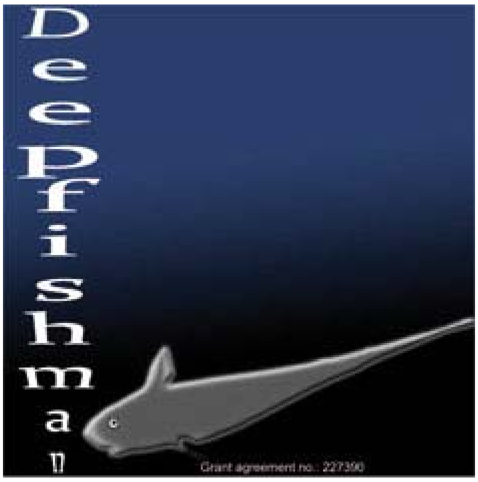

DEEPFISHMAN
Management And Monitoring Of Deep-sea Fisheries And Stocks

Project number: 227390

Small or medium scale focused research action
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FINAL REPORT

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Contents

1. Publishable summary

The project achieved a review of the strengths and weaknesses of the management and monitoring of deep-water stocks, fisheries and ecosystems in DEEPFISHMAN case studies and a number of other areas of the world. The main conclusion was that most of the monitoring and management regimes, including those in the north-east Atlantic, had four major weaknesses: (i) there is lack of an agreed definition of deep-water species and deep-water fishing activity; (ii) only rarely are regulations in place to collect socio-economic data (although such regulation exists in EU waters as part of the DCF); (iii) most have no mechanisms in place to monitor parasites, contaminants and pathogens in deep-water fish; and (iv) there is little monitoring of ecosystem composition, health and productivity. These gaps were addressed by the project.

The socio-economics of the nine studied fisheries were reviewed. These are managed primarily by TACs, licenses, effort restrictions, technical restrictions and spatial and temporal closures. The Greek blackspot seabream fishery is though in effect an open access fishery. The only cases of market-based management are found in Norway and Iceland. Three kinds of bio-economic models were constructed: a basic theoretical model that was not applied to any fishery, but intended to throw light on the general development of deep-water fisheries, and two applied models for the French fishery to the West of the British Isles and the Icelandic fishery for deep-water beaked redfish.

A global review identified the assessment and management approaches currently being implemented for deepwater fisheries and highlighted the need for the development of techniques that allowed a more sustainable exploitation of vulnerable deepwater stocks. New and alternative stock assessment methods in relation to both obvious needs and availability of data were developed. These new modelling approaches included standardisation of Landings Per Unit of Effort (LPUE), a Bayesian state-space model, a Multi-year catch curve (MYCC), a catch-at-age model and a continuous state-space model. The GADGET modelling toolbox was applied in two cases and simulation testing of a number of assessment methods in varied situations of data limitation was carried out. The data used for stock assessment came from data-mining carried out in the project and recent data collected e.g. under the DCF in EU waters. Considerable progress in the assessment of deep-water stocks was made. In particular, a range of suitable assessment models were tested, new assessment methods were developed and some are already in use by ICES.

A comprehensive review of candidate indicators, reference points (RPs) and harvest control rules (HCRs) used for deep-water/data poor species revealed very few instances where RPs or HCRs had been applied to deep-water fisheries, even in a global context. Indicators, RPs and HCRs for each of the case studies were reviewed and appropriate ones were defined including precautionary reference points based on alternative sources of information such as life history theory and spatial information. Simulations were used to develop and test RPs and HCRs.

Analyses of trends in biodiversity and the identification of biodiversity indicators were carried out based upon fishery dependent data including haul-by-haul data provided by stakeholders, on-board observations and surveys in several areas and case studies including: Irish waters, Eastern Ionian Sea, West of Portugal and Icelandic waters. Part of this work was carried out jointly with the project CoralFISH.

Existing and new options for management strategies were identified, including by stakeholder consultation. The management options were tested by Management Strategy Evaluation (MSE) using FLR (flr-project.org/), the spatially explicit simulation platform ISIS-fish (http://www.isis-fish.org/en/index.html) and qualitative modelling.

Guidelines towards management and monitoring framework for deep-water fisheries/stocks in the NE Atlantic were formulated. This document was based on data collated during the project, project results and partners knowledge.

2. Concept of the project

The deep-water is generally considered to be the area of the world's oceans beyond the continental shelf; that is, greater than 200 meters depth. Fisheries targeting deep-water species generally take place in depths below 400 meters. This project addressed the deep-water species listed in Annex I and II of the EC Deep-water Licensing Regulation (Council regulation (CE) No 2347/2002). It also included benthopelagic species such as Greenland halibut (*Rheinhardtius hippoglossoides*) and beaked redfish (*Sebastes mentella*), that are in effect deep-water, at least some populations but excluded the mesopelagic blue whiting (*Micromesistius poutassou*) commercially exploited by pelagic fisheries. An addition reason to consider Greenland halibut and beaked redfish was that these species provided comparatively data-rich case studies and, for Greenland halibut, allowed assimilation of the characteristics, strengths and weaknesses of the NAFO management and monitoring regime.

Using information and data currently available, new information from other ongoing projects, knowledge of the management and monitoring of deep-water fisheries/stocks in other parts of the world and outputs from the project, DEEPFISHMAN aimed to develop a range of strategy options for the exploitation of deep-water species in the NE Atlantic.

The project relied upon a range of case studies selected to reflect the diverse characteristics of the different types of deep-water fishery found in the NE Atlantic. In addition two case studies outside the NE Atlantic and Mediterranean Sea were selected to give a wider perception of the management and monitoring of deep-water fisheries elsewhere in the world. The project included an ICPC country: Namibia. Fisheries data (including all bycatch data) from case studies were used to examine historical catch data for changes in biodiversity and to identify protocols for monitoring biodiversity (of both vertebrates and invertebrates) in the deep-water ecosystem. The project aimed to evaluate the socio-economic profile and projected socio-economic impact of the management strategy options, as applied both through a short- and long-term framework, for selected fisheries. In this way the project aimed to provide robust guidelines for deep-water fisheries management suitable for adoption within the Common fisheries policy (CFP).

The involvement of stakeholders was considered to be key to the success of the project, since they offer a source of unique information to undertake proposed approaches. The project included plans to request the fishing industry to contribute to specific work packages, largely through their participation in workshops arranged through the relevant RACs or by the use of questionnaires and other tools. In particular, an initial start-up workshop to formulate the views of stakeholders on the present and possible future management regimes for deep-water stocks/fisheries in the NE Atlantic was part of the concept. It was anticipated that outputs to stakeholders, policy makers and NGOs would be through a dedicated Stakeholder outreach and dissemination work package.

3. Objectives of the project

The objectives of DEEPFISHMAN were:

- To review (i) salient characteristics of the deep-water environment in the NE Atlantic, (ii) the major features of selected fisheries (this require input from the Industry and the collation and analysis of socio-economic data), (iii) the life history characteristics and vulnerability to fishing of the stocks/species targeted in these fisheries, (iv) the current availability of fisheries, ecosystem and biological data, (v) the current methods used for monitoring, assessing and managing the state of stocks, (vi) the current state of deep-water stocks in the NE Atlantic and (vii) the outcomes and guidelines from the Commission of the European Communities, specific RTD programme "Specific Support to Policies", SSP-2004-22745 "Probabilistic assessment, management and advice model for fishery management in the case of poor data availability" (POORFISH) of relevance to deep-water stocks.
- To draw lessons from the current management and monitoring frameworks for deep-water species used internationally, to identify strengths and weaknesses. These includes e.g. approaches employed by (i) EU and NEAFC in the NE Atlantic, taking into account the recent Review of the Management of Deep-water Stocks carried out by the Commission (ECCOM, 2007), the outcomes of a recent European Parliament Workshop on Deep-water Stock Management (EP, 2007) and the views of fishers as expressed through the relevant RACs; (ii) deep-water fisheries New Zealand, (iii) by NAFO for Greenland halibut fishery in the NAFO Regulatory Area, (iv) orange roughy fishery in Namibia and (vi) the effort-based management framework for deep-water and other species in the Mediterranean and (vii) the experience of CCLAMR in assessing and managing stocks of Patagonian toothfish and finally, and importantly, the views of stakeholders.
- To examine and trial stock assessment methods not previously used or not fully developed for use on deep-water stocks in the NE Atlantic, with the primary aim of evaluating the state of stocks.
- To examine appropriate biological reference points (BRPs, e.g. MSY for stocks prosecuted by selected fisheries) and harvest control rules (HCRs) for deep-water fisheries/stocks in the NE Atlantic, and to explore the feasibility of simple approaches (e.g. the use of biological parameters such as trends in mean length and proportion immature / mature in catches) as indicators of the status of stocks.
- To explore catch data from appropriate case study fisheries for trends in biodiversity, to identify protocols for monitoring biodiversity (of both vertebrates and invertebrates) in the deep-water ecosystem and to integrate issues of by catch species and biodiversity in the management of deep-water fisheries.
- To develop a range of strategic options for the exploitation of deep-water stocks, fisheries and ecosystems in the NE Atlantic with the overall aim of developing a short- and long-term ecosystem based management framework with the aim of reversing any negative trends in abundance and reducing impacts of fisheries on biodiversity and, where feasible, vulnerable marine ecosystems (VMEs). Management frameworks will take into account (i) the outcomes of the objectives above, (ii) the FAO International Guidelines on the Management of Deep-water Fisheries in the High Seas (FAO, 2007), (iii) a risk assessment approach and (iv) the requirement that EU member States commit themselves to maintaining or restoring fish stocks to levels that would produce MSY by no later than 2015.

- To develop a socio-economic profile of selected fisheries and to evaluate projected socio-economic impacts of management strategy options as applied both through a short- and long-term management framework.
- To disseminate outputs/results to stakeholders, policy makers and NGOs.

4. Main S & T results/foregrounds

4.1. WP1 Coordination and management

The coordinator (Ifremer) followed the research activities of the consortium partners in collaboration with the work package (WP) and the case study (CS) leaders, setting up deadlines for each research activity and ensuring that all partners fulfilled their project duties and that task time tables and deliverables were met in due time. The coordinator was responsible for putting together research results and prepared periodic management and technical reports for the EC. All contacts between the project consortium and the EC were undertaken by the coordinator.

The coordination activity fell into three tasks
Task 1.1 Project co-ordination
Task 1.2 Administrative management and project office
Task 1.3 Exploitation and implementation plan

The project co-ordination (task 1.1) and the administrative management (task 1.2) of the project was carried out smoothly. The coordinator and projects partners were in frequent email contact. Project meetings were organised and held in several locations. During the second reporting period, a WP4-WP5 workshop was held at Imperial College (Ascott, UK, 17619 May 2011) a WP7 workshop was held in Bilbao (15-17 November 2012). Steering and governing board meetings were organised during these workshops and at the final project symposium (28-30 August 2012, Galway, Ireland). Further some decisions, e.g. the date and location of the final symposium were agreed by the steering committee members by email.
In task 1.3 links with related projects within the EU and internationally (sub-task 1.3.1) were developed primarily with the EU-project CoralFISH (grant number 213144). A common working meeting was help with this project (with two CoralFISH partners Ifremer and NUIG and two DEEPFISHMAN partners Ifremer and Cefas) and the two projects organised jointly their final symposium. The final stakeholder workshop scheduled in DEEPFISHMAN was also organised jointly, in the same week as the final symposium. In recent months, both projects have presented their outcomes in a number of events mentioned below in the section Potential impact. Some participant scientists have contributed to studies in both DEEPFISHMAN and CoralFISH. The results, publications, tools from several previous FP6 projects including FISHBOAT, POORFISH, TECTAC were used in DEEPFISHMAN approaches. The use and dissemination of the foreground (task 1.3.2) was carried out as scheduled including through input from the project into ICES, STECF, NAFO and other international experts groups. It is worth mentioning here that some DEEPFISHMAN methodologies are already integrated into regular stock assessment made by ICES. The project results were further presented in RACs meetings and RACs representatives have also taken part in stakeholder workshops organised by the project. In addition to the project WIKI, project publications and reports are available from institutional archives of some partners (e.g. http://archimer.ifremer.fr/ and http://www.cefas.co.uk/publications/miscellaneous-publications.aspx). The use and dissemination of the foreground will continue well after the end of the project through continued input into organisation such as ICES, NAFO, OSPAR and publication of project results. In particular, a special issue in underway and will disseminate project results to the scientific community.

4.2. WP2 Review of existing management and monitoring approaches

This work package was lead by Cefas with contribution from all other partners except Imperial College. The work came under two tasks (Cefas leading both):
Task 2.1 – Review of international management approaches
Task 2.2 – collation of data and information

The work was mostly carried out during the first reporting period with the compilation of 9 case study reports. This work package was the major link between case studies, i.e. regional data and expertise and work packages, i.e. research carried out by the project. During the second reporting period some work were published and the collaboration between all partners remained high as case study scientists were strongly involved in the use of their data in the bio-economic modelling (WP3), in stock assessment (WP4), biological reference points and HCRs (WP5), biodiversity analyses (WP6), Management Strategy Evaluation (WP7) as well as in dissemination activities (WP8). For example, the analyses of patterns of fish biodiversity carried out in WP6 were based upon data assembled and formatted in WP2. These analyses involved several case studies and several of the final publications, already submitted or to be submitted in the DEEPFISHMAN special issue, were lead at case study level.

A global review of the strengths and weaknesses of the management and monitoring of deep-water stocks, fisheries and ecosystems in DEEPFISHMAN case-studies and a number of other areas of the world was finalised (D2.3) and is now accepted for publication in Reviews in Fisheries Science. The main conclusion of the review is that most of the monitoring and management regimes, including those in the north-east Atlantic, have four major weaknesses: (i) there is lack of an agreed definition of deep-water species and deep-water fishing activity; (ii) only rarely are regulations in place to collect socio-economic data (such regulation exists in EU waters as part of the DCF); (iii) most have no mechanisms in place to monitor parasites, pollutants, contaminants, as well as viral, bacteriological, fungal and protistan pathogens in deep-water fish, shellfish and other marine organisms; and (iv) there is little monitoring of ecosystem composition, health and productivity. In the north-east Atlantic, this mostly stems from the paucity of extensive internationally coordinated fisheries-independent surveys which can be used as a platform for ecosystem monitoring.
The work carried in other DEEPFISHMAN work packages addressed the definition of deep-water species and deep-water fishing activity (see below WP7) and fish community indicators and modelling were addressed in WP6 and WP4 respectively. Further, an analysis of contaminants, pathogens and parasites in deep-water fish is in preparation for submission to the DEEPFISHMAN special issue. In other words, WP2 provided data and assembled the knowledge from which other WPs could start scientific work but it also identified issues that were addressed by other WPs.

Overall the work, mainly reviews, carried out in WP2 allowed to feed data and background to other WPs and was also a major support of the management and monitoring framework proposed in WP7.

4.3. WP3 Socio-economic study

Work package 3 was lead by the Institute of Economic Studies (IoES) of University of Iceland, with contributions from partners UpO/CEMARE, AZTI; Cefas, MI, HCMR, IEO, MRI IPIMAR.
WP3 analysed the socio-economics of deep-water fisheries, and the work was organized around the analysis of the economic performance of fleets, the effectiveness of management measures and the functioning of markets. These analyses provided information for formulating policy options from the economic point of view. The work package was divided in three main tasks:
T3.1. Economic framework (led by IoES)
T3.2. Management (led by UoP/Cemare)
T3.3. Bio-economic modelling (lead by IoES)

The overview carried out in task 3.1 showed that DEEPFISHMAN case-study fisheries are managed primarily by TACs, licenses, effort restrictions, technical restrictions and spatial and temporal closures. The Greek blackspot seabream (DEEPFISHMAN case study 3b) fishery is though in effect an open access fishery. The only cases of market based management are found in Norway and Iceland. Norwegian vessels taking part in beaked redfish fishery in the Barents Sea and Norwegian Sea are subject to individual vessel quota regime, and although the quotas as such may be non-transferable, it is possible to transfer quotas between vessels owned by the same entity. Furthermore, vessels with quotas can be bought and sold on the market. In Iceland, an ITQ system has been in effect in almost all fisheries since 1990. There are two kinds of quotas, permanent and annual catch entitlements. No restrictions apply to transfers of permanent quotas, but transfers of annual catch entitlements are subject to considerable restrictions. Further details on this overview can be found in D3.1.

Case studies included in DEEPFISHMAN can be classified in a number of ways. The most striking examples are given below focussing on the fleets involved, as the fleets vary considerably in size and scope. In essence, the fleets can be categorised as artisanal fleets, industrial fleets, consisting of only a handful of vessels, and large industrial fleets, primarily the Spanish, Icelandic and Portuguese fleets.

4.3.1 Fleet size (subs-task 3.1.1 and task 3.2)

The Greek artisanal fleet is the most numerous, comprising close to 1,800 vessels, ranging from 10 meter long gillnetters and trammel netters to 23 meter long trawlers. The fleet has numerous home ports and catches are landed in more than 1,200 ports. The socio-economic effects of the blackspot seabream fisheries are therefore not limited to a few communities, but are felt in a considerable part of the country. Reliable information on total catches is though scant.
The blackspot seabream fishery in the Strait of Gibraltar and the black scabbardfish fishery off Portugal are by contrast very local. In Spain, most of the catches are landed in the port of Tarifa and in Portugal in the port of Sesimbra. The Spanish voracera fleet numbers 100 boats, whereas the Portuguese fleet counts 17 vessels in 2009. The local effects of the fishery are quite profound.
In France, Ireland, the UK and Spanish Basque country there are only a handful of vessels, mostly trawlers, taking part in the deep-water fisheries in the waters around the British Isles and west of Ireland. Catches of the fleets have fallen drastically in the last decade; the orange roughy stock and deep-water shark stocks have been depleted, and although the blue ling is

less vulnerable, catches in most ICES areas have declined since the 1970-1980s, in recent year the decline has been mainly driven by the regulation.
The orange roughy stock in Namibian waters has been depleted and a moratorium on fishing has been in effect the last few years. Most of the industrial fleets engaged in the deep-water fisheries have in recent years only contained few vessels.
As a consequence of stocks decline and /or regulations, deep-water fleets have declined since the early 2007. For example, catches of the shallow pelagic beaked redfish in the Irminger Sea and adjacent waters have fallen from 55,700 tonnes in 2003 to 2,000 tonnes in 2008, and catches of deepsea redfish from 100,300 tonnes to 30,100 tonnes over the same period. The number of Icelandic vessels taking part in the fishery has dropped from 26-27 to 12 in less than a decade. Norwegian catches in the redfish fishery in the Barents Sea and the Norwegian Sea have remained fairly stable in recent years, hovering between 4,500 and 9,000 tonnes, but only a handful of Norwegian vessels have taken part in the fishery. The Greenland halibut NAFO fishery has also declined. In 2008, only 14 Spanish trawlers took part in the fishery, whereas in 2005 the fleet counted 35 ships. In 2007, there were 13 Portuguese trawlers taking part in the fishery.

4.3.2 Employment (sub-task 3.1.3)

The total employment of the artisanal fleets of the Mediterranean countries can be estimated at 1,150-1,200. The Greek fleet is estimated to have engaged around 550 individuals in recent years, the voracera fleet 350-400 and the Sesimbra fleet 230.
The Irish longliners and trawlers had on average a crew of 8-10, and the fleet in 2005 probably only employed around 50 seamen. The largest French trawlers usually command a crew of 14-15, while smaller vessels employ 7-9. The seven vessels active in the deepwater fisheries in recent years have thus probably employed around 100 individuals. The UK fleet employed 93 workers in 2007 and the Spanish Basque country fleet around 50 in 2005.
Employment in the Icelandic fleet engaged in the redfish fishery probably totalled around 350 seamen in 2007, while the Norwegian fleet probably employed a third of that. The combined crew of the large Portuguese and Spanish off-shore fleets can be estimated at 500 and 650 members respectively. Taken together all the industrial fleets can thus be estimated to have directly employed around 2,000 individuals in recent years, all males.
Some kind of a share system is the most common remuneration method in all fisheries. In boom times when catches are good and/or prices high, wages will therefore be high and the fishery an attractive way of living. In other times, when catches and/or prices are low the fishery may find it difficult to man the vessels taking part in the fishery.

4.3.3 Processing and markets (sub-task 3.2.2)

Catches of the artisanal fleets are usually sold in open auctions in the port of landing for direct consumption or further processing. The black scabbardfish is though sold fresh or frozen, with most of the catches bought by large distribution stores, while only a small portion is sold in the local market.
As France is the most important European market for deep-water fish products, catches of the Irish, UK and France deep-water fleets are usually transported to France and sold there in auctions or at auction prices. Limited processing takes place in Ireland and the UK, but transport and logistic facilities have been developed in British Isles for swift transport to the continent. In 2006, there were 324 companies active in the French fish processing and marketing sector, and the sector employed a total of 18,500 individuals and a turnover of 1,703 million euros. Most of the firms are located in coastal areas.

Trawlers in the large Icelandic, Portuguese and Spanish industrial fleets usually freeze their catches on-board and the products are then usually exported. Norwegian catches of redfish are either exported frozen or fresh, with exports of the latter having increased in recent years.

4.3.4 Economic performance (tasks 3.1 and 3.2)

The financial performance of the deep-water fleets, or segments to which these vessels belong, varies considerably, both between fisheries, as well as between years.

The Irish orange roughy enjoyed huge profits at first, but their performance deteriorated thereafter. In 2005-2007 the fleet was though operated with profits. The French fleets were run with losses in 2005-2008, except the smaller vessels (24-40 meters) in 2007. The UK fleet has generally experienced profits in recent years, whereas the Spanish Basque country fleet has most often in the last few years been operated with losses. The Spanish NAFO fleet and Norwegian fleet have both enjoyed decent profits, but the Icelandic deep-water fleet appears to have constantly outperformed the other industrial fleets.

Information on the artisanal fleets is limited. The trawl vessel segment of the Greek fleet though appears to have been doing quite well, and the Portuguese black scabbardfish fishery has also enjoyed profits in recent years.

4.3.5 Modelling (task 3.3)

Most of the NE-Atlantic and Namibian deep-water fisheries tell a similar story of good harvests in the beginning of the fishery and then a fairly steep decline, resulting in small or even zero TACs. To analyse this development three kinds of models were constructed: a basic theoretical model that was not applied to any fishery, but intended to throw light on the general development of deep-water fisheries, and two bio-economic models that were applied to specific fisheries in two of the case studies of DEEPFISHMAN.

Theoretical model

In order to set the stage, a generic model was developed that may be used to analyse deep-water fisheries in general. The model is a standard aggregate bio-economic fisheries model. In a competitive setting, the results indicate that the higher the price of landings and the lower the harvesting and fixed costs of the fishery, the more likely that the competitive fishery will exhaust the biomass. In general, for any fishery including deep-sea ones, there is a certain biomass level (possibly zero) at which point profits from fishing will be zero. It follows from this that the higher the minimum viable biomass of the stock the more likely it is that the competitive fishery will exhaust the biomass. The model also reveals that although an equilibrium may be reached, the equilibrium will be unstable if the associated biomass is less than or equal to a certain critical biomass level.

Further, it was shown that if the marginal biomass growth of the stock in question is low enough and/or the rate of interest high enough, no sustainable equilibrium will be optimal. In that case, the optimal policy is simply to exploit the fishery until it is no longer profitable. Unlike mines and non-renewable resources, which may be exhausted, the optimal policy for deep-sea fish resources would in general not be to completely exhaust the stocks. Instead, it might for instance be optimal to introduce rotational fishing, where the biomass is fished down to a certain level and then allowed time to recover without any fishing taking place.

The model indicates that when there is no management both aggregate harvests and profitability are likely to evolve in a cyclical fashion. Aggregate harvests reach a maximum soon after the beginning of the fishery and then evolve cyclically, and profits are highest at the very outset and then evolve cyclically averaging zero over time. These theoretical predictions seem to be largely confirmed by the experience of the deep-sea fisheries in DEEPFISHMAN case studies (see deliverable D3.2 for further details).

Applied models

In order to analyse the deep-water fisheries further, two models were developed for the French and Icelandic fisheries (task 3.3, see D3.3 for further details). The model of the French fishery is a spatially- and seasonally-explicit bioeconomic model with three fleet dynamics processes built in endogenously, i.e. fleet capacity changes, fishing effort allocation shifts and fishing efficiency creeping. For the purpose of investigation, the model was then applied to the complex French deep-sea fishery to west of the British Isles. This comprised a medium depth demersal stock, i.e. North Sea saithe (*Pollachius virens*), and a mix of deepwater species. The model was run over a ten-year period (1999-2008), where the biological, harvest and economic data were available and then contrasted with a forecast.

The best overall fit was achieved where effort allocation was determined 80% by traditions and 20% by economic opportunism, and where fishing efficiency creeping was set at around 8% a year. With this fleet dynamics parameterisation, annual trends in fishing effort and profit were well reproduced by the model over the whole time period. Time series of the observed fishing effort by métier were generally well fitted by the model over the period 1999-2003, but less so over 2004-2008. The model also reasonably reproduced the catches by species over most of the time series, except for black scabbardfish.

Not many studies have attempted to validate comprehensively the simulated outcomes of fisheries bio-economic models at a fine spatial and seasonal scale. In that respect, it is perhaps comforting that the catch and effort forecast were reasonably close to observations over the first five years of the simulated period. It is also important to stress that while the results obtained are likely specific to the case study, the framework developed here could in principle be applied to any mixed fishery, for which sufficient biological and economic information is available to parameterise the underlying model. A key step forward will then be to use this model within a management strategy evaluation framework. That would require to integrating in the model those processes that have been here treated as endogenous, either by making the process explicit (e.g., stock-recruitment relationship, harvest control rule, stock assessment, price elasticity function, competition between fishing fleets), or through sensitivity analyses when information is insufficient, and also to build in uncertainty adequately.

A different model was assembled to analyse the Icelandic pelagic redfish fishery in the Irminger Sea and adjacent waters. Icelandic freezer trawlers have exploited the shallow pelagic redfish stock in the Irminger Sea since 1989, and the deep stock since 1991. Catches from the shallow stock have rarely exceeded 10 thousand tonnes per year, but the deep stock fishery yielded harvests of 40-50 thousand tonnes in the 1990s. Harvests in recent years have though only been a quarter of that. The shallow stock has seriously declined and most of the nations previously engaged in the fishery are party to a ban on fishing from that stock. The deeper stock is in far better shape although recent TACs are much smaller than those set a decade earlier.

For this fishery, a simple bioeconomic model was developed which made it possible to compare results obtained in a wholly deterministic model to those obtained when allowance was made for uncertainty and/or stochasticity. Uncertainty here referred to cases where parameters, such as carrying capacity and harvesting costs, are fixed but unknown, while stochasticity refers to event that are truly stochastic in time, such as stock biomass and output price. For each scenario, the model was run under the assumption of optimal sustainable yield (OSY), maximum sustainable yield (MSY) and maximum economic yield (MEY). OSY was assessed by determining the paths of harvests and biomass that led, using a simple feedback rule, to the highest present value from the fishery.

In the case of the shallow stock, the results indicate that the present value of profits is very similar in a completely deterministic setting to profits in the scenarios where allowance is made for incomplete knowledge of the carrying capacity and harvesting costs, but lower than when either biomass growth or prices are assumed to follow a stochastic process. These results do, however, not carry over to the deep pelagic stock. Here, the present value of profits is smallest in the deterministic model under OSY, but not when the management strategy is based on either MEY or MSY. The results for the deep stock appear to be much more sensitive to the model specification.

Comparison of actual harvest to simulated harvests for the years for which good estimates of stock size exits shows that in the case of the shallow pelagic redfish fishery it would have been more profitable to harvest more in the early years and less – or nothing – in more recent times. This would have allowed the Icelandic fleet to exploit the shallow stock more heavily while the stock was still large. Because stock assessments of the deep stock have not been carried out as frequently as surveys of the shallow stock, there are far fewer data points for similar comparisons. However, model simulations indicate that actual harvests have always exceeded optimal harvests.

The decline of the shallow stock has to a large extent been blamed on changes in the ocean environment. These changes have, however, not been fully understood. The model abstracts from environmental changes, but rather assumes that the development of the size of stock only depends on harvests, natural mortality and growth. The results from the model reflect these imperfections. Incorporating these environmental factors in the model is a daunting task, but would of course make the model much more realistic and make it possible to trace out the effects that such shocks would have on stock size and harvests.

Overall in work package 3 all the intended work was achieved, the economic framework was studied under task 3.1. The overview the economic management measures (Deliverable 3.1) was carried for all case studies, while it was only schedule to do for a subset of selected case-studies. The manuscripts scheduled in Deliverables 3.2 and 3.3 were delivered. At least two scientific papers are being submitted to the DEEPFISHMAN special issue to be published in 2013 and the model for the French fishery is submitted to the Canadian Journal of Fisheries and Aquatic Science.

4.4. WP4 Development of appropriate assessment methodologies

The objectives of this work-package were to review and evaluate the appropriateness of a range of assessment methods currently in use for deep-water fish stocks and to develop novel tools for assessment. Importantly, the research looked beyond the boundaries of traditional single-species stock assessments and encompassed more holistic ecosystem-based approaches.

The tasks of this work package were to:
T4.1 Review alternative assessment method available for deep-water stocks
T4.2 Identify strengths and weaknesses of assessment methods currently used in case study stocks
T4.3 Identify and develop suitable and novel assessments for EU deep-water species
T4.4 FLR suite of assessment methods for use in data poor situations

Since the aim of stock assessment is to evaluate the abundance of the population and current level of exploitation status, WP4 was closely linked with the development of reference points/directions and harvest control rules (WP5). The work was also closely integrated with WP6 and WP7.

A global review (task 4.1) identified the assessment and management approaches currently being implemented for deepwater fisheries and highlighted the need for the development of techniques that allowed a more sustainable exploitation of vulnerable deepwater stocks. The main problems associated with existing assessment approaches were due to: i) data limitations, ii) the use of methods that failed to take advantage of other useful sources of data, iii) violations of the underlying model assumptions and/or iv) high uncertainty associated with the assessment (due to poor knowledge of the biology and/or fishery). The main outcomes of the review work were published in combination with reviews of biological reference points and Harvest Control rules (HCRs) carried out in WP5 (Edwards et al. 2012).
Much more effort than scheduled was focussed on the development of new and alternative methods (Task 4.3 and 4.4) in relation to both obvious needs and availability of data following the work carried out in WP2, the natural lengthening of time-series and new data collected e.g. under the DCF in EU waters. These new methods were specifically formulated to accommodate the issues common to deep-water fisheries with the result that they provide several promising approaches to improving the robustness and reliability of the assessments of data-poor stocks and are given particular emphasis below. The assessment methods developed are mostly coded in R. A stock reduction Analysis (SRA) was coded in FLR and was used for assessment purpose of the blue ling stock to the West of the British Isles in 2012. Lastly an FLR training course was provided by DEEPFISHMAN (Task 4.4) in the framework of ICES training courses on 26-27 March 2012 at ICES headquarters.
Overall all the tasks in WP4 were achieved. Considerable progress in the assessment of deep-water stocks was made. In particular, a range of suitable assessment models were tested, new assessment methods were developed and some are already in use by ICES and are shortly described below. The work carried out includes innovative spatially explicit statistical modelling and the development of a realistic spatial simulation framework.

Main assessment methodologies developed within WP4.

4.4.1 Effect of accounting for discards in the assessment of the roundnose grenadier stock

The effect of including discards in the catch at age of roundnose grenadier (*Coryphaenoides rupestris*) in the Northeast Atlantic fishery, was investigated using a separable virtual population analysis (SVPA). However, because of the lack of discard data for many of the years covered by the study (1990-2008), the catch data used as input to the assessment model had to be reconstructed from the available information (landings, discards, fishing effort and bathymetric distribution of the stock) using two methods. The first method relied on the assumption that the recent length distributions of discards were applicable to the earlier years (1990-1997) and resulted in unrealistic bimodal length distributions, suggesting a change in discarding practices through time, with larger individuals being discarded in the early days. The second method, based on the fishing effort and length distribution by depth strata, produced unimodal distributions for the whole period and confirmed that the average length of discarded fish was higher in the early days of the fishery. Although, this study acknowledged that SVPA will not be the most appropriate assessment model for roundnose grenadier in the future owing to short time series, changing fishing strategies such as changing fishing depth over time and uncertainties in age estimations, it demonstrated that including the discards in the data used for assessment may not change much the estimated stock trends (Pawlowski and Lorance, 2009).

4.4.2 Standardisation of LPUE using fishers tally-book data (discrete time)

Logbooks (tallybooks), from the French deep-water fishery to the west of the British Isles, were used to calculate standardized blue ling (*Molva dypterygia*) landings per unit effort (LPUE) for the period 2000–2008 (Lorance et al. 2010). To investigate how to track stock trends reliably, LPUE values were estimated in five areas for different subsets of the data. The subsets consisted of hauls during the spawning season (when blue ling aggregate), outside the spawning season, and hauls in which blue ling was only a bycatch. The results suggest that blue ling LPUE values have been stable over the period 2000–2008, and that the declining trend previously observed for the stock has been halted. This finding is consistent with stable mean lengths in the landings during the same period and is even more confirmed by an increase in subsequent years.
The same approach was applied to roundnose grenadier and black scabbardfish (*Aphanopus carbo*) and the calculation of biomass indices at stock level were developed by Lorance et al. (2011). For all three species, the depth and area effect were significant. These studies demonstrate the greater suitability of haul-by-haul data than EC logbook data for deriving abundance indices for deep-water stocks. These time-series of LPUE are considered to be the most reliable indices of relative abundance for the three studied species.

4.4.3 Standardisation of LPUE using fishers tally-book data (continuous time)

The continuous space-time distribution of blue ling to the West of the British Isles was modelled using catches per haul from commercial fishing vessels. Generalised additive mixed models (GAMM) were used to separate fishing strategy effects (haul duration, fishing power, fishing location) and species biology (depth preferences, spawning season) from population dynamics. The results confirmed that blue ling in the study area increased slightly over the period 2000-2008 and suggested that no local depletion occurred (Augustin et al. 2013).

4.4.4 Testing assessment methods for data poor deepwater stocks

A data simulator in FLR was used to create simulated stocks with plausible life history characteristics for four deepwater species blue bing, blackspot seabream (*Pagellus bogaraveo*), black scabbardfish and roundnose grenadier. An operating model was used to project these stocks forwards through time under a range of different fishing scenarios and observations with noise. Five different assessment models: Surplus production, Bayesian surplus production, stock reduction analysis (SRA), XSA and Multi-year catch curves (MYCC) were tested as the operating model of which the Bayesian model performed best in terms of providing estimates of stock biomass that best approximated the simulated data.

4.4.5 Multi-Year Catch Curve model (MYCC)

A Multi-Year Catch Curve model was developed for the simulation of annual values of total mortality (Z) and recruitment from proportions-at-age and total catches for the stocks of roundnose grenadier and blue ling to the West of the British Isles (Trenkel et al., 2012). Following the presentation of the model at ICES, this method is now used for regular assessment of the stock of blue ling.

4.4.6 State-space spatial life-stage model for black scabbardfish

A state-space model was developed to describe the dynamics of the subpopulation of black Scabbardfish in ICES Division IXa. The main objective was to evaluate the plausibility of the underlying hypothesis proposed for the dynamics of the species in the NE Atlantic area.

4.4.7 GADGET modelling

GADGET (Globally applicable Area-Disaggregated General Ecosystem Toolbox) was used to investigate the dynamics of beaked redfish (*Sebastes mentella*) in the Norwegian and Barents Seas and blue ling in Icelandic waters (DEEPFISHMAN case study 4).

Beaked redfish

An artificial dataset developed in DEEPFISHMAN will be included in FLR in order to provide a range of data for use in testing assessment models in the JRC research initiative “a4a” initiative (Assessment for All, https://fishreg.jrc.ec.europa.eu/projects). The suite will include a range of life histories, from forage fish through to long-lived species where the redfish case from DEEPFISHMAN will form the long-lived part of this suite. The DEEPFISHMAN redfish model is also used within the "balanced fishing" paper presented at the ICES/PICES Symposium on “Forage fish interactions: Creating the tools for ecosystem based management of marine resources”, Nantes, France, 12-14 November 2012 ICES/PICES. The model is used in the analysis of the impacts of non-selective fishing on a range of different life histories within the Barents Sea. This work will be submitted to the ICES/PISCES special issue.

Blue ling

GADGET was used for the assessment of blue ling in Icelandic waters. The model was able to follow trends in survey indices reasonably but failed in fitting to the limited age structured data. This model was used for regular ICES assessment in 2012 to estimated relative, rather than absolute, trends in biomass and fishing mortality.

4.4.8 Modelling of in-season variations of abundance

A model taking account of seasonal events in abundance was developped for greater forkbeard (*Phycis blennoides*) to the west of the British Isles. This work was presented in an ICES benchmarch. The approach did not reveal appropriate for this stock but it was further developped for a shelf species (Roa-Ureta, 2012). This suggest that ideas and approaches developped for deep-water stock may be of interest in a wider context and contradicts the traditional approach which tends to start from models used in the best documented and data-rich situations and apply them to data limited situations.

4.4.9 Pseudo-cohort analysis and surplus production model: exploratory stock assessment of blackspot seabream in Eastern Mediterranean

The fishery for blackspot seabream, in the East Ionian Sea was no assessed prior to DEEPFISHMAN. Pseudo-cohort analysis and surplus production model were used to generate estimates of fishing mortality and stock numbers. The results indicated that the immature individuals were not subject to the same intensive fishing pressure exerted on older age-groups. The models suggested that the level of exploitation in 2008 was within the sustainable limit but the stock was over-exploited between 2005-2007 (to be submitted to the DEEPFISHMAN special issue).

4.4.10 Spatial assessment testing framework

This investigation explored the benefits of protecting older fish and how spatial management can be used to adjust the age structure and improve the sustainability of the catch (productivity). A non-spatial equilibrium model accounting for biomass growth, mortality and recruitment was used to describe the relationship between mean age of the population and productivity for the South African deepwater hake *Merluccius paradoxus* trawl fishery (Edwards et al. 2011). Results indicated that management measures capable of increasing the mean age at which fish are caught may be of benefit. Furthermore, although the contribution of older fish to recruitment was important, the biomass growth of individuals before they are caught is responsible for the most significant productivity benefit of an older population age structure.

4.4.11 Testing community indicators for future Integrated Ecosystem Assessments

A novel size-structured multi-species community model was constructed for 49 deep-sea fish species from the Northeast Atlantic continental slope off the West of Scotland (Blanchard et al., 2012). The model was used to establish reference-levels of several community indicators in the absence of fishing. The modelled overall community size spectrum slope and % of elasmobranchs were consistent with empirical indicators sampled prior to the period of intensive fisheries exploitation in the same region. By testing a range of fishing scenarios that correspond to recent ideas about sustainable fisheries and balanced harvesting, it was possible to demonstrate trade-offs in conservation and fisheries management objectives in deep-sea fisheries. The results provided the first steps towards reducing the uncertainty about the ecosystem-effects of multi-species fisheries on deep sea fish communities.

4.4.12 Other methodologies

The Stock Reduction Analysis (SRA) was recoded in FLR and applied to blue ling, this assessment model was used in addition to the MYCC for stock assessment in 2012. Spatial indicators for multi-species commercial catch were developed for the multi-species case study of the project (DEEPFISHMAN case study 2, demersal deep-water mixed fishery to the West of the British Isles, Trenkel et al. 2012). A statistical catch at age model was use to reconstruct the time-series of redfish recruitment in the Norwegian and Barents Sea and was further developed to allow a quantitative assessment of the total stock in 2012 (Planque et al., 2012).

4.5. WP5 Reference points and HCRs

The objectives of this work package were to examine and develop appropriate reference points and harvest control rules for deep-water fisheries in the Northeast Atlantic, including indicator-based approaches for evaluating stock status. This work was fully integrated with WP4 on the development of assessment methods and closely connected with the development of indicators to support an ecosystem approach (WP6) and management strategy evaluation (WP7).

Work package 5 included the following tasks:
task 5.1 Global review of candidate biological and economic reference points
task 5.2 Reference points and harvest control rules for case study fisheries/stocks
task 5.3 The design of harvest control rules for case study deep-water species and systems

A comprehensive review (task 5.1) of candidate indicators, reference points (RPs) and harvest control rules (HCRs) used for deep-water/data poor species revealed very few instances where RPs or HCRs had been applied to deep-water fisheries, even in a global context (Edwards et al. 2012). In task 5.2, indicators, RPs and HCRs for each of the case studies were reviewed and appropriate ones were defined (deliverable D5.2). Areas for further development were identified. Testing of HCRs was carried in out in relation to WP7 (e.g. Marchal and Vermard, in prep. see D5.3; Garcia et al., 2012). Taks 5.3 focused on the development of empirical trend-based HCRs, precautionary reference points based on alternative sources of information such as life history theory and spatial information, combined with the use of simulation methods to develop and test reference points, harvest control rules and overall management strategies in order to improve monitoring and management of deep-sea fish and fisheries in the future.

4.5.1 Global review of common approached to fisheries assessment and management of deepwater and data-poor stocks.

The review identified current assessment and management approaches for deepwater fisheries and data-poor stocks and proposed some new approaches that might be suitable in the future. The review included a critical analysis of the use of:

- Simple Indicators of Stock Status - Indicators of Relative Abundance and Indicators based on Catch Size Structure
- Aggregated Biomass Models - Depletion Methods and Biomass Production Models
- Structured Population Models - Catch Curve Analysis, Cohort Disaggregated Models, Virtual Population Analysis (VPA) and Integrated Assessment Methods

Given the limitations in the data, the review highlighted the importance of adequately representing uncertainty in assessment results and emphasised the need for management decision mechanisms that were robust to an incomplete picture of resource dynamics. This required the construction and testing of harvest control rules within a simulation framework. For deepwater stocks where only relative changes in biomass could be discerned from the data, the review recommended that a simple empirical approach with uncomplicated harvest control rules was adequate for management.

4.5.2 Review of the strength and weaknesses of current Biological Reference Points, Harvest Control Rules and indicators for case studies

New and revised BRPs and HCRs were developed (where required) for each of the DEEPFISHMAN case studies. The results are best summarised in table (1).

Table 1. New and revised BRPs and used in DEEPFISHMAN.

Case study	**DEEPFISHMAN recommendations**		
	Assessment method used	**BRP**	**HCR**
1a. Orange roughy in Namibia	none	no change	none
1b. Orange roughy in ICES VI and VII	PSA* (Dransfeld et al., 2012) Spatial ellipse Multispecies Size Spectra	none	none
1c. Blue ling	MYCC SRA LPUE (GAM) Continuous state-space model Spatial ellipses Multispecies Size Spectra Schaefer Production Model (tested but not used)	Calculation of F_{MSY} in WKLIFE (ICES, 2012) based on DEEPFISHMAN $B_{UNDEFINED}$: B_{LOSS} = 17844 $B_{TRIGGER}$: 1.4*$B_{UNDEFINED}$ = 24982 F_{MSY} :$F_{0.1}$ = 0.18	ICES F_{MSY} Framework HCR
2. Roundnose grenadier	LPUE (GAM) Bayesian surplus production SVPA, including discards MYCC Spatial ellipse Multispecies Size Spectra Schaefer Production Model (tested but not used)	$B_{UNDEFINED}$: $B_{MSY}/2$ = 33575 $B_{TRIGGEr}$: B_{PA} = 47005 F_{MSY} : F_{MSY} = 0.08	ICES F_{MSY} Framework HCR
2. Black scabbardfish	LPUE (GAM) Spatial ellipse Multispecies Size Spectra Schaefer Production Model (tested but not used)	$B_{UNKNOWN}$: $B_{MSY}/2$ = 15164 $B_{TRIGGER}$: 1.4*$B_{UNKNOWN}$ = 21230 F_{MSY} : F_{MSY} = 0.21	LPUE ICES F_{MSY} Framework HCR
2. Portuguese dogfish and leafscale gulper sharks	Survey indicators Multispecies Size Spectra		Constant TAC: TAL = 0 t, TAC = 500 t, TAC = 1500 t & TAC = 2500 t.
3a. Blackspot seabream in the strait of Gilbraltar	XSA Schaefer Production Model (tested but not used)	$B_{UNKNOWN}$: B_{LOSS} = 550 $B_{TRIGGER}$: 1.4* $B_{UNKNOWN}$ = 770 F_{MSY} : $F_{0.1}$ = 0.11	Current management, constant TAC = 270 t. ICES FMSY Framework HCR AnnexIV HCR**.**
3a. Blackspot seabream in the Bay of Biscay	YPR and dynamic population model fitted to historic landings (Lorance, 2011)	Stock collapsed. No harvest before rebuilding	none
4a. Redfish in the Norwegian Sea	GADGET	F_{TARGET} of f_{01}= 0.05 and f_{500}=0.25. B_{LIM} = 0.2*max(SSB)= 245149(t) $B_{TRIGGER}$ = 1.4*B_{LIM} = 343208(t)	TAC = 36000(t) ICES F_{MSY} Framework HCR with different F_{TARGET}: f_{01} = 0.055 f_{500} = 0.25

4.5.3 Suitable Biological Reference Points (BRPs) and Harvest Control Rules (HCRs) for EU fisheries for introduction in Management Strategy Evaluation in WP7

A series of Harvest Control Rules and Biological Reference Points for selected case studies were identified for further testing using Management Strategy Evaluation in WP7. The proposed Operating Models, Assessment Models, HCRs and BRPs for each case study are summarised as follows (saithe, *Pollachius virens*, is included here because of the technical interaction between fishing for saithe and deep-water species, see Marchal and Vermard in D5.3).

Table 2. BRPs and HCRs used in DEEPFISHMAN management strategy evaluation studies.

Case study	**Operating Model**	**Assessment Model**	**BRP**	**HCR**
Blue Ling	XSA	XSA Surplus Production Model in FLR	$F_{0.1}$ to be estimated using XSA fit and YPR. F_{msy} when production model is used in MP. B_{lim} $B_{pa} = 1.4B_{lim}$ B_0	Annex IV HCR ICES HCR
Black scabbardfish	Surplus Production Model	Surplus Production Model in FLR	Virgin Biomass = Carrying capacity in production model. F_{msy} to be estimated from production model.	Annex IV HCR ICES HCR
Roundnose grenadier	Bayesian Production Model	Surplus Production Model in FLR	Virgin Biomass = Carrying capacity in production model. F_{msy} to be estimated from production model.	Annex IV HCR ICES HCR
Saithe	XSA	XSA	Current management plan BRPs	Current management plan HCRs
Deep-water sharks (*Centroscymnus coelolepis* and *Centrophorus squamosus*, combined)	Surplus Production Model	Surplus Production Model in FLR	Virgin Biomass = Carrying capacity in production model. F_{msy} to be estimated from production model.	TAL = 0 (discards allowed, current situation) TAC = 0 (metiers where there is positive catchability of Sikis are 'closed' and effort is redistributed to other metiers).
Blackspot seabream	XSA	XSA Surplus Production Model in FLR	$F_{0.1}$ to be estimated using XSA fit and YPR. F_{msy} when production model is used in MP.	Annex IV HCR ICES HCR
Redfish	Gadget	XSA Surplus Production Model in FLR	$F_{0.1} = 0.6$ F_{msy} when production model is used in MP. B_{lim} = 20% of B_0 $B_{pa} = 1.4B_{lim}$	Annex IV HCR ICES HCR

4.6. WP6 Trends in biodiversity

This work package was lead by Ifremer with a significant contribution from MRI, Cefas, HCMR and IPIMAR. Reviews of knowledge and data on biodiversity were made in each case study in work package 2 and further data analyses were carried out in this work package 6.

The work package included five tasks:
Task 6.1: Review of the impacts of deep-water fishing on biodiversity
Task 6.2: Explore trends in biodiversity in time-series catch data from fisheries on the continental slope.
Task 6.3: Explore trends in biodiversity in deep-water survey data
Task 6.4: Trends in invertebrate diversity
Task 6.5: Identify biodiversity indicators from catch data, on-board observations and survey data

The five tasks were completed. Reviews of the impacts of deep-water fishing on diversity (task 6.1) were made in conjunction with work package 2. Four review documents are available on the DEEPFISHMAN wiki. Trends in biodiversity in time-series catch data from fisheries on the continental slope (task 6.2) were carried out based upon haul-by-haul and on-board observations data. Trends in deepwater survey data (task 6.3) were investigated in several areas and case studies (CS): Irish waters (CS1b), Eastern Ionian Sea (CS3b), West of Portugal (CS3c), Icelandic waters (CS5) additional analyses were carried out in the Bay of Biscay (CS3a). These analyses have been finalised and articles are submitted or in preparation for the DEEPFISHMAN special issue. Trends in invertebrate diversity (task 6.4) have been analysed as part of deliverable D6.2. These studies have also given rise to work in connection with the project CoralFISH and have been passed to WP7 and used in the proposal for the monitoring and management framework. The identification of biodiversity indicators from catch data, on-board observations and survey data (task 6.5) was addressed for several studies as reported in deliverable D6.1 and D6.3. Additional studies have been carried out, including an analysis of trade-offs in the management of the blue ling fishery to the West of the British Isles. This analysis showed that management measures taken to protect blue ling from overexploitation may have negative impact on other ecosystem components including the seafloor and deep-water sharks (Lorance et al., 2012).

In this section a few examples of the biodiversity studies carried out in WP6 are given. The relevance of indicators defined in the Data Collection Framework (DCF) and in the Marine Strategy framework Directive (MSFD) was investigated in the case of the Irish Deep-water survey (Dransfeld et al., 2012). The Irish deepwater survey has been conducted between 2006 and 2009 and covers ICES Divisions VIa and VIIc. Three areas (Figure 1) and four depths (500, 1000, 1500 and 1800 m) were studied. The survey was coordinated with the Scottish deepwater survey which covers the slope further North in Division VIa. The DCF indicators Conservation Status of Fish (CSF) and Proportion of large fish (PLF) were calculated as well as total abundance, total biomass and Shannon species diversity (H'). The abundance and biomass of some species and groups such as sharks were also calculated. The results for sharks are taken here as an example of a result that has some significance for fishery management. Twenty one species of sharks were caught in the survey, two of which *Somniosus rostratus* and *Oxynotus paradoxus* as a single specimen. For all sharks taken together, there was a highly significant depth effect in the catch in number and weight (Figure 2). This effect varied slightly but significantly by areas for the weight caught but not for numbers. Lastly, there was not year effect also the number and biomass of sharks in the last year of the survey.

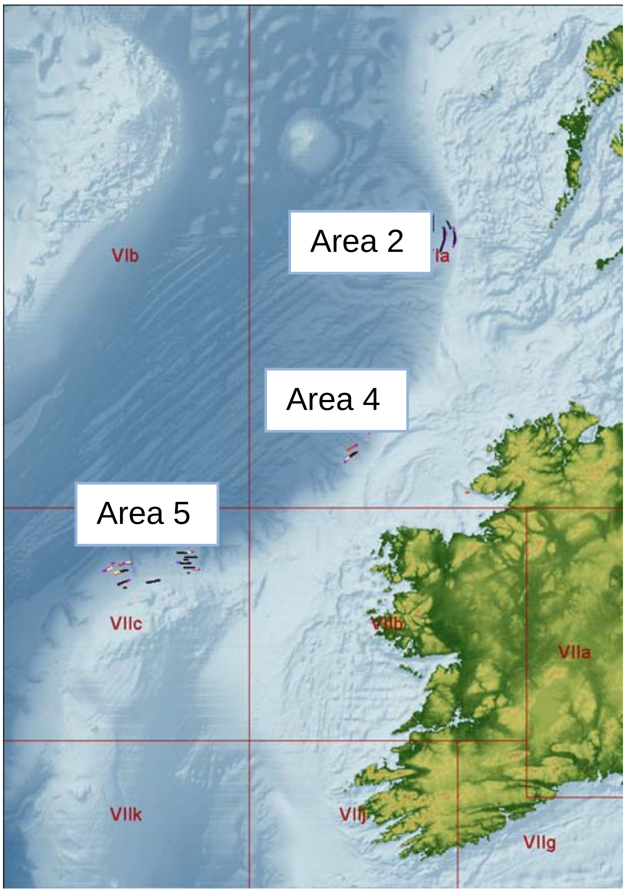

Figure 1. Areas studied in the Irish deep-water survey.

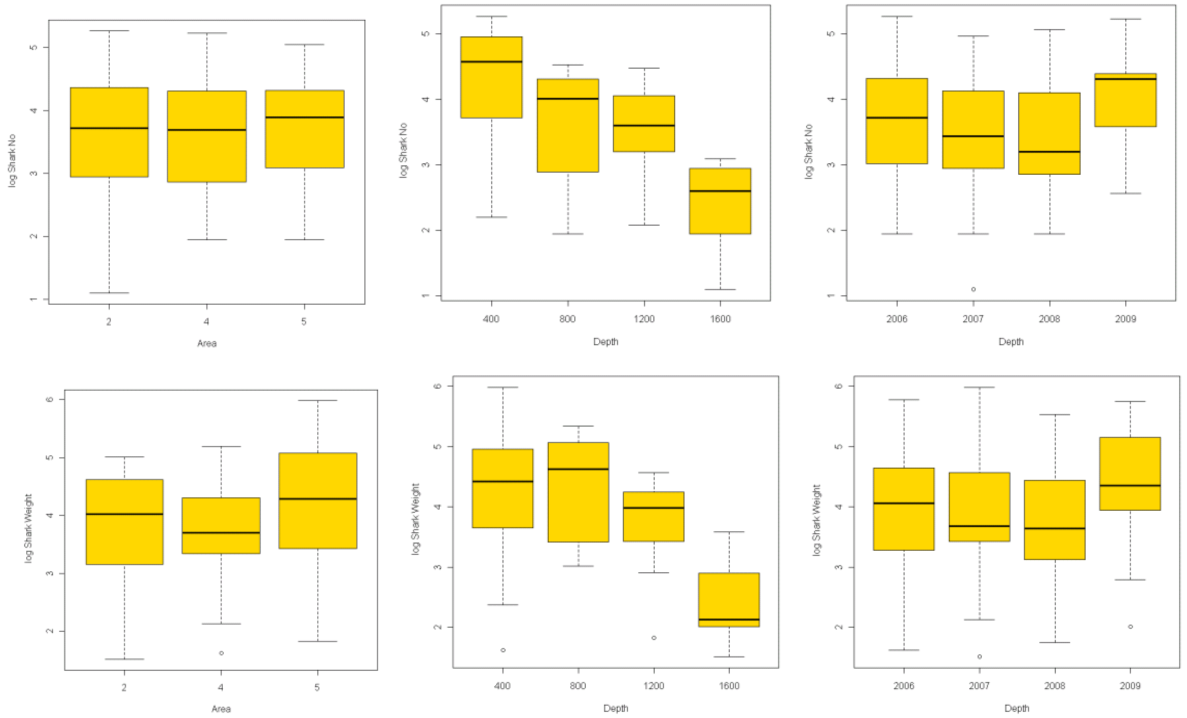

Figure 2. Box-plots of log-numbers (top) and log-weight (bottom) of sharks caught in the Irish deep-water survey by area (left), depth (middle) and year (right).

This study provided several other important results, in terms of distribution of species diversity, abundance and biomass as well as significance of standard indicators.

New results in terms of distribution patterns of fish diversity were obtained from the time-series of the Icelandic deep-water survey and the MEDITS bottom trawl survey in the eastern Ionian Sea (Greek waters). Using the Icelandic survey data, correlative modelling of fish diversity against abiotic variables was used to address two main questions: how do fish communities respond to environmental gradients; and are there generalised responses in fish diversity that would be sufficiently predictive for use in fisheries management in data-poor regions of the deep-sea? Significant responses of diversity to temperature, bottom depth, slope, near bottom current speed and surface primary production were found. However the direction and shape of the response depended on the diversity index used, i.e. comparing Species Richness, Shannon diversity and Taxonomic Diversity (Figure 3). The finding of significant effects of the other variables than depth and temperature on the deep-water fish community is novel. Two elements may have allowed to identify effects previously unnoticed (1) the availability of a time-series with a high number of haul carried out in standardised protocols since 1996 and (2) the use of global marine environment data repositories to extract environmental variables.

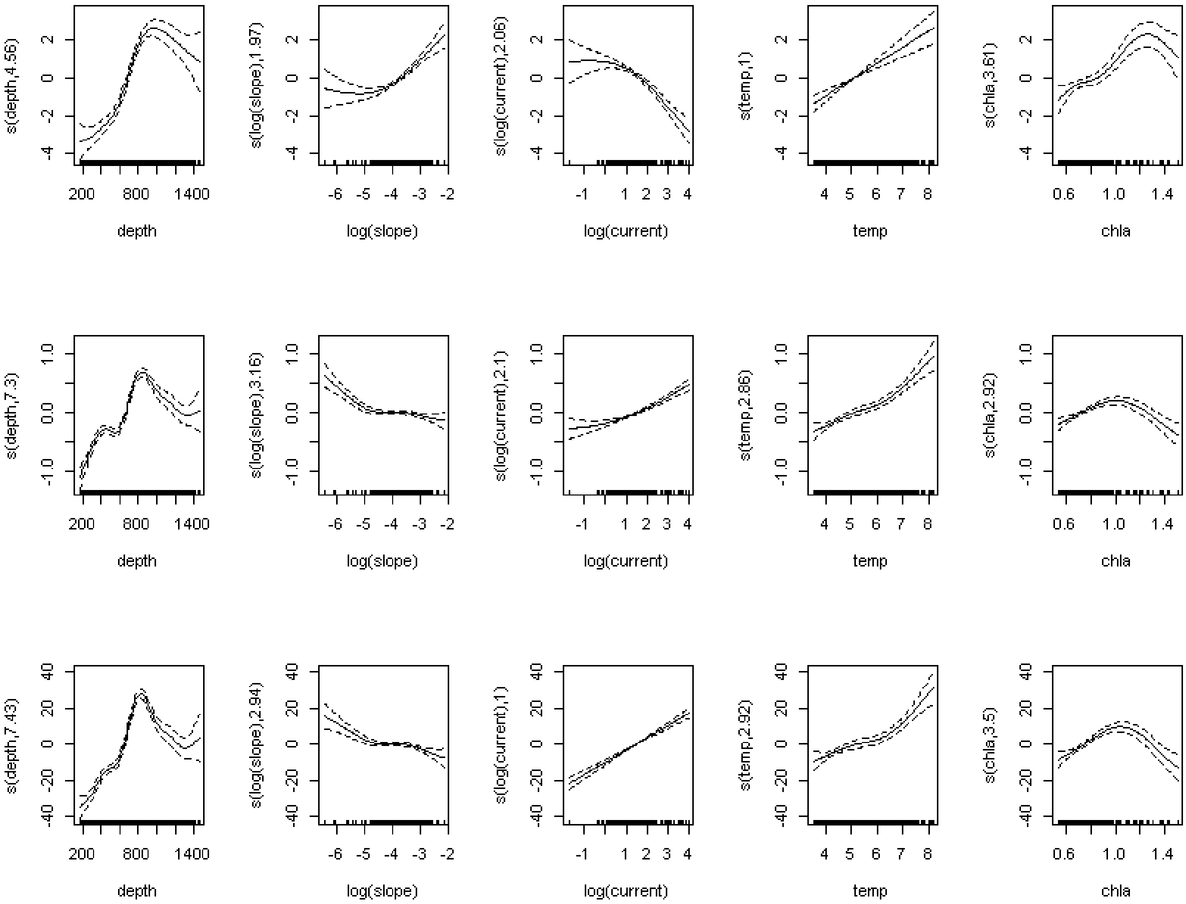

Figure 3. Generalised Additive Model (GAM) partial plots for the Southwest Iceland slope fish community (top, species richness; middle Shannon Diversity and bottom taxonomic distinctness diversity index).

In the Mediterranean Sea, the analysis of the patterns of fish diversity showed that depth and location were the main factors of the observed fish diversity. However, for some diversity metrics, including length metrics temporal (year) and/or fishing effort effects were found. In this area, the fishing effort is estimated to have decreased over the study period (1998-2008) and this may have allowed for an increase in biomass, abundance, species richness and maximum size at sampling station (haul) scale.

These results from Irish, Icelandic and Greek waters are part of studies presented at the joint CoralFISH-DEEPFISHMAN Symposium "The scientific basis for ecosystem based resource management and monitoring in the deep-waters of the Mediterranean & North Atlantic", Galway, 28- to 31 of August.

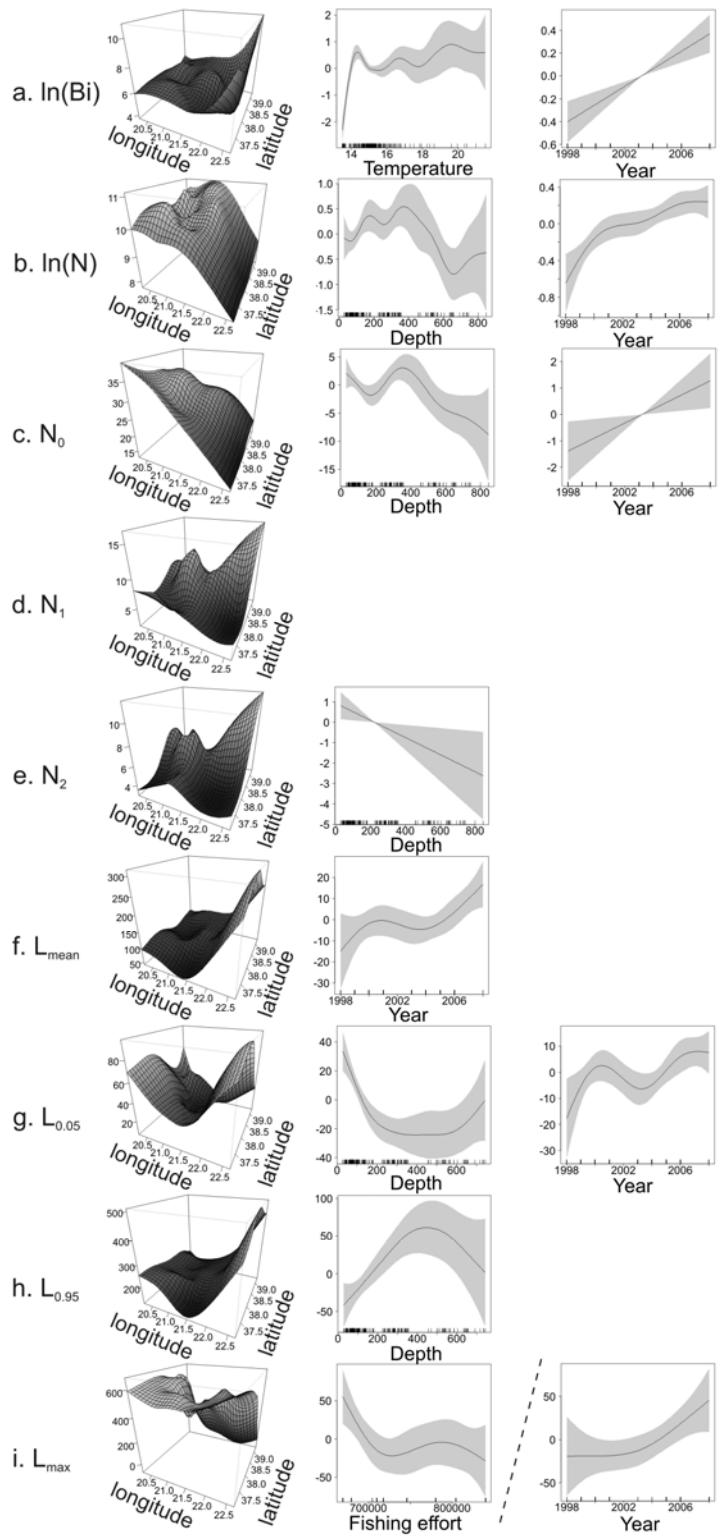

Figure 4. Estimated smooth terms of the parameters contributing to the selected GAMs for metrics of the total fish community in the eastern Ionian Sea. ln(Bi): natural logarithm of biomass; ln(N): natural logarithm of abundance; for definition of the remaining metrics see text. Diagonal dashed lines indicate alternative models. Grey areas are 95% confidence intervals. Temperature: natural log transformed values of temperature. Rug plots indicate the distribution of the observed values.

4.7. WP7 management strategy framework

This work package was led by AZTI-Tecnalia with a significant contribution from Cefas and UoI, Imperial college of London and UoP/CEMARE, a workshop was organised in Bilbao, from 15 to 17 November 2011, in order to assure the consistency between the definition of the Management Strategy framework and the assessment methods developed in WP3, WP4 and WP6 and to optimise the integration of all the work carried out in DEEPFISHMAN into the WP7. In addition IFREMER had a larger than scheduled contribution to WP7 with the development of two Management Strategy Approaches (see below).

The two objectives of WP7 were:
- to define case study management strategies, both in the short and long term, in order to evaluate the biological, bioeconomic and ecosystem implications of these strategies and to perform management strategy evaluation (MSE) for selected case studies.
- to develop a prototype short and long-term management and monitoring framework for deep-water fisheries/stocks.

Work package 7 included three tasks:
Task 7.1. Definition of management strategies
Task 7.2 Management Strategy Evaluation (MSE)
Task 7.3 Prototype short- and long-term management and monitoring framework for deep-water fisheries and stocks in the NE Atlantic
All three tasks were lead by AZTI-Tecnalia

4.7.1 Objective 1: case study management strategies and MSE

For the first objective, the management options and monitoring data were reviewed, existing and new options for management strategies were identified, including by stakeholder consultation (task 7.1). The strategy management options have been tested by MSE using FLR, the spatially explicit simulation plateform ISIS-fish and qualitative modeling (task 7.2).
The results of these developments from these three types of approaches were presented in the joint CoralFISH-DEEPFISHMAN Symposium "The scientific basis for ecosystem based resource management and monitoring in the deep-waters of the Mediterranean & North Atlantic", Galway, 28-31 August, they are included in Deliverable D7.5 and scientific papers are submitted to journals.
Further details of the MSE carried out under FLBEIA are given in the section "Development and test of FLBEIA" below. Details of the ISIS-FISH and the qualitative modelling approaches can be found in deliverable D7.5, which includes 3 manuscripts to be submitted to the DEEFISHMAN special issue in Aquatic Living Resources (MSE using FLBEIA from Garcia *et al.*,); to Canadian Journal of Fisheries and Aquatic Sciences (MSE using ISIS-Fish from Marchal & Vermard) and Fish & Fisheries (Qualitative Modelling from Trenkel et al.).

MSE using FLR

The tool FLBEIA developed as an R package was tested in three selected case studies with different characteristics:
- Blackspot seabream in the strait of Gibraltar as an artisanal mono-specific and single fleet fishery;
- Blue ling mixed and multifleet French fishery in VIa, VII and XIIb,
- Redfish in I and II as an example of data rich stock.

The multi-fleet and multi-stock characteristics of the FLBEIA tool has allowed, in each case study, to define (as a preliminary approach) the management strategies in the short and long term for these stocks. To do this, for each case study several scenarios were defined combining the specific Harvest Control Rules, fleet dynamics, observation and assessment models and management advice in order to evaluate the biological, bioeconomic and ecosystem implications of the management plans.

Spatially explicit simulation using the ISIS-Fish platform

A spatially-explicit bioeconomic modelling framework to evaluate management strategies, building in both data-rich and data-limited harvest control rules, was developed for DEEPFISHMAN case study 2. Trends in catch per unit effort were used as a surrogate for stock abundance variations, either to tune stock assessments, or to trigger directly management action. This approach differs from that developed using FLBEIA in that it is spatially structured.

Qualitative modelling

A framework for qualitatively evaluating fisheries management plans, both rebuilding plans and others, which allows a first rapid appraisal before any quantitative analysis was developed. The framework includes three steps: 1) assessment of the sustainability of the objectives of the plan, 2) assessment the theoretical chance of success using qualitative analysis of a bio-economic model, and 3) assessment of the expected operational success using empirical rules derived from the literature. The framework has been demonstrated for evaluating the management measures currently in place for the roundnose grenadier stock exploited to the west of the British Isles (DEEPFISHMAN case study 2).

Development and test of FLBEIA

FLBEIA is an R package build on top of FLR libraries. The purpose of the library is to provide a flexible and generic tool to conduct Bio-Economic Impact Assessments of harvest control rule based management strategies under a Management Strategy Evaluation Approach (Punt and Donovan, 2007; Rademeyer et al., 2007; De la Mare, 1998). This approach is widely used in fisheries modeling and management to evaluate the performance of management strategies taking into account the main sources of uncertainty present in the fishery system. It consists in simulating the real fishery system together with the management process. The simulation is divided in two blocks, the Operating Model (dotted area in figures 5) and the Management Procedure (solid grey area in figures 5). The Operating Model (OM) represents the real fishery system formed by the stocks, the fleets and the covariables in FLBEIA. The Management Procedure Model (MPM) simulates the whole management process starting with data collection, followed by the assessment model and ending with the management advice. In this way, when a management strategy is tested, the management advice is not given based on the population simulated in the operating model (the real population as referred in MSE literature) but on the population estimated by the assessment model in the management procedure (the observed population as referred in MSE literature). Thus when the goodness of a management strategy is evaluated, not only the strategy itself is evaluated but also its performance in combination with the data collection and the assessment model.
In Figure 5, the rectangles represent models and the ellipses particular blocks within a model component. The rectangles in grey indicate that the corresponding function is fixed within the algorithm and the ones in white are chosen by the user. The user can choose among existing functions or develop new ones. The Covariables of the Operating Model are thought to accommodate variables relevant to fishery system that are not included in the biological and

fleet data containers. It is expected for these variables to be dependent on specific problems and/or case studies. The Management Procedure runs annually and it mimics the management process as it is done in reality. It has three components, the observation model, the assessment procedure and the management advice. The observation model simulates the data stock by stock and it simulates two kind of data, on the one hand it simulates catch and biological data and on the other hand abundance indices. All the simulated data is generated annually despite of OM's seasonal dimension and it is done stock by stock independently. The Assessment models are applied independently stock by stock in order to obtain estimates of abundance and/or exploitation level of the stock. Any assessment model coded in R and which input data can be generated based on the data simulated in the OM can be used. FLBEIA does not include any assessment model. The management advice is generated by means of the harvest control rule (HCR). The advice in the HCR could be given in terms of catch or effort but at the moment only catch based HCRs are implemented.

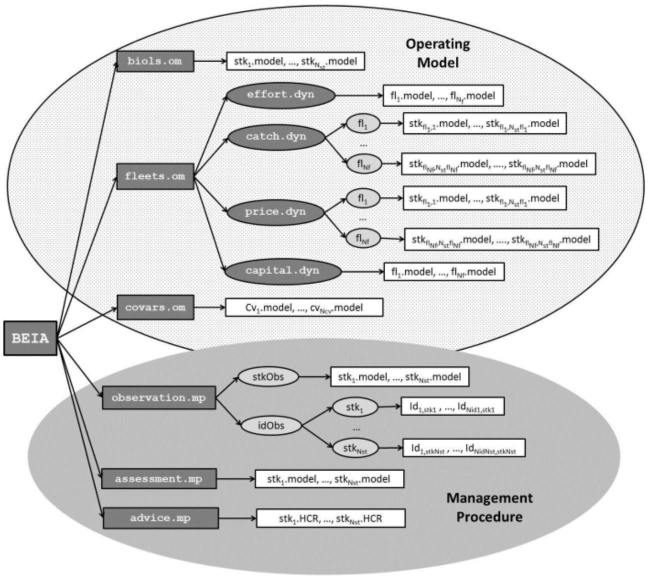

Figure 5. Scheme showing the top-down (left-right in the diagram) structure followed in the algorithm. Rectangles represent functions/models and ellipses particular blocks within model components. Grey rectangles represent fixed models and white ones represent models that need to be specified by the user.

4.7.2 Objective 2: prototype management and monitoring framework for deep-water fisheries/stocks in the NE Atlantic

The second objective of the work package was achieved in task 7.3 by the preparation of an extensive document presented in the Deliverable 7.4 that describes the **Guidelines towards a prototype management and monitoring framework for deep-water fisheries/stocks in the NE Atlantic**. This document was constructed from several sources outputs and knowledge gained from (i) deliverables from the various DEEPFISHMAN Work Packages, (ii) feedback from a European Commission review (EC, 2009a) of the current EU Deep-sea Access Regime (EC, 2002), (iii) the requirements of EU Regulations and developing policy, (iv) a DEEPFISHMAN review (D2.3) of the management and monitoring regimes applying in the north-west Atlantic, the south-east Atlantic, off Brazil, in the Antarctic, off Australia and New

Zealand and in the Mediterranean, (v) outcomes from consultations with stakeholders in the deep-water fishing industry in the NE Atlantic (vi) information on the strengths and weaknesses identified in the existing management and monitoring of DEEPFISHMAN case study stocks/fisheries and (vii) relevant information from other DEEPFISHMAN Deliverables.
A step-wise approach has been used to address several topics for (i) EU vessels and (ii) vessels of all nationalities fishing in the Northeast Atlantic Fisheries Commission (NEAFC) Regulatory Area (RA). A summary of the DEEPFISHMAN recommendations is given below.

Management in the NE Atlantic at the macro-level, (TACs, effort, rights-based management, etc)

DEEPFISHMAN recommends that EU vessels fishing for deep-water species in EU waters and in international waters of the NEAFC RA continue to be managed by TACs and effort/licensing.
Notwithstanding, DEEPFISHMAN recommends that the TAC and effort regimes currently incorporated in the EU Access Regime should be revised in content and scope and this is addressed deliverable 7.4.
Consistent with proposed CFP reforms (EC COM, 2011), DEEPFISHMAN recommends the introduction of a system of transferable fishing rights (preferably ITQs) for EU vessels having deep-water licences. Distributed by Member States, the concessions will grant their owner an entitlement to a share of the national fishing opportunity for each year. Operators will be able to lease or trade their shares. This will give the fishing industry a long-term perspective, more flexibility and greater accountability, while at the same time reducing overcapacity. In making this recommendation the project assumes that ITQs will be tradable between fishers in different Member States, subject to the principle of overall relative stability (which we assume will remain in the reformed CFP). The project consortium acknowledges that stakeholders consulted during the project strongly opposed to an ITQ approach to management of deep-water fisheries.
DEEPFISHMAN recommends that TACs be evaluated using management strategy evaluation (MSE) where possible. MSE developments made in WP7 provide a number of options for analytical (FLBEIA) spatially explicit (ISIS-FISH) and qualitative MSE.
DEEPFISHMAN recommends that vessels of all nationalities fishing for deep-water species in international waters of the NEAFC RA should continue to be managed by TACs and effort control. However, these regimes should be revised and strengthened as described further in Deliverable 7.4.

Definition of deep water and deep-water species

DEEPFISHMAN recommends that in the NE Atlantic deep water be defined as waters where the depth is >200 m; this is consistent with the FAO definition applied globally in all of the world's oceans.

- DEEPFISHMAN recommends that in the NE Atlantic deep-water species be defined as those which spend a significant part of their life-cycle at depths >200 m. More practically, this can be defined by >50% of adult biomass located at depths >200 m, or by >50% of expected lifetime spent at depths >200 m. Information on the depth distribution of species biomass should, where possible, be sourced from available fisheries independent survey data and, in the absence of these, time series abundance and landings data from commercial vessels and available information on the maximum and minimum depth range of species distribution. In areas of narrow shelf, this rule may need some adjustment.
- DEEPFISHMAN recommends that for EU deepsea fishing licensing purposes the species listed in Annex I and II be combined, that conger eel (*Conger conger*) and Norway

redfish (*Sebastes viviparus*) be deleted and Greenland halibut (*Reinhardtius hippoglossoides*), tusk (*Brosme brosme*) and beaked redfish (*Sebastes mentella*) be included.

• DEEPFISHMAN recommends that tusk and Greenland halibut continue to be included in species treated as deep-sea by NEAFC, that beaked redfish is added, and that ling (*Molva molva*), conger eel and Norway redfish be removed.

Total Allowable Catch (TAC) management: review of the current list of species and the periodicity of TAC reviews

DEEPFISHMAN recommends that EU TACs be introduced for the following:

- o Common Mora (*Mora moro*) and the Moridae
- o Rabbitfish (*Chimaera monstrosa* and *Hydrolagus* spp.)
- o Baird's smoothhead (*Alepocephalus bairdii*)
- o Wreckfish (*Polyprion americanus*)
- o Blackbelly rosefish (*Helicolenus dactylopterus*)
- o Silver scabbardfish (*Lepidopus caudatus*)
- o Black (deep-water) cardinal fish (*Epigonus telescopus*)
- o Deep-water red crab (*Chaceon* (*Geryon*) spp.)

• DEEPFISHMAN recommends that consideration be given to allocating a specific EU TAC to beaked redfish (*Sebastes mentella*).

• DEEPFISHMAN recommends that the historical landings data for the NEAFC RA be evaluated to determine the scale and extent of landings of the species proposed for EU TAC regulation.

• DEEPFISHMAN recommends that the deep-water species managed by TACs in the NEAFC RA be revised as appropriate.

• DEEPFISHMAN recommends that EU TACs for orange roughy and deep-water sharks be reviewed every five years.

• DEEPFISHMAN recommends that EU TACs for roundnose grenadier and beaked redfish these species be reviewed on a triennial basis.

• For all other existing and proposed deep-water species, DEEPFISHMAN recommends that EU TACs be reviewed biennially, except where long-term management plans are in place.

• DEEPFISHMAN recommends that if the range of deep-water species managed by TAC in the NEAFC RA is expanded, consideration should be given to reviewing these TACs with the same frequency as recommended above for EU TACs.

Review of TAC management units taking into account known information on stock structure

The project reviewed the current management areas and the state of knowledge of the stock structure. Based upon this a number of recommendations for adjustment of management areas were made. Table 3 provides examples for two species (see deliverable 7.4 for similar results for all deep-water species currently managed by EU-TAC).

Table 3. Recommendations for changes in EC management units and assessment units for roundnose grenadier and black scabbardfish.

Roundnose grenadier

EC Management units	ICES Assessment units	Comment	Recommendation
EU and international waters of: Vb, VI, VII (RNG/5B67-)	Faroe-Hatton area, Celtic sea (Divisions Vb and XIIb, Subareas VI, VII)	Advice for landings in are given separately for: (1) Vb, VI, VII (2) XIIb	Add XIIb to the management unit
VIII, IX, X, XII and XIV (RNG/8X14-)	Mid-Atlantic Ridge 'MAR' (Divisions Xb, XIIc, Subdivisions Va1, XIIa1, XIVb1)	EU TAC mostly exploited in XIIb and set according to advice for Divisions Vb and XIIb, Subareas VI, VII (see above). Minor EU fisheries in other areas	Separate XIIb (Western Hatton) from other areas in management unit and merge it with Vb, VI and VII
III (RNG/03-)	Division IIIa		No change
I, II, IV (RNG/124-)	All other areas (Subareas I, II, IV, VIII, IX, Division XIVa, Subdivisions Va2, XIVb2)	Small fisheries in all areas, TAC set to prevent misreporting	No change

Black scabbardfish

EC Management units	ICES Assessment units	Comment	Recommendation
EU and international waters of I, II, III and IV (BSF/1234)	Other areas (Divisions IIIa and Va Subareas I, II, IV, X, and XIV)	Minor TAC set to prevent misreporting	
EU and international waters of V, VI, VII and XII (BSF/56712-)	Northern (Divisions Vb and XIIb and Subareas VI and VII)	In subarea XII, landings out of XIIb are minor	Separate XIIb (Western Hatton) from other area (Mid-Atlantic ridge) in management unit
EU and international waters of VIII, IX and X (BSF/8910-)	Southern (Subareas VIII and IX) Other areas (Divisions IIIa and Va Subareas I, II, IV, X, and XIV)	Most of the fishery in VIII and IX occur in IXa and in other areas in X, both are Portuguese	Split the management area in: (1) X and (2) VIII and IX
EU and international waters of CECAF 34.1.2 (BSF/C3412))	Not an ICES area	CECAF area 34.1.2 covers Madeira and Canaries, not appropriate to managed the assume spawning area around Madeira	No change

Definition of deep-water fishing effort and capacity ceilings

Some VMS data were analyzed in DEEPFISHMAN. In particular UK VMS data became available by the end of the project, Irish VMS data were available for studies of the trends and distribution of fishing grounds to the West of Ireland, French VMS data were available aggregated for the French deep-water fleet by depth strata of 100 m and a spatial resolution of 10' x 10'. The data from these three countries (including data for vessels of all flags) all appeared very useful for fisheries assessment and were used in for scientific work presented at the joint CoralFISH-DEEPFISHMAN symposium. All data showed strong decreased in deep-water fishing effort since 2003, and this was interpreted as an effect of the EU-management.

The main recommendation that can be drawn is that **deep-water fishing effort is estimated from VMS data as this allows an accurate tracking on fishing effort by depth.** Effort management may not be required if an effective catch management is in place. In EU waters in recent years, the management of landings through TACs and quotas has probably been effective and allowed effort was not all used. However, even if it is not a management tool, an accurate monitoring of effort is essential, as accurate effort data are essential to both stock and ecosystem assessment

Management and monitoring of bycatches, discards and protected, endangered and threatened (PET) species.

Mobile PET species to consider for deep-sea fisheries are primarily deep-water sharks. There is no known significant impact of deep-sea fisheries in the North-East Atlantic to marine mammals, seabirds and marine turtles.

Fixed species are best addressed primarily in terms of VMEs and spatial management. These aspects are mainly in the remit of the CoralFISH project.

Further work is needed on deep-sea shark assessment. The ban of fisheries have reduce available data. Trends-based assessment from survey and on-board observation indicators, have been investigated in DEEPFISHMAN and are the main current way forward for assessing the status of deep-sea sharks. These have the potential to provide relative quantitative trends but no absolute assessment. A bayesian assessment model of sharks was developed in DEEPFISHMAN and will be presented in the relevant expert groups.

Spatial and temporal closures and technical measures

DEEPFISHMAN recommends priority should be given to fully quantitative and high resolution (spatial and temporal) assessments of both seabed habitat features and fishing pressure (effort), and research should be allocated to increasing knowledge to fulfilling an analysis of the following key elements essential for undertaking an appropriate seabed spatial risk assessment:

- Mapping of actual and predicted VME habitat and VME indicator species distributions and densities
- Mapping of actual fishing effort distribution and intensity in order to define the fishing footprint. VMS data are readily available for the deep-water where mostly large vessels operate, so it is a matter of all flag countries to be obliged to provide data
- Assessment of actual and predicted sensitivity/vulnerability of habitats and species to fishing pressure to determine risk
- Assigning the calculated risk to a defined risk category (as outlined above)
- An evaluation of uncertainty in the risk

These aspects are mainly in the remit of the CoralFISH project, innovative habitat modelling and management approaches, including the used of stakeholder knowledge, have been shown by CoralFISH scientists in the CoralFISH-DEEPFISHMAN final symposium.

EU Data Collection Framework (DCF) and observer sampling plans

This topic is a revision of the new Data Collection Framework (DCF), a summary of its different modules and a review of the DCF in relation to deep-water fisheries. Further details can be found in delivrable D7.4

Deep-sea fishery independent surveys and monitoring regimes

For most deep-water stocks there is no adequate survey coverage. Nationally funded surveys are carried out by Norway, Faroes, Iceland, Ireland, Scotland, Portugal and Spain. Target species are Greenland halibut and deep-water redfish in the Faroe Islands, Norway and Iceland, although data for other species are also collected. The main commercial targets of the

Scottish and Irish surveys are roundnose grenadier and black scabbardfish, these surveys also provide indicators for deep-water sharks and all species caught are sampled.

Only few surveys funded by DCF may give adequate coverage in space, depth or in time, the implementation of WGNEACS ICES expert group proposals for deep-water survey has the potential to produce stock-indicators for several stocks, it is depending on DCF funding.

Management of mixed-fisheries: species/fishery level

This topic summarizes several of approaches to address mixed fisheries management problems that have been developed seeking to maximize yield from a complex of species without overexploiting any one species whilst calculating foregone yields.

Data-poor stock assessment methods and biological reference points (BRPs)

This topic provides a review of stock assessment methods and BRPs for deep-water stocks. It shows that stock assessment advice has greatly improved for a number of stocks in recent years and that some stocks are showing sign of recovery following the management that has been implemented since 2003.

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6. Potential impact and main dissemination activities and exploitation results

In DEEPFISHMAN dissemination and outreach activities were carried out in WP8, which was led by MRI, 5 tasks were identified:
T8.1. Establishment and maintenance of public web site
.T8.2. Publications
T8.3. Conferences, workshops and stakeholder for a
T8.4. Policy delivery approaches

All task were achieved. In task 8.1 a web site and a WIKI were developed, the WIKI was an active communication media between DEEPFISHMAN partners and with stakeholders. In task 8.2, some scientific publications are already published, a larger number are in press or will be submitted to a DEEPFISHMAN special issue of a journal. In task 8.3, in addition to the two planned stakeholder workshops at the start and at the end of the project (task 8.3), two additional workshops were held. This close collaboration to stakeholders from the beginning of the project proved fruitful for the project, in addition to the publication mentioned above, stakeholder data and knowledge were used in several project studies, in particular in WP3 socio-economic studies. Results from the project were presented in a number on conferences (see list of dissemination activities) and a final symposium was organised jointly with the project CoralFISH. In task 8.4, DEEPFISHMAN results and policy proposal were delivered to DG-MARE and other policy makers.

6.1.1 Website and WIKI (task 8.1)

A website (http://www.ifremer.fr/deepfishman) and a WIKI (deepfishman.hafro.is/doku.php) were launched at the start of the project. The WIKI was actively used during the project both as an active communication and collaboration interface for external stakeholders and for project partners. The site served as a gateway for the web-based survey and questionnaire directed toward stakeholders. A section of the site was closed to public view but served as a working platform for partners (exchange of working documents, data exchange, final documents, announcements, guidelines etc.) and was actively used as such by partners throughout the project lifetime. Project documents and publications have been accessible through the WIKI. New documents, including publication will continue to be made accessible after the end of the contract.

6.1.2 Publications (task 8.2)

Some scientific publications are already published in the following journals: ICES Journal of Marine Science, Canadian Journal of Fisheries and Aquatic Sciences, Aquatic Living Resources, Journal of applied ecology, Reviews in Fisheries Science. Open access is or will be available for the majority of these. A larger number of articles are in press or will be submitted. In particular, most of the DEEPFISHMAN studies presented in the symposium in Galway are being submitted to a DEEPFISHMAN special issue of the Journal Aquatic Living Resources (http://www.alr-journal.org/).

6.1.3 Stakeholders' workshops and surveys (task 8.3)

Following two stakeholder workshops and numerous informal contacts and two surveys (both web-based and face-to-face) organised during the first reporting period, an article on the use of stakeholder knowledge and data was published in 2011 (Lorance et al., 2011).

During the second reporting period, a third workshop was held in Lisbon 4th July 2011 with the aim of collecting stakeholders' contribution to a model development of a Bayesian state-space model for the assessment of black scabbardfish population. Stakeholders from the fishing sector for this species from Portugal (mainland and Madeira) and France contributed to this workshop with DEEPFISHMAN partners IFREMER and IPIMAR.
The fourth and final stakeholder workshop was held on 31th August 2012 in Galway, Ireland. This was a joint workshop with the EU-project CoralFISH with two goals: firstly to introduce DEEPFISHMAN proposed options for management of deep-water fishery and secondly to collect views and comments of stakeholders on the management framework output of the project. This workshop was attended by 39 persons. Attendees included DEEPFISHMAN participants (13) and CoralFISH participants (9), scientists outside of the projects (3), FAO (1), ICES (1), fishing catching sector (4), seafood sector (1), RAC representative (1), National Administration (1) Government Agency (1) and NGOs (4). Four government public bodies were represented:

- AAMP (Agence des Aires Marine Protégées) France
- BIM (Bord Iascaigh Mhara, Irish Sea Fisheries Board) Ireland
- DPMA (Fisheries directorate), France
- JNCC (Joint nature and Conservation Committee), UK

The NGOs represented were Oceana (http://oceana.org), Seas at Risk (www.seas-at-risk.org/) and Pew Environment group (http://www.pewtrusts.org).
During the wokshop, questionnaires were distributed with all topics listed where stakeholders could document their views on each issue presented. They could either return the questionnaire at the end of the workshop or by email after consulting with their organization. Completed questionnaires were appended to the stakeholder workshop report.

6.1.4 Conferences (task 8.3)

Dissemination within the scientific community was achieved by the participation of project partners in scientific conferences and workshops. A final conference entitled "The scientific basis for ecosystem based resource management and monitoring in the deep-waters of the Mediterranean & North Atlantic" was held as a joint symposium with the project EC FP7 project CoralFISH 28-30th August in Galway Ireland. The conference offered an excellent opportunity from confronting the mostly fishery-based approach from DEEPFISHMAN to the conservation approach for CoralFISH. The focus of CoralFISH was Vulnerable Marine Ecosystems, (VMEs) mostly cold-water coral and sponge beds but also some vulnerable species such as sea pens. The topics addressed by CoralFISH presentations and posters in the symposium included:

- Underwater observations
- Distribution factors, habitat suitability and ecological modeling of VMEs
- Impact of human activities, primarily fishing
- Ecological relationships between VMEs and fish
- Genetics of cold-water corals

Valuation and management of the biodiversity associated with cold water corals

Overall, 18 oral communications from DEEPFISHMAN and 35 from CoralFISH as well as 5 posters from DEEPFISHMAN and 10 from CoralFISH were presented. Communications from DEEPFISHMAN are being submitted to a special issue of the journal Aquatic Living Resources (http://www.alr-journal.org/).

6.1.5 Policy delivery (task 8.4)

DEEPFISHMAN methods, analyses and other material have been introduced since 2010 into the fish stock and ecosystem assessment and advice process by DEEPFISHMAN scientists participating to fisheries and ecosystem management advice. This has primarily taken place through ICES experts groups, in particular on the biology and assessment of deepsea fisheries resources (WGDEEP), on Deep-water Ecology (WGDEC), on Elasmobranch Fishes (WGEF), on artic fisheries (AFWG) as well as through benchmark workshops on Deep-water Species (WKDEEP 2010) and on redfish (WKRED 2012). Through this process, DEEPFISHMAN methods and results have fed into fisheries advice from ICES. This utilization of DEEPFISHMAN methods and results will continue in the same ICES expert groups and in relevant benchmark workshops.

The project has been in email contact will the European Commission DG-MARE, in particular about the monitoring and Management framework. Comments from the commission have been addressed in the final version. Members of DG-MARE participated in some project meetings in particular the meeting of WP7 "management Strategy framework", 15-17 November 2011, Bilbao, Spain. Contacts with DG-MARE also occur in external meeting such as ICES experts groups.

The policy advice and guidelines are based on the various output of the project and views and comments from stakeholders from the last stakeholders´ workshop have been integrated.

The project results and monitoring and management framework were presented at the Science Policy Panel (SPP) of the FP7 HERMIONE project (contract number 226354) on 19 September 2012 and to EC policy makers in a "Conference de Midi" on 26 October 2012. This latter event was attended by an audience of about 50 people from diverse services of the European Commission. The results of the project were further presented in a joint RACs focus group on deep-sea habitats and species, in CNPMEM, Paris, 21 November 2012.

The "Conference de Midi" and joint RACs meeting occurred after the end of the contract and further dissemination of DEEPFISHMAN results and foreground will be pursued with the EC, Regional Advisory Councils (RACs), national administrations/governments and other foras.