Making the European Fisheries Ecosystem Plan Operational

SOUTH WESTERN WATERS FISHERIES ECOSYSTEM PLAN:

WORK PACKAGE 7 REPORT

EC FP7 PROJECT # 212881

"....we need to make sustainability our primary goal; we need to base our management decisions strictly on science; we need to adopt an ecosystem approach that is geographically specified, adaptive and capable of balancing diverse social objectives....forgive me for borrowing a somewhat trite old saying: when the wind of change is blowing, some build walls, others build windmills."

Maria Damanaki

European Commissioner for Maritime Affairs and Fisheries
Brussels, 16th November 2010

Please cite as:

Borges, M.F., Mendes, H., Bloomfield, H.J., Raakaer, J., Pinho, M. R., Duchêne, J., Porteiro, C., Velasco, F., Hilly, C., Aanesen, A., Armstrong, C., Piet, G.J. and Frid, C.L.J (2011). *Fisheries Ecosystem Plan: South Western Waters.* Making the European Fisheries Ecosystem Plan Operational (MEFEPO): Work Package 7 Report.

EXECUTIVE SUMMARY

Science based fisheries management developed late in the 19th century with a narrow focus on the dynamics of fish stocks. Now, early in the 21st century fisheries management is becoming integrated into wider environmental management. The July 2011 Green Paper on the Reform of the Common Fisheries Policy (CFP) identified the need reform European fisheries management and advocated the application of an Ecosystem Based Fisheries Management (EBFM) approach to deliver ecological, social and economic sustainability, stated an intention to move towards a longer term approach to fisheries management, and made commitments to greater stakeholder involvement in management. The Marine Strategy Framework Directive (MSFD) defines environmental objectives for European seas, based on sustainable utilisation of healthy marine ecosystems in support of sustainable development, and the Integrated Maritime Policy requires that individual sectors (e.g. fisheries) need to support MSFD objectives.

The Making the European Fisheries Ecosystem Plan Operational (MEFEPO) project was conceived to further the development of a framework, and the supporting evidence base (natural and social science), required to integrate the MSFD objectives within a reformed CFP in the context of sustainable ecosystem based fisheries management (EBFM). Fisheries Ecosystem Plans (FEPs) have been developed as a tool to assist managers and stakeholders simultaneously consider the ecological, social and economic implications of management decisions within a framework supporting EBFM. The aim of FEPs is to provide managers with a strategic rather than prescriptive plan for the adoption of EBFM. Through structured interaction with stakeholders, the MEFEPO project developed this FEP for the South Western Waters (SWW) Regional Advisory Council area.

Ecosystem impacts of fishing activities on the South Western Waters

As a first step towards the development of a FEP for the SWW we assessed to what extent the ecological policy objectives for this region were compromised by fishing. For this we focussed on the four MSFD descriptors that were considered to be affected by fishing: (1) biodiversity, (3) commercial fish and shellfish, (4) foodweb and (6) seafloor integrity and attempted to assess their current status using the most appropriate available indicators.

The selected indicators were applied to the SWW Regional Advisory Council (RAC) region to (i) trial combined simultaneous assessment of environmental status across a large multi-national region to examine the practicality of operationally implementing the approach; and to (ii) attempt to assess the current status of the SWW RAC region in relation to the impacts of fishing on GES.

The two survey based indicators, the conservation status (biodiversity) and large fish indicators (food webs), could be applied across this region, and the status of commercial stocks indicator (commercial fish and shellfish) could be applied to the extent that stock assessments are available. Applying the indicator of the proportion of area not impacted by mobile bottom gears (seafloor integrity) proved problematic as VMS data is required from individual nation states and national datasets were not made available to all partners.

Whilst there are a number of limitations in terms of data availability, and lack of guidance on how to combine assessments within a descriptor and across descriptors, this preliminary assessment concluded that GES is currently compromised within the SWW RAC region by fishing activities. Thus

there is a clear requirement for Fisheries Ecosystem Plans (FEPs) to assist in working towards GES for the SWW region.

Supporting governance structure

The transition to EBFM requires appropriate institutional structures. Through structured interaction with stakeholders, the MEFEPO project developed a proposed institutional framework based on a decentralised management structure with decision-making power devolved to regional cooperating groups of Member States (MS), supported by enhanced (Regional) Advisory Councils (ACs) with appropriate scientific support, and a more collaborative approach between MS, ACs and scientists to develop management plans. Whilst the institutional structure and formal distribution of powers remains largely unchanged, this model would: enhance stakeholders' participation in management at the regional scale; facilitate stakeholder involvement in the development of management objectives and appropriate descriptors for all three pillars, and in the evaluation of management strategies; and thus give greater credibility to the management process and foster stakeholder support for management decisions.

Management strategy evaluation approach

Central to the development of the FEP is a management strategy evaluation matrix, a management support tool that allows simultaneous consideration of the potential impacts of different combinations of management measures on the ecological, social and economic status of the system. 'Descriptors' for the ecological, social and economic status of the fisheries were developed and utilised within the matrix.

Ecological descriptors were drawn directly from the MSFD and were selected at a MEFEPO stakeholder workshop as those most impacted by fishing activities (biodiversity, commercial fish, food-webs and seafloor integrity). Social and economic descriptors were defined to monitor the main aspects of fishing contributing to the economic and social wellbeing of society, in particular coastal communities. Economic descriptors focus on fishers' ability to maximise economic efficiency of fishing operations (efficiency) and minimising fluctuations in harvesting possibilities over time (stability). Social descriptors monitor employment opportunities within the catching sector (community viability) and securing catch potential for human consumption (food security).

The potential performance of a limited suite of case-study specific management strategies was evaluated against these descriptors; management strategies comprised of "business as usual" (BAU) and alternative strategies, applying different management tools. Four cases study fisheries were used as examples of matrix application within the South Western Waters SWW region: (1) *Nephrops;* (2) mixed demersal trawl fishery; (3) purse seine fishery; and (4) long line fishery. The case study fisheries examined should be seen as heuristic examples and not definitive assessments of the potential effects of different management strategies. The case study fisheries examined should be seen as heuristic examples and not definitive assessments of the potential effects of different management strategies. Matrices were completed based on best available evidence (modelled, empirical and expert judgment), which for the SWW case studies predominantly focussed on expert judgement and empirical data due to low accessibility/availability of quantitative data.

Case study fisheries

Consideration of alternative management strategies for case study fisheries indicated that there was scope to improve the status of ecological descriptors without significant deterioration in social and economic descriptors. For example, in the *Nephrops* fishery, an increase in the use of creels and associated reduction in the use of trawls was predicted to provide improvement in the status of all ecological descriptors. The strategy was also predicted to provide improvement in terms of stability of catches and food security, due to improvement in commercial stocks.

However, some of the alternative management strategies were predicted to have negative effects on the status of social and economic descriptors. For example, in the introduction of management tools to minimise discards in the Iberian mixed trawl fishery is considered to be ecologically sound due to predicted improvements in biodiversity and commercial fish stock status. However a switch to more selective fishing gears, or alternative fishing methods, may have a negative impact of efficiency and community viability in the short term.

The outcomes of these management strategy evaluations for the SWW case studies show that there is scope for EBFM in order to achieve (or at least progress towards achieving) the ecological policy objectives as stated in the MSFD. Crucially, application of the matrix approach demonstrated the complexity of interconnections among descriptors, and highlighted that trade-offs among objectives are required. Due to the nature of the trade-offs, it may not be possible to satisfy all stakeholder groups or objectives simultaneously.

Steps required for implementation of EBFM

The MEFEPO project has demonstrated the application of a management strategy evaluation matrix approach to the development of regional Fisheries Ecosystem Plans (FEPs) to help decision-makers to simultaneously consider ecological, social and economic implications of decisions, and to inform the development of ecosystem based fisheries management (EBFM) for European fisheries. Five key steps make ecosystem based fisheries management a reality for European fisheries have been identified:

- Develop long-term management plans (LTMPs) for each of the region's fisheries considering the ecological, economic and social implications for ecosystem components. LTMPS should be integrated into regional FEPs.
- Develop closer integration among stakeholders, fisheries scientists, ecologists, social scientists and economists to develop effective management advice for LTMPs. Social and economic descriptors, and appropriate (region specific) indicators, require further scrutiny and development.
- Develop qualitative assessments and expert judgement to supplement analytical modelling to meet the increased data requirements of LTMP development and make them operational in the short term.
- Ensure that the management framework is adaptive and able to respond to new information and understanding to allow decisions based on the best available evidence.

- Implement appropriate governance mechanisms that facilitate true stakeholder engagement to generate credibility in the management process and foster stakeholder support, this includes both in definition of objectives and indicators as well as the development and evaluation of LTMPs.

Fisheries Ecosystem Plans and non-technical summary documents

This report is one a series of 3 Fisheries Ecosystem Plans (FEPs) produced by the MEFEPO project; the other two FEPs cover the North Sea and South Western Waters RAC regions.

Stakeholder summary documents have been produced for each FEP to accompany this technical report and can be accessed via the project website at http://www.liv.ac.uk/mefepo/reports-and-outputs/wp7/

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GLOSSARY and ACRONYMS

BAU	Business as usual
CFP	Common Fisheries Policy
EBFM	Ecosystem based fisheries management
EC	European Commission
EU	European Union
FEP	Fisheries Ecosystem Plan
GES	Good Ecological Status (defined by the MSFD)
LFI	Large Fish Indicator
Management objectives	Overarching objectives (would be set/decided by managers/society)
Management scenario	Possible (sets of) operational targets for management
Management strategies	Management tool(s) proposed to meet management scenarios
Management tools	Input/output/technical measures
MS	Member State
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield
SBL	Safe biological limits

ACKNOWLEDGEMENTS

This research was undertaken by the EC-FP7 funded Making the European Fisheries Ecosystem Plan Operational (MEFEPO) project (Project number: 212881), co-ordinated by the University of Liverpool, UK (www.liv.ac.uk/mefepo). The MEFEPO team would like to thank our colleagues outside of the core project team, and external experts, who provided input in the development of the case study fisheries in the development of the MEFEPO Fisheries Ecosystem Plans. The MEFEPO project would like to thank all stakeholders who have taken part in interviews and workshops, and the MEFEPO Advisory Committee who provided invaluable guidance throughout the project.

1.1. European fisheries

The EU fishing industry is the fourth largest producer (fisheries and aquaculture) in the world, accounting for 4.6% (6.4 million tonnes live weight) of the global production in 2007 (EC 2010). The EU currently consists of 27 Members States (Fig. 1.1.1), and fishing and associated activities (e.g. processing) provide jobs for more than 400,000 people[1]. The number of (full-time equivalent) people employed in the fish catching sector was estimated at 141,110 in 2007 (< 0.1% of total employment in the EU[2]), with a further 126,000 (full-time equivalent) employed in the processing industry (EC 2010). The total income generated by EU fisheries sector in 2005 was EUR 10.9 billion(EC 2009a), approximately 0.1% of EU GDP; the majority of this income was concentrated in a small number of coastal areas. The overall value of the outputs of the processing industry in 2007 was estimated at EUR 23 billion (~US$ 32.5 billion), approximately 3 times the value of the catch. Spain (1.0m tonnes), France (0.8m tonnes) and the UK (0.8m tonnes) are the top 3 producers, together accounting for ~40.5% of total production (EC 2010). Spain, Denmark and the UK dominated the catches (Fig. 1.1.1; EC 2010) and Spain is by far the greatest recipient of fisheries funds, receiving almost half of EU subsidies[2].

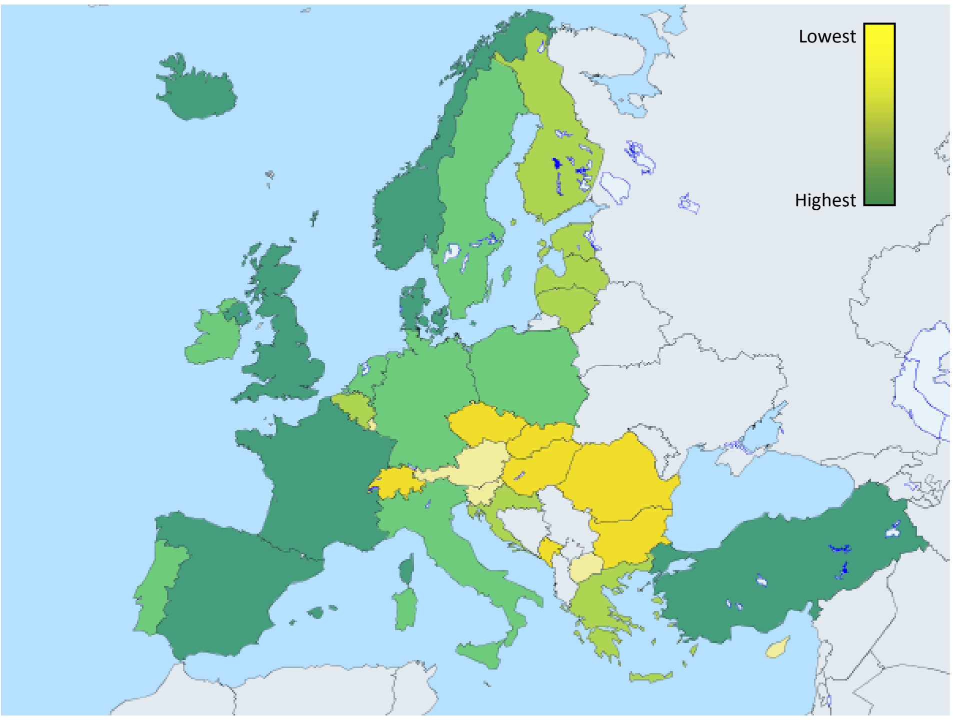


Fig. 1.1.1 Relative annual catches (based on live weight equivalent of landings) of fishery products by EU Members States, Iceland and Norway and other major fishing nations, in 2009. Data excludes any products which, for a variety of reasons, are not landed (Source: Eurostat[3]).

Employment in marine fisheries is concentrated in a handful of countries in the EU. In 2007, Spain accounted for ~25% of the total employment in the fish catching sector (35,274 full-time equivalent)

1 http://europa.eu/pol/fish/index_en.htm (accessed 07/08/11)

2 http://www.cfp-reformwatch.eu/category/top-menu/sea-facts-and-figures/ (acccessed 07/08/11)

3 http://epp.eurostat.ec.europa.eu/guip/mapAction.do?mapMode=dynamic&indicator=tag00076#tag00076 (accessed 02/08/11)

and the top 3 EU countries (Spain, Greece and Italy) accounted for 60% of EU employment in this sector. Spain, the UK and Italy lead in terms of processing value, and employment numbers in the processing sector by Member State broadly reflect processing value (EC 2010). Spain, Greece and Italy also account for ~50% of the vessels in the European fleet (EC 2010), which range from small artisanal boats focussed on activities in inshore waters to large factory ships operating in international waters.

Fleet capacity has decreased over the last 2 decades, at an annual average rate of just below 2% (tonnes and engine power) and in 2009 was estimated at 85,000 vessels (EC 2010). However, the reduction in fleet size has potentially been compensated by technological advances and increased efficiency ("technology creep") estimated at 2-4% per annum (Sissenwine & Symes 2007). Fleet overcapacity remains a fundamental problem in EU waters, with the number of vessels (and associated effort) considered to be too high for the resources available (EC 2009b; EC 2011).

The EU fleet operates worldwide but catches are predominantly taken in the Eastern Atlantic and the Mediterranean. In terms of tonnage, catches are dominated by the Atlantic herring and sprat which accounted for almost a quarter of the total landed catch (Fig. 1.1.2). However, catches vary considerably among Member States and fishing regions in terms of quantities and species caught (EC 2010; Table 1.1.1).

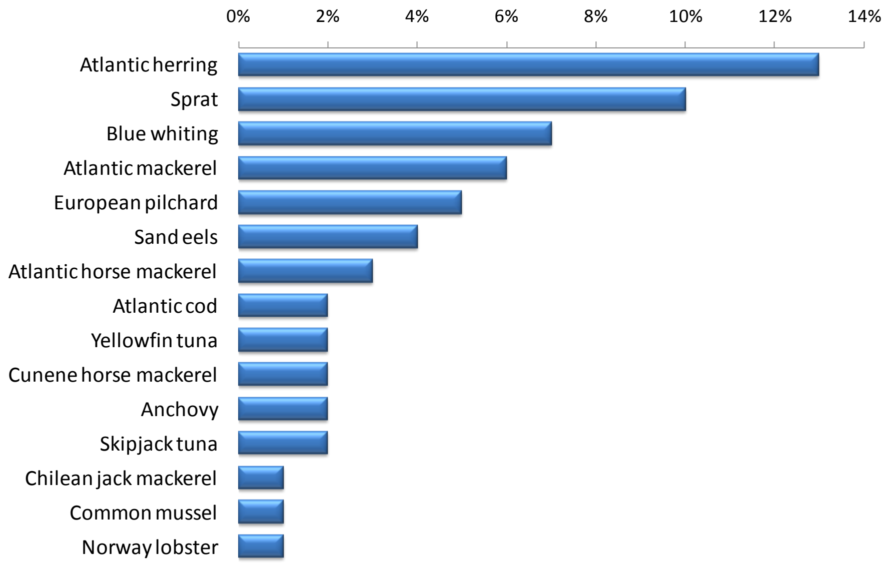


Fig. 1.1.2 The 15 main species caught and their contribution to the total EU production (6.4m tonnes based on live weight) in 2009 (EC 2010; Source: Eurostat).

Table 1.1.1 Examples of the diversity of catches by Member States based on the three main species caught by the fleet of each nation (% of tonnes (live weight) based on total catch of that species across the EU; EC 2010).

Denmark Sand eel *Ammodytes* sp. (26%) Sprat *Sprattus sprattus* (22%) Atlantic herring *Clupea harengus* (18%)	**France** Yellowfin tuna *Thunnus albacares* (8%) European pilchard *Sardina pilchardus* (7%) Skipjack tuna *Katsuwonus pelamis* (7%)
UK Atlantic mackerel, *Scomber scombrus* (22%) Atlantic herring *Clupea harengus* (15%) Blue whiting *Micromesistius poutassou* (9%)	**Portugal** European pilchard *Sardina pilchardus* (36%) Chub mackerel *Scomber japonicus* (11%) Atlantic horse mackerel *Trachurus trachurus* (5%)
Netherlands Atlantic herring *Clupea harengus* (25%) Blue whiting *Micromesistius poutassou* (20%) Atlantic horse mackerel *Trachurus trachurus* (15%)	**Spain** Yellowfin tuna *Thunnus albacares* (10%) Mackerel *Scomberomorus* sp. (8%) European pilchard *Sardina pilchardus* (8%)

1.2. Management of European Fisheries: the Common Fisheries Policy

The Common Fisheries Policy was established in 1983 (Regulation (EEC) No 170/83) to provide an integrated framework for the management of European fisheries *"....which enshrined commitment to EEZs, formulated the concept of relative stability and provided for conservatory management measures based on total allowable catches (TACs) and quotas"* (Olivert-Amado 2008). The CFP is subject to review every 10 years (Box 1), and in 1992 was reformed (Regulation (EEC) No 3760/92) with the intention of remedying the serious imbalance between fleet capacities and catch potential through fleet reduction and associated structural measures to alleviate social and economic impacts. The *"...concept of 'fishing effort' was introduced with a view to restoring and maintaining the balance between available resources and fishing activities in response to changes in EU membership and associated fleet structure".*

Box 1 Summary of the development of the Common Fisheries Policy

1970 First common measures for EU waters agreed which allowed EU fishers equal rights to exploit Member States' waters, with the exception that local fishers had exclusive fishing rights to 6 miles.

1976 MS rights were extended from 12 – 200 miles in line with international agreements in 1976; 6 to 12 miles was restricted to local vessels and vessels from MS with historic entitlements (Styring 2010)..

1983 Common Fisheries Policy (CFP) established with stated overarching aim to "*...the protection of fishing grounds, the conservation of biological resources of the sea and their balanced exploitation on a lasting basis and in appropriate economic conditions.*" (Regulation (EEC) No 170/83)

1992 First reform of the CFP stated an overarching objective to *"...protect and conserve available and accessible living marine aquatic resources, and to provide rational and responsible exploitation on a sustainable basis, in appropriate appropriate economic and social conditions for the secgtor, taking account of its implications for the marine ecosystem, and in particular taking account of the needs of both producer and consumer."* (Regulation (EEC) No 3760/92)

2002 Second reform of the CFP stated an overarching objective to *"...provide for sustainable exploitation of living aquatic resources and of aquaculture in the context of sustainable development, taking account of environmental, economic and social aspects in a balanced manner*." (Council Regulation (EC) No 2371/2002)

However, these measures were not effective; they failed to prevent overfishing and further depletion of many fish stocks accelerated. In response, the major challenge of the 2002 reform (Council Regulation (EC) No 2371/2002) was *"....tackling simultaneously the risk of collapse of certain stocks, the impact on marine ecosystems, significant economic losses for the industry, the fish supply to EU markets and the loss of jobs."* These reforms also sought to address the increasingly acrimonious and polarised positions of managers and the fishing industry. Governance reforms included the provision of greater industry scrutiny of the advisor process and the establishment of Regional Advisory Committees consisting of representatives from the commercial fishing industry and non-governmental organisations. The 2009 Green Paper on the Reform of the CFP identified key failures of the 2002 reforms in relation to overfishing and stock depletion, fleet overcapacity, continued heavy subsidies, low economic resilience and decline in the volume of fish (EC COM(2009)163 final).

Most EU fish stocks have been fished down to below levels considered sustainable, with 88% being fished beyond MSY and 30% considered to be outside safe biological limits (EC COM(2009)163 final). The 2002 Reform has also been criticised due to the absence of guidance in terms of scaling and trade-offs between ecological, social and economic objectives, and for failing to specify what timeframe should be used when considering these objectives (Sissenwine and Symes 2007). For example, long term sustainability of fish stocks has the potential to deliver long-term ecological, social and economic benefits but may have short term economic and social costs which potentially jeopardize economic and social sustainability (Sissenwine and Symes 2007).

Box 2 Five key structural failings of the CFP identified in the Green Paper on the Reform of the CFP (EC COM(2009)163 final)

1. Deep-rooted problem of fleet overcapacity;
2. Imprecise policy objectives resulting in insufficient guidance for decisions and implementation;
3. Decision-making system that encourages a short-term focus;
4. Framework that does not give sufficient responsibility to the industry; and
5. Lack of political will to ensure compliance and poor compliance by the industry.

The recently published Communication on the 2012 Reform of the CFP (COM(2011) 417 final) states an overarching objective,

> "*By bringing fish stocks back to sustainable levels, the new Common Fisheries Policy (CFP) aims to provide EU citizens with a stable, secure and healthy food supply for the long term. It seeks to bring new prosperity to the fishing sector, end dependence on subsidies and create new opportunities for jobs and growth in coastal areas. At the same time, it fosters the industry's accountability for good stewardship of the seas.*"

1.3. Ecosystem based management and integration of the CFP with other marine policies

The concept of Ecosystem Based Management (EBM) has been recognised in a number of international agreements, and derives from the 1992 Convention on Biological Diversity and the subsequent 2002 World Summit on Sustainable Development. EBM is also central tenant of the FAO (UN) Code of Conduct for Responsible Fisheries (FAO 1995), and new policies are being developed in response to these drivers to integrate management across sectors (e.g. Canada's Oceans Act 1997; Australia's Oceans Policy 1998; DEFRA 2002; EC COM(2008) 187) rather than focussing on a particular sector (Pascoe 2006). Fisheries management can no longer be seen in isolation and the 2008 (COM(2008) 187) and 2011 (COM(2011) 417 final) Communications on the Reform of the CFP acknowledge the interaction between fisheries and other maritime sectors, highlighting the importance of ecosystem based approach to marine management, covering all sectors, and states:

> "*The future CFP must be set up to provide the right instruments to support this ecosystem approach."* (COM(2008) 187)

Within the EU, the cross-sectoral approach is being pursued under the Integrated Maritime Policy (IMP; COM(2007) 575 final) which has been implemented to take account of the multiple pressures from the different sectors and address interactions between European policies and maritime affairs (EC 2007). The Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) forms the environmental pillar of the IMP and is the thematic strategy for the protection and conservation of the marine environment "*with the overall aim of promoting sustainable use of the seas and conserving marine ecosystems*" (EC 2008). Economic and social sustainability are acknowledged as dependent on productive fish stocks and healthy marine ecosystems, and the Green Paper sets out a commitment to manage European fisheries within the constraints of the MSFD to achieve good environmental status (GES), defined as,

> "*environmental status of marine waters where these provide ecologically diverse and dynamic oceans which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations…*" (Article 3(5); EC 2009b).

The EU is a signatory to 2002 World Summit on Sustainable Development target for fish stocks to be exploited at maximum sustainable yield (MSY), and achievement of this objective would also enable the reformed CFP to contribute to achieving GES in the marine environment, in line with the provisions of the MSFD (EC 2011).

Commitments through OSPAR and the 2002 World Summit on Sustainable Development call for the establishment of a representative network of marine protected areas (MPAs) by 2012 to help restore degraded marine ecosystems and fish stocks to sustainable levels (WSSD 2002; Pita *et al.* 2011), and there is growing support for zoning of marine activities in the context of ecosystem based marine management (Charles 2001).

1.4. Developing Ecosystem Based Fisheries Management: Fisheries Ecosystem Plans

The 2009 Green Paper on the Reform of the Common Fisheries Policy (EC 2009):

- identified the need for ecosystem based fisheries management (EBFM);
- stated an intention to move towards a longer-term approach to fisheries management;
- made commitments to greater stakeholder involvement and management to support the three pillars of sustainability: ecological, social and economic.

Understanding of the links between ecological, social and economic systems is essential in order to ensure that management decisions are appropriately informed. One of the greatest challenges of management, and to managers, is finding ways to achieve objectives simultaneously; in practice achieving multiple objectives is difficult and trade-offs have to be considered.

In the US, Fisheries Ecosystem Plans (FEPs) were developed to further the development of the ecosystem approach in fisheries management as a tool to assist managers to consider the ecological, social and economic implications of their management decisions (Fluharty *et al.* 1999). The core concept of the Making European Fisheries Ecosystem Plans Operational (MEFEPO) project is the development of operational Fisheries Ecosystem Plans (FEPs) for three regional seas (North Sea, North West Waters and South West Waters) to support the transition to EBFM, building upon lessons learned from previous EU project (e.g. European Fisheries Ecosystem Plan, EFEP, completed in 2005) and international experience (e.g. Fisheries Ecosystem Planning for Chesapeake Bay[4]).

The aim of FEPs is to provide managers with a strategic rather than prescriptive plan for the adoption of EBFM. FEPs are thus a guide for use in FM planning and development (or amendment of fisheries management plans), and should realistic, focussing on critical features and processes of ecosystem vital in managing fisheries resources (Link 2002).

1.5. Making the European Fisheries Ecosystem Plan Operational

The Making the European Fisheries Ecosystem Plan Operational (MEFEPO) project team has been supported by an Advisory Committee, consisting of senior figures from the industry and management organisations, engagement with 4 Regional Advisory Councils and stakeholder interviews and workshops. Through structured interaction with stakeholders, the project has developed Fisheries Ecosystem Plans (FEPs) for three regional seas (North Sea, North West Waters and South West Waters) to support the transition to EBFM. These regions were selected as they represent a range of challenges in terms of: knowledge; data availability; the number of national interests; spatial extent; and a broad range of physical and biological characteristics.

Central to the FEPs is a management strategy evaluation matrix, developed with stakeholders (see van Hoof *et al.* 2011), which can be used to explore the potential impacts of different combinations of management measures on ecological, social and economic descriptors, and assist managers to understand the ecological, social and economic implications of their decisions. This management

4 February 2004 the FEP was published [provide details].

support tool is demonstrated using case study fisheries within each region (Table 1.5.1) and gaps in knowledge (ecological, social and economic) which may limit the ability to successfully implement EBFM are identified.

Table 1.5.1 Regional Advisory Councils and associated case study fisheries

North Sea	**North Western Waters**	**South Western Waters**
Mixed flatfish beam trawl	North East Atlantic mackerel	Purse seine fishery
Sandeel industrial fisheries	Dublin Bay prawn (*Nephrops*)	Mixed demersal trawl fishery
Herring pelagic fisheries	Northern hake	Mixed demersal line fishery
Cod-otter trawl fishery	Scallops	*Nephrops*

This report focuses on the South Western Waters and case study fisheries and is one a series of 3 Fisheries Ecosystem Plans (FEPs) produced by the MEFEPO project; the other FEPs focussing on the North Sea and North Western Waters RAC regions. Stakeholder summary documents have been produced for each FEP to accompany this technical report and can be accessed via the MEFEPO project website at http://www.liv.ac.uk/mefepo/reports-and-outputs/wp7/

Whilst the geographical focus of the FEPs is different, the structure remains the same and draws upon the wealth of information and outputs from the MEFEPO project, consisting of:

- Section 3 provides an overview of the critical ecological, economic and social ecosystem components of the South Western Waters;
- Section 4 provides a summary of the ecological state of the South Western Waters ecosystem;
- Section 5 examines the regional case studies and provides an introduction to the fisheries and state of the stock, current management tools and performance, evaluation of alternative management strategies against ecological, social and economic descriptors, and management guidance; and
- Section 5 considers the next steps required for implementation of EBFM.

The MEFEPO project has also examined stakeholder views on the governance and institutional frameworks in European Fisheries (Raakjaer *et al.* 2010) and, with stakeholders, developed an operational model for a regionalised CFP to support successful implementation of an EBFM in Europe (van Hoof et al. 2011). The proposed model is common to all of the FEPs and is presented in Section 2.

2.1. Governance challenges

Although the extent of the failure of the Common Fisheries Policy (CFP), the fisheries policy framework of the EU, can be debated, it is clear that the policy has not delivered satisfactory results. Recent reflections on the CFP (Sissenwine & Symes 2007), the Green Paper (EC 2009b) and Raakjaer (2009) paint a rather depressing picture of the performance of the CFP. Many fish stocks are fished to the limits and some stocks are overfished and on the brink of collapse, although it should be noted that there is evidence of improvements in some small pelagic stocks following implementation of long-term management plans (LMPs). The EU fisheries sectors are characterised by poor profitability with sector employment steadily declining according to the Commission (EC 2009b) . In addition, the EU fishing sector is facing intensive competition from freshwater and marine aquaculture production, making the market extremely competitive. The lack of success of the CFP is primarily caused by a lack of political will and ability among Member States to reduce fishing efforts and alter the present management path (Hegland & Raakjaer 2008). Further shortcomings of the present CFP that need to be considered when reforming the governance system by the end of 2012 include:

- Lack of clear principles and long-term objectives
- Mismatch between the scale of the governance and the ecological systems
- A tendency to apply one-size-fits all-solutions
- Micro-management trap
- Low legitimacy among fishermen
- The type of co-management introduced has not led to responsible behaviour among fishermen
- Problems of 'implementation drift' and inconsistent enforcement exist in the member states
- Discrepancies in the ways administrators and fishermen view the goals and means of the management regime

Over the last couple of years, *the governance option of regionalising the Common Fisheries Policy* (CFP) has become one of the hot topics in the debate about the content of the upcoming reform of the CFP. The recent Green Paper from the Commission has been instrumental in putting regionalisation firmly on the reform agenda. Spurring from the nature of the shortcomings facing the CFP and the focus of public discussions on introducing new modes of governance generally to the EU, discussions of further regionalisation of the CFP (in line with the principles of subsidiarity) have increased considerably over the years. Stakeholders, researchers, administrators, and politicians still struggle to find long-lasting and innovative solutions to put the CFP on a sustainable track and create a governance structure that facilitates the move towards ecosystem-based fisheries and marine management in accordance to the Johannesburg Declaration (United Nations 2002).

2.2. Meeting the governance shortcomings of the CFP

Understanding the structural failures of the CFP is closely related to the mismatch in scales of governance, particularly the lack of ability to find the 'right fit' of scales for governance intervention. Additionally, allocating power and responsibility to the best-suited scale of governance in line with the principle of subsidiarity has become an increasingly challenging task in the light of adopting ecosystem-based management in EU fisheries. Regionalisation has been seen as one answer to solve this problem.

Regionalisation of the CFP has been discussed at varying intensities beginning in the mid-1990s (e.g. Symes 1997) through the 2002 CFP reform, which made the first move in this direction by establishing Regional Advisory Councils (RACs). Since 2004, seven RACs have been established, organised along either specific sea areas roughly corresponding to large marine ecosystems (Baltic Sea RAC, North Sea RAC, South Western Waters RAC, North Western Waters RAC and Mediterranean RAC) or specific types of fisheries (Pelagic RAC and Distant Waters RAC). The RACs were introduced to provide a forum for stakeholders to discuss particular issues in their region and bring attention to those issues and convey advice to managers and decision-makers in the central EU institutions as well as the member states.

The discussions on regionalisation of the CFP are complex and compound. In Raakjær *et al.* (2010), we focused attention on the issue of regionalisation of the CFP by identifying and organising explanations for why particular actors with an interest in EU fisheries management would want to (or not want to) regionalise the governance system. Strikingly, the discussions of regionalisation in relation to the CFP have shown that the concept has been employed in both a multi-faceted manner—in the sense that it subsumes several discussions under one heading—and in an ambiguous manner—in the sense that as a description of a way of governing, it means different things to different people. In short the concept of regionalisation subsumes three interrelated discussions pertaining to who, where, and what—although achieving this separation can be difficult in practice.

The discussion of where to regionalise is related to the relative importance of different geographical levels in a perceived politico-administrative hierarchy of the CFP. The governance system of the CFP operates across three politico-administrative levels: the member state level, the intermediary level of regional EU seas (or the RAC areas), and the EU central level. One of the present challenges is that the scale of the governance system often does not correspond to the ecological system being managed. Matching the scale of the natural system with the scale of the governance system is essential and this supports calls for regionalisation in the shape of strengthening the intermediary (generally sea basin) level between the EU central level and the member state level.

The discussion whom to regionalise to has primarily focussed on the extent to which stakeholders should be involved in the fisheries management process of the CFP or merely subject to it. In the EU it is commonly accepted that those dependent on fishing for their livelihood ought to be well-represented in the management process. In scientific fisheries management literature, many different setups for devolution of management exist. Hegland *et al.* (2012) describes five different setups: 1) Top-down hierarchical management by the state where mechanisms for dialogue with users and stakeholders might exist, but only minimal exchange of information takes place and EU/National governments decide what information to share. 2) Co-management by consultation where extensive formal mechanisms for consultation (and feedback on use of recommendations) with users and stakeholders exist, but all decisions are taken by EU/National governments. 3) Co-management by partnership where EU/national governments, users, and stakeholders cooperate as decision-making partners in various aspects of management. 4) Co-management by delegation where EU/national governments have devolved de facto decision-making power to users and stakeholders in relation to various aspects of fisheries management. And 5) industry self-management with reversal of the burden of proof where government has devolved wide-ranging management authority to users and stakeholders, who must demonstrate to EU/national governments that management decisions are in accordance with the given mandate.

The question of what to regionalize has mainly evolved around what tasks need to be kept at a central level and which can be devolved. Many different kinds of decisions have to be made in European fisheries management. The decisions can be ordered in a system starting at the top layer, which covers the general conditions and frameworks (e.g. the Basic Regulation of the CFP), going down to a layer that contains policymaking and management plans (e.g. stock recovery plans), and finally down to a layer of formulation of the national obligations (e.g. distribution of quotas or days-at-sea). In reality the layers interact and are difficult to separate (there may even be more layers). However, the layers help to visualise the management; as you go down the layers, the number of details in the regulation increases but the span of influence decreases. Currently the CFP suffers from an approach to governance that requires the upper levels to take decisions on detailed issues (e.g. mesh sizes) with little span of influence in specific sea areas.

Given the complexity and multidimensionality of regionalisation of the CFP, there are a number of different ways in which the political aim of regionalisation could be made operational. We initially focused on five different models of regionalisation; 2 of the models (Regional Fisheries Management Organisation and Regional Fisheries Co-Management Organisation) were identified as having the greatest stakeholder support following interviews with RAC participants (Raakjaer *et al.* 2010). Each of these 2 models has advantages and disadvantages, but implemented in the right way any of these models could be put into practice and deliver many of the benefits that people are seeking in relation to regionalisation. It is notable that both models build on the matching of ecosystem scale and governance levels and therefore, in contrast to the current system, could facilitate the adoption and implementation of regionally distinct, tailor-made management approaches.

It is important that the chosen model can work as a common framework for all regions but also that the model incorporates flexibility to accommodate regions who develop their own regional governance approach. Based on our findings it seems likely that for some time it will be necessary to retain the 'default option' of the present system to allow regions who do not current have the capabilities/resources to take on extra authorities presented by a more ambitious model freedom to mature and develop at their own pace.

2.3. Operational challenges – and their regional differences

2.3.1. Legal challenges

It is important to note that some models for regionalisation may pose legal challenges due to the Lisbon Treaty. Long (2010) describes the uncertainty about the legal limitations imposed by the overall policy framework of the Lisbon Treaty in relation to increasing the regional scope of the governance system of the CFP.

However, the legal challenge is also considered one of the defining elements of the regionalisation debate; the question of the level of de facto authority that the regional level should have. There are differences in opinion on this, one position being that the member states cooperating at the regional level should be in a position—although subject to approval at the central level—to decide on vital issues such as whether and how to use quotas and/or effort regulation to reach long-term management targets. At the other end of the spectrum, it has been argued that the regional structure should basically be restricted to something that can facilitate member states cooperation on issues of implementation.

2.3.2. Challenges of increasing administration costs

Regionalisation of the CFP is likely to increase the administrative costs of the management system and the costs for stakeholders participating in the management processes. Both stakeholders from the fishing industry and managers from the national administrations have expressed concerns in this regard (van Hoof *et al.* 2011).

These costs could be mitigated by shifting towards a management approach where the industry carries a larger share of the burden of management by introducing result-based management, possibly combined with reversal of the burden of proof. In general this approach entails that the industry is presented with certain targets or limits that they have to comply with and—as long as respecting those limits—the industry itself may decide on how it wants to do management. If this is combined with a reversal of the burden of proof, the industry itself would have to cover the costs of documenting that they are within the limits. This way of perceiving regionalisation also links it to the issue of financial efficiency by giving the industry more manoeuvrability and self-determination with the caveat that the industry takes over (some of) the costs associated with fisheries management.

2.3.3. How can the institutional set-up foster ownership and facilitate compliance of management measures?

It is not only the direct, goal-achieving value of more tailor-made management from regionalisation that is important; the value of regionalisation also responds directly to another key problem of low legitimacy of the CFP, which has contributed to the failure to cultivate a culture of compliance. It is important to distinguish between two kinds of legitimacy when discussing fisheries management: process (or procedural) legitimacy refers to the legitimacy that fisheries management measures derive from being the product of a governance process perceived as fair and just (Jentoft 1989; Jentoft 1993; Jentoft & McCay 1995; Raakjaer Nielsen & Mathiesen 2003); and content legitimacy broadly refers to the legitimacy that a measure can derive from being perceived as reasonable and appropriate by those subjected to it or with an interest in it. Many stakeholders perceived that a regionalised governance process has the potential to strengthen the process legitimacy of the CFP and the improved outputs capable of strengthening the content legitimacy—at best this could break the cycle of failed management, low legitimacy, and non-compliance that the CFP has for long found itself in.

2.3.4. Challenges of differences in the organisational capabilities of various stakeholders

Major differences exist among EU member states on many levels, e.g. culture, framework conditions, organisational structures. Regionalisation of the CFP poses a new set of institutional and structural challenges for the stakeholders involved as well as for the governments of member states. In the southern part of Europe, the fishing fleets are composed of many small scale actors and their capacity is considered to be relatively weak. In contrast, in northern Europe the traditions and mechanisms for decentralised decision making are much stronger. These differences have to be considered when making an operational model for a regionalised CFP and the incentives for tailor-made management to suit regional needs minimising one-size-fits-all solutions.

2.3.5. Experiences from the RACs

A key focus of the MEFEPO project is how best to make current institutional frameworks responsive to an ecosystem approach to fisheries management at regional and pan-European levels in accordance with the principles of good governance. The principles of fisheries policies and management (CFP) should be consistent with and complement other EU legislation (e.g the Marine Strategy Framework Directive (MSFD), Habitats Directive etc.) rather than additive or contradictory. However, for the development of Fisheries Ecosystem Plans one does not necessarily have to involve all the other industries in the marine environment.

The RACs are relatively new bodies created by the 2002 CFP reform. The RACs consist of fisheries stakeholders mainly the fishing industry and eNGOs. As such the RACs are naturally oriented towards fisheries and are maturing as fisheries advisory bodies. This process presents a number of internal challenges (see below), however, this process is under pressure as fisheries is just one of the many sectors exploiting the marine environment and environmental Non-Governmental Organisation (eNGOs) are pushing for more restrictive regulations o protect the marine environment. Thus questions are being asked as to whether the RACs can continue to operate as a stand-alone advisory body or will be ‘forced’ to merge into more integrated marine co-management bodies with broader representation. If so, how could or should this be achieved? Unfortunately, these questions are outside of the remit of the MEFEPO project due to our focus on fisheries management; however it is clear that the RACs will play a key role in the future for wider marine ecosystem based management.

Various stakeholders (e.g. industry representatives and eNGOs) and both EU and national managers participated in an email survey on regionalisation and the work of the RACs. In the questionnaire, the respondents were asked for their views on a number of challenges for the RACs including: ‘reaching consensuses’, ‘communicating in different languages and across cultures’, ‘balancing small-scale vs. large-scale fishing priorities’, ‘addressing different national catching sector priorities’, ‘responding to specific advice requests’ and, ‘cultivating better cooperation between industry and non-industry interests’. The survey totals 138 observations, of which 100 participants completed an online questionnaire, 30 completed a paper version, and eight partially responded online providing enough answers to merit inclusion. The response rate for the survey stands at 41.9 % (138/329). The respondents were asked different questions in the survey: basic questions about their background and their way of working, questions on their views on different models of regionalisation, questions on their view on the RACs work and the challenges of the RACs. The answers from the last group of questions that are synthesized below focusing on the regional differences between the RACs (Table 2.5.3.1).

Table 2.3.5.1 The table shows the averages of the rankings of the challenges for each of the RACs and the overall average. Respondents are asked to state how challenging they find various aspects of the RACs from one (very easy) to five (very difficult); hence the average is three. The table shows the averages in the answers from each RAC – green marks that the average is 'below 3' (easy or very easy) and red marks that the average is above three (difficult or very difficult).

	Reaching consensuses	Balancing small-scale vs. large-scale fishing priorities	Addressing different national catching sector priorities	Responding to specific advice requests	Communicating in different languages and across cultures	Cultivating better cooperation between industry and non-industry interests
NWW RAC	4.00	3.45	3.63	3.44	3.00	3.60
SWW RAC	3.78	3.77	3.27	2.91	2.60	3.52
NS RAC	3.60	3.38	2.83	3.45	2.67	3.67
Pelagic RAC	3.38	3.36	3.32	2.95	2.76	3.16
All RACs	3.72	3.52	3.29	3.19	2.76	3.51

2.3.6. The experiences on reaching consensuses

RACs were put in place as advisory bodies as an initial step toward more stakeholder participation in developing EU fisheries policy. The idea being that the stakeholders on a RAC will seek consensus on issues to do with fisheries management and policy, and thereby allow DG MARE to weigh the political advantages of following the RAC's consensus against any differences between the consensus and other preferences of DG MARE (Hegland & Wilson 2009). Hegland (2009, p. 13) argues '*…the main tool of the RACs in relation to gaining an impact on the decision-making process remains the alternative instrument of consensus-building: in the first instance the RAC needs to build consensus among the various stakeholder groups within it; at the same time, however, the RAC needs to anticipate the Commission's position so that the RAC's consensus does not fall too far from that. If a consensus or a 'close-to-consensus' can be found between the RAC and the Commission, it could be argued that the member states (or smaller groups of member states) in the Council would find it politically too costly to overrule that consensus. It could be argued that this represents a dispersion of power from the central state governments to other actors, i.e. the Commission and the RACs, which are in turn becoming increasingly interdependent (vertical and horizontal interdependence)*'. Indicating the RACs can gain political impact if they could reach consensus or at least establish a situation of 'close-to-consensus'.

Despite the potential for increased political impact – or perhaps because of it – respondents in all four RACs ranked 'reaching consensus' as one of the two most difficult challenges; this challenge was ranked most difficult by respondents in the NWW RAC and least difficult for respondents in the Pelagic RAC.

2.3.7. The experiences on balancing small-scale vs. large-scale fishing priorities

Along with fostering consensus, the SWW RAC has the greatest difficulty with ‘balancing small-scale versus large-scale fishing priorities’. A majority of the SWW respondents rank the measure somewhat difficult to ‘very difficult’; while in the other RACs such answers less than half of responses. In addition to the difficulty, a quarter of the SWW participants select this challenge as the most critical to the RAC’s success. Notwithstanding, geographic affiliation highlights a starker contrast for the difficulty associated with the proposed obstacle. A third of the survey participants from the North rate the challenge as more difficult than neutral; in comparison two thirds of those from the South rank it as more difficult than neutral. Like in the case of the SWW RAC, more than a quarter of the 52 South category participants believe the issue of scale is the most critical to the RAC’s success while none in the North category regard scale as the most important challenge.

This challenge demonstrated one of the more pronounced cleavages between northern (e.g. NS and NWW RACs) and southern (SWW) perspectives among our results.

2.3.8. The experiences on addressing different national catching sector priorities

‘Addressing different national catching sector priorities’ was identified as a key challenge within the NWW RAC while the NS RAC stands apart from the other three RACs on this measure because of the below average. Two thirds of the NWW respondents rank the challenge as somewhat ‘difficult’ to ‘very difficult’ compared to approximately one quarter of the NS RAC respondents. Nearly half of the Pelagic RAC respondents ranked this challenge as neutral. Half of the NS RAC respondents found the challenge of addressing different national catching sector priorities ‘somewhat easy’ or ‘very easy’; whereas few respondents from the other RACs (NWW, SWW and Pelagic) selected these responses.

2.3.9. The experiences on responding to specific advice requests

There was disagreement among RACs on the difficulty of “*responding to specific advice requests (‘fire fighting’)*”. Respondents from both the NS and NWW RACs experienced greater difficulty with this challenge compared to those from the Pelagic and SWW RACs. It could be speculated that this divide is due to the precarious situation of several stocks in the NS, and to a lesser extent the NWW, has led to more demands on providing advice to specific requests, often referred to as ‘fire fighting’, compared to the Pelagic and SWW RACs. However, few participants from each of the RACs selected this challenge as the most critical; highlighting that is in any case not one of the most salient issues to RAC participants

2.3.10. The challenge of communicating in different languages and across cultures

The survey included a question on the difficulty of ‘*communicating in different languages and across cultures*’ to examine whether RACs with more diverse composition of countries and languages, such as the NWW RAC, struggle with this factor more than a RAC that is able to communicate almost entirely in one language, for example, the NS RAC where English is the dominant language. To a degree this question also gauges the North-South divide without explicitly naming the ostensible phenomenon. The mean score for the NWW RAC as higher, indicating that communication was perceived as more of a challenge for this RAC than the NS, Pelagic and SWW RACs. However, the NWW RAC mean score reflected a neutral rating overall. Therefore, communicating in different languages and across cultures does not seem to pose a major challenge in the perception of participants for any of the RACs. Somewhat surprisingly the SWW RAC averages the lowest in terms of difficulty, but is in close proximity to the North Sea RAC and the Pelagic RAC averages; moreover, there is little difference in the frequency distribution of answers along North-South lines. Communicating in different languages and across cultures does not seem to pose a major challenge in the perception of participants for any of the RACs.

2.3.11. The experiences on cultivating better cooperation between industry and non-industry interests

Survey responses indicated that all RACs struggle with the challenge of "cultivating better cooperation between industry and non-industry interests". This challenge is closely related to the challenge of 'reaching consensus' as it is – most frequently – the industry and non-industry stakeholders' positions that are hard to combine. Respondents from the NS RAC ranked this challenge the most difficult challenge of all challenges presented but the NWW RAC and SWW RAC fall close to the overall mean. These results from these three RACs are fairly close; however the Pelagic RAC averages the lowest of the RACs on the industry and non-industry challenge. Probably the main explanation for this situation is that the industry stakeholders pre-dominate the composition of Pelagic RAC respondents with few other stakeholders counterbalancing. The Pelagic RAC's small size and relative stakeholder homogeneity may also contribute to the tightness of the range in difficulty for the presented challenges.

2.3.12. Differences in experiences between the RACs

There is no significant association between the choice of most critical challenge and the RAC membership; however, the North-South divides proved a strong relationship. Overall, respondents from NS, NWW, and Pelagic RAC ranked the consensus measure and the cooperation between industry and non-industry members as the first or second most critical challenge to the RAC's success (approximately one third of respondents within each RAC). While SWW participants recognise reaching consensus as a critical challenge, a higher proportion of respondents from this RAC (25%) selected 'balancing small- versus large-scale priorities' as the most critical challenge. The North-South divide demonstrated division over scale; none of the respondents the north (NS, NWW, and Pelagic RAC) viewed scale as the most critical issue, compared to more than a quarter of the respondents from the south (SWW). There was also significant association between geographic affiliation and the most critical challenge, with respondents from the north more concerned about consensus and cooperation between industry and non-industry members, and respondents from the south more concerned about scale issues (82% of respondents in this region ranked this as the most critical issue). The challenges of 'reaching consensus' and 'addressing different national catching sector priorities' were also considered to be critical by respondents from the south.

2.4. Operational model for a regionalised CFP[5]

The suggested model for regionalisation by establishing Decentralized Fisheries Management Boards (DFMBs) is drawing closely on the model Raakjaer *et al.* (2010) labelled "Cooperative Member State Council" and what Symes (2009) labelled "Standing Conference of member states administrators". The DFMB model this was developed with stakeholders from a range of backgrounds and regions as part of WP6 (van Hoof *et al.* 2011). This model will largely keep the institutional structure and formal distribution of powers unchanged. The model is based on voluntary agreements, soft law and de facto authorities based on quality of input rather than de jure authority to take decisions. Thus, regionalisation will have to be seen in the light of implementation, where the Council and the Parliament will take all essential decisions and set the high level objectives.

The aim of Fig. 2.4.1 is to illustrate how regionalisation of the CFP could be institutionalised. Regionalisation is considered a vehicle to overcome the present shortcomings of the CFP and not a mean in itself. It is acknowledged that the move to ecosystem approaches in fisheries management requires appropriate geographical scale, both in terms of the eco-system per se and the governance system responsible for management. Regionalisation, as outlined here, would be a step towards introducing tailor-made regulations based on an understanding of the dynamics of specific fisheries and ecosystems and creation of an institutional framework wherein the CFP becomes a suite of de facto eco-region fisheries policies to address many of the political challenges the CFP is currently facing.

[5] In MEFEPO WP 4 (Raakjaer *et al.* 2010) a set of models for regionalisation of the CFP developed and tested by stakeholders in four RACs (NWW, SWW and NS and Pelagic) and two/three models emerged to have potentials. These were presented and discussed at a workshop with broad stakeholder representation a part of WP 6 (van Hoof *et al.* 2011) and that lead to shared agreement among stakeholders and project scientists for proposing one model. It is important to remember that in the drafting this document we have no knowledge about how proposal from the Commission on the CFP reform will deal with regionalisation.

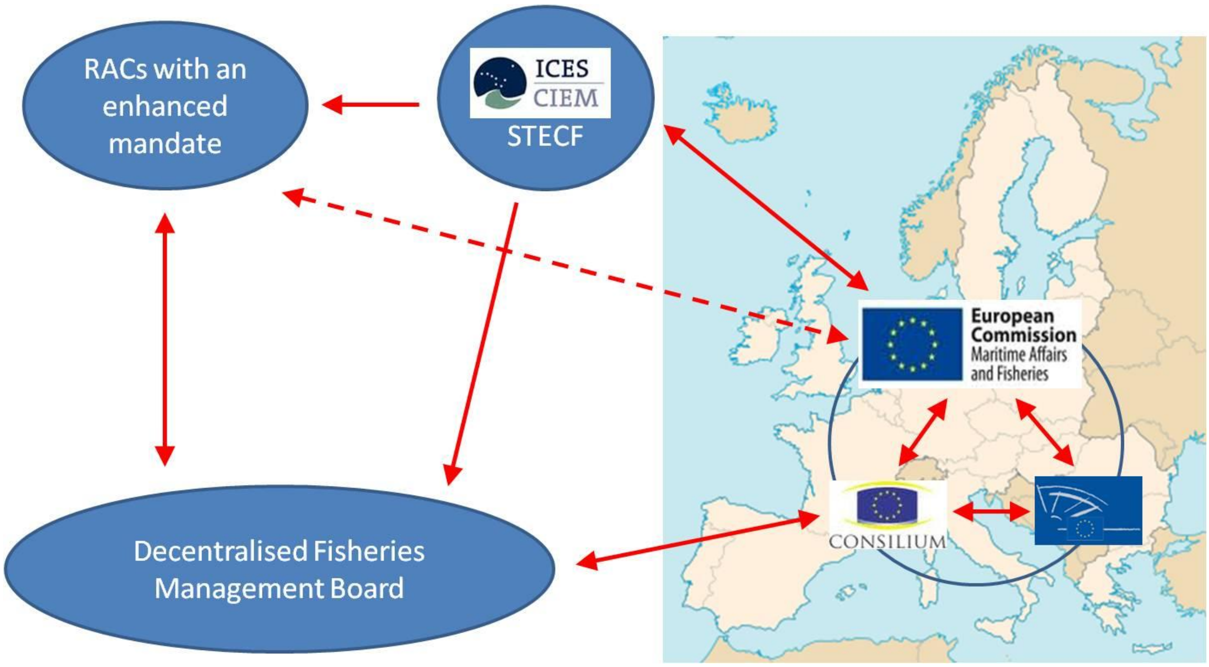


Fig. 2.4.1 Governance model for regionalisation of the Common Fisheries Policy developed by stakeholders at the MEFEPO workshop in Haarlem, April 2011. Decentralised Fisheries Management Board (FMB) similar to the 'Cooperative Member State Council' model put forward by Raakjaer *et al.* (2010) but supported by RACs with an enhanced mandate.

Based on development with stakeholders, the MEFEPO project recommends that Decentralised Fisheries management Bodies (DFMBs) are established for each of the existing 5 geographical RACs (Baltic Sea, North Sea, North Western Waters, South Western Waters and Mediterranean Sea) and for the two RACs (Long Distance Waters and Pelagic) dealing migratory stocks covering more than one of the present geographical RAC areas (Long Distance Waters and Pelagic). DFMB would address fisheries management issues specific to their geographic area or stock, and member states with fishing interests in a regional sea or migratory stocks would become members of the respective DFMB. The mandate of the DFMBs would be to draft long term management plans (LTMPs) and establish implementation strategies and thus become de facto involved in drafting proposals. This setup is close to what has previously been described as co-management by informal partnership (Raakjær *et al.* 2010), and would provide RACs with an enhanced mandate to be involved in the decision-making process and create incentives for tailor-made management to suit regional needs reducing off-the-peg and one-size-fits-all solutions in European waters. This framework between the EU institutions and the member states would enable the model to meet the shortcoming of 'implementation drift' and lack of enforcement that exists in the member states.

The DFMB provides proposals to the Commission on LTMPs and their implementation. The DFMBs will consist of members from fishing member states and observers from enhanced RACs. The exact numbers depend on member states having fishing interests in the management area. The DFMBs would forward their recommendations for LTMPs and implementation to the overall EU Fisheries Council for formal approval. RACs with enhanced mandate make recommendations to the DFMBs and the Commission.

RACs would become a working group for DFMB, and indirectly to the Commission, and provide input to and suggestions for LTMPs and their implementation. RACs would also identify and put forward requests for provision and improvement of scientific advice. In most cases, the enhanced RAC would advise the DFMBs rather than the central EU institutions. The exact extent to which stakeholders' input is given weight in the recommendations of the mini-council is up to that mini-council on a case-by-case basis. Representatives of the RACs will be granted 3 observer seats at DFMBs: the RAC chair and two others from the RAC maintaining the 2-1 balance between industries and NGOs as presently used to determine representation in RACs. If effectively implemented, this structure should serve to increase the legitimacy of the CFP and associated regulations among stakeholders (which presently is low) and reduced conflict between administrators and the industry due to differences in how these groups view the goals and means of the management regime. It is envisaged/hoped that this may lead to more responsible behaviour among fishermen. The DFMB model would allow each region to calibrate the model to their situation, providing a high degree of flexibility within the present structures despite based on de facto delegation of authority.

The approval of LTMPs would remain with the Commission which is responsible for auditing that existing, proposed and future plans are implemented in accordance to the principles and long-term objectives that have been decided by the EU.

2.4.1. Migratory Stock RACs

For the majority of migratory stocks, the EU needs to collaborate with other (non-EU) countries and mechanisms to address how these stocks and countries should be dealt has to be considered in a regionalized CFP. One solution could be that the North East Atlantic Fisheries Commission (NEAFC) is transformed into an equivalent to the Decentralised Fisheries Management Board and a management set-up with an advisory structure covering all relevant countries in a similar way to that proposed above for the regional RACs. These different options have not been fully explored and we therefore recommend that that more attention is directed to the issue of migratory stocks and third countries.

3.1. Introduction to the region

The South Western Waters (SWW) Regional Advisory Council (RAC) area covers the south-eastern of the North Atlantic Ocean, with Brittany as the northern limit, up to the Strait of Gibraltar to the south, including also the ultra-periferic regions of Madeira, Azores and Canary Islands (Fig. 3.1.1). Only the Azores Archipelago is considered in the MEFEPO project. The SWW RAC area has a very diverse range of depths from the broad shelf in the French area, to the narrow and steep shelf with numerous canyons in the Cantabrian Sea, and the Iberian Basin with numerous sea mounts that arise from the deep sea to the mid Atlantic Ridge. The oceanic marine environment around the Azores is characterized by narrow coastal island platform surrounded by deepwater and large proportions of the abyssal areas punctuated by seamounts.

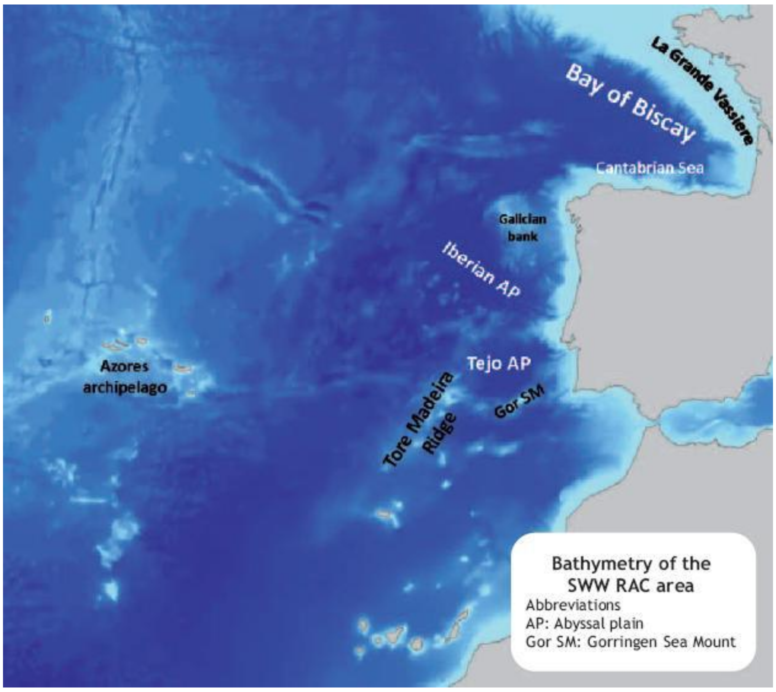


Fig. 3.1.1 The south-eastern North Atlantic region (source: Velasco et al., 2009).

The SWW Region is characterized by well-mixed waters and upwelling of nutrients and cold water along the continental slope. The oceanic waters are dominated by the high-salinity North Atlantic Central Water separated into Polar and Tropical modes. The Polar mode is formed at the Bay of Biscay and diffuses east and south-east, reaching the Azores. The Tropical mode is observed mainly close to the continental margin, between the Canaries and Iberian Peninsula. The main large-scale currents associated with the eastern part of the anti-cyclonic North Atlantic sub-tropical gyre are the North Atlantic Current, the Azores Current, Portugal Current, Canary Current and the Mediterranean flow that sinks to around 1000 m depth as it enters in the Atlantic and flows northwards. These currents in combination with the winds produce upwelling events of great importance on the food web in the Portuguese and Galician Atlantic coasts, which form the northern part of the Canary upwelling system.

3.2. Ecological

Biogeographically the region is classified in two provinces, the Lusitanean and the Macaronesian (Dinter, 2001) and is situated in warm-temperate waters (Fig. 3.2.1). The northern Bay of Biscay biogeographically is classified as a transition from Lusitanean to Boreal. The species distribution can be explained by the rivers' plumes influence in coastal zone, modifying temperature, salinity, turbidity and nutrients availability, while offshore hydrological conditions are more stable.

The SWW region is highly productive and support large populations of pelagic fish. During spring, blooms of algae on the Iberian coast attract huge shoals of sardines and other pelagic fish. The coast is diverse, with many different habitats, from muddy shores to rocky cliffs. Many northern species reach their southern limits of distribution in the Lusitanean province, and many southern species reach their northern limit of distribution. Mediterranean species occur in the South.

There are many important fish prey species and sardine, anchovy, mackerel, and horse mackerel have all been found in the diet of fish (e.g.: hake, tuna, John Dory, etc.). Cetaceans play an important role in the regional trophic web both as zooplankton consumers as well as competitors with the commercial fisheries. Sardine and anchovy are the main preys of common dolphins.

The distribution of organisms which live on or near the sea floor is determined by the type of substrate present (e.g. mud, sand, gravel or rock) and the seabed has some outstanding features, with seamounts and deep underwater canyons where giant squid and large sponges can be found (OSPAR, 2010; Goikoetxea, et al., 2009).

In the Azores archipelago several physical seamount characteristics, stratification and oceanic flow conditions interact to provide different local dynamic responses at seamounts. They are a unique habitat for mega-benthos, corals and mid and deep water fauna due to distinctive environmental conditions.

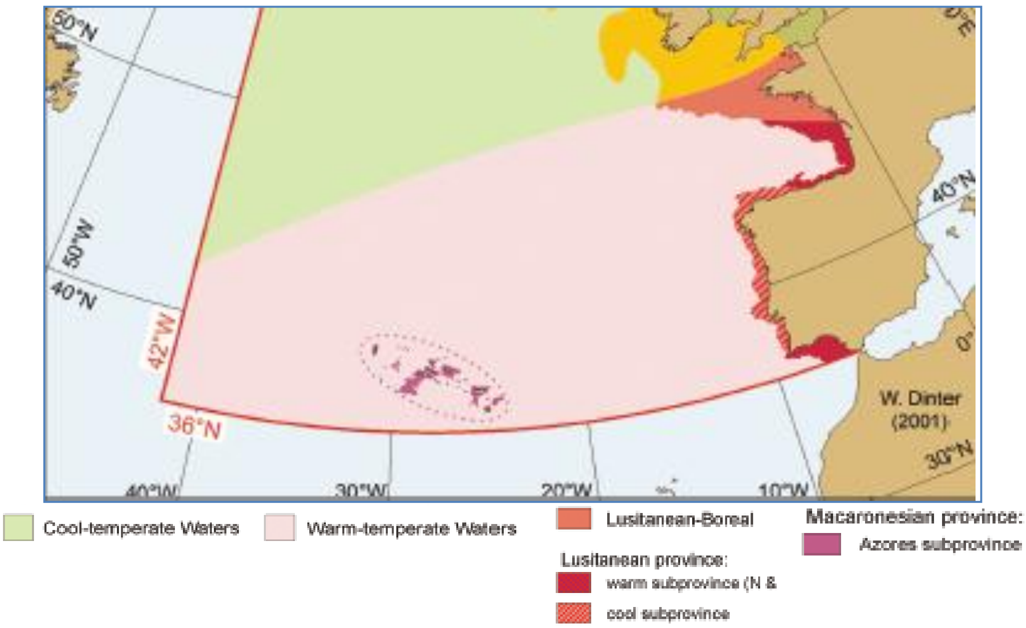


Fig 3.2.1 Biogeographical classification of the benthal and neritopelagial areas of the shelf and upper continental slope (<1000 m depth), (adapted from Dinter (2001).

3.3. Social

Fishing is an important source of income for coastal communities in the SWW area, many of which are dependent on fisheries and related activities. The three countries involved in this area (France, Portugal and Spain) have high consumption levels of fish per capita in the range of 45-60 kg, depending on the country. In 2006, the three MEFEPO SWW area fisheries case studies; mixed demersal trawl, purse seiner and mixed demersal lines generated 2261, 2294, 1257 direct jobs, respectively, Full Time Employment (FTE).

Moreover, the artisanal fleet, using vessels of 0-12m and passive gears, is considered of special interest in Portugal because of the high number of vessels and employment it generates and is also the major fleet segment of the Spanish national fleet in terms of vessel numbers. About half of the Portuguese mainland active fleet is in this segment (2,015 vessels), employing almost 4,000 people. In 2008, the total number of fishing enterprises in Portugal was 3,987, composed of small individual vessels where the master is also the owner. Companies with more than one ship usually own vessels with great compliance that operate offshore. The same occurs in France as the vast majority of fishing enterprises in the French fleet owned a single vessel.

The following individual fisheries employment summaries for the three countries in the SWW area were sourced from the STECF Annual Economic Report (STECF, 2010):

Portugal: The total employment and FTEs was 12,964 in 2008, with a decrease of 21.9% between 2003-2008. In the Azores archipelago, total employment was around 2,500 for the Azores fleet (mostly longline and gillnets) in 2007. The total amount of income generated by the landings of the Portuguese mainland fleet was approximately 374 million euros.

Spain: *In 2007*, the total FTEs was 19,284. The reduction in FTEs from 2003 to 2007 was around 27% while total employment decreased by around 49% during the same period[6].

France: The number of FTEs in the French national fleet was around 13,100 in 2008. The trend in employment correlates to the decrease in vessel numbers observed during the same period. The total amount of income generated by the French fishing fleet in 2008 was 1,118 million Euros. This consists of 1,096 million in landings values, 3 million in non fishing income and 19 million in direct subsidies. Income subsidies and other income (the allowance of towing of a ship for example) constituted a weak share of total income (less than 2%) in 2008.

3.4. Economic

The individual economic indicators for the countries enclosed in the SWW area were sourced from the STECF Annual Economic Report (STCEF, 2010).

Portugal: In 2008 the fishing fleet consisted of 4,527 licensed active vessels with a total tonnage of 80,180 GT, total power of 279,163 kW and an overall average age of 19.4 years, and 2,826 inactive vessels accounting for a total of around 12,445 GT and 37,950 kW. The fishing fleet spent around

[6] It does not include FTEs and total employment for vessels below 24 metres in length.

327 thousand days at sea, 95% of which was actual fishing days. The total volume of landings was around 180 thousand tons of seafood and consuming around 107 million litres of fuel. In terms of landings value, the most important species for the Portuguese Mainland fleet were sardines with an amount of 41.7 million Euros 11.2% of total value), followed by common octopus, cod and redfish, representing 10.4%, 8.5% and 6.9% respectively of the total value of landings. In 2007, the Azores fleet consisted of 664 registered vessels, with a combined registered tonnage of around 7.9 thousand GT and total power of around 39,900 kW. The overall average age of these vessels was 26.2 years. In the same year the fishing fleet spent around 48 thousand days at sea. In terms of landings values, red seabream (*Pagellus* bogaraveo) had the highest total value of landings (10 million euros), followed by wreckfish (*Polyprion americanus*) with landings around 5.5 million euros, and skipjack tuna (*Katsuwonus pelamis*) with 4.8 million euros.

Spain**:** In 2007 the Spanish fishing fleet consisted of 13,310 registered vessels having a combined tonnage of 478,000 KW and total power of 1,086,000 GT. The overall average age of vessels was 28 yrs. In the same year, sardine was the most common species landed in terms of tonnage (around 50 thousand tons), followed by blue whiting (around 31 thousand tons) and mackerel (around 22 thousand tons). The total income for the Spanish fleet was around 1,130 million euros. Variable costs amounted to around 350 million euros (31% of income), crew wages were around 294 million (26% of income) and fuel costs were around 254 million euros. The total amount of GVA (Gross Value Added) generated was 241 million euros (21% of total income), while negative an operating cash flow of 52 million euros was recorded (-4.6% of total income).

France**:** In 2008 the French fishing fleet consisted of 4,485 active vessels accounting for a total of around 175,057 GT and 737,640 kW The French fleet is ageing, and only a few vessels are replaced by new builds. The average age of vessels continues to increase, reaching 23.4 years. In 2008 the French fishing fleet spent a total of 764 thousand days at sea. The total volume of landings achieved during those fishing days was 342 million tons of seafood. The amount of fuel consumed while catching this seafood reached a total of 371 million liters. In terms of landings composition, sardine was the most common species landed in terms of tonnage (38 thousand tons), followed by scallop (*Pecten maximus*) with 23 thousand tons and saithe (*Pollaccius virens*) with 20 thousand tons. Anglerfish (*Lophius* spp) landings were the most valuable with 94 million euros, followed by common sole (S*olea solea*) with €82 million and scallops (*Pecten spp)* with €56 million Euros. A total income of €1,118 million was generated in 2008, being 35% spent on crew costs and 18% on fuel.

In addition to the above mentioned fleets (see section 3.1.2), the other fleets of special economic interest for the region are demersal trawl and purse seiners (24-40m) in Portugal mainland, demersal trawl and seiners (12-24m) in France, and pelagic trawl and seiners (24-40 and over 40m) in Spain. The large Spanish fleet (over 40) is one of the most important in terms of income per vessel. The fishing opportunities for large vessels have not shown a decrease given that they can change their fishing grounds by moving to other oceans. The purse seiners (12-24m) in France are also one of the most important segments in their fleet, particularly in terms of turnover and the average income was around 566,000 euros per vessel. However, the high fuel dependency of these vessels, the dependence on quota restricted species and the relatively old age of the fleet limits the possibilities for development (STECF, 2010).

Besides fishing, the SWW RAC waters are also subject to other human activities including tourism, aquaculture, shipping, sand and gravel extraction, and new development of wave, tide and wind power generation. The SWW waters are crossed by several obligatory routes for commercial maritime transport from South to North Atlantic and West to East. The maritime traffic is intense in the region with a privileged position focused in the transoceanic routes and the North of Europe routes. Port activities are centred on twenty principal ports; the three most important being Nantes-Saint-Nazaire (France), Bilbao (Spain) and Sines-Leixões (Portugal). Shipping is also an important economic human activity on the oceanic region of the Azores archipelago, since this is one of the most important routes of commercial transport in the NE Atlantic.

Marine aquaculture is spread widely along the Atlantic coast and concentrated in several well defined areas. In France, is more intense in southern Britanny and the areas around Bourgneuf Bay, Ré Island, Marennes-Oléron and Arcachon Bay. In Spain, aquaculture takes place along the greater part of the coastline, being particularly important in Galicia and on the north-west coast. In Portugal, marine aquaculture occurs along the western and southern coasts, particularly in some of the more important estuaries (e.g. Ria Formosa).

Coastal and maritime tourism are also important social and economic activities along the Atlantic coast of the SWW region and the Azores archipelago, especially during the summer. Camping and bathing, yachting, recreational fishing, surfing, scuba diving and bird- and whale-watching are among the most popular activities.

4.1. Introduction

The goal of the Marine Strategy Framework Directive (MSFD) is to achieve or maintain good ecological status (GES) across all European waters by 2020. GES is defined as "*the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations*." The MSFD identifies eleven qualitative ecosystem descriptors with which to measure GES, which range from marine biodiversity to underwater noise levels. The MEFEPO project (see Borges et al., 2010 – MEFEPO WP 2 Technical Report) identified four of these descriptors as being significantly affected by fishing activity and attempted to assess their current,. This assessment is summarised below.

4.2. Biodiversity

MSFD GES Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

The indicators chosen to assess this descriptor were two variations of the conservation status of fish species (CSF). Slight modifications to the method described in COM (2008) 187 were made to each indicator calculation (Borges *et al.* 2010). The calculations were based on the findings of four fishery independent surveys covering the SWW: The French Bay of Biscay (EVHOE-BoB), the Spanish Ground fish Survey (SPNGFS), the Portuguese Ground fish Survey (PTGFS) and the Azorean Demersal Longline Survey (DLL) (Table 4.2.1).

Table 4.2.1 Surveys and data used on the estimation of the Conservation Status of Fish Species in the SWW region. Numbers in brackets indicate years not included.

Survey	Type Survey	Gear	Data Series	No. Years	No. Species
EVHOE BoB	Bottom trawl	GOV	1997-2007	11	190
SPNGFS	Bottom trawl	Std. baka	1992-2007	16	180
PGFS	Bottom trawl	Campell	1989-2008 (96, 99, 03-04)	20 (4)	199
Azores DLL	Demersal long-line	Long-line	1996-2008 (98, 06)	13 (2)	113

Conservation Status of Fish Species A (CSFa)

The CSFa indicator is a composite indicator, reporting the average abundance trend of large fish species in the survey assessed according to the IUCN decline criteria. A CSFa score of one indicates all species in the list are considered threatened; a score of three indicates all species are endangered. The target for the CSFa indicator is a score less than one (for detailed methodology see Borges *et al*., 2010).

In general the CFSa indicator present values well below the proposed reference level of 1, although individual species are regarded as vulnerable, threatened or critically endangered. The shortness of the series and the three years mean reference to compare with, seems to be the reason for the poor results. Therefore these results should be only considered as an exercise and further research is necessary prior to operational use. The requirement of 10 years data to start obtaining values for the CSFa indicator reduced the results from EVOHE and Azores DLL surveys to just two points which do not show any change between them (Fig. 4.2.1 panels A and D). For these surveys the method used to generate the species list made no difference and therefore the three years option is not shown.

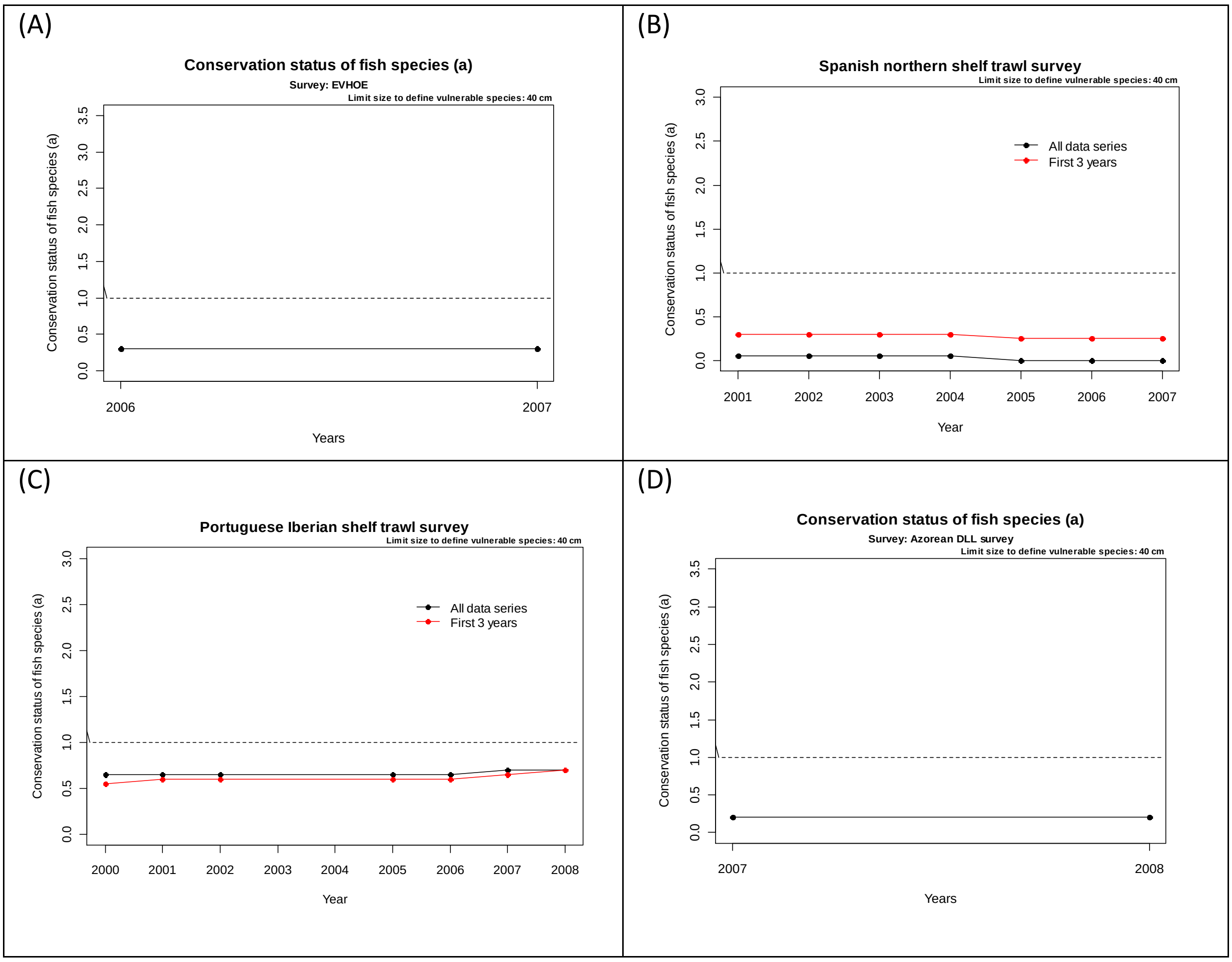


Fig. 4.2.1 CSFa score by survey area in SWW. (A) French survey Bay of Biscay EVHOE; (B) Spanish Ground fish survey SPGFS; (C) Portuguese Ground Fish Survey PTGFS; and (D) Azorean Demersal Long Line Survey Azorean DLL. Note: the "full list" and "three year list" refer to two different methods of choosing fish species to be included in the analysis. The "full list" of species is calculated as in COM(2008) 187 and the "three year list" is modified to ensure species that are declining (or disappear) over the time series are included, despite not reaching the original minimum abundance threshold.

Conservation Status of Fish Species B (CSFb)

CSFb is a comparison of the relative survey abundance of each species, each year relative to a reference level (mean abundance of first three years). Trend analysis is done for the CSFb indicator with no target value. Regarding this indicator, there is an apparent recovery of the status of fish species, with an increase of the larger sizes in EVHOE and SPNGFS surveys, and an apparent slight decrease in the Portuguese survey area. Nevertheless these results have to be taken with caution because the time series are relatively short.

The shortness of the survey time series used in this study does not allow comparison with a non-impacted reference status. In the Iberian shelf ecosystem historically the seventies and the eighties might have been a period of sustainability which should be further investigated to decide on a reference status and possible target. An important effect of schooling/pelagic species that produces saw teeth effect in parts of all the series considered, and additional rules to select the species entering in the calculation of the indicator should be further detailed. The saw teeth effects might not be indicate changes or threats to biodiversity, but caused by climatic drivers (Fig. 4.2.2).

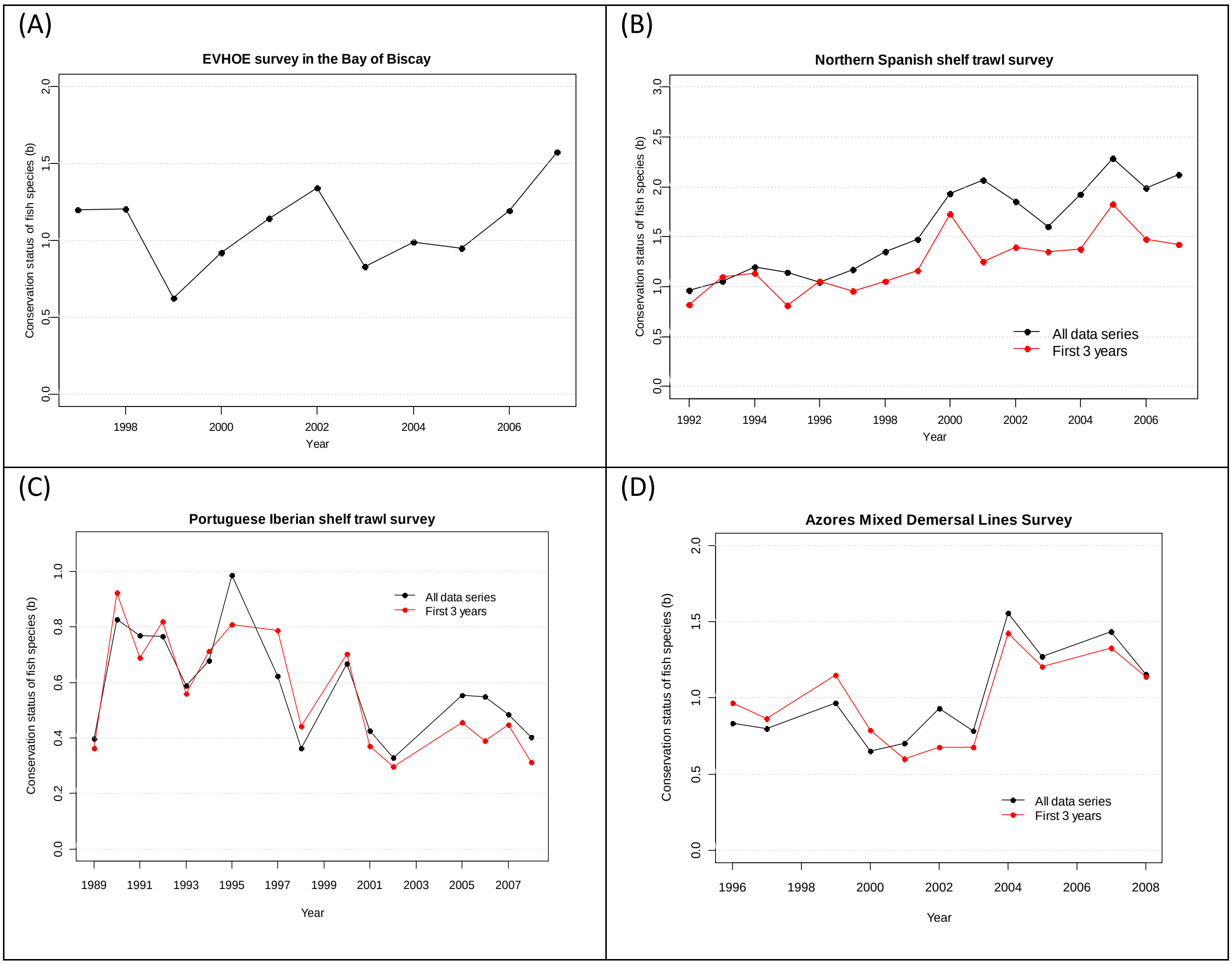


Fig. 4.2.2 CSFb score by survey area in SWW. (A) French survey Bay of Biscay EVHOE (three years method as the same species list as full data series); (B) Spanish Ground fish survey SPGFS; (C) Portuguese Ground Fish Survey PTGFS; and (D) Azorean Demersal Long Line Survey Azorean DLL.

4.3. Commercial stocks

GES Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

The indicator used to assess status against this objective is the proportion of commercially exploited stocks within safe biological limits. This indicator was calculated according to the method developed by Piet and Rice (2004) apart from slight modifications detailed in the technical report (Borges *et al.* 2010). Only stocks for which SSB ≥ SSBpa and F ≤ Fpa are considered to be within safe biological limits (SBL). The initial reference point for this indicator is that 100% of assessed stocks should be within safe biological limits as this reference level is inherent in the wording of GES descriptor 3 where it says "populations of *all* commercially exploited…".

The data required to calculate the commercial species indicator is yearly assessment values of SSB and F for a stock and the reference values for SSB_{pa} and F_{pa} for the same stock. Ideally this would be known for all stocks, as this is practically unfeasible target coverage of including stocks that made up 75% of the value of the landings was identified as desirable.

This RAC area encloses ICES sub-divisions VIIIa,b, d,e, IXa,b and Sub-area X. Within SWW there are 118 species- or species groups each contributing with more than 0.1% to the total landed weight. These species together make up more than 98% of the landings. The assessed species represent roughly 50% of the landed weight of fish in SWW. Coverage could be extended by including wide spread pelagics such as mackerel, horse mackerel, blue-whiting which straddle the SWW boundaries.

Within SWW there were seventeen assessed stocks with population size estimates. From these only three stocks met the criteria for inclusion in this indicator. This was due to the fact that the reference values have not been defined for the other 14 ICES stocks with biomass and fishing mortality estimates. Fig. 4.3.1 shows the proportion of these stocks within SBL over time.

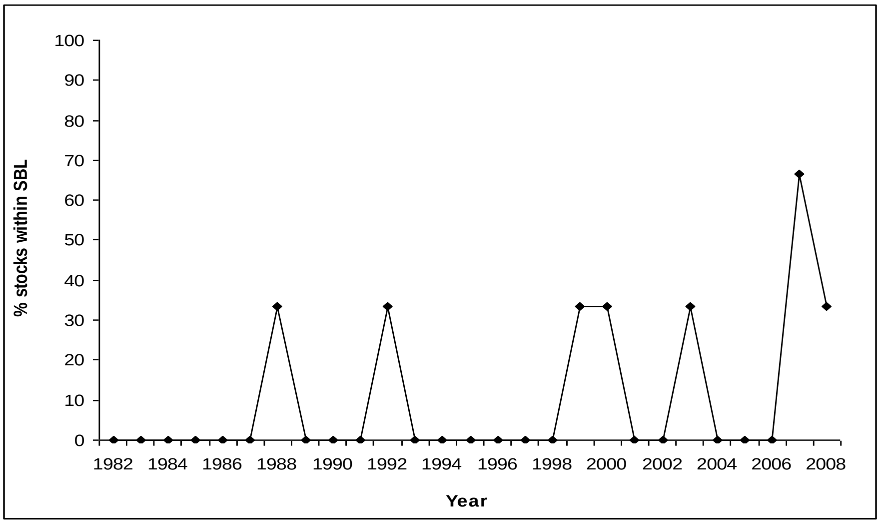


Fig. 4.3.1 Evolution of the proportion of within safe biological limits stocks in SWW.

4.4. Food webs

GES Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

The indicator chosen for the assessment of this descriptor was the large fish indicator (LFI). Calculation of the LFI is based upon fishery independent trawl survey data that reports catch per unit effort of species by length. The surveys and data used for this indicator are the same as those described in *Biodiversity*. The formula used to calculate the LFI for each year was:

LFI = Weight of fish ≥ 40cm in length / Total weight of fish

For the SWW region it was also calculated the LFI corresponding to the weight of fish ≥ 30cm and 25cm (for Portuguese survey), to compare with, because of ecosystem fish size differences from farther Northern areas. The limit reference level for the LFI for the North Sea, as implement by OSPAR, is for the LFI to be 0.3 or greater. This reference level was originally defined for the North Sea, and further analysis is required to establish if this reference level is also appropriate for use in SWW. The southern Iberian shelf ecosystem is part of the Canary upwelling system where small pelagic species are dominant, it is then expected that the larger demersal species have naturally a small proportion in the overall upwelling ecosystem. It is therefore important to exclude the pelagic species in order to make the LFI indicator to be indicative of the demersal group of species which are more impacted by bottom trawl fishery.

From the analysis of the indicator for the different areas it is evident that the choice of a 40 cm threshold represents less than 0.2 in the proportion of large fish for the French and Spanish surveys (Fig. 4.4.1) and less than 0.1 for the Portuguese area (Fig. 4.4.2). As no reference limit has been defined for this indicator for the SWW RAC region it is not currently possible to assess the current status in terms of whether fishing compromises GES. To make LFI indicator operational in SWW area is necessary to define a reference limit. This can be examined by further research to find other sources of the historical size structure of the demersal species (Dinter, 2001) in each of the biogeographical provinces of the SWW area. An alternative approach based on metabolic theory could be used to theoretically define the proportion of large fish that would be expected in the region.

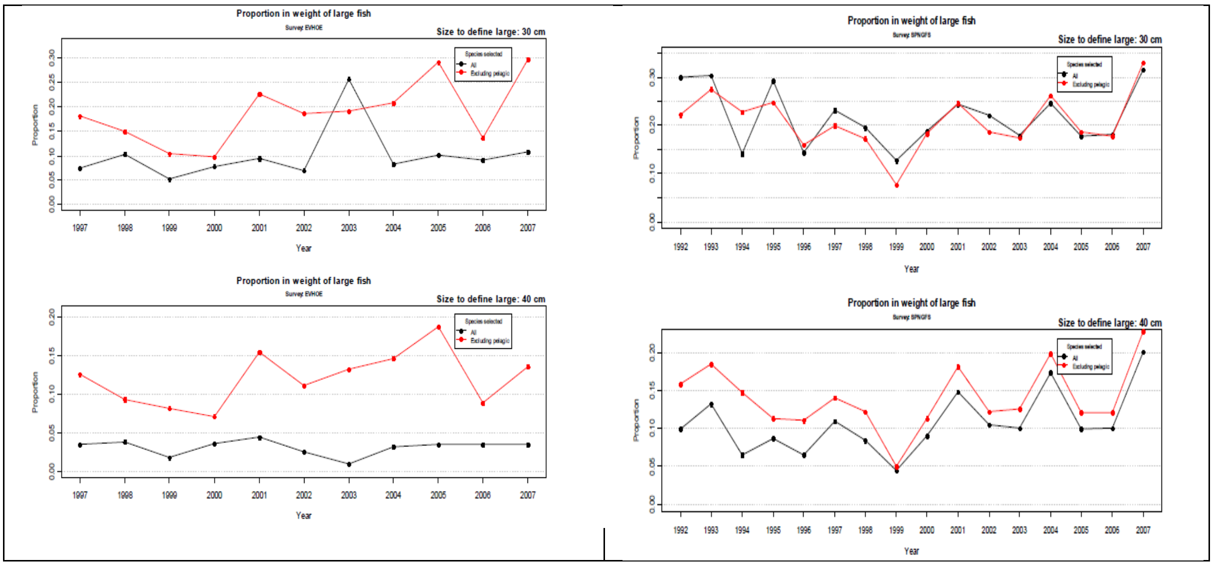


Fig. 4.4.1 Evolution of the proportion of large fish using different sets of species (all species and excluding pelagics) and limits (30 and 40 cm) to define large fish in Bay of Biscay part of the EVHOE survey from 1997 to 2007 (left panel) and in northern Spanish shelf bottom trawl survey from 1992 to 2007 (right panel).

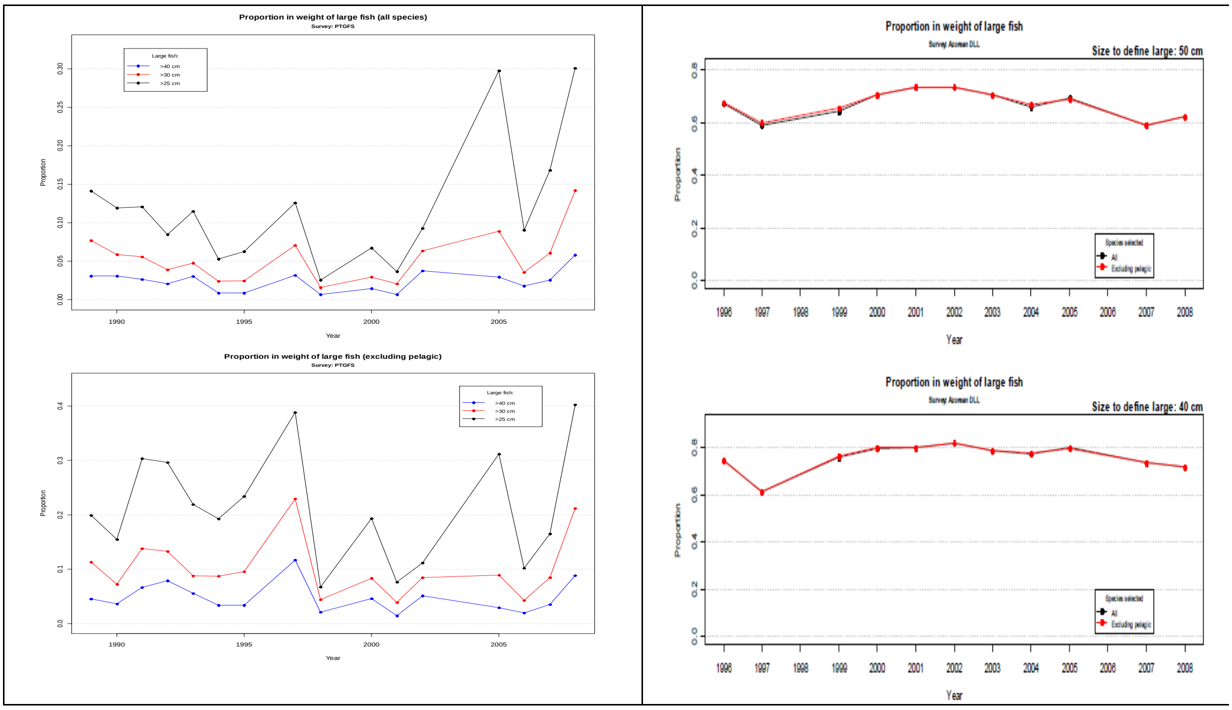


Fig. 4.4.2 Evolution of the proportion of large fish, using 25 (black), 30 (red) and 40cm (blue) to define large fish on the Portuguese bottom trawl survey from 1991 to 2008 (right panel). Evolution of the proportion of large fish using different sets of species (all species and excluding pelagics) and limits (50cm and 40cm) to define large fish in Azores (left panel).

4.5. Seafloor integrity

GES Descriptor 4: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

The indicator used to assess this descriptor was the proportion of area not impacted by mobile bottom gears. This is calculated using vessel monitoring systems (VMS) and provides a direct measure of the main pressure on benthic systems. However, it provides no indication of the actual state of the benthic habitat. Currently there are no robustly justified reference levels as target or limit values for this indicator. The acceptable level of mobile bottom gear impact will depend on the resilience and susceptibility of the habitat to damage, thus a single reference level may not be applicable across all habitat types. Until justified reference levels are developed the target reference direction for the indicator is for the proportion of area not impacted by mobile bottom gears to remain constant or increase.

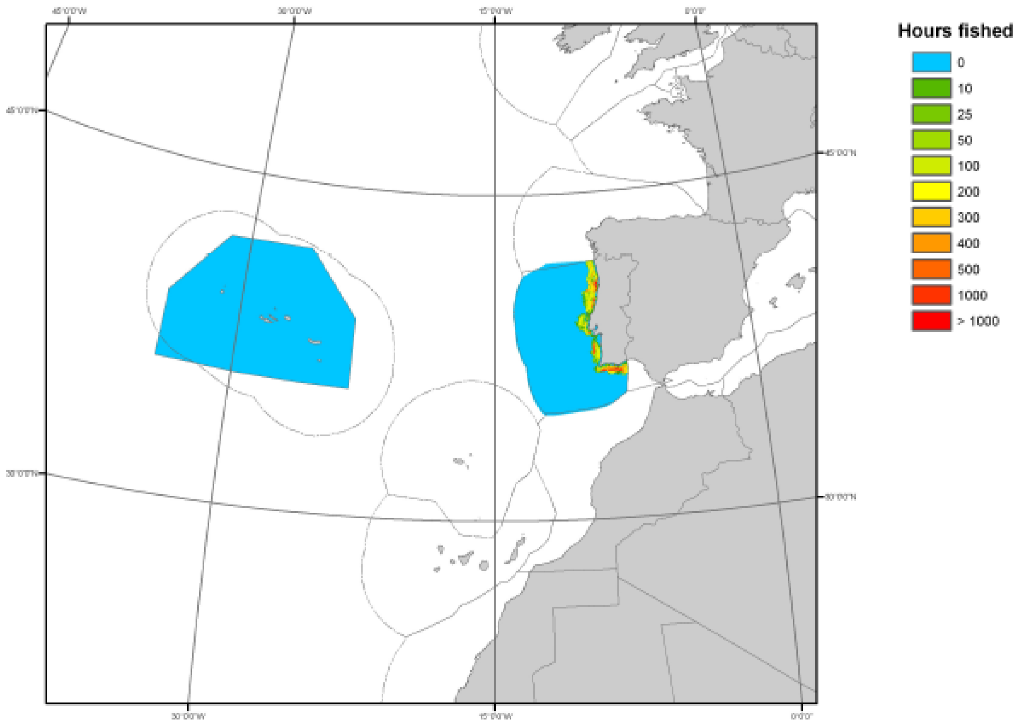


Fig. 4.5.1 Distribution of fishing effort by mobile bottom gears in 2005 by 3'x3' cells based on VMS records from submitting nations.

The proportion of area not trawled indicator was calculated for 2005 by depth band. These reveal the bottom-fishing hotspots in SWW particularly trawling for *Nephrops* in mud paches. Overall, very little mobile bottom gear activity impacted habitats deeper than 200m and the intensity of fishing pressure remained stable for the vast majority of cells (Fig. 4.5.1)

4.6. Summary/limitations

The SWW do not achieve GES according to the terms of this assessment (Table 4.6.1).

Table 4.6.1 Summary of current GES status for the four fishing related descriptors.

GES Descriptor	Associated indicator	Current status
GES 1: Biodiversity	Conservation Status of Fish Species	√/?
GES 3: Commercial species	% stocks within safe biological limits	??
GES 4: Food webs	Large fish indicator	√/?
GES 6: Benthic processes	% not trawled	?

4.6.1. GES Descriptor 1: Biodiversity

The interpretation of this indicator suggests GES is being attained. The CSFa score (average IUCN threat rating) is below the target level of 1 in all the areas surveyed of the SWW. The regional overall trend in CSFb is positive, in spite of the high variation and decreasing trend scored by the Portuguese survey. However, the reference period on which the CSFb score is based is relatively recent meaning the improvement is likely from an already severely impacted state.

4.6.2. GES Descriptor 3: Commercial Species

Unfortunately it is not possible to evaluate this indicator for the SWW because from the seventeen stocks with population size estimated by ICES, only three stocks had the SSBpa and the Fpa values adopted by ICES. This means that other criteria are needed to check if these stocks are within safe biological limits. The three stocks landings correspond only to less than 10% of the total SWW landings. During the period of 1982 to 2008, and using these three stocks to compute the indicator, 35% of assessed stocks fell within safe biological limits in the SWW, except in 2007 where it increased to 65%.

4.6.3. GES Descriptor 4: Food Webs

Considering LFI computed with fish larger or equal to 40 cm, the target of 30% adopted for the North Sea is never reached in any of the regions covered by the groundfish surveys. Nevertheless considering fish larger than 30cm, and excluding pelagics to compute the indicator, the target of 30% of large fish is met for all regions. Except for the Portuguese shelf, where only considering fish larger or equal of 25cm it is possible to meet the target. For the Azorean area the survey uses Long line and represents the adult fish present in the area which is about 60-80%.

4.6.4. GES Descriptor 6: Benthic Processes

In the case of this descriptor an assessment of the impact of fishing on GES is not currently possible. Here there are two related stumbling blocks. Firstly the indicator is a pressure indicator rather than a state indicator, thus the indicator does not directly provide information on the environmental status of the sea-floor processes. Using a pressure indicator to inform on status can only be achieved when the link between pressure and state is well known; at present the link between pressure by mobile bottom gears and the state sea-floor functioning is not strongly developed only limited conclusions can be drawn about the impact of fishing on GES with respect to sea-floor processes. The second related stumbling block is that no reference limit has been identified by which to assess current status in relation to objective for GES. However no reference limit can be expected to be developed until the link between pressure and state has been better established.

5.1. Introduction

5.1.1. Drivers of Change in European Fisheries Management

The Green Paper on the Reform of the Common Fisheries Policy (i) identified the need for EBFM taking account of the ecological, social and economic pillars of sustainability, (ii) stated an intention to move towards a longer term approach to fisheries management, and (iii) made commitments to greater stakeholder involvement in management. The Marine Strategy Framework Directive (MSFD) defines environmental objectives for European seas, based on sustainable utilisation of healthy marine ecosystems in support of sustainable development. The Integrated Maritime Policy specifies that individual sectors (e.g. fisheries) need to support MSFD objectives. These commitments have shaped the development of the MEFEPO Fisheries Ecosystem Plans (FEPs).

5.1.2. Developing the regional case studies

'Descriptors' for the ecological, social and economic status of the fisheries were developed to enable simultaneous consideration of the potential impacts of different management strategies on the three pillars of sustainability (Fig. 5.1.2.1). Stakeholders supported the MEFEPO "three pillar" approach to explore potential impacts of different management strategies on multiple objectives for the marine environment.

Ecological descriptors, drawn directly from the MSFD, were selected at a MEFEPO stakeholder workshop as those most impacted by fishing activities (biodiversity, commercial fish, food-webs and seafloor integrity). Social and economic descriptors were defined to monitor the main aspects of fishing contributing to the economic and social wellbeing of society, in particular coastal communities. Economic descriptors focus on fishers' ability to maximise economic efficiency of fishing operations (efficiency) and minimising fluctuations in harvesting possibilities over time (stability). Social descriptors monitor employment opportunities within the catching sector (community viability) and securing catch potential for human consumption (food security).

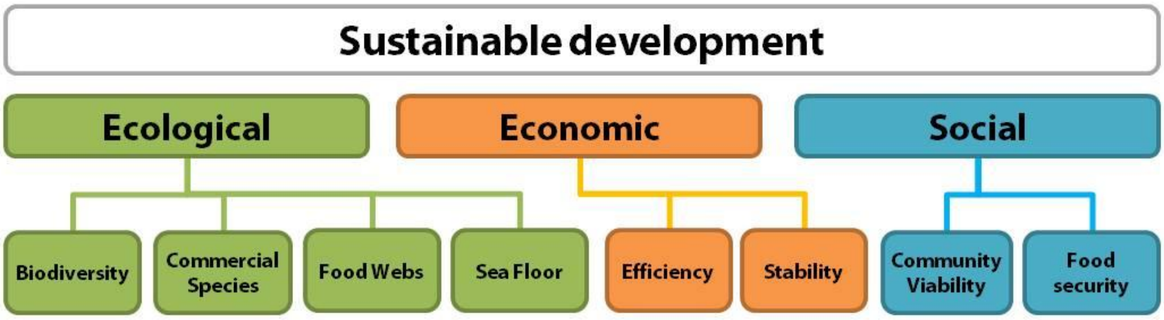


Fig. 5.1.2.1 Descriptors chosen to reflect the three pillars of sustainability (see Annex A for further details).

Preliminary case studies of selected fisheries have been developed to demonstrate practical application of the management strategies matrix approach. In each case, the potential performance of a limited number of management strategies (consisting of the application of multiple management tools) was evaluated. The efficacy of the management strategies was considered in the context of high level management objectives for European fisheries. The predicted change in the descriptor status associated with implementation of each management strategy was assessed:

Green	Yellow	Red	Grey
Expected improvement in the status of the descriptor	Stable (i.e. no change in the status of the descriptor)	Expected deterioration in the status of the descriptor	Outcome unknown

The suite of management strategies comprised of "business as usual" (BAU) and alternative strategies applying different management tools, to explore how the objectives of EBFM may be most effectively achieved. Given that it may possible to deliver the same set of objectives in more than one way or it may be impossible to fully achieve all objectives simultaneously, consideration of alternatives management strategies allowed the trade-offs associated with different management approaches to be examined.

The results of this review are reported using a common format, a management strategies matrix, developed in consultation with MEFEPO stakeholders (see van Hoof *et al.,* 2011). Management strategy matrices were completed based on the best available evidence (modelled, empirical and expert judgment) under the following assumptions:

- Time frame: in keeping with the principles of the ecosystem based fisheries management (EBFM), the management strategies matrix was populated based on expected medium to long-term (5-10 year) outcomes. This means that other effects may take place in the short term.
- Partial assessment: we have examined changes in one (or a few) selected management tools and assume all other measures used in the fishery are kept constant.
- Constant external environment: we have assumed that all exogenous conditions (e.g. market price on fish, fuel prices, water temperature, fish food availability, etc.) are constant.

Information on the application and success of management tools from earlier project work (Aanesen *et al.* 2010), scientific literature and expert opinion was used to inform the choice of management tools in the development of the management strategies. Examining the performance of management strategies was more complex for the mixed-species fisheries case studies as it may not be possible to achieve MSY for more than one species at the same time. Thus management strategies explored possible trade-offs in terms of prioritising stocks.

Ultimately the decision on which management strategy should be adopted will be based on overarching management objectives (ecological, social and environmental). The aim of this process was to demonstrate the application of the management strategy matrix approach to present the information to help decision-makers to take appropriate decisions, rather than to pass comment on the "best" management strategy. However, information on stakeholder preferences for particular management tools (e.g. from EFEP) is used to provide commentary on which strategies might receive better stakeholder support. Gaps in knowledge (ecological, social and economic), which may limit our ability to successfully implement EBFM, were identified and likely consequences of management strategy application are discussed.

5.2. Case study: Bay of Biscay *Nephrops* Fishery

5.2.1. Introduction to the fishery

An important French bottom trawling fishery is taking place on the Bay of Biscay shelf and coastal waters: in 2011, 204 boats target *Nephrops norvegicus* (Direction des pêches maritimes et de l'aquaculture, 2011) in Divisions VIII a,b where there are two Functional Units, which are assessed as one entity: a) Bay of Biscay North (FU 23) and b) Bay of Biscay South (FU 24) (Fig. 5.2.1.1). This is one of the most important fisheries in the SWW area and *Nephrops*, a high commercial value species, are targeted on a sand-muddy area called "La Grande Vasière" (≈ 11,680 km²). Hake (*Merluccius merluccius*), whiting, blue whiting, mackerel, horse mackerel, monkfish, pouting and cuttlefish are also caught but are mostly a by-catch.

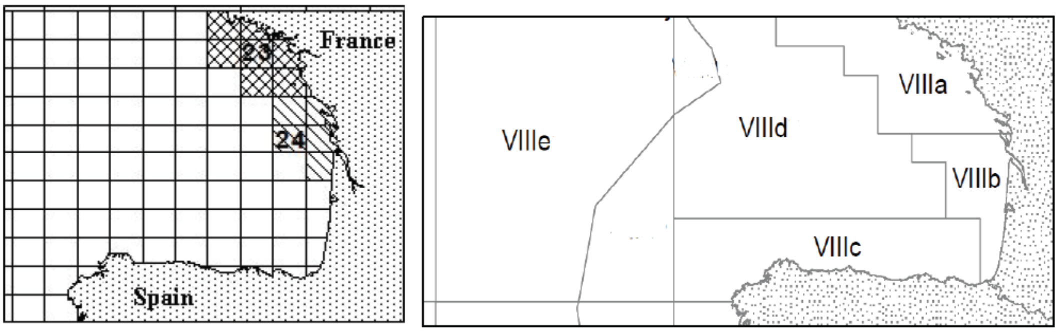


Fig. 5.2.1.1 *Nephrops* in Division VIIIa and b (Bay of Biscay, FUs 23-24). Left: assessment areas for FU 23-24. Right: EU TAC Regulation management areas VIIIa,b,d and e (Source: ICES, 2010b).

Each vessel using mostly twin trawls employs between 3 and 5 men on board, during 12 hours until 2 days, between mid-April and August, sometimes till December (average of 193 days at sea according to boat targeting *Nephrops* for principal or marginal activity). The average vessel length and age are 15 m and 19 years old respectively. Ten harbours of France west coast, particularly in the north, are involved in this fishery. In France, *Nephrops* fishery generates 830 FTE jobs on board and between 1,035 and 1,080 jobs FTE jobs (RICEP, 2010). In 2007, within the Bay of Biscay, the *Nephrops* fishery represents up to 15% of the number of fishing vessels (250 out of 1600 active vessels in the area).

Development of this fishery has been high during the second half of the twentieth century, mainly through the advent of trawling. A decrease in the number of vessels targeting *Nephrops* in the Bay of Biscay has been observed during the last decades, due to a decommissioning programme for French vessels (- 20% since 10 years) but it has been largely offset by increased fishing efficiency (Marchal *et al.,* 2007). Landings peaked at about 6,000 tonnes per year during 80s and then decreased throughout the decade 1990 - 2000 (ICES, 2008). Since the early 2000s, landings have been fluctuating between 3,000 and 6,000 tons per year according to the resource abundance. In 2009, total landings amounted to 3,029 t. The corresponding estimated discards were 1833 t (STECF, 2010). France holds 94% of the TAC, Spain the rest. After exchange of quotas (EC n° 685/95), France holds the total of the TAC. This fishery is important in terms of economics, social factors and ecology.

5.2.2. State of the stock

IFREMER carry out surveys on the resource since 1987 (Fig. 5.2.2.1) and FU 23 and FU 24 are subject to analytical assessments by the ICES Working Group on the Assessment of Southern Shelf Stocks of Hake, Monk and Megrim (WGHMM). ICES 2010 advised for these Functional units (FUs) regarding 2011 and 2012. The analytical assessment used the extended survivors analysis model (XSA). Discards and by catch are included in the assessment. Catch-at-age data were generated by slicing catch length distributions combined for males and females.

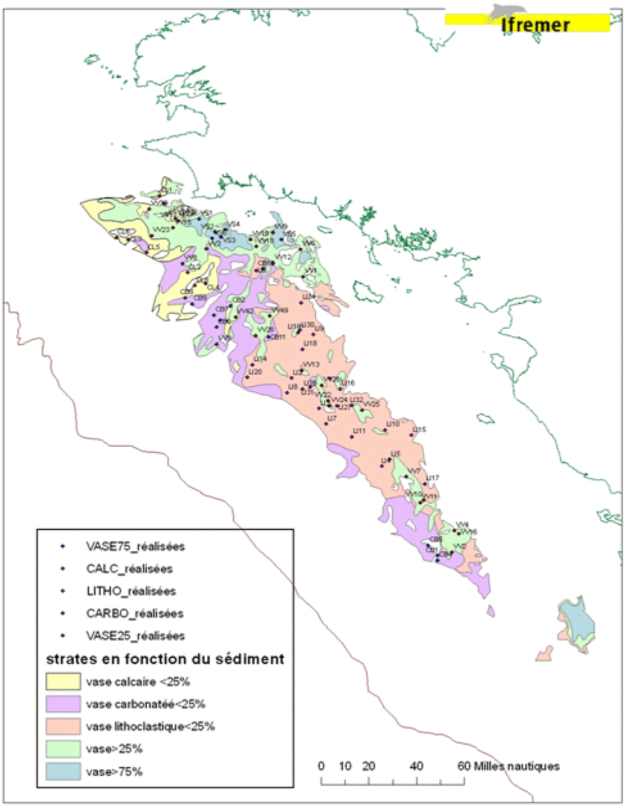


Fig. 5.2.2.1 Distribution of the sampling units for IFREMER 2010 survey. Vase calcaire (CALC)=Calcareous mud (CL); Vase carbonatée (CARBO)=Carbonated mud (CB); Vase carbonatée (CARBO)=Carbonated mud (CB); Vase lithoclastique (LITHO)=Lithoclastic mud (LI); Vase>25%=25% mud and silt (VV) Vase>75%=75% mud and silt (VS) (Source: IFREMER).

There are no precautionary reference points defined for this stock. However, spawning biomass and fishing mortality have been relatively stable over most of the period. Recruitment showed a declining trend up to 1998, but seems to have improved since then. Considering only Le Guilvinec District to calculate fishing effort, WGHMM (ICES, 2010c) has assessed that it is decreasing since 1994. Landings declined until 2000, but they were stabilized in the early 2000s with a slightly increasing trend. Landing Per Unit Effort in Le Guilvinec District reached 14kg/h in 2009 (Fig. 5.2.2.2).

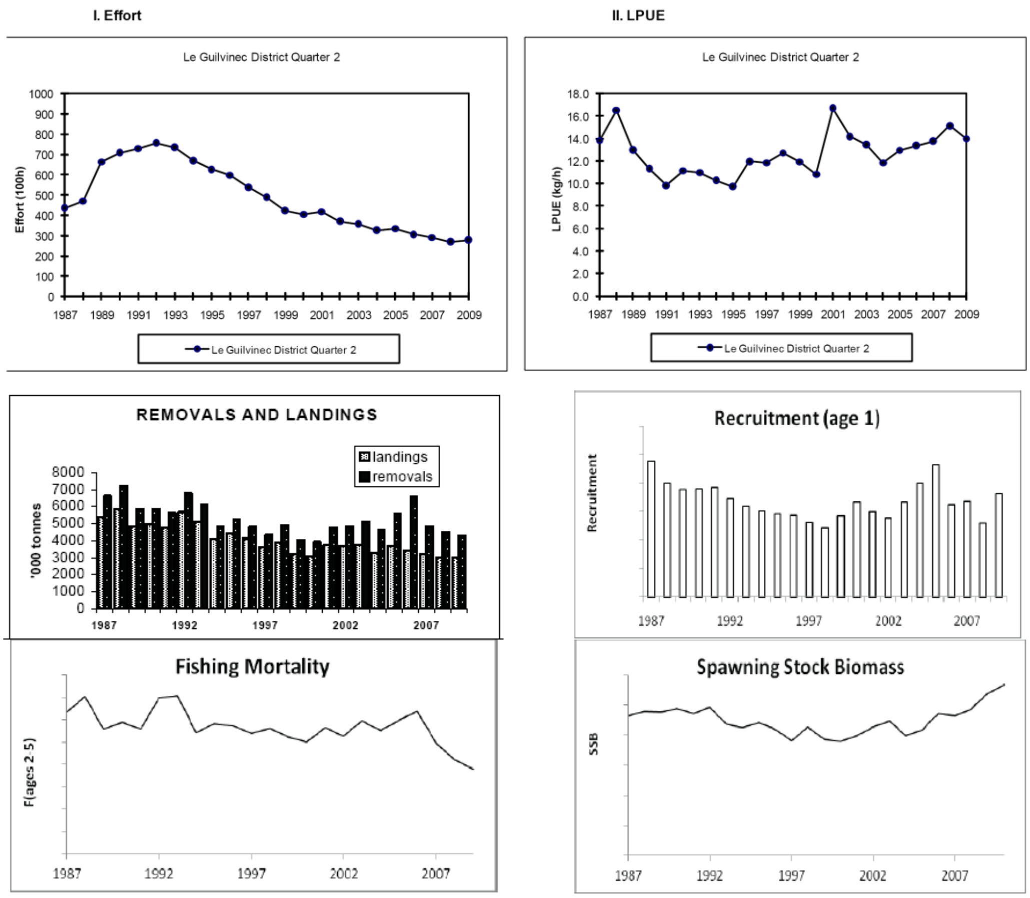


Fig. 5.2.2.2 Summary of *Nephrops* stock assessment in Division VIIIa,b - Bay of Biscay, FU 23-24 (Source: ICES, 2010c).

According to ICES MSY approach, catches should be reduced from recent levels (Table 5.2.2.1). ICES cannot quantify the rate of reduction required. According to precautionary approach (PA), catches should not exceed the recent catches, corresponding to landings of 3,100 t. In light of the EU policy paper on fisheries management (17 May 2010, COM (2010) 241) this stock is classified under category 6, which according to annex IV corresponds to unchanged TAC in 2011. This option allows for an increase in landings, which is not in agreement with either ICES MSY or PA approach. STECF has agreed with the ICES assessment of the state of the stock and the advice for 2011.

Nearly 5% of the TAC is lost every year. For instance, in 2007 in Divisions VIII a,b,d and e, the TAC was of 4,320 tonnes (Guigue, 2007). In 2010, it raised 3,899 t. Fishermen consider that due to the good state of the stock (decreasing effort, increasing biomass and recruitment), TAC should be stable. After negotiation in Fisheries Ministers Council, instead of a 15% TAC decrease recommended due to the PA, the TAC was unchanged in 2011.

Table 5.2.2.1 Advice summary for 2011 and 2012 (Source: ICES, 2010b).

Management Objective(s)	**Landings in 2011 and 2012**
Transition to an **MSY approach** with caution at low stock size	Reduce from recent levels
Cautiously avoid impaired recruitment (**Precautionary Approach**)	Not to exceed recent levels (3100 t)
Cautiously avoid impaired recruitment and achieve other objective(s) of a **management plan** (e.g. catch stability)	n/a

5.2.3. *Main interactions with ecosystem components*

Recent analysis carried out on sediment in fished tracks emphasized that the fishing operations with *Nephrops* trawls have significant impact on the fine sedimentary composition of the sea bottom. The surface of the traditional compact mud bottom seems to be reduced and gradually replaced by less muddy sediments similar to the outer edge of the central mud bank. This depletion may have an effect on carrying capacities of *Nephrops*.

The current fishing pattern implies high mortality of small *Nephrops*. The minimum landing size increased in 2006 and induced a higher discard rate. Trawling activities on *Nephrops* cause high discard rate on species such as hake and seasonally blue whiting and horse mackerel.

5.2.4. *Current management (Business as usual)*

No specific management objectives are known to ICES (ICES, 2010c), nevertheless French fishermen are concerned to protect the resource and have for several years demonstrated their involvement in this field. In 2003, a national *Nephrops* commission was created within *National Committee* for Sea *Fisheries* and Aquaculture, gathering all the regional and local professional structures. Its first decision was to establish a *numerus clausus* licence system (since 2004). Globally, management of the *Nephrops* fisheries is essentially based on conservation measures implemented by Community regulation:

- TACs,
- logbooks,
- minimum landing size (MLS) of 7 cm,
- selective gears for hake (since 2005): 100 mm square mesh panel on the upper part and at the entry of the trawl (fig. 5), and national regulation :
- contingent of licences (230 in 2011) for vessels catching more than 2 t. per year or since there is more than 200 kg of *Nephrops* on board per day,
- Monthly quotas since 2006 supervised by French producers' organisations,
- maximum vessel size (22.5 m),
- MLS of 9 cm, based on French fishermen will, compared to MLS of 7 cm in the rest of Europe,
- minimum net mesh size (70 mm stretched mesh),
- at least one of the following selective device for *Nephrops* (following the French 25th Nov. 2010 Ministerial decree from the Ministry of food, fishing, agriculture, rurality and country planning n°281) since 2008 for vessels catching more than 50 kg of *Nephrops* per day:
  . increased codend mesh size (from 70 mm to 80 mm or more),
  . minimum 60 mm square mesh panel on bottom of the trawl conical part (Fig. 5.2.4.1),
  . sorting grid with 13 mm between bars.

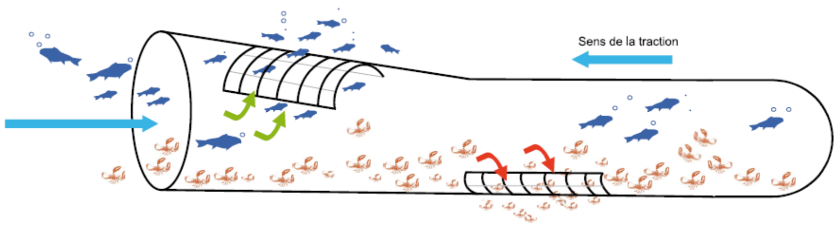


Fig. 5.2.4.1 Square mesh panels to hake and *Nephrops* escapement (Source: AGLIA, 2010a).

5.2.5. Key management issues / BAU performance

Fishery: Key issues remain the significant level of discards and hake by-catch. The average weight of discards per year in the period 1987–2009 is about 30% of the total catch in weight, whereas discards in the recent sampled years (2003–2009) reached 43%, with the highest discard rate in 2006 (ICES, 2010c). The effect of the recent regulations on the discard rate is not exactly known. In a context of UE plan to end discarding, there is an ongoing research program on selectivity and sustainable fishing (PRESPO and CHALUTEC projects), lead by AGLIA applying notably a kind of channel to release undersized *Nephrops*. Currently the survival rate of discarded individual is assumed to be around 30% (ICES, 2010b). But with "channels" it's could be better according to time spend on board, temperature, etc. (IFREMER). Moreover, selectivity trials are lead for years and fishermen are well-involved in it: selective devices are currently used (square mesh panel, sorting grid, larger codend mesh size) and tried to be improved in order to prevent undersized *Nephrops* and hake from fishing.

Assessment: ICES assessment is considered indicative of historic trends. Because of the retrospective pattern, trends in recent years are not considered reliable. There is evidence of a consistent bias with underestimation of F and over-estimation of SSB. Discards estimation is another source of doubt: prior to 2003 discards were only sampled in three years. Discards in years not sampled onboard are estimated, but with greater uncertainty: the derivation method is suspected to induce lack of contrast on annual recruitment indices (ICES, 2010b). The effort data used in the assessment do not take into account likely increases in catch efficiencies associated with the introduction of new gears and equipment in this fishery (ICES, 2010b).The fishing industry underlined the heterogeneous feature of the whole area of the stock and emphasized the necessity of applying additional tuning information on the southern part of fishery which is at this time an extrapolation of the northern part (ICES, 2010b). There is a proposal to benchmark this stock in 2012.

5.2.6. Other potential management tools

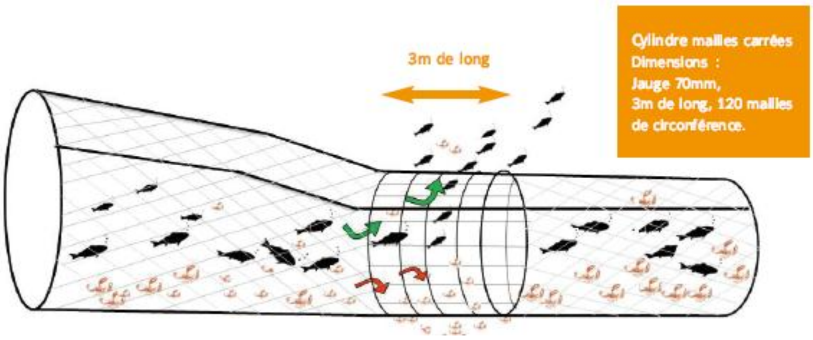
The current fishing pattern implies high mortality of small *Nephrops* so the exploitation rate is likely too high to reach a maximum sustainable exploitation (Biseau, 2011). The minimum landings size increased in 2006 and induced a higher discard rate. The impact of the selective devices applied since April 2008, aiming to reduce discards, is not known and should be evaluated (ICES, 2010c). IFREMER is leading a study about impacts of current measures on stock. It could be a reference point to assess the efficiency of new measures implementation. Indeed, the following propositions are based mostly on theoretical view of impacts of such measures. Assessment and monitoring should be realised to confirm it.

A change in the fishing pattern to reduce small *Nephrops* catches could lead to an higher MSY (Biseau, 2011). In order to maximise the three pillars of sustainability, considering that the spawning biomass and recruitment are increasing while fishing mortality is decreasing (ICES, 2010c), *Nephrops* discards, undersized catch and hake by catch should be reduced.

5.2.6.1. Overview of management strategies

Management strategy A - Increasing the use of selective devices

With additional measures (notably fishing effort regulation), improve selectivity, such as increasing mesh size or adopting more selective gear or devices (like Nephrops grids), avoids by-catches, catches and discards of the youngest individuals (Beverton and Holt, 1957; Ward, 1994; Suuronen and Sardà, 2007; Pascoe and Revill, 2004 in Macher et al., 2008). It enhances the exploitation pattern: it increases the age at first capture (prevent small Nephrops to be caught), the catch per unit effort and the sustainable total yield (MacLennan, 1995; Stergiou et al., 1997; Van Marlen, 2000; Kvammeand Froysa, 2004; Salini et al., 2000 in Macher et al., 2008; Biseau, 2007).



Management strategy B. Changing gear from simple trawl to creels

Changing *Nephrops* fishing gear, increasing the use of creels (Fig. 5.2.6.1.1) instead of simple trawls.

Fig. 5.2.6.1.1 Danish and Scotish creels used in the PRESPO project study on the feasability of *Nephrops* creels in the Bay of Biscay (Source: Figarede et al., 2011).

Management strategy C. Limiting the fishing effort decreasing days at sea

According to a bio-economic model, if benefits of selectivity are reinvested to increase nominal effort, they dissipate rapidly: regulating access to the fishery is also required to ensure the sustainability of the fishery and a better exploitation of the production potential (Macher et al., 2008). A limit on number of days at sea would ensure that the rent formed by selectivity measures will not be dissipated by an increase in effort (*Macher* et al., 2008).

Management strategy D. Using "channel" to release undersized Nephrops and by catch

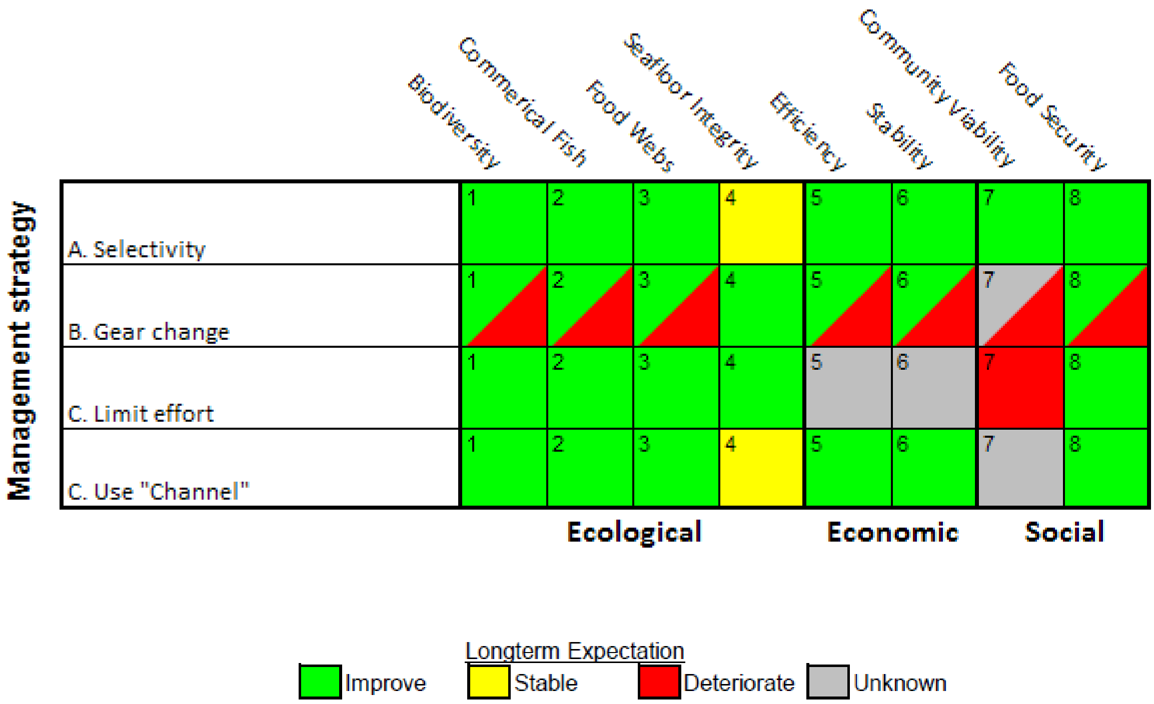
Decrease the fishing mortality on *Nephrops* juveniles by releasing them rapidly (Fig. 5.2.6.1.2). (During the IFREMER survey Survie 1 in 2009, survivors have been assessed between 54 and 88 %. The second survey Survie 2 shows that the mean survival rate was 61% at 12°C and 51% at 20°C. Two associations (AGLIA and Planète Mer) will help 30 vessels to get channels by subsidizing them).

Fig. 5.2.6.1.2 *Nephrops* sorting out and release thanks to a channel on trawler' board (Source: Planète Mer).

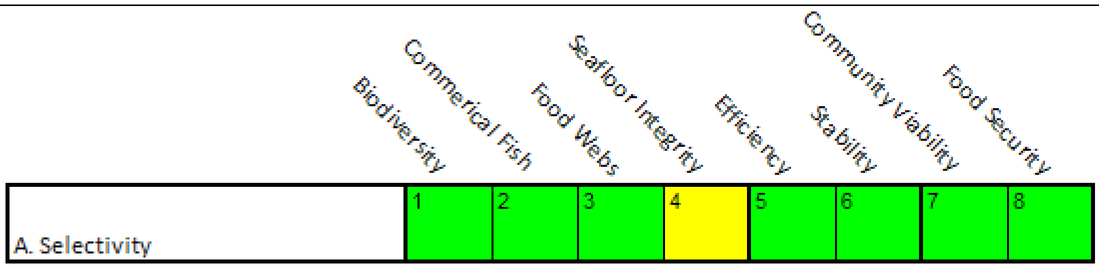
5.2.7.

5.2.8. Management strategy matrix evaluation

The matrix below compares the expected long-term outcomes from the selected management strategies. Narrative for each of the management strategies is included below.



Management strategy A: Increasing the use of selective devices



Assumptions

The management tools in the BAU strategy remain in place. Improve selectivity, such as increasing mesh size or adopting more selective gear or devices (like *Nephrops* grids).

Ecological descriptors

A.1, A.3 - *Nephrops*, commercial and non-commercial species could escape more easily, therefore it would be less fishing mortality and discards, which decrease opportunistic species abundance in favour of higher interest species.

A.2 - Selectivity has positive consequences on the biomass and age-structure of commercial stocks (Beverton and Holt, 1957; Kvamme and Fröysa, 2004; MacLennan, 1995; Salini et al., 2000; Stergiou et al., 1997; Suuronen and Sardà, 2007; VanMarlen, 2000; Ward, 1994 *in* Macher and Boncoeur, 2010). Currently used 100 mm square mesh panel is efficient for hake (27% under commercial size can escape), whiting, blue whiting, mackerel, horse mackerel (AGLIA, 2010b). Experimental 70 mm square mesh cylinder (on the trawl straight part) (figure x): 20% of undersized *Nephrops* escapement, with the same losses as current system and 11% or more depending on hake density of undersized hake can escape. Effects appears (no data yet) to be positive on blue hake, horse mackerel, pouting and squat lobsters (AGLIA, 2010b).

A.4 - Trawl impact remains the same on the seabed.

Economic descriptors

A.5 - Larger individuals caught are sold at higher prices (Biseau, 2007; Macher et al., 2008). Nevertheless, losses at short term on small individuals could be noted (Figarede, pers. comm.), as well as on associated species: a grid with a 20 mm bar spacing enable a significant loss of commercial catch (Loaec et al., 2006). The current 13 mm bar spacing grid too (Figarede, pers. comm.). Increased mesh size can cause significant losses for sole, red mullet and cephalopods (AGLIA, 2009).

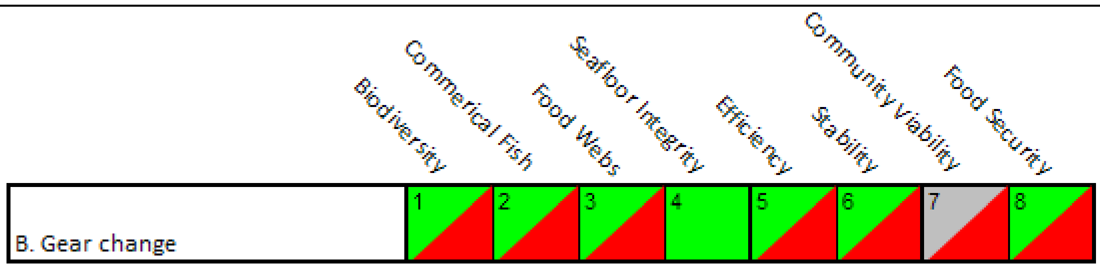
A.6 - Selectivity smoothes fluctuation in recruitment and thus guarantees more even yields for the fishery (Macher and Boncoeur, 2010).

Social descriptors

A.7 - Selectivity may generate some private benefits, such as minimizing time spent by crew sorting catches (Macher and Boncoeur, 2010). More stability in revenues would be appreciable. Selectivity also generates costs: apart from the possible higher price of selective gears, a major source of costs arises from the use of more selective gears, which often reduce catches of marketable fish per unit of effort (Fonseca et al., 2005; Kvamme and Fröysa, 2004; Madsen et al., 1999; Suuronen, and Jounela, 2004; VanMarlen, 2000 in Macher and Boncoeur, 2010; Macher et al., 2008).

A.8 - Long-term yield increasing, landings could be more stable.

Management strategy B. Changing gear from simple trawl to creels



Assumptions

The management tools in the BAU strategy remain in place.

Ecological descriptors

B.1 - The use of simple trawl lead to larger hake and pelagic fish catches, so higher discards for these species. Creel is a high selective gear which contributes to reduce discards, so to increase biodiversity, namely of more interesting species. At short term, likely probable biodiversity increase but at long term, risk of *Nephrops* biomass decrease due to other competitor species development (Figarede et al., 2011). Lost creels could generate a ghost fishing risk.

B.2 - Because simple trawl is less efficient than twin trawl, *Nephrops* is less impacted by fishing and thus population sustainability is ensured but not the pelagic associated commercial species that are more caught. With creel, the target species is only caught. Moreover, catches are made by larger individuals. Nevertheless, sex ratio and size structure could be modified as a larger part of females are caught, often with eggs (Figarede et al., 2011).

B.3 - Benthos community will be less impacted by the use of simple trawl. That is not the case for pelagic fish. Currently associated fish caught would no longer be caught as creel is mainly mono-specific (Figarede et al., 2011).

B.4 - The impact of simple trawl on sea floor is less significant than with twin trawl: invertebrates diversity would increase and largest body mass class of invertebrates would appear (Blanchard et al., 2004). Creel is a lower impacting gear on the seabed, as it is a “sleeping gear”. It will be less physical perturbations on it.

Economic descriptors

B.5 - According to the ISIS fish model, the twin trawl ban yields the highest catch over the entire period (10 years) (Pelletier et al., 2009).Although *Nephrops* caught by creels are larger, healthier, sold at higher prices and get a good image, it is not economically viable to adapt the whole trawling fleet in a creeling fleet: huge losses on associated species, even compensated by higher *Nephrops* prices and lower fuel consumption would disrupt harbour activity. In addition, costs to change the fleet equipment would be huge (Figarede et al., 2011).

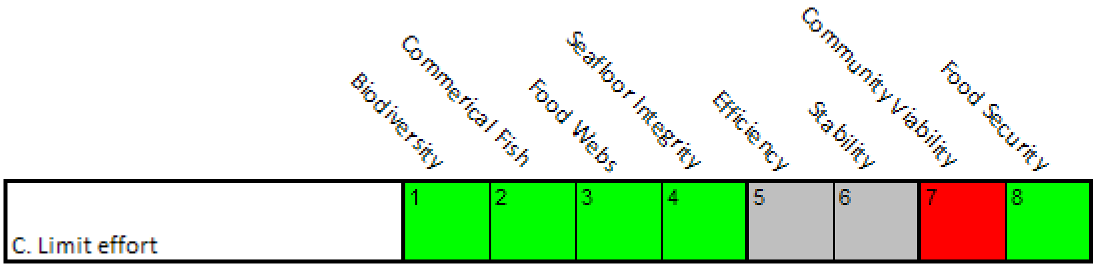
B.6 - It is a scenario that improves both stock status and economic return for the fleet (Pelletier *et al.*, 2009): the twin trawl ban stabilizes the *Nephrops* population under dynamic effort allocation and restores it in the static case, with an increase in biomass from year 7 of the simulations. Moreover, fuel consumption is lower with a simple trawl than with a twin one, which is considerable in the current context of fuel increasing prices. Due to the reasons previously enounced, it is not conceivable to restructure the whole fleet. More studies need to be lead to assess the benefits of the conversion of a small part of the fleet (Figarede et al., 2011).

Social descriptors

B.7 - Huge modification of harbours’ balance would not ensure the coastal communities if the whole fleet is changed but no data yet could help to assess the consequences of just a part of fleet reconversion (Figarede et al., 2011). Simple trawl visible effects take a long time to come, that may discourage fishermen. A short-term balance sheet should be made to assess the effects of reducing catches but reducing fuel costs. Harder work with creels and security has be strengthened. Conflicts for space can appear, as it should be shared with the other fishing activities on the zone under consideration.

B.8 - Concerning the simple trawl use, food security may improve as *Nephrops* landings will increase, but not the associated commercial species. With creels, it is risky to remove females with eggs. That is not sure it would be sustainable.

Management strategy C: Limiting the fishing effort decreasing days at sea



Assumptions

The management tools in the BAU strategy remain in place.

Ecological descriptors

C.1 - Biodiversity (benthos and pelagic) will increase due to less impact of fishing gears.

C.2 - *Nephrops* catches and associated species will reduce if effort remains the same when fishing is allowed. The long term impact expected is a stock improvement.

C.3 - Considering a constant effort when fishing is allowed, less days at sea could reduce the fishing pressure and improve the food web as it could be larger and longer lived fish.

C.4 - Impact on the sea floor will decrease.

Economic descriptors

C.5 – Unknown

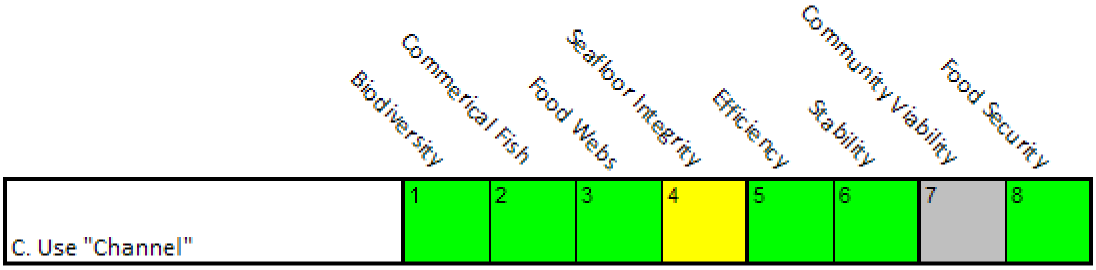
C.6 - The same quantities will be removed from an increased biomass.

Social descriptors

C.7 - It may be unnecessary to keep the same employment rate due to the number at sea decrease.

C.8 - Future catch potential will be higher.

Management strategy D. Using “channel” to release undersized Nephrops and by catch



Assumptions
The management tools in the BAU strategy remain in place.

Ecological descriptors

D.1 - Fishing mortality will be reduced, leading to the presence of higher interest species rather than scavengers.

D.2 - By catch and juveniles of *Nephrops* survival rate will enlarge therefore biomass.

D.3 - Cf. A.1, A.3

D.4 - Trawl impact remains the same on the seabed.

Economic descriptors

D.5 - Lower mortality on juveniles of *Nephrops* will enhances the exploitation pattern increasing the age at first capture, the catch per unit effort and the sustainable total yield (MacLennan, 1995; Stergiou et al., 1997; Van Marlen, 2000; Kvammeand Froysa, 2004; Salini et al., 2000 *in* Macher *et al.*, 2008; Biseau, 2007). Landings would increase.

D.6 - In theory, reducing non-commercial *Nephrops* discards leads to positive net present values of rent with better value realized from the production potential and limited short-term losses for the fishing units (Macher et al., 2008).

Social descriptors

D.7 - Stock improvement ensures the fishing activity durability but is not enough (costs related to the activity for example).

D.8 - Biomass increase leads to more available resource.

5.3. Case study: Iberian mixed demersal trawl fishery

5.3.1. Introduction to the fishery

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations and in different fisheries. In these cases management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those with reduced reproductive capacity, necessarily become the overriding concern for the management of mixed fisheries where these stocks are exploited either as a target species or as a by-catch.

In the SWW region there are several bottom trawl fleets operating in ICES Divisions VIIIc and IXa. From the North to the South this area is formed by the Spanish part of Bay of Biscay (VIIIc East) the Galician coast (VIIIc West and IXa North), the Portuguese coast (IXa Centre and South) and the Gulf of Cadiz (IXa Southeast). Several species populations are caught by the trawl fleets depending of the area they operate. The EU within the Common Fisheries Policy CFP) has regulated these fleets and their target species through TAC´s and technical measures (minimum landing size, mesh size, closed areas). Since 2006 a recovery plan was implemented for Iberian hake stock and Norway lobster. In the next paragraphs is explained in detail the characteristics of the different type of operating fleet/gear/métiers.

5.3.1.1. Spanish fleets

Analysis from the period 1989-1993 showed that hake, the main target species in the 70´s, had decreased 6% of the total weight landed, while catches of blue whiting and horse mackerel increased up to 47% and 18% respectively. At the end of the 80´s and early 90´s this fleet included bottom otter trawlers (OTB) and bottom pair trawlers (PTB). Regarding the OTB fleet, including two different gears: the *baca* and the *jurela* gears.

The *baca* is the traditional trawl gear targeting demersal species. It has a cod-end mesh size of 70 mm, a vertical opening of 1.2-1.5 m and a wingspread of 22-25 m. The more recent *jurela* gear also uses a cod-end mesh size of 65 mm, a vertical opening of 5-5.5 m and a wingspread of 18-20 m. The vessels of these fleets employ between 3 and 10 crewmembers. The PTB fleet uses a specific gear with a cod end mesh size of between 55 mm, a vertical opening of around 25 m and a wingspread of 65 m, and employs between 4 and 9 crewmembers.

Analyzing the log-books for the last years (2004-2006) by both trawl fleets operating in division VIIIc and IXa North, OTB is mainly targeting horse mackerel (42%), mackerel(37%) and demersal species traditionally appreciated in the Spanish markets (hake (2%), megrim(2%), monk(3%) and Norway lobster (1%)). PTB is especially efficient targeting blue whiting (64%) but also lands catches of hake (10%), most of both fleet catches, OTB and PTB, are landed in Galician ports.

For the period 2004-2006 the Spanish trawl fleet operated in division VIIIc and IXa north (OTB) with 87 boats, corresponding to 16,872 fishing days and 39,258 landing tonnes. The mean fishing was 1.4 days at sea and the mean characteristics of the vessels were 27.9 meters length, 137.5 GTR and 313.2 kW.

The pair trawl fishing fleet in the same period of time and fishing area presents the following averages 53 boats, 8 396 fishing days and landings of 28,987 tonnes. The mean trip was 1.1 days at sea and the technical boat characteristics were 27.60 total length, 144.3 GTR and 336.5 kW.

The value of landings from both Spanish fleets was close 90 million euros in 2006, and most important costs were to the crew share (37% of landings value) and fuel (24% of landings value). This fleet employs 1400 direct jobs (in FTE). Analysis conducted on the trawl fleet fishing in the Division IXa southeast (Gulf of Cadiz), shows the following species composition blue whiting (18%), octopus (14%), chub mackerel (11%), cuttle fish S*epia officinalis* (7%), hake (6%), rose shrimp -*Parapenaeus longirostrus* (5%), squid (4%) and Norway lobster (*Nephrops norvegicus* (1%) as main species.

5.3.1.2. Portuguese fleets

The Portuguese trawl fleet operating in Portuguese waters, comprises two components: 1) the trawl fleet direct to fish species catching hake, other demersal fish, and horse mackerel using a mesh size of 65mm and 2) the trawl fleet directed to crustaceans, using a mesh size of 70 mm when targeting norway lobster and using a mesh size of 55 mm when directed to shrimps. The fleet directed to demersal fish operates on the entire Portuguese shelf mainly at depths from 100 m to 200 m while the fleet for crustaceans operates) in restricted areas of the South and South west of Portugal, in deeper waters (100 m-750 m). A total number of 102 trawlers operated in the period 2003–2005, 72 fish trawlers and 30 crustacean trawlers. The mean values of the main characteristics of these trawl vessels were: i) Fish trawlers: 705 HP, 182 GRT, and 27 m overall length, and ii) crustacean trawlers: 563 HP, 178 GRT, and 25 m overall length. This fleet employed on the same period an average of 1500 direct jobs.

In 2009, 485 thousand tons of horse mackerel (*Trachurus trachurus*), 171 thousand tons of blue whiting (*Micromesistius poutassou*) and 1,7 thousand tons of jack mackerel (*Trachurus picturatus*) were landed. These three species combined represent more than 50% of the total weight landed (15,41 thousand tons) by the Portuguese trawl fleet (31% for horse mackerel, 11% blue whiting and 11% jack mackerel). In addition to these species other significant (in weight and value) species as hake (*Merluccius merluccius*), Norway pout (*Trisopterus luscus*), axillary sea bream (*Pagellus acarne*), megrims (*Lepidorhombus spp*.), monkfish (*Lophius spp*) and octopus (O*ctopus vulgaris*) are also important species for this fleet. The main crustacean landings include red shrimp (*Aristeus antennatus*), rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus).*

Analyzing log-book data from 2003-2005, three main fishing activities were found when analyzing the trips of the bottom-trawl fleet targeting finfish. One group is well defined, having horse mackerel as target species. Two other groups include trips targeting a mixture of species such as horse mackerel, hake, Norway pout and the other with dominance of octopus and squids as targets. The group targeting the mixture of species represented 47% of all fish trips, followed by the horse mackerel trips (35%) and the cephalopods trips with 17% of the total fish trips. The increasing importance of blue whiting in landings resulted in a new group. This species was caught as a by-catch in the trawl fleet and was previously discarded. In the beginning of 2005, a greater demand of this species at the Spanish market created a new fishing trip group directed at blue whiting. Regarding the crustacean fishing activities, there are two main target species: Norway lobster and deepwater rose shrimp but the main target groups changed between years as a result of changes in the abundance of the two main species. In 2003, one group targeted rose shrimp and the other contained a mixture of this species and Norway lobster, whilst in the following years the last group became more focused towards Norway lobster, in line with an increase in abundance of this species during 2004 and 2005 (Silva et al., 2009).

The majority of the trawlers had more than 50 % of their trips allocated to one main target group. Some of these vessels directed their effort towards species different from those specified in the fishing license. In fact, a fraction of the crustacean trawlers (11 % in 2003 and 4 % in 2005) had more than half of their trips targeting mixed fish cluster while 5 % of the finfish trawlers, in 2004 and 2005, had more than half of their trips targeting Norway lobster (Silva et al., 2009).

MEFEPO case study refers to the trawl fleets licensed to catch demersal fish. The species populations caught by these fleets are mainly hake, monkfish, megrims, horse-mackerel, and blue-whiting. In this case study we focus on the southern hake stock.

5.3.2. State of the stocks

Southern Hake *(Merluccius merluccius)* in ICES Divisions VIIIc+IXa. Recruitment has been improving since 2005, and there is a corresponding increasing trend in the spawning stock biomass. Fishing mortality has been around 0.8, from 2006 to 2009, and seems to have been reduced to 0.5 in 2010. Nevertheless the F_{2010} = 0.5 is still well **above** F_{MSY} estimated as F_{max} =0.24 (ICES, 2011).

White anglerfish *(Lophius piscatorius)* in Divisions VIIIc and IXa. The biomass of white anglerfish (in 2011) is estimated to be approximately 30% of B_{MSY} and the fishing mortality (in 2010) is estimated **below** $F_{MSY..}$

Black-bellied anglerfish *(Lophius budegassa)* in Divisions VIIIc and Ixa. Recruitment has been around average since 2000. Spawning stock biomass shows a slightly upwards trend after reaching a minimum in 2001. During last decade Fishing mortality has been stable and above F_{MSY}.

Megrim (*Lepidorhombus whiffiagonis*) in Divisions VIIIc and IXa were fished below Fmsy in 2010. Recruitment has been low for over a decade with the exception of the 2009 year class estimate. Spawning stock biomass has been relatively stable over the same period. Fishing mortality has fluctuated over last decade, and has decreased after 2006 and the mean F of 2008-2010 was estimated as 0.14, below Fmsy =0.17.

Megrim (*Lepidorhombus budegassa)* in Divisions VIIIc and IXa were fished above Fmsy in 2010. Recruitment as been around average since 2000. Spawning stock biomass shows a slightly upwards trend after reaching a minimum in 2001. Fishing mortality has been stable and **above** F_{MSY}

Southern Horse mackerel *(Trachurus trachurus)* in ICES Divisions IXa. Recruitment is generally stable with occasional large peaks like the latest that occurred in 2010. Spawning stock biomass has been stable as well as fishing mortality. The MSY reference points have not yet been established.

Blue whiting (*Micromesistius poutassou)* in Sub-areas I-X XII, and XIV (combined stock). Fishing mortality in 2009 was estimated **above** Fmsy and Spawning stock biomass below MSY $B_{trigger}$. Recruitment since 2005 are estimated to be amongst the lowest (ICES, 2010b).

5.3.2.1. Hake (Merluccius merluccius)

The Southern stock of hake (ICES Div. VIIIc and IXa) is distributed along the Atlantic coast of the Iberian Peninsula. The northern boundary of the stock is on the Spanish – French border; in the south the Gibraltar strait is the boundary splitting the Southern Stock from the Mediterranean hake. Southern hake spawns mainly from December to June, with a maximum between February and March, and the adults concentrate mainly in canyons and rocky bottoms of the shelf break area. According to Sánchez and Gil (1999) hake recruitment leads to well-defined patches of juveniles, found in localized areas of the continental shelf. These concentrations vary in density according to the strength of the year-class, although they remain generally stable in size and spatial location.

European hake is a serial or batch spawner. Duration of spawning season at the population level may differ between areas (Pérez and Pereiro, 1985; Alheit and Pitcher, 1995; Ungaro et al., 2001; Domínguez-Petit, 2007); but a latitudinal gradient exists such that the latest peaks of spawning occur in higher latitudes. In general, adults breed when water temperatures reach 10º or 12ºC, changing their bathymetric distribution depending on the region they are in and the local current pattern, releasing eggs at depths from 50 to 150m (Murua et al., 1998; Alheit and Pitcher, 1995). In general males mature earlier than females. Size at maturity is determined by density-dependent factors like abundance or age/length population structure and density independent factors like environmental conditions or fishing pressure. The abundance of small individuals is higher between autumn and early spring and can be distributed from 200-300 meters depth through coastal waters. These different depth-areas associations may be related with the feeding habits of the recruits, since the zooplankton biomass is relatively higher at those areas.

For assessment purposes Southern hake stock is considered to comprise the Atlantic coast of Iberian Peninsula corresponding with the ICES divisions VIIIc and IXa. The Northern limit is in the Spanish – French boundary and the Southern one in Gibraltar Strait (ICES, 2010b). Historically this stock has been mainly caught by Spain and Portugal. Fig. 5.3.2.1.1 indicates hake historical catches from 1972 to 2010.

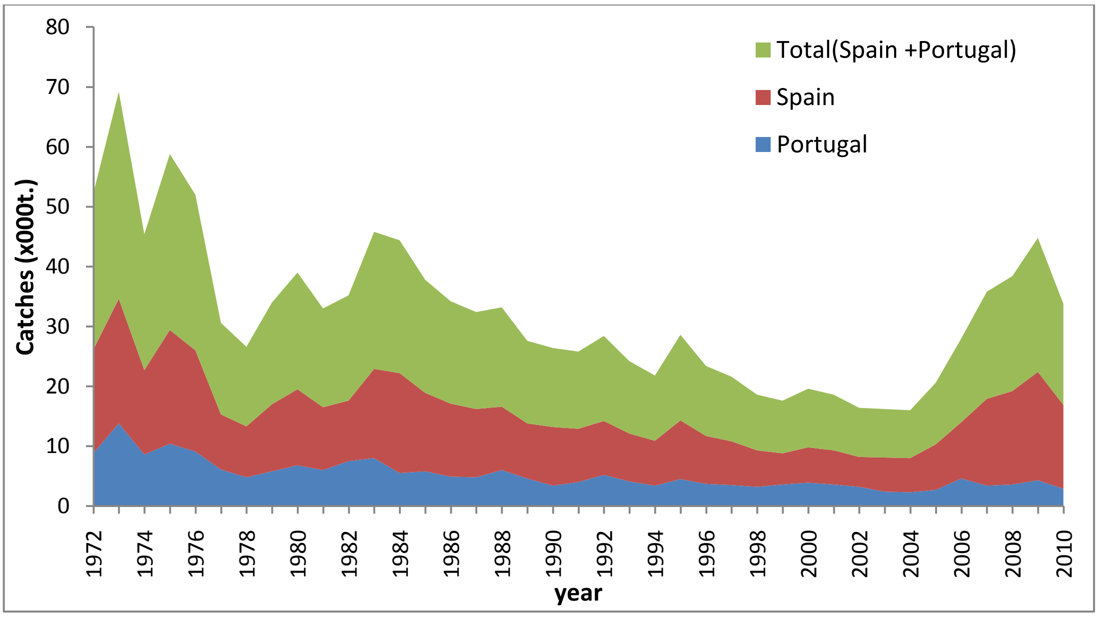


Fig. 5.3.2.1.1 Historical hake catches in ICES Divisions VIIIc and IXa, from 1972 to 2010

The assessment of this stock is based in several data sources: i) landings by country, quarter and area, discards; ii) annual surveys by area and season; iv) and commercial catch per unit effort (cpue), from different area based commercial trawl fleets operating in Galicia, Cantabria, Portugal and Cadiz. To perform a stock assessment the analytical model denominated GADGET (Globally Applicable Area Disaggregated General Ecosystem Toolbox), is used since 2010 (ICES, 2010b). According to the latest assessment performed by ICES (2011a), hake recruitment has been improving since 2005, and there is a corresponding increasing trend in the spawning stock biomass. Fishing mortality has been around 0.8, from 2006 to 2009, and seems to have been reduced to 0.5 in 2010. Fig. 5.3.2.1.2 summarizes the assessment of hake stock since 1982 to 2010 indicating recruitment (R) and Spawning Stock Biomass (SSB) (in upper panels) and fishing mortality and catches (removals) in the lower panels.

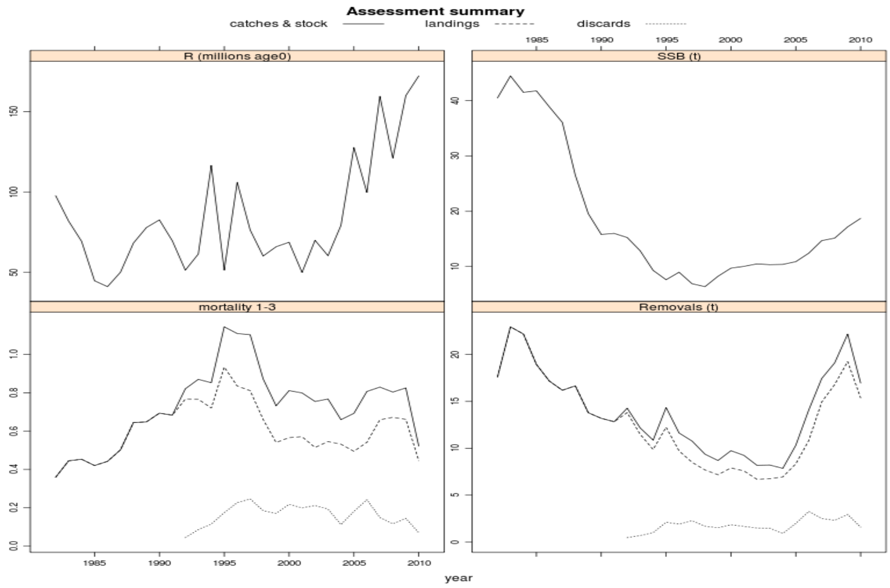


Fig. 5.3.2.1.2 Hake stock assessment estimates of recruitment (R) and Spawning Stock Biomass (SSB) (in upper panels) and fishing mortality and catches (removals) in the lower panels from 1982 to 2010.

Nevertheless the $F_{2010} = 0.5$ is still well above F_{MSY} estimated as F_{max} =0.24 (ICES, 2011a). Fig. 5.3.2.1.3 illustrates the yield per recruit (YPR) and spawning stock per recruit (SPR) relationships with fishing mortality estimates of Fmax=0.24, which was accepted as a proxy of F_{MSY}, and $F_{0.1}$ and the estimated F for 2010 (F_{sq}).

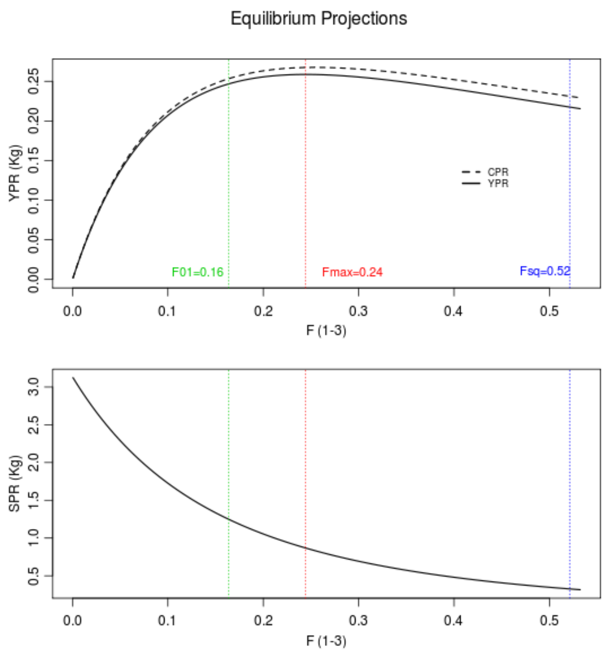


Fig. 5.3.2.1.3 Modelled Yield-per-recruit and Spawning-per-recruit of Hake stock ICES div. VIIIC +IXa, indicating estimates of F $_{0.1}$=0.16, Fmax=0.24 and current F_{2010} =0.52.

5.3.3. Main interactions with ecosystem components

Hake *(Merluccius merluccius* L.) has been identified as an important top predator in several regions of the North-east Atlantic (Guichet, 1995; Velasco and Olaso, 1998). It is an opportunistic feeder (Du Buit, 1996; Hill *et al*., 1999), and adult hake feed mainly on other fish species (Guichet, 1995; Velasco and Olaso, 1998; Cabral and Murta, 2002). Hake main prey species, vary by hake length group and by species local availability. In the Cantabrian Sea hake longer than 20cm preyed manly on blue whiting and horse mackerel, and smaller hake preyed on small crustaceans and silvery pout (*Gadiculaus argenteus*) (Velasco & Olaso, 1998). Further south in the Portuguese waters, the main hake preys are blue whiting (*Micromesistius poutassou*), mackerel (*Scomber scombrus*), chub mackerel (*Scomber japonicus*), anchovy (*Engraulis encrasicholus*) sardine (*Sardina pilchardus*), and even hake juveniles (cannibalism) (Hill & Borges, 2000; Cabral & Murta, 2001). Spatial patterns of groundfish assemblages on the continental shelf of Portugal were first identified by Gomes *et al.,* (2001) based on five surveys from 1985 to 1988, they differentiated 5 major typical assemblages closed aligned with depths: 2 shallow groups from 20-100 meters, 1 intermediate group from 75 – 150m and 2 deep groups from 150 meters depth along the shelf and upper slope. Within the shallow and deep groups the major separation was associated with latitude to the northern and to the southern of Peniche (ca 39º N Lat) The most abundant species in the northern shallow assemblage were sardine, mackerel, horse mackerel , European squid (*Loligo vulgaris*) and relatively to the southern shallow group horse mackerel and seabreams. In the deep assemblages these authors found the biomass dominated by blue whiting. Hake was found in all five assemblages. A more recent study of Sousa et al. (2005) based on twenty-two surveys from 1989 -1999 confirmed the existence of five assemblages and despite the different number of species analyzed the composition of species was very similar within the groups. These did not change significantly between the summer and fall surveys, but there were seasonal changes in relative species composition within assemblages. On the shelf plateau (<150 m), horse mackerel (*Trachurus trachurus*) was more important in autumn assemblages, whereas the pelagic crab (*Polybius henslowii*), and boarfish (*Capros aper*) dominated summer assemblages to the north and south, respectively. On the upper slope, the fish community was dominated by blue whiting (*Micromesistius poutassou*). Most species were confined to certain depth and latitudinal ranges, and the ubiquitous species (*Merluccius merluccius*, *Trachurus trachurus*), mean body size increased from the shallower to the deeper assemblages.

Fishing pressure exerted on hake has indirect effects on its prey abundance through the trophic chain. It is therefore expected that hake low abundance will decrease top predation on these pelagic prey populations in the area of their overlapping distribution, and that hake predation increase when its stock abundance increase.

In the Cantabrian Sea deeper areas large hake and anglerfish are both top predators and seek the same prey, the blue whiting. In this area there are low niche overlaps between large hake and small hake and they prey different species (Sanchez and Olaso, 2004). These authors applied a mass balance model of trophic interactions on Cantabrian Sea shelf ecosystem to understand the effects of the different fisheries that operate in the area and concluded that trawling had a strong impact on large hake, small hake, anglerfish, megrim, dogfish and rays. Furthermore trawling and gillnets compete for large hake and anglerfish in the Cantabrian Sea. Discards of by-catches and undersized fish species are also occurring in the mixed trawl fishery. Based on 2010 discard sampling in Portuguese waters for the trawl fishery, main species discarded were chub mackerel, blue whiting, jack mackerel, sardine, and hake.

5.3.4. Current management (Business As Usual - BAU)

The following tools are currently being employed:

- Recovery plan for hake
- Total Allowable Catch
- Effort (days at sea)
- Minimum landing size
- Mesh size restrictions
- Seasonal closures

5.3.4.1. Recovery plan for hake

A recovery plan for Southern hake has been approved and applied since 2006 (STCEF, 2010). The recovery plan scenario is to achieve F_{MSY} by 2015. Consists mainly of 10% annual reduction in F and a 15% constraint on TAC change between years- aiming at a spawning stock biomass of 35 thousand k tonnes by 2015 (ICES, 2011a).A decrease of hake fishing mortality is also beneficial to the other species populations caught in the same trawl fisheries along the region.

5.3.4.2. Total Allowable Catch (TAC)

Southern Hake (*Merluccius merluccius*) - For 2011 an EU TAC of 10,695 tonnes applies for hake in ICES divisions VIIc and IXa divided by countries in quotas (Spain - 6,844 tonnes., Portugal – 3,194 tonnes. and France - 657 tonnes.).

Horse-mackerel (*Trachurus trachurus* and *Trachurus picturatus*) - The EU TAC includes both *Trachurus* species under *Trachurus spp.* but ICES advises only on *Trachurus trachurus* stock population. For assessment purposes Atlantic Horse Mackerel in Division IXa is considered by ICES as a stock population separated from VIIIc Division. For 2011, Division IXa *Trachurus spp.* EU TAC is 29,585 tonnes divided by quotas (Portugal – 21,931 t. and Spain – 7,654 t.), up of 5% of these quotas may be fished in division VIIIc. (of which, notwithstanding Article 19 of Regulation (EC) No 850/98, no more than 5 % may consist of horse mackerel between 12 and 14 cm). Catches and fishing mortality have been relatively stable since 1999. Biomass has been stable during the assessment period. Recruitment is variable with occasional large peaks, like the latest in 2010. The state of the stock is undefined relatively to Fmsy.

Anglerfish (*Lophius piscatorius* and *Lophius budegassa*) - For 2011 in ICES Divisions VIIIc and IXa the TAC for both anglerfish species is 1,571 tonnes, divided by country in quotas (Spain – 1,310 t., France - 1 t. and Portugal - 260 t.). The state of the stock is undefined relatively to Fmsy.

Megrims (*Lepidorhombus boscii* and *Lepidorhombus whiffiagonis*) - For 2011 the EU TAC is of 1,094 tonnes for ICES Divisions VIIIc and IXa divided by country quotas (Spain 1,010 t., France - 50 t. and Portugal - 34 t.) The state of the stock is undefined relatively to Fmsy.

Blue-whiting (*Micromesistius poutassou)* - This species is assessed by ICES as one Atlantic stock from Norwegian waters to Portugal (with different sub-components). For 2011, the total TAC is 40,100 tonnes divided by the applicable European countries in quotas. For Divisions VIIIc and IXa the quota is 1,030 tonnes (Spain - 824 t. and Portugal - 206 t.) The state of the stock is undefined relatively to Fmsy.

Skates and Rays (*Rajidae spp.*) - Precautionary TAC for 2011 in Divisions VIIIc and IXa of 4,640 tonnes. The EU TAC does not apply to undulate ray (*Raja undulata*), common skate (*Dipturus batis*) and white skate (*Rostroraja alba*). Catches of these species may not be retained on board and shall be promptly released unharmed to the extent practicable. Fishers shall be encouraged to develop and use techniques and equipment to facilitate the rapid and safe release of the species.

5.3.4.3. Minimum Landing Size (MLS)

- Hake= 27 cm total length
- Horse Mackerel=15 cm total length
- Anglerfish= no MLS
- Megrims=20 cm total length
- Blue whiting= no MLS

5.3.4.4. Mesh Size restrictions

In the region the general rule is that bottom otter trawl have to use a minimum of 65 mm diamond cod end mesh size with some exceptions:

- In the Gulf of Cadiz bottom trawl may use a minimum of 55 mm cod end diamond mesh (Spanish fleet in IXa south)
- In the north of Spain (VIIIc and IXa north) otter bottom trawl fleet cod end mesh size is restricted to 70 mm.
- For pelagic fish In the north of Spain (VIIIc and IXa north), the pair trawl fleet is allowed to use a minimum of 55 mm cod-end mesh size

5.3.4.5. Effort restrictions

Effort control also applies under the hake management plan. Annual fishing days are limited as well as engine power size.

5.3.4.6. Seasonal closures

To protect nursery grounds there are 7 closed areas: i) in the Cantabrian, 3 closed areas to trawl fishing during all year round and 2 seasonal closed areas; ii) in Galicia, one seasonal trawl closed area; iii) in Southwest shelf of Portugal, one seasonal closed area to all gear types (Fig. 5.2.4.6.1).

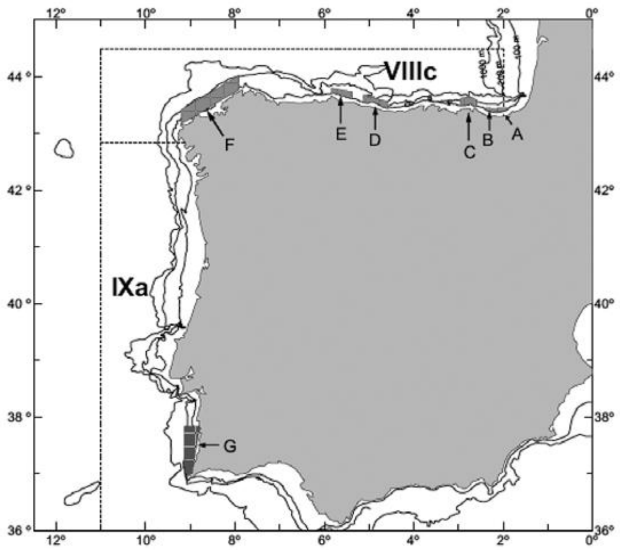


Fig. 5.2.4.6.1 Existing Spanish and Portuguese closed areas A: Fuenterrabia, C: Bermeo and D: Llanes - Trawl prohibited all year; B: Guetaria - Trawl prohibited September to December; E: El Callejón and La Carretera - Trawl prohibited September to March; F: A Coruña and Cedeira -Trawl prohibited October to December; G: Milfontes and Arrifana - All gears prohibited December to February.

5.3.5. BAU performance

Current management scenario is set to obtain MSY in 2015 (ICES, 2010b). Analytical or Precautionary TACs are in place for hake, horse-mackerel, anglerfish, megrims, blue-whiting. Catches of undulate ray (*Raja undulate*), common skate (*Dipturus batis*) and white skate (*Rostroraja alba*) cannot be retained onboard and shall be promptly released unharmed to the extent practicable (EU, 2011). Annual fishing days are limited as well as engine power size. Minimum Landing sizes (Hake=27cm; Horse mackerel= 15 cm; megrims 20cm).

A recovery plan was implemented in 2006, with effort control measures in place, together with TACs. The recovery plan scenario is to achieve F_{MSY}

In 2010 ICES estimated F_{MSY} for southern hake and anglerfish (ICES, 2010b). For southern hake F_{MSY} was defined equal to 0.24 but still the 2010 fishing mortality doubled the desired target. The plan aims at recovering the southern hake stock to a spawning stock biomass above 35,000 t and to reduce fishing mortality to 0.27 by 2015. A decrease of hake fishing mortality is also beneficial to the other species populations caught in the same trawl fisheries along the region.

Since 2005 that hake recruitments have been strong and should be protected from by-catch and discards. The legal MLS is 27cm for all gears and this is a management issue because this length does not correspond to the length expected to be retained using the legal the trawl mesh sizes. According to selectivity experiments performed in the Southwest of Portugal the selectivity curve of legal cod-end of diamond mesh size of 65 cm used by fish trawlers is $L_{50} =$ 18-19 cm (Campos, et al., 2003). This promotes juvenile hake discarding. A possible option is to change the net design to square cod-end mesh size to allow a better escapement of juvenile hake up to the MLS of 27cm.

Nevertheless this measure avoids discarding but does not prevent the killing of hake juveniles, therefore to rebuild the hake spawning stock biomass is necessary to avoid fishing where juvenile hake might be present to allow the new individuals to grow and start to reproduction. Females mature at a larger size (33-43cm) than males (22-40cm) (Perez and Pereiro, 1985).

5.3.6. Other potential management tools

Potential management tools for the demersal trawl fishery include:

- Real time spatial management by Increasing fisheries closures to protect juvenile fish using real time devices onboard
- Ban/minimize discards - using square mesh panels , selection grids, other escapes or gears
- Individual Vessel Quota Limits - IVQs
- Marine Protected Areas (real time, seasonal or permanent)

5.3.6.1. Overview of management strategies

Management Strategy A: Real Time Spatial management

Along the area there are differences in the species distribution and the nature of species mixing. An increase of closed areas for juvenile hake using spatially disaggregated management areas could be feasible. In some geographic locations hake nurseries mostly overlap with blue whiting. In others were there is a mixture of species there are already seasonally closed to fishing. A detailed spatial management plan differentiated with regard to species composition could be feasible allowing the catch of horse mackerel TAC and other commercial species of interest. Maps of Spatial distribution of juveniles are available from IBTS ICES Working Group (ICES, 2011a) which can help on the design of real time closed areas for juvenile hake and other associated species.

Management Strategy B: Ban/minimize discards

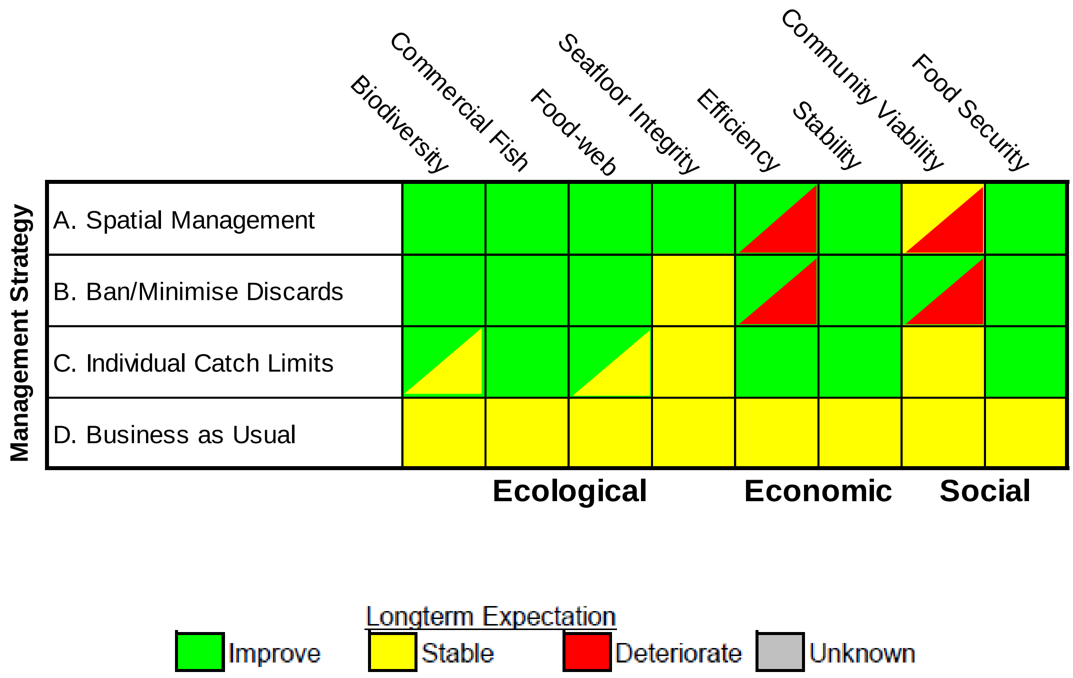
In this region currently discards seem to be mainly caused mainly by the MLS of the species caught. Minimum landing size for hake does not correspond to the legal common bottom trawl mesh size selectivity of 65 mm which is common for all area. Nevertheless in 70 mm size and 55 mm mesh sizes are also legal to be used for depending of the area and target species. This causes discards of juvenile hake even using the legal mesh size. Revision of minimum landing size for hake and other species in the trawl fishery is necessary to reduce discards. Nevertheless this does not prevent killing the fish that are by-catch. Alternative gear design, square mesh panels or selection grids are necessary to be introduced in the fleet to ban or mitigate discards.

Management Strategy C: Individual Vessel Quota Limits/IVQs

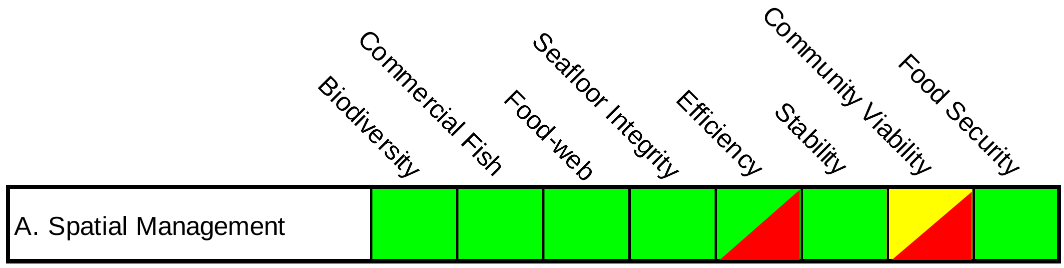
To increase responsible fishing and adaptive management. Currently one of the governance issues of this fishery is the frequency of hake TAC over-passing. There is already in place a group/individual vessel hake catch limit in the Portuguese area of the stock. The implementation of the IVQs should be explored in this fishery and others to increase the responsible fishing.

5.3.7. Management strategy matrix evaluation

Below is a traffic light matrix table with the potential additional management tools described in the previous section in addition to the current *business as usual* (BAU) scenario. An appraisal of the direction of change relatively to the BAU scenario is made for each of the attributes of ecological, economic and social pillars considered by MEFEPO. The long term management scenario is maintained equal to the overall goal of MSY to be attained by 2015 according to the Common Fisheries Policy. The interaction of the MSY goal and the Good Environmental Status (GES) from the MSFD to be attained by 2020 is considered when appraising the selected ecological attributes. Narrative for each of the management strategies is included below and comparisons were supported by relevant literature and were made in consultation with stock assessment experts.



Management strategy A: Real time spatial management



Assumptions

The current management tools in the BAU strategy remain in place. The number, size and location of the closed areas have to be selected on best available scientific information based on research surveys results and with the cooperation of the commercial fishing fleet.

Ecological descriptors

A.1 Biodiversity - Bottom trawling has been demonstrated to reduce benthic biodiversity is identified as having high impact on target and non target species and consequently reducing biodiversity. Increasing closed areas is expected to improve biodiversity by facilitating the replenishment of site attached vulnerable organisms. Improvement will depend on species recovery periods and may be limited when closure is only seasonal.

A.2 Commercial fish -Closing nursery areas to fishing is expected to improve hake recruitment and SSB and thus providing improvement in the commercial fish indicator. The improvement in recruitment and SSB is also expected to help hake stock recover to MSY levels.

A.3 Food-web - Spatial management it will be geographically disaggregated according to the main assemblages of region. By Increasing closed areas for juveniles is expected to increase, in the long term, the proportion of large fish and therefore contribute to a positive change on the food web descriptor.

A.4 Sea Floor Integrity - Is predicted to increase in response to the removal of some trawling activity which has been demonstrated to increase the homogeneity of the sea floor permanently (Collie et al., 2000; Kaiser et al, 2002). Closed areas would facilitate an improvement relatively to current BAU.

Economic descriptors

A.5 Efficiency - closures of fishing grounds will reduce profitability, on the short term, and is likely to increase fishing pressure in neighbouring areas if an adequate effort spatial management in the entire area is not in place.In the long term is expected an increase of the yield which increases efficiency.

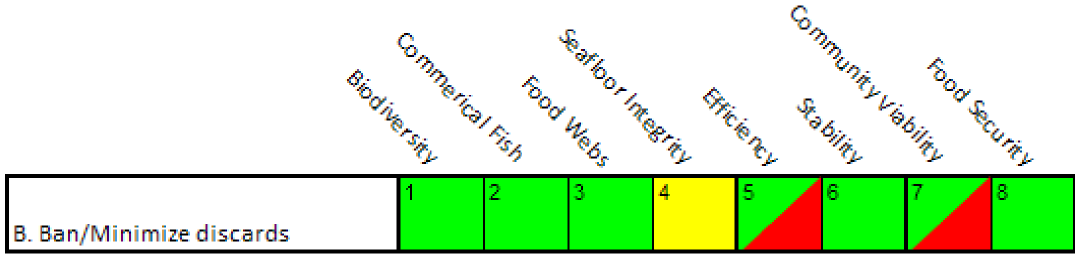
A.6 Stability - In the long term closed areas in juvenile areas will bring to an increase SSB provided fishing mortality is kept low. A management plan aiming at a stable catch for hake can then be decided by the governance structure in place.

Social descriptors

A.7 Community viability - The fishers of the fleets involved in this fishery are not expected to have a significant change on their communities. Nevertheless they will lose profitability in the short term which will have a negative impact. This might becompensated by the displacement of fishing effort to other grounds outside the closed areas aiming at a different species.

A.8 Food security - The long term improvements in hake stock levels and consequently higher stability and landings levels is expected to provide an improvement in food security.

Management strategy B: Ban/Minimize discards



Assumptions

The management tools in the BAU strategy remain in place. Revision of Minimum Landing Size for hake and other species. Introducing by-catch devices and another mesh design, as the mesh squared to avoid retaining immature juvenile hake and other species.

Ecological descriptors

B.1 Biodiversity - The reduction of discards is expected to improve biodiversity by avoiding the removal from the sea of target and no-target species usually discarded.

B.2 Commercial fish - Minimizing discards by increasing or changing the mesh size from diamond to square it is expected to allow the individual fish to grow larger and rebuild the stock structure to an healthy state. This in the long term improves the state of hake and other commercial stocks in the region and the GES descriptor.

B.3 Food web - Minimizing discards in this mixed demersal fishery means avoiding the unnecessary catch of many non-target species, therefore leading to improvement on the food-web structure. Minimizing discards and allowing young fish to escape will increase the proportion of large fish and therefore facilitates a positive change on the food web.

B.4 Sea floor Integrity - No expected changes in the seafloor integrity are expected by minimizing discards, as increasing mesh size, or changing the mesh shape does not prevent the bottom gear to impact the fragile benthic seafloor.

Economic descriptors

B.5 Efficiency - In the long term minimizing discards are likely to increase fishery profitability by the gain in the value of mean weight of the fish in the catch. However in the short term profitability is expected to be lower than current BAU.

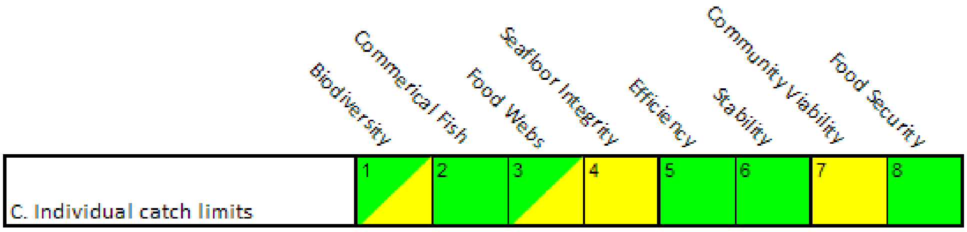
B.6 Stability - In the long term minimizing discards by increasing selectivity increases the level of the stock biomass of the exploited commercial stock. This means that a management plan aiming at a constant catch can be achievable for example for hake.

Social descriptors

B.7 Community viability - Introduction of the square mesh and other gear devices to avoid discards has the potential to negatively impact upon the fishery community e.g. fishers will be required to purchase new gear/nets. However in the long run minimizing hake discards is expected to increase commercial value and catch rates.

B.8 Food security - Improvements in the commercial fish descriptor will improve food security.

Management strategy C: Introduction of ITQs



Assumptions

The management tools in the BAU strategy remain in place. To increase responsible fishing and adaptive management. One of the governance issues of this fishery is the frequency of hake TAC overpassing. There is already in place a group/individual vessel hake catch limit in the Portuguese area of the stock. The implementation of the IVQs should be explored in this fishery and others to increase responsible fishing.

Ecological descriptors

C.1 Biodiversity - The introduction of IVQs does not change the current BAU state of this descriptor. Nevertheless effort is likely to decrease and this will facilitate a positive effect on biodiversity.

C2 Commercial fish- It is expected that individual vessel catch limits (IVQs) will make the agreed TAC to not be overpassed. If the agreed TAC is set in accordance with the scientific advice, IVQs will help hake recovery and improve other species state in the region. It is therefore expected a positive change in the number of stocks exploited within safe biological limits and consequently in this descriptor.

C.3 Food web - Introduction of Individual vessel catch limits (IVQs) may help in the control of catches and fishing effort, but is not much different from the current system BAU if the TAC is well controlled and divided by individual vessels. This management strategy is likely to help to reduce unsustainable catches and decrease fishing effort in some stocks which in the long term may facilitate an increase in the proportion of large fish leading to a positive change on the food web

C.4 Sea floor integrity - No changes in this descriptor are expected with this additional management tool.

Economic descriptors

C4 Efficiency - It is expected that ITQs introduction lead fishers to keep only the sustainable fisheries and this may improve efficiency.

C5 Stability - If the fishery is kept sustainable then is possible to keep a stable catch as part of a management plan set by the adequate governance structure.

Social descriptors

B.7 Community viability – In the industrial Trawl fishery the introduction of ITQs is not much different that the current BAU system based on the TAC, with the difference of not allowing each individual vessel to overpass a certain quota. It is therefore nor expected any major difference in this descriptor

B.8 Food security – This tool it is expected to increase food security in accordance with commercial fish positive change

5.3.8. Management guidance

If the overarching management objective is to work towards Good Ecological Status (GES) in the context of the MSFD, then strategy A is considered to be the most appropriate given that a reduction in trawling in some geographical areas is considered to provide improvement across all four ecological descriptors (biodiversity, commercial fish, food webs and seafloor integrity). Introducing closed areas improves the overall ecological status and sustainability of target species and is predicted to provide improvement in terms of stability of catches and food security. However, closed areas are likely to have a negative effect on employment and will also limit choice on where fishers can fish on. Improvements in target stock status may however lead to improve efficiency and thus maintain community viability.

Strategy B is ecologically sound, with biodiversity improving and commercial fish stock status also improving. The more suited selectivity and improved fishing technology in trawl gears across the region will require that individual fishers and fishers organisations invest in new gears to adapt to changes in legal mesh sizes and fishing devices with improved selectivity. Thus, a negative impact in terms of efficiency and community viability is expected in the short term.

The proposed reform of the CFP includes plans for the introduction of individual fishing quotas for assessed stocks. A similar system using individual vessel quotas is already in use for hake in a regional part of the fishery. The introduction of Individual catch limits over the whole area of the fishery (Strategy C) is not much different from the existing TAC system for assessed stocks. However, potential improvement in catch and fishing effort regulation is expected to lead to improvements in efficiency, stability and commercial fish status by facilitating catch/quota and effort control at the individual vessel level, leading to a more efficient response and adjustment at particular stock levels.

If the management objective is to improve the state of the demersal fish stocks any of the three strategies presented could be chosen because they all lead to improvements in the commercial fish descriptor. The examination of the considered alternative management strategies indicates that it is possible to modify management in the mixed demersal trawl fishery to provide improvement in the ecological descriptors. The choice therefore depends on the trade off with other descriptors. The implementation of Strategy A is believed to have an expected improvement in all ecological descriptors without significant deterioration in the social and economic aspects of the fishery, potentially improving some of them as well.

5.4. Case study: Iberian Purse seine fishery

5.4.1. Introduction to the fishery

5.4.1.1. Cantabrian - Northwest area and Gulf of Cadiz Purse Seine Fleet

The geographical distribution of effort shows that the activity off this fleet takes place in ICES Divisions VIIIb, VIIIc and mainly in the northern part of IXa (*Rias Baixas* of Galicia). The seasonality of effort indicates that the purse seine fleet in Division VIIIc has more activity between February and October, while in IXa, where it concentrates in the summer.

The landings of the this fleet are distributed among the different ports along the northern coast (up to 60 ports), those of Galicia and the Basque country being the most important (37.5%), followed by those of Cantabria (21%) and Asturias (3%). Mackerel landings are more important in Basque and Cantabrian ports, while those of sardine, chub mackerel and horse mackerel are more widely spread although with a greater importance in ports of Galicia.

Sardine (*Sardina pilchardus*), makes up 50% of catches landed in 2004 followed by horse mackerel (*Trachurus spp*), anchovy (*Engraulis encrasicolus*) mackerel (*Scomber scombrus*) and chub mackerel (*Scomber colias*). In 2005 and 2006 the percentage of landings by species changed due to the closure of the anchovy fishery, established by the EU in mid-2005, which led to a considerable increase in mackerel and Spanish mackerel landings. The profile of the catch landed in 2009 was predominantly made up of mackerel, followed by sardine, horse mackerel and Spanish mackerel, the three with very similar percentages.

Mackerel fishery it is seasonal and used to take place during March- April but in the last decade fish became available already in February. Traditionally the anchovy fishery had its peak of catches between April and June. The remaining important species are caught throughout the year, although in greater quantities in summer and autumn.

According to 2009 log-books, the purse seine fleet of the Cantabrian-Northwest area consisted of a total of 250 vessels with a total effort of 21 622 fishing days and 107 778 t. The mean technical characteristics of this fleet were 20.1 m total length, 48 GRT (Gross Registered Tonnage) and 197.8 kw of engine power. Large differences exist between the technical characteristics from the vessels of Galicia (17.8 m, 32.4 GRT and 164.6 kw) and those from Cantabria (29 m, 98.8 GRT and 270.5 kw) and the Basque country (33 m, 130.2 GRT and 450.9 Kw.). These differences are partly explained by the different strategies of the fleets. The purse seiners from Cantabria and the Basque country operate in waters farther from the home port and during the summer and in early autumn they change the target fish to tunas, a fishery that involves large displacements and need larger vessels. On the contrary the purse seine fleet of Galicia is mainly dedicated to resources in coastal waters throughout the year.

The purse seine gear used in the Cantabrian-Northwest area (PSN10) is officially defined as a rectangular net of less than 600 m length, less than 130 m height and a minimum mesh size of 14 mm (*Orden* APA/676/2004, BOE nº 65). The authorized period for the use of this gear is five days a week for each vessel (*Real Decreto* 429/2004, BOE nº 65). This fleet is authorized to operate in both national and non-Iberian Community waters of the Bay of Biscay (Divisions VIIIabd) (Reg. CE nº

2371/2002), as well as in Portuguese waters (ICES Division IXa) through “border agreements” with Portugal.

The collapse of the anchovy fishery in the Bay of Biscay in 2005 led to the establishment of areas closed to fishing and successive management measures with the aim of its recovery (Reg. CE nº 1037/2005; Reg. CE nº 51/2006; Reg. CE nº 116/2006; *Orden APA*/2150/2007; *Orden ARM*/1905/2008 and *Orden ARM*/2120/2009; Reg. UE No 23/2010; Reg. CE nº 1181/2010). Specifically, for 2009 the TAC set was zero tonnes (0 t).

In the Gulf of Cadiz in 2004-2006 the purse seine fleet is composed by 85 vessels exerting a mean annual effort of 6,162 fishing days and reporting corresponding landings of 10,390 t. In 2009, 76 vessels conducted the activity for 6,289 days. The seasonal activity of purse seiners peaks during March - September, with the anchovy fishery in spring summer, followed by the sardine in summer - autumn, coinciding with the spawning periods of each species in the area. Sardine is the species with the highest total catch in the Gulf of Cadiz representing half of landings, followed by anchovy and as secondary species chub mackerel and mackerel.

The value of landings by this fleet was ca. 52 million € in 2006, and its most important costs were the crew share (56% of landing value) and fuel (20%). This gear employs between 6 and 8 crewmembers by vessel and generates 1 700 direct jobs.

5.4.1.2. Portuguese Purse Seiner Fleet

The Portuguese purse seine fleet is the most important fishery in Portuguese waters in terms of landings. In 2009, the fleet was composed of 159 licensed purse seiners, ranging in size from 10.5 to 27 m, with an average of 20 m, an average engine horsepower of 250 hp (range from 71 to 449 hp) and uses a minimum mesh size of 16mm. The mean age of the purse seine fleet is 20 years with a strong seasonality in landings during the year. This fleet uses mainly seine nets and targets small pelagic species usually close to the home port, on short (daily) trips where the net is set once or twice, usually around dawn. A large part of a typical fishing trip is spent searching for schools with echo-sounders and sonars. Once schools of pelagic fish have been detected, large nets (up to 800 m long and 150 m deep) are set rapidly with the help of an auxiliary small vessel, and hauled in a largely manual operation involving all members of the crew (usually between 15-20 people).

Sardine (*Sardina pilchardus*), chub mackerel (*Scomber colias*) and Atlantic horse mackerel (*Trachurus trachurus*) are the most important species landed by the Portuguese purse seine fleet, both in terms of weight and value. In 2009, 52,5 thousand tons of sardine, 8, 5 thousand tons of chub mackerel and 2,2 thousand tons of horse mackerel were landed, which constitutes more than 98% of the total landings. Other medium-size pelagic species, as mackerel (*Scomber scombrus)* and jack mackerel (*Trachurus picturatus*) are also landed. Anchovy (*Engraulis encrasicolus*), with a higher auction market value, is occasionally caught especially in south Portugal, and has proven to be important for local fishing communities. Purse seine catches are mainly consumed fresh by the internal market and about a third of the national production is sent to canning factories based in the centre

(Peniche) and north (Matosinhos, Póvoa de Varzim) of the country, from here, more or less 50 % of the canned sardines are exported.

5.4.2. State of the stocks

Sardine (*Sardina pilchardus*)

The assessment and advice for Sardine in Divisions VIIc and IXa is primarily based on abundance estimates from acoustic surveys and egg surveys together with commercial catch - at –age data. 2011 age based analytical stock assessment indicated that SSB declined since 2006 due to lack of strong recruitments since 2005 (ICES 2011b). Fishing mortality in 2010 was 28% higher than in 2009. The 2010 year class is estimated as the lowest of the last 32 years available time series. ICES Advice for 2011 sardine advice is based on the precautionary approach based on the trend analysis. Fishing mortality has increased and Spawning Stock Biomass has decreased in the most recent years despite advice not to increase F since 2002. F should be brought back to where it was before the start of this increase, i.e. the 2002 - 2007 average which corresponds to landings of less than 36,000 tonnes for 2012 (ICES, 2011b) The MSY reference points have not been established so far. Candidate reference points have been outlined this year by ICES expert group (ICES, 2011b). The stock recruitment relationship for this stock is poorly defined and thus very sensitive to which data points are used for fitting a Stock-Recruitment (S-R) model. As a consequence, F_{MSY} calculated combining an S-R model with the YPR curve is very unstable. Because of the uncertainties surrounding the form and parameters of the S-R relationship, reference points based on spawner per recruit analysis (%SPR) were considered more appropriate as proxies of F_{MSY} as indicated by Clark (1991, 1993).

Western Horse mackerel (*Trachurus trachurus*)

Western stock is one of the three components in which this species distribution area is divided, extending from Subarea VIII in the south to Division IIa in the north, except for the North Sea, which is considered a separate stock. It is regulated by a management plan put forward by the Pelagic RAC and based on the triennial eggs surveys. Spawning biomass remains stable in the period 1995-2009, within a range of 1,42 and 2,36 million tonnes. Fishing mortality has shown an increase since 2006, though it has remained at low levels. No strong year classes have been recorded since 2001. This species is not only captured by purse seiners but also by trawlers. With regards the MSY approach and following the ICES MSY framework Btrigger is undefined, but F is considered to be below Fmsy for the years 2007-2009.

Southern Horse mackerel (*Trachurus trachurus*)

This stock is distributed in ICES Division IXa. The latest assessment in 2011 is primarily based on abundance estimates from two bottom trawl research surveys carried out during the fourth quarter in Galicia and Portugal together with catch-at age. Discards are considered negligible. The analytical assessment indicates that SSB has been stable as well as fishing mortality. Recruitment is rather stable with occasional large peaks like the latest that occurred in 2010. The 2010 estimated fishing mortality does not seem to be detrimental to the stock. Therefore, based on precautionary considerations, ICES recommended that fishing mortality for 2012 should not be allowed to increase from recent levels (ICES, 2011b). The MSY reference points have not been established by ICES so far, but several proxies for FMSY are being considered by the expert group including reference points based on spawner per recruit analysis (%SPR).

***Subarea VIII* Anchovy (*Engraulis encrasicolus*)**

This stock species has been closed to fishing for the last five years, and recovered to SSB levels to values above Blim with 100% probability following this period, which means that the recovery has reached the population levels of the years prior to the closure imposed due to the low biomass levels. This stock is highly dependent of recruitment variability. 2011 Age based analytical stock assessment indicated that SSB abruptely declined in 2002 due to a recruitment failure in the same year (ICES 2011b). Fishing mortality has decreased only three years later in 2005 and since then has been closed to fishing. The SSB recovery reflected the decrease or absence of fishing mortality and a good recruitment in 2010. The assessment is primarily based on acoustic and egg surveys together with catch at age data from the French and Spanish fisheries. Under ICES MSY framework a Biomass escapement (B escapement) of 33 thousand tonnes was defined based on Bpa and so far Fmsy has not been established ICES, 2011b)

***Division IXa* Anchovy (*Engraulis encrasicolus*)**

Acoustic and egg survey results demonstrate independent dynamics of the anchovy in the northwestern part of the Division IXa from the dynamics of the population in the southern part of Division IXa (ICES 2011b). For anchovy in the Northern part of the area the biomass index shows a more than 10 fold increase, with an acoustic estimate of 27,000 tonnes (ICES 2011b). For anchovy in Sub-division IXa south (where the main part of the catch is taken), survey biomass indices show a decline up to 2010. The situation in 2011 is uncertain, as the acoustic abundance and the egg abundance indices show opposing trends. There are also information on the size composition in landings and landings-at-age from Sub-division IXa South, and species-specific standardised effort and lpue of the Spanish purse-seine fleet in Gulf of Cádiz. The fishery data indicate that in the landings the 0 age group were almost absent in 2009 and low in the most recent years, confirming decrease in the stock. The MSY reference points have not been established so far.

***Mackerel* (*Scomber scombrus)* in the Northeast Atlantic**

This species is divided in three spawning components, South, West and North Sea, though the results of its assessment are expressed in a combined form. The most recent fishing mortality rate is at precautionary F levels and spawning biomass has increased considerably since 2002 to levels above Bpa. The 2002 year class is the highest recorded and those of 2005 and 2006 are strong, while that of 2007 is medium. Not enough information is available to confirm sizes from the most recent years. In the areas further south of the distribution area, this species is often captured together with jack mackerel (*Scomber colias)*. In relation with the MSY approach and following the ICES MSY framework Btrigger was estimated as 2,2 million tonnes and associated with this biomass an F of 0.22. This means that F should be reduced from recent levels.

5.4.3. Main interactions with ecosystem components

Results from various studies have shown sardine dynamics to be affected by several environmental variables at global, regional and local scales: sunspots numbers (Guisande et al., 2004), poleward current intensity (XXX), wind strength (Borges *et al*., 2003) and upwelling intensity (Santos *et al*., 2004), river outflow, Mediterranean water outflow, and meso-scale circulation features created from the interaction of the especially mixed-layer depth (Oliveira and Stratoudakis, 2008). This indicates that environment in which pelagic fish lives is intrinsically multidimensional and it may simply be wrong to assume that a single process is the most important one (Santos et al., 2011).

Sardines are both filter and particulate feeders, depending on prey size. Phytoplankton and micro-zooplankton dominate as prey items, in terms of numbers and volume, respectively, and there are indications that the size range of prey is inversely related to sardine size (finer gillrakers in larger/older fish). Fish eggs are highly appreciated as food by sardine (including cannibalistic behaviour) (Garrido et al, 2007). As a forage fish, sardines at different life stages are prey for many predator species, such as demersal and medium to large pelagic fish, marine mammals, and seabirds, (Santos et al., 2004; Petitgas, 2010; ICES, 2011). Sardine may exert bottom-up control of their predators or top-down control on their zooplanktonic prey, or they may control both prey and predators (wasp-waist control). Because of their central position in marine food webs it is important to understand their role.

5.4.4. Current management (Business as usual)

There are annual TACs in place for anchovy, mackerel, horse-mackerel, (CE Reg.(EU) No 57/2011 of 18 January 2011 minimum landing sizes, and mesh sizes. These species besides the purse-seine are also caught by other fleets.

Sardine is not managed by a TAC. It is subjected to a national management plan and has a minimum landing size in place. After having experienced very low recruitments, declining stock biomass and very high catches during the 1990s the EU authorities suggested to take over the regulation of the Atlantic sardine fishery in the Atlantic waters off the Iberian Peninsula. As an alternative to this solution, Portuguese and Spanish authorities and producers' organizations established a national management plan for the fishery, and though catches have decreased during the last decade, stock levels seem to be stabilized. The Portuguese government limits Sardine annual catch based on the IPIMAR and ICES advise with the agreement of a national commission constituted by the Portuguese Fisheries Directorate, IPIMAR, the Producers Associations (ANOP CERCO) and the Canning Industry Association (ANICP).

Each year a seasonal area closure of the Portuguese purse-seine fishery is enforced. This has been agreed by the producers' organizations in the northern Portuguese coast since 2003. This closure usually lasts for 2 months,a greater percentage of vessels in and since 2006 the period may be selected between 1st of February and 30th of April (*i.e*. boats stopped fishing in February to March or in March to April). A direct control of fishing effort is also enforced using compulsory stops during 48h at weekends, a maximum of 180 days of purse seiner annual activity. There were also in place limits to vessel catch limits to land sardine at the harbor.

The national and regional/local regulation of the sardine fishery seems to have worked well in stabilizing stock levels and the Portuguese sardine purse seine fishery has applied for, and at the end of 2009 achieved, the MSC´s (Marine Stewardship Council) certificate (ecolabel) for good environmental standards.

5.4.5. BAU performance

- Short-living species whose dynamics are mainly driven by the strength of the incoming recruitments, like anchovies, and in a lesser extent sardines have high uncertainty associated with catch forecasts to base TACs.
- Business as usual, does not respond quickly enough to the highly variable dynamics of short-lived species as anchovy.
- Sardine seasonal closure of two month seems to work well during the spawning period, but during years of very low recruitment like the most recent period a seasonal closure during the recruitment season or special designed closed areas for juveniles it is also necessary.
- To control Sardine total catch the daily limits by vessel currently in place (similar to ITQs) seem to work well.
- Discards are mainly due to market price variations.

5.4.6. Other potential management tools

Individual Vessel Transferable Quotas (ITQs) are a catch control system increasingly being applied world- wide being used with relative success in several fisheries in Canada and USA (Costello et al. 2008). Pros and cons of this system have been discussed. Critics argue that because quotas are transferable, the system promotes quota leasing, and can deteriorate the financial performance of working fishermen (crews and captains) in comparison to quota owners (Ecotrust, 2009), and as any quota system promotes discarding of less valuable species to avoid reaching the quota. Other issue is the large number of registered small vessels and the complexity of applying this catch control system in the case of artisanal fisheries from different countries. Some argue that one of the dangers is excessive trading on the ITQs. If this trading is not prevented the system is highly beneficial for the owners of the ITQs but these benefits would not revert to the community when quotas are traded outside the community.

A combination of different strategies including individual vessel catch limits, but not transferrable, (IVQs) and in-season management would be an improvement from the actual system based on fixed quotas that do not respond quickly to changes in the recruitment fluctuations.

The stocks targeted by the SWW purse seine fishery are highly dependent on the strength of incoming recruitment, this fact advocates an in-season management, which could be supported with an IVQ system that favours fisheries responsibility, providing that quota leasing is not allowed or very limited kept under control to avoid speculation.

The adaptive management or feedback control (Cochrane and Garcia, 2009) based on Harvest Control Rules (HCRs). For example in the case of Bay of Biscay anchovy it is expected that harvest control rules (HCRs) for the Bay of Biscay anchovy include a recruitment index that would help to improve the management of the stock. This population autumn recruitment index should be available for the formulation of management advice at the beginning of the year, leading to a management calendar from January to January with a revision (if necessary) at the middle of the year according to the spring acoustic and egg direct surveys.

Other potential management tool is to limit the size of the vessels. Parente (2004) demonstrated that Gross Registered Tonnage (GRT) and engine power are the most important predictors of purse-seine CPUE (Kg per fishing day). Increasing efficiency of the fishing operation but it is also related to the need to achieve high cruising speeds, to reach the port as quickly as possible (due to market reasons) and to enhance vessel security. Gross registered tonnage is correlated with the CPUE due to the expected relationship of this parameter with the seine net dimension. For the control of purse seine fishery aiming at small pelagic fish small vessels are more efficient than larger ones in this fishery since they fish close to the home ports and land most of the species, while larger vessels tend to target other species (e.g. tuna) to compensate the larger vessel power and costs, thus larger vessels carry out trips further from the home port.

5.4.6.1. Overview of management strategies

Management Strategy A: Avoid discards

It is considered that a ban or avoiding discards is relatively easy to be put in practice in this fishery. This fishery captures mainly the target species and has low discards of other species; this strategy will also reduce fishing mortality of target species.

Management Strategy B: Limit GRT and vessel size

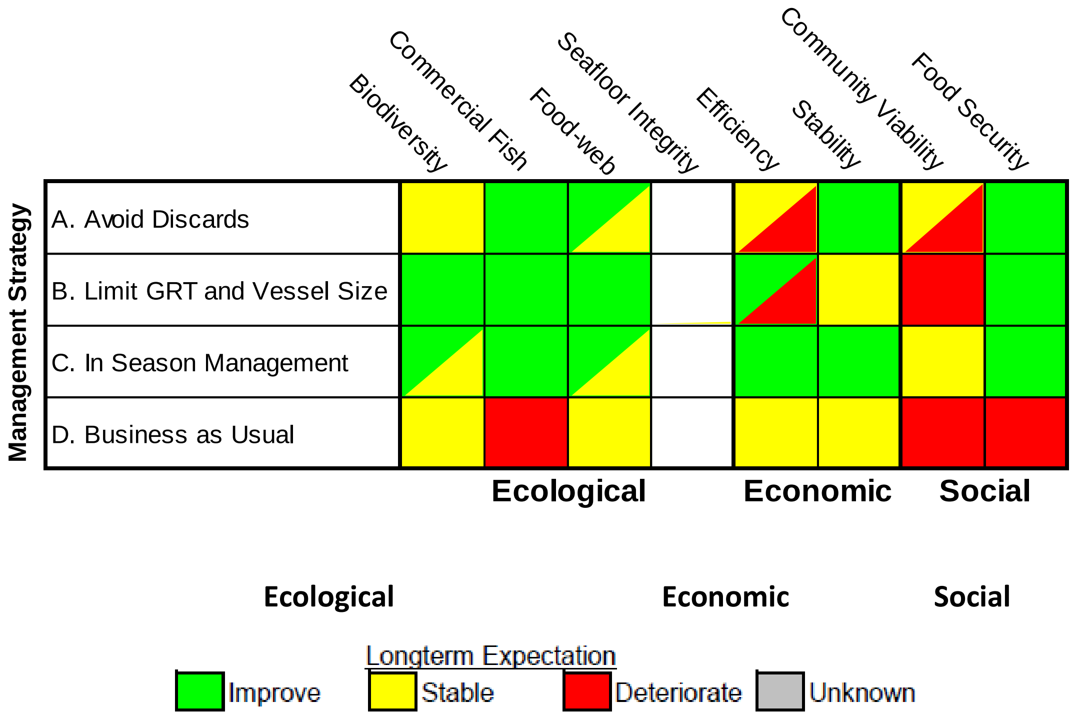
Recent studies suggest that small vessels with reduced GRT and lower costs are more efficient than larger ones in this fishery, since they fish close to the home ports and land most of the species, while larger vessels tend to target more valuable species to compensate the larger vessel power and costs, thus larger vessels carry out trips further from the home port increasing fuel costs and tending to increase discards. This measure would reduce costs.

Management Strategy C: in season management

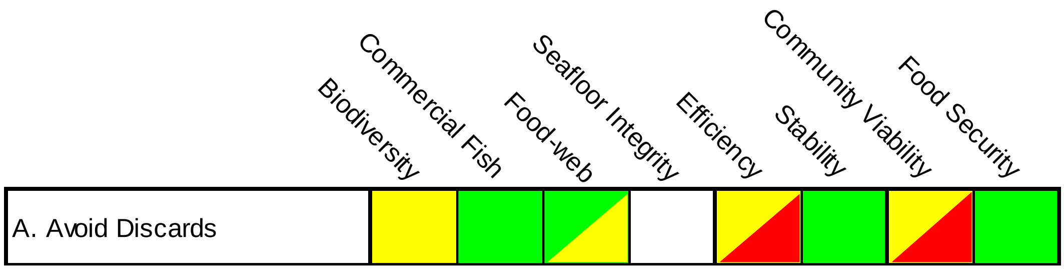
The stocks targeted by the SWW purse seine fishery are highly dependent on the strength of incoming recruitments; this fact advocates an in-season management. In season management will be close to a real time management and it is able to improve the management of anchovy and sardine by making the best use to the latest recruitment and biomass indices information.

5.4.7. Management strategy matrix evaluation

The matrix below compares the expected long-term (5-10year) outcomes from the three management strategies described above for the purse seine fishery to the business as usual management strategy. Narrative for each of the management strategies is included below. White boxes indicate that this fishery is not considered to impact on seafloor integrity.



Management strategy A: Avoid discards



Assumptions

The management tools in BAU strategy remain in place. The introduction of a phased or complete discards ban in the reformed CFP. All other management tools already in place remain constant. Enforcement of and compliance with new regulation is effective.

Ecological descriptors

A1 Biodiversity: avoiding discards in the purse seine fishery will have almost no change from BAU on this descriptor. Unlike other type of fishing gear, purse seines have low by-catch of non-target species: when targeting sardine or anchovy, the catches are virtually monospecific. Observer data and interview surveys of fishers also indicate a low impact on charismatic megafauna (cetaceans, seabirds and turtles). The most likely impacts will take place through alterations of prey-predator relationships via modification of sardine abundance, size structure and behaviour

A2 Commercial fish: avoiding discards will have a positive effect on the commercial fish descriptor. To reduce fishing mortality on the commercial species is very important especially sardine which is recently suffering from a recruitment failure. This management strategy will help to keep the state of the purse seine stocks within safe biological limits.

A3 Food web: It is expected that avoiding discards will improve the food web descriptor because the major impact on the food web of these fisheries is the waist-wasp control of both prey and predator, discards reduction would reduce the impact of the direct catch of discarded fishes and would be good for top-predators, on the other hand if would have a negative impact on the plankton preyed by sardine, anchovy, horse mackerel, mackerel.

A4 seafloor integrity: this management strategy does not affect this descriptor. Since purse seiners operate in open waters, there is little impact on the seabed given that the gear does not touch the seafloor, and hence it has no effect on it. Therefore purse seine could be considered green in the sense that the gear does not deteriorate the sea floor integrity.

Economic descriptors

A5 Efficiency: avoiding discards it is unlikely to change the profitability of this species because there are already negligible discards in the purse seine fishery. Market control of prices sometimes leads to discards practices to keep the price stable in years of surplus of abundance therefore efficiency might decrease the prices cannot be controlled by discarding practices.

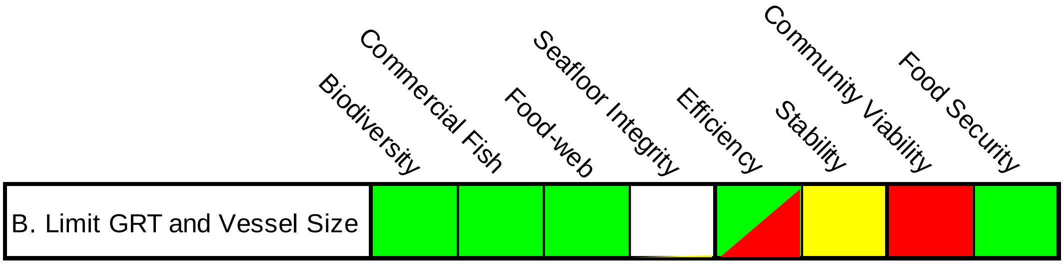
A6 Stability: Avoiding discards may help on stability of catches if the stock is managed within appropriate limits as indicated in the commercial fish descriptor.

Social descriptors

A7 Community viability: avoiding discards does not seem to change the fishers community living from purse-seine fishery nevertheless if prices decrease too much and efficiency decreases then the impact might be negative.

A8 Food security: It is expected a positive change following the improvement of the commercial fish state inside safe biological limits, which will bring the stocks to its maximum production of protein.

Management strategy B: Limit the GRT and size of vessels



Assumptions

The management tools in the BAU strategy remain in place. Appropriate control in place to limit size of vessels.

Ecological descriptors

B1 Biodiversity: There is no change relatively to BAU. Unlike many other types of fishing gear, purse seines monospecific, therefore no remarkable changes in biodiversity can be expected by limiting GRT and size of purse seiners.

B2 Commercial fish: Reducing GRT and size of the vessels would protect the commercial stocks reducing the fishing mortality and consequently will help to increase the number of commercial stocks in the region considered to be within safe biological limits.

B3 Food web: Limiting the GRT and size of boats would force the purse- seine vessels to fish closer to their home ports, and would help reducing discards. This fishery captures mainly the target species and has low discards of other species, this would reduce fishing mortality of target species, nevertheless the wasp-waist control exerted by this species on their predators and preys may turn the impact equal to no change from current BAU on the this descriptor.

B4 Seafloor integrity: Limiting the TRB and size of vessels in the purse-seine fishery has no impact on this descriptor. Since purse seiners operate in open waters, there is little impact on the seabed given that the gear does not touch the seafloor, and hence it has no effect on it.

Economic descriptors

B5 Efficiency: This management strategy is expected to reduce economic costs for the vessels, by reducing fuel consumption and crews and may increase profitability if target species fish schools are reachable to the vessels.

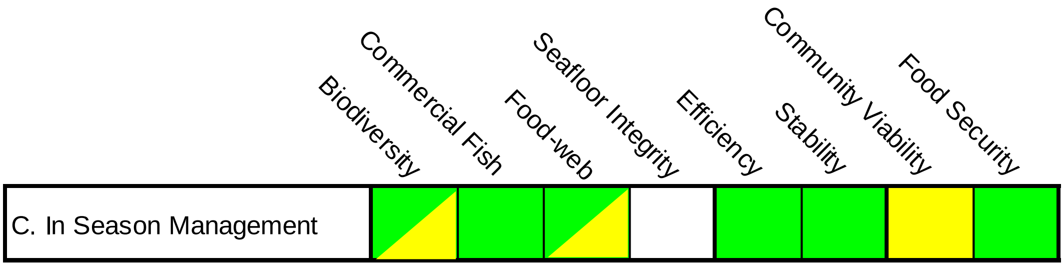
B6 Stability: This measure is intended to help to keep stock biomasses at high level and therefore would support TACs and catch options stability. Nevertheless the fishery and catches would still depend on recruitments and a succession of low recruitments could produce a reduction of the stock and affect TACs and catches. In this case fishing effort has to be quickly reduced in time to prevent SSB to be low , and the catch has to be very reduced or even fishing cannot be allowed.

Social descriptors

B7 Community viability: Reducing TRBs and size of vessels would require smaller crews, and thus would be negative for the viability of the villages depending on the fishery unless other changes are taken.

B8 Food security: Assuming that the stocks are kept inside safe biological limits according with descriptor commercial fish, food security would be favoured by this strategy.

Management strategy C: In-season management



Assumptions

The management tools in the BAU strategy remain in place. Close to real time in season management. Taking into account the most updated survey indices on recruitment and biomass.

Ecological descriptors

C1 biodiversity: This management strategy is likely to not change the current BAU state of biodiversity. Nevertheless helps on preventing the stocks collapse of purse seine species, becausethis risk would be minimized with the in-season management strategy.

C2 commercial stocks: Management based on in-season information on the recruitments will allow setting Harvest Control Rules (HCRs) to make operational an adaptive response to variations in the stock size. This avoids overexplotation of the stock and would permit the stock to keep inside safe biological limits.

C3 Food web: In season management strategy will not change the state of food web descriptor from BAU current state.

C4 Sea floor integrity: In season management has no impact on this descriptor. Purse seiners operate in the water column and there is no impact on the seabed given that the gear does not touch the seafloor.

Economic descriptors

C5 Efficiency: It is expected that this strategy has a positive impact on profitability because it prevents stock collapsing by following almost real time its sustainability.

C6 Stability: It is expected to have positive effect by not allowing the SSB to decrease below a certain buffer level when recruitment is consecutively failing.

Social descriptors

C7 Community viability: This management strategy may not **change** the fisher's conditions on the community. The high risk of collapses and possible zero TAC is already high in the current system. Nevertheless with a in- season management operational it is easier to act quicker than currently and therefore decrease the risk of stock collapses

C8 Food security: If this strategy is made operational it is expected to improve food security, according to the commercial fish descriptor status.

5.4.8. Management guidance

The proposed reform of the CFP includes plans for the introduction of individual fishing quotas for assessed stocks. A similar system using individual daily landing limits by vessel is already in use for sardine in this region and is considered as the current management in 'business as usual'. Avoiding or banning discards (Strategy A) is relatively simple measure to implemented in this fishery. Avoiding discards is expected to reduce fishing mortality of target and non target species, thus leading to improvement in the status of the commercial fish and food security descriptors, and increasing stability of catches. However, banning discards may reduce profitability by restricting fishers ability to respond to market deman and prices.

Reduction in vessel size is predicted to decrease fishing mortality due to reduced fishing capacity and Strategy B is considered to be the most appropriate if the overarching management objective is to work towards GES in line with the MSFD. Strategy B is expected to reduce economic costs for a given catch due to lower fuel consumption and crew requirements, and thus may increase profitability. Stability is likely to improve if the total capacity of the fleet is adjusted to stock size. However, reductions in harvest may also lead to an increase in the cost per unit harvest, and thus reduce efficiency. Reducing GRT, vessel size and crew size would have a negative effect on community viability.

Strategy C allows an adaptive response to variations in the stock size. This avoids overexploitation of the stock and would help to maintain the stock within safe biological limits, thus improving stability of catches and long term profitability. Regulations which respond to variations in the stock are predicted to increase both efficiency and stability if they are implemented and react appropriately to the state of the stock.

A combination of the alternative management strategies including the current individual daily landing limits by vessel, complemented by seasonal juvenile boxes and in-season management, would be an improvement from the current system based on fixed quotas that are not able to respond rapidly to fluctuations in recruitment. Nevertheless, this fishery and catches would still depend on the strength of target pelagic recruitments and a succession of low recruitments could lead to a reduction of the stock, affecting TACs and catches. Where this occurs, fishing effort should be quickly reduced and measures such as closed areas should also be considered.

5.5. Case study: Azorean Long Line Fishery

5.5.1. Introduction to the fishery

The mixed demersal line fishery, on ICES subdivision Xa, has been traditionally a multispecies fishery (Menezes *et al*, 2006; Pinho and Menezes, 2005; 2009). The key species of this fishery is Black spot seabream (*Pagellus bogaraveo*) and the most common species co-ocurring with catches of blackspot seabream are bluemouth rockfish (*Helicolenus dactylopterus*), conger (*Conger conger*), wreckfish (*Polyprion americanus*), forkbeard (*Phycis phycis*) and offshore rockfish (*Pontinus khulii*) (Pereira *et al*, 2010). These species are structured on three depth assemblages covered by the fishery: Shallow (<200m), Intermediate (200-700) and Deep (>700).

Three main fleet components can be identified on the Azorean demersal fleet: (a) artisanal open-deck vessels, characterized by a mean length less than 12 m and a gross registered tonnage (GRT) <50 ton, (b) artisanal closed-deck vessels, with mean lengths less than 18 m and a GRT <50 ton and (c), the industrial vessels with mean lengths greater than 18 m and a GRT >50 ton (Silva and Goulding, 2003). The operational regime of each vessel type varies considerably. Small open-deck vessels usually operate in areas near the coast, using mainly hand lines. Small closed-deck vessels are considered the main component of the fleet targeting demersal/deepwater species and cover almost all areas and depth strata. They use mainly deep longlines and hand lines, operating in coastal areas of the islands and in the main banks and seamounts inside the 100 miles box. Industrial vessels operate mainly on banks and seamounts, inside or outside the EEZ, including the ICES and CECAF areas, using deep longlines. The structure of this fleet is predominantly small-scale with the open deck component representing more than 70% of the total fleet. However, during the last decade the fleet has increased significantly the efficiency due to the incentives for new constructions targeting the small close deck vessels (8-12m).

Total demersal landings increase significantly until the end of the nineties (from 1500t to 5200t) and start decreasing thereafter to approximately the same level of the eighties (2500t). Landings in value increase almost linearly along all the period due to the increase of the mean price of fresh fish on first sale. A very significant increase was observed during the eighties and nineties due to the introduction of the longline, new markets, better transports, new vessels, etc (Menezes, 1996). However, during the last decade landings start decreasing as a consequence of intense fishing effort (mainly due to the increase of efficiency as a consequence of better technology on board of vessels) and so management measures, like area restriction (3 miles box) and catch restriction (TAC), were introduced. Total landings are dominated by few high commercial species. The ten top species from the landings in weight during the last decade were the blackspot seabream (*Pagellus bogaraveo*), bluemouth (*Helicolenus dactylopterus*), conger eel (*Conger conger*), silver scabbardfish (*Lepidopus caudatus*), wreckfish (*Polyprion americanus*), alfonsinos (*Beryx sp*), forkbeard (*Phycis phycis*), red porgy (*Pargus pargus*), common mora (*Mora moro*) and rajas (*Raja sp*). Most of this species are from the intermedian habitat (200-700m) with exception of the forkbeard, red porgy and raja (mainly *R. clavata*) that are the key species on the shallow strata (inner shelf areas of the islands). The blackspot seabream is nowadays the objective species of the fishery, being far the most important species due to its very high price on first sale.

5.5.2. State of the stock

The assessment and advice for mixed demersal stocks in Subdivision Xa is primarily based on abundance estimates from longline surveys and fishery data as landings and effort. There is no management objectives defined for this species.

The Azorean mixed line demersal fishery can be considered as multiarea, multifleet, multigear and multispecies fishery (Pinho and Menezes, 2005; 2009). Although the blackspot seabream has been considered the objective species of the fishery, the definition of a target species of the fishery has been a complicated scientific process for the assessment because the discontinuity of the Azorean ecosystem (suggesting meta populations), gear, vessel and area combination on the operational regime of the fleet (almost different métiers can be defined within this fishery) and the unknown stock structure of most species (no precise management units are defined) (ICES, 2007). As a result the assessments are no analytical because models do not catch the dynamic of the populations or the fishery (VPA results are very imprecise suggesting stable stock indicators), or there are no assessments at all for some other co-ocurring species (like alfonsinos or wreckfish) due to the lack of information for the management unit defined (ICES, 2006, 2007, 2008). The stocks have been considered intensively exploited with possible local depletions probably occurring (mostly in the seamounts areas) (Pinho and Menezes, 2009). Management measures to prevent resources depletion were on the past sometimes difficult to implement or not implemented at all due to the governance structure where local government had no competence to produce valid regulations (e.g. TAC/Quota system or area restrictions) and due to imprecise results from science in appropriate scales.

5.5.3. Main interactions with ecosystem components

Fisheries in the Azores in general are defined as small-scale, meaning that the majority of the fleet are composed of small vessels (<12m) of limited autonomy, using artisanal gears and operating mainly inside the Azores EEZ (Carvalho et al., 2011). This small-scale characteristic is an adaptation to the ecosystem, particularly to the benthic one (Pinho and Menezes, 2005; 2009). The main properties of this ecosystem are the deep water environment and the discontinuity on the stock/area relationship, having as predominant features the islands, seamounts and abyssal plains. Fisheries occur mainly on the former (islands and seamounts) applying necessary for small scale impact, since the ancient times (Silva and Pinho, 2007), due to the nature of the population dynamic of the resources inhabiting these ecosystems (Menezes *et al*, 2006; Pitcher et al, 2007). So, the main interaction is related with the possible fishery impact on the bottom (on deep-water corals for example) due to high concentration of effort on a limited area.

5.5.4. Current management (Business as usual)

The management measures (local, national or EC regulations) introduced since the end of the nineties (ICES, 2006) include:

- Area restriction implemented by the Regional Government (3 miles box for protection of island coastal assemblages, where only hand lines are permitted) (Decree no. 101/2002, October 24th) and restrictions at the EC level (100 miles box where only Azorean vessels can fishing) (EC. Reg. 1954/2003). Coastal Marine Protected Areas have been proposed and implemented under the E.U Natura 2000 network (http://redenatura2000.azores.gov.pt) and offshore MPAs have been also proposed (see section 1.2 of WP1 report). During 2010 a seamount (Condor seamount) was temporally closed to the demersal/deep water fishery (Decree no. 48/2010, May 14th).
- Effort restrictions. During 1998 and 2000 some technical measures were implemented, including restrictions on licenses based on a minimum threshold landing in value (Decree no. 27/98, July 9th). EC regulations limited also the effort for deep water species (EC Reg. 2347/2002). New regulations restrict the new licenses by assemblage (coastal demersal, slop demersals and deep water) (Decree 43/2009, May 27th).
- Gear restriction. Hook size limit and fishing area restrictions by vessel size and gear type were implemented (Decree 43/2009, May 27th). Some gears like bottom trawl and bottom gillnets were forbidden in the Azores under the EC Fisheries Common Policy (EC. Reg. 1568/2008).
- By-catch control. Landings of some species are limited (through minimum size) or forbidden in a policy of bycatch regulation (e.g. deep-water sharks).
- TAC and Quotas for some deep water species (black scabbard fish, orange roughy, blackspot seabream, alfonsinos, and deep water sharks) were implemented under the EC Fisheries Common Policy (EC Reg. 1225/2010);
- Minimum lengths are also in force for some target species (Decree 1/2010, January 18th).
- Subsides have been implement under the EC CFP (new constructions, fuel, commercialization, etc) (EC. Reg. 791/2007).

5.5.4.1. Key management issues

There are several important points. The first is related with the uncertainty of the assessments as a result of the system complexity (dynamic of the fishery, resources and ecosystem). The assessment of the target species was benchmarked during 2010. However, most of the key issues related with the patchy and multispecies nature of the fishery were not addressed due to scientific or data limitations. An additional associated problem is related with the fishery overcapacity and the exploitation tradeoffs between the inshore (islands coastal) and offshore (seamount) areas.

5.5.5. BAU performance

The actual exploitation pattern (BAU) of the mix demersal lines fishery of the Azores is characterized by three fleet components (artisanal open deck coastal vessel, artisanal semi-industrial close deck coastal/offshore vessels and industrial offshore vessels) operating with two types of gears (hand lines and longlines) on two areas (nine island coastal and seamounts). The technical management tools used until now and described above try to adjust the fishing mortality and selectivity of these fleets on three depth demersal/deep water species assemblages. In practices the implementation of those measures construct conceptually a spatial management scheme which can be resumed as: the artisanal hand liners operating on the island coastal areas (on a 3 miles box), industrial longliners on the seamounts and semi-industrial operates on both (as hand lines on coastal or longliners on seamounts). The exploitation pattern (effort and hook size) is principally adjusted to the slope species, mainly to the target species like Red (black spot) sea bream (*Pagellus bogaraveo*). The sustainable long term fishing mortality of this species may be similar to the one corresponding to the estimated natural mortality (about 0.2 $year^{-1}$), as suggested by the yield per recruitment analysis (ICES, 2006, Lorance, 2011). The actual fishing mortality to this stock may be slight larger, or at least of the same level (as suggested by catch curve analysis), than the sustainable one and so this target resource may be intensively exploited or even outside safe biological levels. Furthermore, in a multispecies context, the actual fishing mortality level may be also unsustainable for other more vulnerable species (at which some may be even overexploited).

For this MEFEPO exercise we will adopt this management structure as a scenario for the BAU management strategy and will assess (describe) the impact on the descriptors by pillar if we maintain this scenario (actual effort level) for a long term (5-10 years). The performance of the other possible management scenarios will be compared with this one.

5.5.6. Other potential management tools/strategies

Potential management tools for this fishery include:

- Multispecies TAC
- Increase close areas to fishing
- Spatial management areas (Functional management Units)

5.5.6.1. Overview of management strategies

Management Strategy A: Spatial management areas (Functional management Units)

It has been argued that under the metapopulation (patchy distribution) assumption we should manage the fisheries under definition of functional management units (metapopulations) approach in order to control local depletions and maintain the rate of mixing between areas (Levins, 1969, 1970). The Azores is a discontinued territory where predominate Groups of islands and seamounts. Under this strategy we define each island (or groups of islands), banks and seamounts or group (clusters) of seamounts as “management units”. In some way, the actual technical measures implemented in the Azores try to address this issue but with primary objective to protect coastal areas and communities. The general idea is to try to adjust the effort spatially. One practical difficulty under this strategy is the clear mapping of what are considered the fishing areas, particularly on the seamounts (see Pitcher *et al*, 2007), for this fishery and the management of the effort allocation and control by area. The precise identification of source areas, population components and their habitats within each management area is also not very well understood or even unknown. However, it is not unrealistic (although difficult to implement on short term) to address spatial management particularly for the seamounts. For this exercise we consider as management units the statistical areas defined for the bottom demersal longline survey (Pinho, 2003, Menezes et al., 2006) (3 groups of islands, major banks on Central and Este group of islands and in addition another group (or groups) to address other commercial important seamounts around the Mid Atlantic Ridge). We assume that allocation by area is made through TAC/quota system by vessel. Difference from the close areas scenario is that now we are concerned with areas (or group of areas) and adjust of effort to the “production” of those areas.

Management Strategy B: Increase close areas to fishing

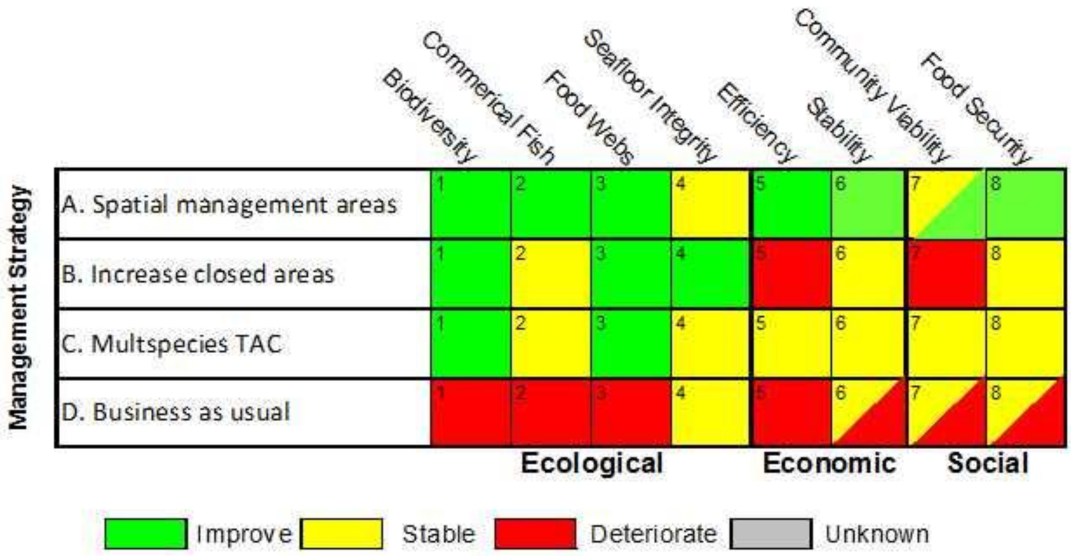
The Azores are a discontinued territory where the predominant topographic features are seamounts, including islands. These are also the available fishing areas. So, uder this strategy some selected seamounts and coastal areas should be closed to the mixed lines demersal/deep-water fishery, as a complement of the actual ones. The idea is to maintain without impact a proportion of the species habitat in order to secure some probability of other areas recruitment, on the assumption of stock recruitment interactions between areas. So, for this strategy we maintain the actual structure of exploitation and management and just increase the number of close areas.

Management Strategy C: Multispecies TAC

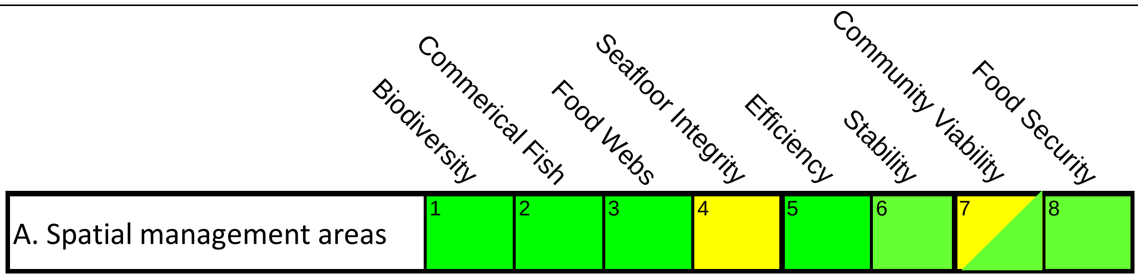
There is a perception that the actual effort for the assemblage of the target species is very high due to technological improvements. Eventually, the use of effort control to attain a multi-species maximum sustainable yield (MSY) could be used as the target value. So, under this strategy we propose a reduction from the actual level to the effort level correspondent to the assemblage MSY (adopting the Fmsy corresponding to the target species of the slope assemblage). A fishing mortality (or effort) level correspondent to MSY for the target species (*Pagellus bogaraveo*) may be a reasonable sustainable value for almost all the important commercial species of the demersal assemblages. However, this strategy may imply in practice a significant reduction on the actual effort and the assumption that this species control the fishery tactics. The effort reduction could be complemented with increasing the hook size for example. A practical way to implement this scheme is to define a TAC/quota system for the target species, correspondent to the species MSY, and then TAC`s for the other species as a proportion of occurrence with the target species (adjusted for the non associated catches based on historical data) (Silva et al, 1994; Pinho, 2003).

5.5.7. Management strategy matrix evaluation

Below is a matrix comparing the expected long-term outcomes from four possible management strategies to "business as usual" The comparisons were supported by relevant literature and were made in consultation with IMAR/DOP fisheries ecology and stock assessment experts.



Management strategy A. Spatial management areas



Assumptions

The management tools in the BAU strategy remain in place. Are introduced TAC/quotas by vessels and fishing areas. We consider as fishing areas the actual areas covered by the Azorean spring demersal longline survey plus the seamounts areas on the west, along the Mid Atlantic Ridge.

Enforcement and compliance with this management strategy is assumed to be high for longliners due to the Vessel Monitoring System (VMS) and electronic logbooks capabilities. For the coastal areas management should be based on individual island.

Ecological descriptors

Spatial management of effort should increase biomass of the important commercial stocks and so improve significantly the overall ecological stock status (A2). This measure may imply a significant reduction of the actual effort, particularly on the seamounts, and so biodiversity (A1) and food webs (A2) should also improve because the risk of sequential depletion is reduced. Discards may increase as a consequence of TAC/quota system introduced by area. The strategy does not introduce significant effects on seafloor integrity (A4). In a multispecies context sustainability is never completely fulfilled and this measure success is dependent on recovery time of some actual very intensive exploited areas and the connectivity problem between areas. This last concern may be overcome with additional measure of closing key (source and sink) areas to fishing and assuming a long term recovery effect.

A1. Biodiversity: Improve. Biodiversity should increase at long term since depletion and the risk of sequential seamount depletion should be reduced. With the actual exploitation pattern it is expected an increase on discards (particularly on the longliners), however, some of the key target species may be discarded alive.

A2. Commercial Fish: Improve. At long term the stock status should improve because this measure may imply significant effort reduction in some areas, which may not displace for other areas due to overcapacity. In a multispecies context sustainability is never completely fulfilled and the measure success is dependent on recovery time of some actual very intensive exploited areas and the connectivity problem between areas. This last concern may be overcome with additional measure of closing key (source) areas and assuming a long term recovery effect.

A3. Food web: Improve. Food web may increase because fishing mortality should be adjusted by area which implies a very significant reduction on effort. Discards should however increase due to management restrictions.

A4. Seafloor integrity: Stable. This measure has no significant effect on seafloor unless the strategy is complemented with close areas.

Economic descriptors

Efficiency (A5) by vessel should deteriorate at short term, with some vessels leaving the fishery, because the effort reduction. At long term it should increase since the biomass of the resources are expected to increase and maintained at the MSY level. Individual quota should be introduced at least for medium term with freedom to manage it along the year to allow the adaptation of the exploitation dynamic to the seasonal market opportunities and so increase the stability (A6). However, attention should be call for the fact that these descriptors are highly dependent on the islands fish prices and markets that we assume constant.

A5. Efficiency: Efficiency by vessel should deteriorate at short term because the effort reduction. Some vessels are expected to leave the fishery, particularly those industrial or semi-industrial using longlines. At long term it should increase since the biomass of the resources may increase. The strategy should permit the free management of the individual quota along the year to allow the adaptation of the exploitation to the seasonal market opportunities. Discards may increase due to TAC/quota effects.

A6. Stability: Stable. Stability may improve, if we assume that the stock abundance of target and valuable species would increase and maintain at the sustainable level (Bmsy). However this indicator may be dependent of other factors like markets, prices and seasonal variability on the species abundance. For example, more offers (abundance) tend to decrease the first sale value on the auctions and so change the fleet dyamic. Quota system by vessel for a medium term may increase stability by vessel.

Social descriptors

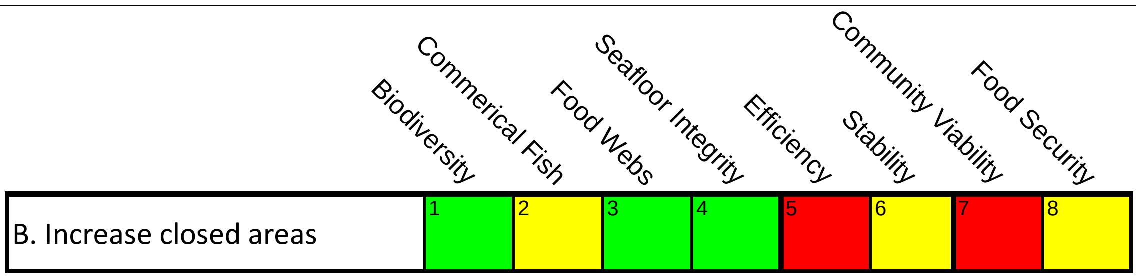
Under the effort and area restrictions scenario the number of jobs for example may decrease and so community viability (A7) may be reduced. The effect may be however differentiated by the different communities on the different islands depending of the fleet structure within the community. On the small islands community viability may increase but on the larger ports may decrease because the loss of jobs on the fleets operating on the offshore areas.

Theoretically food security (A8) should increase at long term since it is expected that the resources biomass increase (recovering some of the intensive species exploited). However, it is not expected significant increase on total landings above the actual values because the fishery is considered already at the intensive exploitable phase, unless new fisheries developed considerably, like black scabbard fish, what may happen under this scenario due to effort diversification.

A7. Community viability: Stable. Under the effort and area restrictions scenario the number of jobs for example may decrease. The effect may be however differentiated by the different communities on the different islands depending of the fleet structure within the community. On the small islands this indicator may increase but on the larger ports may decrease because the loss of jobs on the fleets operating on the offshore areas.

A8. Food security: Stable. Theoretically total landings should increase at long term since it is expected that the resources biomass increase (recovering some of the intensive species exploited). However, it is not expected significant increase on total landings above the actual values because the fishery is considered already at the intensive exploitable phase, unless new fisheries developed considerably, like black scabbard fish, what may happen under this scenario due to effort diversification.

Management strategy B. Increase close areas to fishing



Assumptions
The management tools in the BAU strategy remain in place. Selected seamounts and coastal areas should be closed to the mixed lines demersal/deep-water fishery. Area selections (number and size) are theoretically based on the best scientific knowledge about the regional meta population dynamics, and in consultation with stakeholders, in order to secure replacement (recruitment) of the fishing areas. Compliance with this management strategy is assumed to be high (particularly on the offshore areas) due to the Vessel Monitoring System (VMS) capabilities.

Ecological descriptors

This measure may increase the ecological descriptors but may not improve the stock status of the main commercial species (B2) because the imbalanced effort by area. Effort from close areas will be concentrated on the adjacent fishing area and so local depletion, of seamounts for example, may be not avoided. Dependent on the number and size of the closed areas and species population dynamic, biodiversity (B1) and food webs (B3) may increase due to the larger proportion of the habitat with no fishing impact. Seafloor integrity (B4) improves with this strategy being possible to fully conserve some particular habitats like seamounts or deep sea corals.

B1. Biodiversity: Improve. Biodiversity should increase if depletion of the adjacent areas is avoided by complementary measures. However, as a unique measure the overall biodiversity may be maintained because the danger of sequential depletion of some resources by area due to high effort concentration. The level of improvement is dependent on the close area size, type of the area and levels of interactions between close/open areas for the different species.

B2. Commercial Fish: Stable. The benefit for the commercial fish may increase on the long term on the closed areas. However, if there are areas interactions through fish movements or stock recruitment relationships maintaining unsustainable some fishing areas may maintain stable the overall stock status.

B3. Food web: Improve. Food web may increase because the proportion of the area not impacted increase. However, this measure should be followed by a management of the effort to avoid concentrations on the adjacent areas. If not, food web may not improve significantly because some areas may be depleted. To be effective a significant proportion of the fishing area should be closed, in order to fit the different species spatial population dynamics, with the consequent reduction on the effort.

B4. Seafloor integrity: Improve. On the assumption that mixed hook and line gears have little effect on the seafloor, increasing the proportion of the area without impact may increase significantly the integrity of the seafloor.

Economic descriptors

If not followed by an effort reduction the efficiency (B5) at short/medium term will be reduced significantly. Since it is not expected an increase on the exploitable biomass at the actual effort level efficiency will tend to deteriorate. Conflicts from technological interactions (vessels competition for space) will tend to increase due to area restrictions for fishing.

Stability (B6) may be maintained since increase in the stock biomass is uncertain under imbalanced effort distribution.

B5. Efficiency: Deteriorate. If not followed by an effort reduction the efficiency at short/medium term will be reduced significantly. Since it is not expected an increase on the exploitable biomass at the actual effort level efficiency will tend to deteriorate. Conflicts from technological interactions (vessels competition for space) will tend to increase due to area restrictions for fishing.

B6. Stability: Stable. It is not sure that more stable landings for example can be taken from main commercial species because the prediction of the recovery on the closed areas and the evolution of the exploitable biomass at long term are uncertain.

Social descriptors

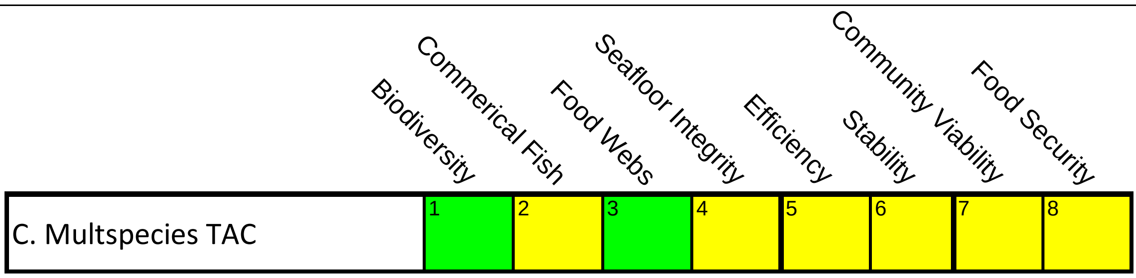
Along with the directions on the stock status and efficiency it is expected an overall negative impact on the communities. However, this impact may be differentiated because not all the communities may be affected on the same way, depending on the location, number and size of the selected closed area, fleet structure, target species, effort level, etc.

Food supply should reduce at short term because the expected change on the effort allocation and maintained thereafter, if we assume that at long term the overall stocks biomass of commercially important species will maintain stable around some value as a benefit from closed areas. Due to the multispecies character of the fishery and the imbalanced effort distribution under this strategy, it is also very uncertain the effect of closed areas in different stocks with different life histories. To fit a reasonable number of species the proportion of closed areas should be far larger with unreasonable socio-economic costs.

B7. Community viability: Deteriorate. Along with the directions on the stock status and efficiency it is expected an overall negative impact on the communities. However, this impact may be differentiated because not all the communities may be affected on the same way, depending on the fleet structure, target species, effort level, etc.

B8. Food security: Stable. Food supply should reduce at short term because the expected change on the effort allocation and maintained thereafter, if we assume that at long term the overall stocks biomass of commercially important species will maintain stable around some value as a benefit from closed areas.

Management strategy C. Multispecies TAC



Assumptions:
The management tools in the BAU strategy remain in place. Additionally are introduced TAC/quota systems by vessel for the target species and associated species as a proportion of occurrence with the target one.
Compliance with this measure is high for vessels operating on offshore areas and may be reasonable for small artisanal vessels since landings are monitored by the auctions.

Ecological descriptors

Ecological descriptors, particularly biodiversity (C1) and food webs (C3) may improve if the fishing mortality, under the multispecies context, is set on an appropriate level (Fmsy) because the species biomass may increase and so maintaining a significant proportion of stocks under safe biological limits. However, without effort control by area there is no guarantee of sustainability from some areas (particularly seamounts) because effort will be concentrated on the more productive ones with the risk of local depletion occurring (C2). On the multispecies context MSY cannot be achieved at the same level for all species and it is likely that some species with lower MSY of the same fishery become overfished, unless the exploitation pattern is adjusted in accordance with the most vulnerable species. It is also expected an increase on discards due to TAC/quota effect.

This strategy has no significant effect on the seafloor integrity (C4) although it may imply a reduction on the overall effort.

C1. Biodiversity: Improve. If the fishing mortality, under the multispecies context, is set on an appropriate level it is expected an increase on the species biomass, maintaining a proportion of stocks under safe biological limits. However, without effort control by area there is no guarantee of sustainability from some areas (particularly seamounts).

C2. Commercial Fish: Stable. Commercial fish stocks would improve, since reducing fishing mortality at F_{msy} for target species a significant proportion of the stocks should get a sustainable status. However, due to imbalanced effort by area there is no guarantee of sustainability (effort concentration on more productive areas) and the biomass of some intensively exploited species may not recovery at the desired level. As a consequence the overall result at long term may be a stable situation.

C3. Food web**:** Improve. To attain single species MSY it is necessary to reduce effort (fishing mortality), eventually complemented with the increase on hook size, and so overall we may observe an improvement at long term. However, the multispecies MSY cannot be achieved at the same level for all species and it is likely that some species with lower MSY of the same fishery become overfished, unless the exploitation pattern is adjusted in accordance with the most vulnerable species. It is also expected an increase on discards due to TAC/quota effect.

C4. Seafloor integrity**:** Stable. Even with a reduction on the effort, it is not expected a significant change on the lower level of actual impact (same fishing area), unless the measure would be complemented with closed areas in order to increase the proportion of no fishing impacted area.

Economic descriptors

The economic descriptors may improve relatively to the BAU situation. The Efficiency (C5) (income of the fishery) would increase in the medium-long term because stock biomass of important commercial species is expected to increase. Constrains may be arise because do not account with seasonality or market demands and discards may increase due to TAC/quota effects. However, at short term a significant reduction in the efficiency is expected and so some vessels will leave the fishery.

Stability (C6) may improve on a sense that access rights are secure by the individual quota by vessel. However with spatial imbalanced effort the stock status (C2) may not improve as desired because the risk of sequential depletion and the consequent effect on the connectivity between areas.

C5. Efficiency: Stable. The Efficiency (income of the fishery) would increase in the medium-long term because stock biomass of important commercial species is expected to increase. Constrains may be arise because do not account with seasonality or market demands and discards may increase due to TAC/quota effects. However, at short term a significant reduction in the efficiency is expected and so some vessels will leave the fishery.

C6. Stability: Stable. Stability may improve, if we assume that the stock abundance of target and valuable species would increase and maintain at the sustainable level (Bmsy). However with spatial imbalanced of effort the stock status may not improve as desired because the risk of sequential depletion and the consequent effect on the connectivity between areas.

Social descriptors

Social descriptors will not improve significantly under this strategy because the imbalanced spatial effort that may affect efficiency and profitability. The number of jobs and total landings may decrease at short time due to the reduction of effort. However, community viability (employment) (C7) and food supply (landings) (C8) at long term may maintain stable as the biomass of the resources increase.

C7. Community viability: Stable. The number of jobs will decrease at short time due to the reduction of effort. Community viability (employment) at long term may maintain stable although efficiency and stability of the fishing activity are expected to maintain or improve at long term.

C8. Food security: Stable. Food supply should reduce at short term due to the effort reduction and maintained thereafter around the actual levels if we assume that the stock is managed at sustainable level.

Management strategy D. Business as usual (BAU)

Ecological descriptors

D1. Biodiversity: Deteriorate. Because the fishery is considered to have an inadequate fishing exploitation pattern and so, some target species will be harvest unsustainable (biomass will be reduced) and other non target (or of secondary economically priority) probably will be overfished.

There is a danger, on short/medium term, of sequential depletion of some areas and certain commercial fish species, particularly on the seamounts areas (ICES, 2008).

D2. Commercial Fish: Deteriorate. Target species may be explored on an unsustainable way (because the unbalanced fishing mortality by area) and some non target species will be overfished (too high effort for more vulnerable species). It is expected a reduction on the catches (already observed) (Pinho and Menezes, 2009). To maintain the actual income the effort or the catchability (through technological improvements) should increased. As a consequence the proportion of stocks outside safe biological limits may increase.

D3. Food web: Deteriorate. Predators are exposed to high fishing mortality and so may be reduced in medium term.

D.4 Seafloor integrity: Stable. Hook and line gears are supposed to have less impact on seafloor than other gears. However it is not a free impact because the gear effects on the bottom during the operation (anchors, lines, weights, gangions, hooks, etc), or as a consequence of “ghost” or litter due to the lost gears. For the seamounts case it is a concern because the high concentration of fishing effort on a small area.

Economic descriptors

D5. Efficiency: Deteriorate. Total landing in value for example may punctually increase or be maintained on short time because the increase on the mean price per Kg by species, particularly for those large value species on the fresh market. However, operation costs (profits) may increase significantly, because the extra effort needed to expand to get similar income. This aspect will be more evident on the industrial (and some semi-industrial) segment of the fishery that operates on the seamounts because species biomass tends to decrease faster and costs are higher for this fleet (Carvalho et al, 2011).

D.6 Stability: Stable. A stable situation has been defined by the exploitation because a quota is available every year by vessels for the target species and have not been adapted annually according the stocks biomass due to the lack of analytical assessment and stock indicators used on the trend assessment suggests an overall stable status (ICES, 2008). However, since the biomass of the target species may be decrease at long term, at least in some areas, it is expected a decrease on this indicator at long term. But stability may be also a result of other factors like target fishing, adjusted by gear configuration on a seasonal planning regime of operation (substituting longline by hand line for example) or fishing area expansion (for longliners).

Social descriptors

D7. Community viability: Stable. Employment may be maintained because the effort is the same. A reduction may be expected on the offshore industrial (or even semi-industrial) longliners, however most of the important local employment is based on the small scale fleet component. Along with efficiency it is expected a deterioration.

D8. Food security: Stable. Total yield landed (all species together) for example may be maintained because the decrease of the landing of one species tend to be substitute by another one, due to target seasonal effects and market opportunities. However, at long term it is possible to observe a decreasing pattern for the total landings (already observed during the last years).

5.5.8. Discussion

Under the actual strategy (BAU) the resources will be overfished at long term maintaining the fishery at unsustainable levels with impacts on the ecosystem because the high effort. Important socio-economic consequences are expected at short/medium term if management measures are not introduced. The Introduction of individual additional measures may improve the actual situation but may not correspond necessarily to a sustainable exploitation pattern. For example, introducing closed areas may not conserve the stocks at sustainable levels because the effort will be concentrated on adjacent areas increasing the vessels competition/interaction. Similar pattern is expected with the introduction of a multispecies TAC due to the effects of the imbalanced spatial effort distribution, particularly on the seamounts. The definition of "functional management units", designing by selecting appropriate areas, may overcome part of these concerns. However, none of the proposed strategies seems to fulfil the three pillars, as expected. A combination of the three proposed strategies is theoretically the best approach to this fishery at long term. So, the total fishing area should be clearly defined and divided as functional management units. A selected proportion of the area within each functional management unit should be closed to the fishery to secure recruitment of the other areas. Appropriate technical management measures, including a multispecies TAC/quota system, should be developed adjusted to each management unit and metier.

5.5.9. Management guidance

None of the management strategy fulfilled an improvement on the three pillars as expected. Due to the discontinuity of the Azorean territory all the measures may have also a differential effect on the communities of the different islands in function of the fleets' structure, target species, and other external effects. Introducing closed areas alone may improve the overall ecological status but sustainability of important commercial species may be not achieved maintaining or deteriorating socioeconomic aspects of the fishery.

If multispecies TAC management strategy (B) is adopted a slight improvement is obtained on socioeconomic aspects due to the access rights introduced with the individual quota by vessel adjusted to the MSY of the main fishery target species. However, sustainability may be not achieved for some key target species due to the imbalanced effort distribution.

Considerable improvements are obtained if spatial management areas strategy (A) is adopted because increases on stock biomass of main target species are expected on long term. However, it may imply a considerable effort reduction on short term (1-2 years) with severe socioeconomic impacts. Several steps are necessary to implement this measure, which includes: a) Definition of total fishing area for this fishery; b) Definition of "Functional management units" (FMU); c) Definition of a network of closed areas to fishing matching the FMU; d) Estimation of TAC by species and FMU.

The MEFEPO project has demonstrated the application of a management strategy evaluation matrix approach to the development of regional Fisheries Ecosystem Plans (FEPs) to help decision-makers to simultaneously consider ecological, social and economic implications of decisions, and to inform the development of ecosystem based fisheries management (EBFM) for European fisheries. We have identified 5 key steps to developing such an integrated ecosystem based fisheries management regime (Box 6.1) and have illustrated our approach using a number of case study fisheries. The case study fisheries examined should be seen as heuristic examples and not definitive assessments of the potential effects of different management strategies.

Box 6.1 Key steps to make ecosystem based fisheries management a reality for European fisheries

- Develop long-term management plans (LTMPs) for each of the region's fisheries considering the ecological, economic and social implications for ecosystem components. LTMPS should be integrated into regional FEPs.
- Develop closer integration among stakeholders, fisheries scientists, ecologists, social scientists and economists to develop effective management advice for LTMPs. Social and economic descriptors, and appropriate (region specific) indicators, require further scrutiny and development.
- Develop qualitative assessments and expert judgement to supplement analytical modelling to meet the increased data requirements of LTMP development and make them operational in the short term.
- Ensure that the management framework is adaptive and able to respond to new information and understanding to allow decisions based on the best available evidence.
- Implement appropriate governance mechanisms that facilitate true stakeholder engagement to generate credibility in the management process and foster stakeholder support, this includes both definition of objectives and indicators as well as the development and evaluation of LTMPs.

The transition from single species management to EBFM will have significant implications for the knowledge base required to underpin management. Long term management plans (LTMPs) should be developed for each of the region's fisheries that include consideration of the wider ecosystem (ecological, social and economic) interactions. Implementation of the management strategy evaluation matrix (hereafter the matrix) approach developed by the MEFEPO project will allow the broad range and quantity of information on potential impacts of different management strategies to be summarised in a concise manner, accessible to all stakeholders and so support the production of robust, evidence based and inclusive Long Term Management Plans.

Whilst the matrix approach is conceptually simple, a considerable amount of information is required to support its application. Much of this information, while routinely collected, is 'new' to a formal fisheries advisory process. It is also clear that it is not possible to meet all the additional data requirements using the data that are currently collected. For example, the ecological descriptors utilised were drawn directly from the Marine Strategy Framework Directive (MSFD), and were selected as those most likely to be impacted by fishing activities (biodiversity, commercial fish, food-webs and seafloor integrity). Social and economic descriptors were defined to monitor some of the main aspects of fishing contributing to the economic and social wellbeing of coastal communities but the choice was constrained by available data. Concerns therefore remain over the choice and application of all the descriptors utilised, and the definition of social and economic descriptors and appropriate indicators requires further scrutiny and development before this approach is applied within a formal advisory framework. However, these concerns need not be a barrier to implementation of EBFM due to the adaptive and consultative management process within the new management regime (Fig. 6.1), and we recommend a process of collaborative (Member State, scientists, and industry) to ensure that descriptors and indicators for all pillars are fit-for-purpose.

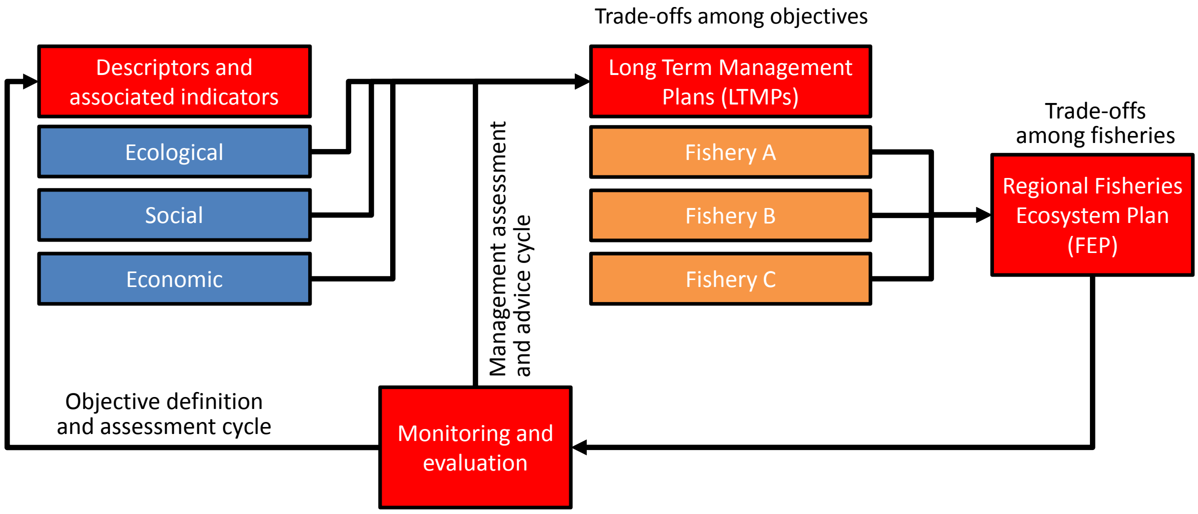


Fig. 6.1 Adaptive management framework proposed by the MEFEPO project for the development of Fisheries Ecosystem Plans to support ecosystem based fisheries management in European fisheries.

The institutional framework developed by MEFEPO (Section 2) would enhance stakeholders' participation in management at the regional scale, and facilitate stakeholders' involvement in the development of management objectives and appropriate descriptors for all three pillars, and in the evaluation of management strategies to give credibility to the processes and foster stakeholder support. If effectively implemented, this governance structure should serve to increase the legitimacy of the CFP and associated instruments among stakeholders (which presently is low) and reduce conflict between administrators and industry.

The absence of data must not be allowed to prevent decisions from being made and management advice should be formulated based on the best available evidence (be it modelled, empirical or expert opinion), consistent with the FAO Code of Conduct for Responsible Fisheries (FAO 2005) and the precautionary principle. Development of matrices for the case study fisheries demonstrated that qualitative assessments and expert judgement are needed to supplement analytical modelling, particularly with respect to social and economic pillars, if EBFM is to be made operational. Effort should be expended on developing approaches to incorporate qualitative data, expert judgment and data from outside of the traditional scientific fisheries advice domain (e.g. from industry, environmental scientists) to ensure that management decisions are appropriately informed.

LTMPs developed based on best available evidence must be implemented within an adaptive management regime, responsive to changes in environmental conditions, and new knowledge and understanding on the marine environment. Furthermore, the regime should be able to respond to advances in technology and associated changes in fishers' behavior to ensure that the long term sustainability is not compromised. Monitoring should be implemented to report on progress in meeting management objectives, with action taken where objectives are not being met (Fig. 6.1).

Ultimately management decisions will be made by politicians or managers (at EU and MS level), on the basis of overarching objectives. However, the joint development and evaluation of management strategies in the format described here has the potential to develop common understanding of the long-term implications of management decisions, and build communication and trust between industry and managers. Trade-offs are required among the pillars of sustainability in the development of LTMPs, and among fisheries when integrating LTMPs into regional FEPs; managers and stakeholder must work together to address priorities. Due to the nature of the trade-offs, it may not be possible to satisfy all stakeholder groups simultaneously (e.g. high level objectives call for EU fisheries to be exploited at MSY, however it may not be possible to achieve this for all fisheries simultaneously). Resolution of these trade-offs is not a technical scientific decision, however development of decision support frameworks such as the management strategy evaluation matrices can aid managers in making appropriate decisions on the basis of the best available information.

During the last decade Long Term Management Plans (LTMPs) have been in place to recover the biomass of overexploited stocks like hake and *Nephrops*. However, these LTMP have taken a single stock perspective and a rather limited scope on the related fishing fleets. In the current set up management plans are generally based on a biological assessment and wider ecosystem considerations are lacking. Also in the majority of cases, if at all, the economic analysis is only included after the biological assessment has been implemented. A firm bio-economic feedback loop is generally lacking and social considerations of reliance and resilience are excluded.

In order to curb this trend an effort should be made to devise analytical tools that do enable an integrated assessment of ecological, economic and societal impact of LTMP. This will also require a considerable effort in making available relevant economic and social indicator data, equivalent to the ecological data

Pivotal in the analysis of a LTMP is the evaluation of measures at the geographical ecosystem level. This will require a regional scope in the analysis and thus an integration of data sets on ecological, economic and societal aspects from different nations, both EU MS and third countries. Also it will call for cooperation between MS, EC and stakeholders at the regional level. Currently this regional level has no formal position in the EU treaty.

Central to this analysis will be appropriate governance mechanisms that facilitate true stakeholder engagement to generate credibility in the management process and foster stakeholder support. However, the policy development cycle is currently geared towards a traditional science-policy interface, with a linear process form science to policy. In the evaluation of LTMP it is recommended to acknowledge that traditional science is not fit to meet the challenges of many policy questions of today, but that these questions require (1) new, trans-disciplinary approaches, (2) an awareness of how values are embedded in the framing of policy questions and the choices of scientific methods and (3) that uncertainty be addressed more adequately.

In order to fuel a participatory regional ecosystem evaluation of fisheries plans in the SWW the development of tools are needed to facilitate the spatial management strategies through spatial analysis and mapping of log-books, VMS, discards, research surveys, collected under Data Collection Framework (DCF) and interfaces with participatory science-policy servicing the needs of all parties involved in the policy evaluation cycle.

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9.1. ANNEX A: Descriptors and related indicators

For these descriptors/indicators is indicated how they were considered within the case study fisheries' management strategies matrices (Table A1). One descriptor for the social pillar, job attractiveness, was dropped in this exercise as it was severely criticised in a previous stakeholder workshop and was believed to be very difficult (if not impossible) to determine the effect of management measures on this descriptor.

Table A1 Descriptors, related indicators used in MEFEPO, and their consideration within the case study fisheries' management strategies matrices.

Pillar	Descriptor	Indicator(s) used in MEFEPO*	Consideration
Ecological	Biodiversity	Conservation Status of Fish	Related to fishing pressure (mortality) applied to fish. Measures of genetic diversity are not taken into account. The existence of "sub-species and populations where they need to be assessed separately" is included. It may also be related to more specific known impacts (particular gears impacting particular vulnerable species) that may be mitigated by specific spatial or technical regulations.
	Commercial fish	Proportion of stocks within safe biological limits (SBL) with regard to SSB and fishing mortality (F)	Related to the state of the case study fishery stock and other commercial stocks that interact with the case study fishery.
	Food-webs	Large fish indicator (LFI)	Related to fishing pressure on the fish community (especially larger longer lived fish). Indirectly, it may also be related to effects of discards on local food webs.
	Seafloor integrity	Proportion of area not impacted by mobile bottom gears	Pressure indicator of the extent of trawling impacts, related to the effort applied by mobile bottom gears and to the areal coverage of bottom trawling.
Economic	Efficiency[1]	Fishers' ability to take a given harvest at the lowest possible cost	Related to benefits and costs: social, economic (e.g. input) and ecosystem (externalities e.g. costs of by-catch and discarding).
	Stability	Minimising fluctuations in harvesting possibilities over time	Related to stability in fishing opportunities (e.g. fluctuations in TAC). If stock above SBL it is more likely that it will be more robust to short term environmental 'noise', therefore less need for regular changes to quotas to respond to changes in recruitment/environmental noise. Note that this is only true for stocks with strong stock-recruit linkages.
Social	Community viability	Employment linked with fisheries	Related to employment (e.g. catching, amount and type of employment, processing, administration, science,…) As this is a social descriptor, including cultural values, it is not only linked to "efficiency". .
	Food security	Securing a sustainable and sufficient supply of marine protein as food	Related to marine protein caught from the sea, hence this is related to yield, but not exclusively to commercial fish stock status.

* Earlier in the MEFEPO project, more than one indicator per descriptor had been suggested.

[1] NS beam trawl: Net revenues were the prime consideration.