies who provide funding (including stipends, awards, grants and fellowships) to public and private research institutions, including institutions for higher education.

#### Relevant Indicators

##### *Training*

- Assessment of opportunities, access, treatment and outcomes of marine science and technology in Europe;
- Expenditure on education and training on science and technology as a percentage of total expenditure on education and training;
- Expenditure on education and training on marine science and technology as a percentage of total expenditure on education and training on science and technology;
- Graduates in science and technology as a percentage of all graduates;
- Graduates in marine science and technology as a percentage of graduates in science and technology.

##### *Management*

- Employment contracts for researchers (fixed term or non-fixed term)

- Salary level according to career stages
- Incentives for career development (training, mobility, etc.)

## Developments over the past 20 years

### Human resources in Science and Technology

R&D and other S&T activities are not possible without human resources. If the R&D expenditure target of 3% of GDP is to be achieved, ensuring that there are sufficient human resources for research is a preliminary step in the right direction. To this end, the European Commission advocates increasing the proportion of researchers in the labour force from 5000 to 8000.

This section first analyses investment in education and, more specifically, investment in tertiary education. This is followed by an assessment of the number of graduates from tertiary education and the participation of foreign students in tertiary education. Finally, we provide an overview of human resources in science and technology and of R&D personnel and researchers.

#### *Investment in education*

Education and in particular tertiary education not only renews stocks of human capital but also promotes economic growth. Therefore, investment in education can be seen more as an investment in future economic wellbeing rather than as an investment in individual success. Within the EU, total public expenditure on education in 2003 amounted to 5.17% of GDP. Only 1.14% of GDP was allocated to tertiary education. However, wide differences exist between EU Member States at all levels of education, and specifically at the tertiary level. In terms of public expenditure as a percentage of GDP on tertiary education, the Nordic countries have the greatest share, with Denmark at the top (2.50%), followed by Sweden (2.16%) and Finland (2.05%). Public expenditure on tertiary education also accounts for more than 2% of GDP in Norway (2.32%). Expenditure on educational institutions from public sources represented 4.88% of GDP in EU-27 in 2003, compared with 0.63% of GDP for expenditure from private sources. Among Member States, Malta and Cyprus were the only countries where expenditure on educational institutions from private sources was >1%.

► As training may be provided in one country to meet demand from other countries, it is difficult to segment the 'market' by regions. To a certain extent this is the case for higher education.

#### *Graduation from tertiary education*

New technologies are developed and applied very quickly, so the renewal of a highly skilled workforce is crucial to managing these rapid changes in science and technology. The number of new graduates from tertiary education, particularly graduates in Science and Engineering (S&E), is a measure of the supply of human resources. In EU-27, the total number of graduates from all fields of education amounted to 3.57 million in 2004. Across all disciplines, the United Kingdom and France had the largest number of new tertiary graduates, together contributing one-third of the EU-27 total, and Poland had the third highest number. In Science and Engineering, though, the other large countries such as Germany, Italy and Spain accounted for a much larger share than Poland in the total production of new graduates.

► Higher education establishments offering marine courses total at least 241 worldwide. However, it is difficult to estimate all associated expenditure in this area because the total operating costs of institutions often greatly exceed the fees charged. In addition, it is difficult to clearly separate the educational element of institutions' activities from research activities.

- What remains unknown is the share of new graduates that actually
- Stay in the EU – brain drain towards other regions of the world
  - Enter a S&T career – skill drain towards other sector activities

#### *International mobility flows of foreign tertiary students*

With the free movement of people within the EU and also with the progress of economic globalisation, the international migration of students and/or human capital has become more

and more notable. At a European level, some 8 out of every 100 students participating in tertiary education in 2004 were foreigners. After Cyprus, where 32% of students in tertiary education were foreign, the United Kingdom had the highest European share with 16.2%. Only two other Member States – Germany and Austria – had shares of foreign students >10%. Estonia, Lithuania, Romania, Slovenia and Slovakia had very low shares of foreign students participating in tertiary education. Shares were also low in Greece, Spain, Italy, Latvia and Finland. In the field of Science the situation was similar, with Cyprus and the United Kingdom also having the highest shares of foreign students. In the field of Engineering, the share of foreign students participating in tertiary education was lower at EU-27 level. However, this was not the case for several countries, including the UK, where more than one-quarter of the students in the field were foreign.

► Education and training has a strategic role in ‘marketing’ the supplier country and its technology to foreign students.

► Marie Curie actions tend to “market” ERA to foreign researchers

#### *S&T labour force*

The role of human resources educated *and* employed in science and technology occupations (‘highly-qualified S&T workers’) is fundamental in knowledge-driven economies, because these people contribute directly to the expansion of R&D activities and to the development of technological innovations. Within EU-27, half (50.6%) the S&T human resources with a tertiary education were also *employed* in S&T. The highest shares were in Luxembourg (64.5%), Sweden (62.5%), Romania (62.4%) and Portugal (61.4%), whereas outside the EU, Iceland’s share of 71.7% was noticeably high. In 2006, highly qualified S&T workers represented 15.4% of the EU-27 labour force. At a national level, they accounted for more than one-fifth of the labour force in Belgium, Denmark, Luxembourg, the Netherlands, Finland and Sweden, as well as in Norway. As one might expect, highly R&D-intensive countries have the largest shares of core S&T workers in the total labour force.

At EU-27 level, 35.3% of highly-qualified S&T workers were aged 45–64 years. Denmark, Finland, Sweden and Germany – the four Member States with the highest R&D intensities – had the oldest population of highly qualified S&T workers, with the 45–64 years age group exceeding 40% of the total. By contrast Cyprus, Malta and Poland had shares of more than 40% of highly qualified S&T workers in the youngest age group of 25–34 years.

#### *R&D personnel and researchers*

If S&T is a key element of knowledge, the numbers of R&D personnel and, in particular, researchers are key indicators of its dissemination and development because they demonstrate the human resources going directly into R&D activities. In 2005, the EU employed more than two million R&D personnel in terms of Full Time Equivalent (FTE). This unit is a measure of the real volume of R&D performed.

Germany and France were the largest R&D employers in the EU, with more than 40% of the EU’s R&D personnel employed in these two countries. Of the new Member States, the main countries employing R&D personnel were Poland, Romania and the Czech Republic. With the exception of the Czech Republic, Malta and Romania, most R&D personnel in the new Member States were employed in the public sector (government and higher education). This is in contrast to most of the other Member States, where the private sector accounted for the highest share. Of the two million R&D personnel in the EU, approximately 60% are employed as researchers, i.e. professionals who are engaged in the conception or creation of new knowledge, products, processes, methods and systems. The most important European employers of researchers are, again, Germany and France, but the highest proportions of researchers among R&D personnel are in Portugal, Poland and Slovakia.

#### **People-Specific Programme – actions at EU level**

The ‘Marie Curie Actions’ have long been one of the most popular and appreciated features of the Community Framework Programmes for Research and Technological Development. They have developed significantly in orientation over time, from a pure mobility fellowships programme to a programme dedicated to stimulating researchers’ career development. The

'Marie Curie Actions' have been particularly successful in responding to the needs of Europe's scientific community in terms of training, mobility and career development. This has been demonstrated by a demand in terms of highly ranked applications that in most actions extensively surpassed the available financial support.

The ['Marie Curie Actions' under the Sixth Framework Programme](#) were part of the Specific Programme dedicated to structuring the European Research Area. In the Seventh Framework Programme, the 'Marie Curie Actions' have been regrouped and reinforced in the 'People' Specific Programme. Entirely dedicated to human resources in research, this Specific Programme has an overall budget of €4.7 billion over a seven-year period until 2013, which represents a 50% average annual increase over FP6 (2002–2006).

### **Rationale of the 'People' Programme**

'Abundant and highly trained qualified researchers are a necessary condition to advance science and to underpin innovation, but also an important factor to attract and sustain investments in research by public and private entities. Against the background of growing competition at world level, the development of an open European labour market for researchers free from all forms of discrimination and the diversification of skills and career paths of researchers are crucial to support a beneficial circulation of researchers and their knowledge, both within Europe and in a global setting. Special measures to encourage young researchers and support early stages of scientific career, as well as measures to reduce the 'brain drain', such as reintegration grants, will be introduced.'

The People-Specific Programme acknowledges that one of the main competitive edges in science and technology is the quantity and quality of its human resources. To support the further development and consolidation of the European Research Area, this Specific Programme's overall strategic objective is to make Europe more attractive for the best researchers.

### **Objectives of the 'People' Programme**

'Strengthening, quantitatively and qualitatively, the human potential in research and technology in Europe, by stimulating people to enter into the profession of researcher, encouraging European researchers to stay in Europe, and attracting to Europe researchers from the entire world, making Europe more attractive to the best researchers. Building on the experiences with the 'Marie Curie' actions under previous Framework Programmes, this will be done by putting into place a coherent set of 'Marie Curie' actions, particularly taking into account the European added value in terms of their structuring effect on the European Research Area. These actions address researchers at all stages of their careers, in the public and private sectors, from initial research training, specifically intended for young people, to life long learning and career development. Efforts will also be made to increase participation by women researchers, by encouraging equal opportunities in all 'Marie Curie Actions', by designing the actions to ensure that researchers can achieve an appropriate work/life balance and by facilitating resuming a research career after a break.'

### **Activities**

The People-Specific Programme will be implemented through actions under five headings:

- ['Initial training of researchers to improve mostly young researchers'](#) career perspectives in both public and private sectors, by broadening their scientific and generic skills, including those related to technology transfer and entrepreneurship.
- ['Life-long training and career development'](#) to support experienced researchers in complementing or acquiring new skills and competencies or in enhancing inter/multidisciplinarity and/or intersectoral mobility, in resuming a research career

after a break and in (re)integrating into a longer term research position in Europe after a trans-national mobility experience.

- '[Industry-academia pathways and partnerships](#)' to stimulate intersectoral mobility and increase knowledge sharing through joint research partnerships in longer term cooperation programmes between organisations from academia and industry, in particular SMEs and including traditional manufacturing industries.
- '[International dimension](#)', to contribute to the life-long training and career development of EU researchers, to attract research talent from outside Europe and to foster mutually beneficial research collaboration with research actors from outside Europe.
- '[Specific actions](#)' to support removing obstacles to mobility and enhancing the career perspectives of researchers in Europe.

## Hypotheses (2020)

**1. Unvalued knowledge:** Research has not become more attractive in 2020. European researchers are still underpaid and with limited career paths at national and European levels. The brain drain has not slowed, and Europe is losing more and more of its trained scientists without attracting foreigners.

**2. EU Marie Curie programme – a catalyst for national funds:** Acknowledging the benefits and the success of European Marie Curie actions, Member States now (in 2020) invest in Human Resources in research. National Marie Curie counterpart frameworks have been established to foster initial research training, to life-long learning and career development. The EU and the Member States train and keep more and more researchers, and continue to attract foreign researchers.

**3. Education = Research = Innovation; the “virtuous triangle” :** In 2020, the EU together with Member States have succeeded in developing the Education/ Research/Innovation triangle with three balanced poles. The research agenda is set by market interest, but research findings are freely available. There is good private–public cooperation in financing research.

## Sources

- European Charter for Researchers - Code of Conduct for the Recruitment of Researchers
- Marine Industries Global Market Analysis, Marine Foresight Series No.1 - Douglas-Westwood Limited, March 2005
- Key Figures 2007 on Science, Technology and Innovation – Towards a European Knowledge Area, DG RTD, June 2007.
- People Specific Programme - [www.cordis.lu](http://www.cordis.lu)

## RESEARCH

### G5 Communication flows (inc. IPR)

#### Driver Definition

*Communication flows between research, policy makers, sector and public opinion*

This refers to public opinion of research both in general terms and specifically in terms of fisheries and aquaculture. There is an increasing need for communication: (marine) scientists share with other stakeholders (e.g. EU MS, NGOs) the responsibility of elaborating and disseminating scientific information and analyses on issues of societal concern, recognising that they have to deal with uncertainty, complexity of the issues, and varying time-scales.

Public opinion in a way drives priorities in policy and hence also in research.

Researchers at all levels need to be familiar with national, sectoral or institutional regulations as well as contractual and legal obligations. This includes Intellectual Property Rights (IPR) regulations, and the requirements and conditions of any sponsor or funder.

IPR is the achievement of fair and equitable treatment for the inventor (researcher), funder and user. The European Charter for Researchers recommends that researchers should deliver the required results (e.g. thesis, publications, patents, reports, new product development) as set out in the terms and conditions of a contract or equivalent document.

As for the European Research Framework Programme, the ownership of the IPR rests with the partners in the research activity, and consortia are encouraged to conclude between themselves a Consortium Agreement covering such issues as IPR and settlement of internal disputes.

#### Relevant Indicators

- Public perception of research as a whole, and more specifically of fisheries and aquaculture  
*Potential source : sociological surveys - e.g. EuroBarometer*
- Material availability: publications, electronic dissemination material, television and film media, exhibition material, etc.  
*Potential source: Member State marine research organisations, EU marine education projects (MARBEF etc.), Commercial Aquaria / Marine World exhibitions.*
- IPR: level of exploitation (if any) of R&D results – number of patents

#### Developments over the past 20 years

##### EU citizens' perception of science

*General trend*

According to recent Euro barometers, 71% of EU citizens agree that collaborative research at an EU level is growing in importance and 59% consider that the EU should spend more money on scientific research. However critical messages arise from this consultation exercise:

- Europeans tend to resist certain technologies – food produced from GMO is seen as dangerous by 54% of Europeans;
- Science and technology are seen as impacting negatively on society – i.e. on the environment, or for employment (e.g. IT would eliminate more jobs than they create);
- Europeans feel poorly informed and not involved in science and technology matters.
- Europeans recognise the positive role scientists play in society, but the way they explain their achievements and handle information in the public arena is much criticised

64% of Europeans agree that their economy can only become competitive and efficient by applying the most advanced technologies available, and they acknowledge the role S&T plays in industrial development. Europeans also expect more investment in scientific research, at both national and EU levels, more intensive collaboration between researchers in Europe, and better coordination between Member States, in which the EU must play a key role.

Regarding science and technology decision making, 73% of EU citizens want politicians to rely more on scientists' skills.

#### *Fisheries and aquaculture*

No specific data are available regarding EU citizens' perception of the science of fisheries and aquaculture and related topics. However, we should assume that citizens' support and concerns would be similar to those described above regarding science in general. In addition to these general statements, though some paradoxes may be identified: on the one hand concern from public about the depletion of fish stocks, on the other hand a trend towards increased fish consumption which can partially be attributed to awareness of Omega 3 fatty acids and a clear consumer preference for wild fish and reluctance towards eating farmed fish.

From the above, we can also derive the assumption that EU citizens would welcome research in support of policy (i.e. CFP) which can contribute to the evaluation and development of management strategies – taking into account biological, environmental, technical and socio-economic aspects.

### **Education and outreach**

#### *Scientists engagement with the public – consensual recommendations*

In terms of education and outreach to the general public, marine scientists should be encouraged to communicate the implications of their work to the wider public. Given the need for increased communication, marine scientists should take on the responsibility of elaborating and disseminating scientific information and analyses on issues of societal concern, recognising that they have to deal with uncertainty, complexity of issues, and varying time-scales.

Marine scientists need to engage more with society, not only with regard to research outcomes, but also in the processes of science, drawing on peoples' natural affinity for and curiosity about the sea. Marine scientists should also be encouraged to translate their findings into information that can be used by experts from other disciplines, to support policy advice and awareness-raising initiatives. Further, marine scientists need to engage with the educational community and support the development of revised curricula, even at primary school level. Curriculum development is vital to develop a nurturing ground for future scientists, the recruitment of whom continues to decline, and yet is fundamental to securing the research and technology skills base. Well-founded education is essential to enable the next generation of scientists to meet future challenges not only in marine science, but also in its inherent topics that will become increasingly important to society as a whole. National marine institutes and university faculties, together with experts on scientific public awareness, should take an active role in elaborating and disseminating information on the latest marine scientific initiatives, discoveries, technologies and issues. This initiative should be developed in association with educational and political authorities (including local ones), professionals and representatives of industry, and the media.

### *Factors affecting science communication*

A study funded by the Royal Society, Research Councils UK and the Wellcome Trust examined the factors influencing science communication by scientists and provides a series of recommendations for actions to encourage scientists and engineers to communicate with the public, media and policy makers. The study, entitled *Factors affecting science communication*, argues that, in British universities, a 'research driven' culture, the pressure to publish research, to attract funding to their departments and build career on 'hard research' are key barriers to scientists communicating their work with the public. The study shows that scientists even think that public engagement is bad for their careers, because they believe such engagement should be carried out by those who are 'not good enough' for an academic career.

### **Level of exploitation (if any) of R&D results**

It is commonly acknowledged that Europe produces almost one-third of the world's scientific knowledge. However, Europe is currently failing to convert these achievements into commercial technologies and socio-economic innovations.

### *EU-27 world shares of scientific publications*

The EU is the world's largest producer of scientific output, as measured by its share in the total world number of peer-reviewed scientific articles. Its world share in 2004 was 38.1%, a slight decline since 2000. Among individual EU Member States, the United Kingdom, Germany, France and Italy were the biggest producers of scientific publications in absolute terms, accounting for more than 70% of the EU's scientific publication output in 2004, and some 27% of the world's output. However, most Member States contribute only very small shares of worldwide publication output. In fact, 16 Member States contribute with less or, in many cases, very much less than 1% each. Taken together, these 16 Member States only contribute some 6% of the world's scientific output.

### *R&D knowledge flows from science to technology are weaker in the EU*

There is strong evidence that, in recent years, science has become increasingly important for innovation. This trend is clear from the number of citations in patents to scientific work, the number which grew substantially in the 1990s, at both the European (EPO) and US Patent offices (USPTO). Comparing the EU with the US in this regard, however, shows that in EU countries, the linkage between patented inventions and the science base is much weaker than in the US: European science is relatively under-represented among publications that provide key contributions to technological developments. Moreover, the propensity of European technology to build upon US scientific developments is generally higher than the propensity of US technology to build upon European science. The contribution of private companies to the production of scientific publications highly cited in patents is significantly lower in the EU than in the US. Compared with the US, the EU is characterised by a low degree of involvement of private companies in the conduct of research leading to publications cited in patents.

Whereas the contribution of the public system of scientific research, i.e. universities and public research organisations, is generally comparable with the contribution of the corresponding system in the US, the fraction of scientific publications accounted for by the private system of research is considerably lower.

## Hypotheses (2020)

**1. Research in the EU – the more democratic, the less competitive:** Research findings are freely available but generally in Europe inappropriately focused. Therefore, Europe's competitiveness and growth is not fully based on creativity and ideas. On the one hand, curiosity-driven investigation can be the basis for creating new knowledge and advancing existing understanding, so leading to innovation. Such fundamental knowledge of unknown benefit can be ignored by a public-led research policy. On the other hand true innovation should be driven by private interests, which do not benefit necessarily from societal support.

**2. The more communication about its results, the more financial support marine research gets:** An informed and engaged public leads to societal debate, so opening new avenues in science:

- a transparent culture of explanation, consultation and dialogue
- researchers are hired for their specific skills as well as for their communication skills

**3. Market-driven research:** Research findings are no longer freely available. In 2020, investment in R&D has reached the 3% of GDP target in the EU, and two-thirds of these investments come from private sources. This major step towards the Lisbon strategy for growth and employment has induced a paradigm shift: researchers now report to their new funders, i.e. private companies. Research is mainly market-driven, and no longer driven by societal concerns.

**4. Research is not innovation:** In 2020 EU is still the world's largest producer of scientific output, but R&D knowledge flows from science to technology remain weak. There is an urgent need to invest on **and train** innovators as well as basic researchers. Europe suffers from a lack of the entrepreneurial spirit, and perhaps a willingness to undertake work with some risk attached. The outcome is that much if the R&D results have little application in the market

## Sources

- Survey of factors affecting science communication by scientists and engineers, The Royal Society, June 2006
- Key figures on science, technology and innovation – Towards a European Knowledge Area, European Commission (DG RTD), June 2007
- Marine related research and the future European maritime policy, European Commission (DG RTD), 2006