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<sup>1</sup> Document will be a draft until it was approved by the coordinator

<sup>2</sup> PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

<sup>3</sup> The initials of the revising individual in capital letters



## **Deliverable 6.3**

# DSF interface software

01/06/2015



## Executive Summary

Deliverable 6.3 summarizes the outcomes obtained for Subtask 6.4.2: “DSF interface development”. The MareFrame DSF (Decision Support Framework) is a pragmatic planning process, and the *DSF interface* software makes the necessary information and tools available within this process. For each case study, the *DSF interface* integrates information from the ecosystem models (Ecopath with Ecosim, Gadget, and/or Atlantis) with Multi-Criteria Analysis (MCA) and Bayesian Belief Networks (BBN) decision tools into a common framework. The *DSF interface* is designed to be user friendly, and enables the user to explore the characteristics and likely impacts of a selection of alternative management scenarios. The management scenarios presented in the *DSF interface* are defined in other parts of the MareFrame project through a cooperative process to represent candidate approaches to address the identified case study problem. In the *DSF interface* the user evaluates the relative merits of the alternative management scenarios in terms of a set of key indicators. The user does so through defining utility functions and by adjusting the relative importance between the different attributes. The *DSF interface* is primarily intended as a tool to be used in facilitated decision support workshops (see Milestone 16), but may also be used online by individuals. Individual choices may be recorded, enabling a transparent basis for comparison and collective decision-making. The decision support workshops will provide the basis for selecting a preferred approach/scenario, which will subsequently be improved through modifications in a cooperative process, and which will comprise the starting point for the development of management proposals. At the time of writing, a prototype of the *DSF interface* is working, although all functionality has not been implemented. The *DSF interface* is expected to be completed and in full operation by the end of 2015.



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## 1. Introduction

This document describes the *DSF interface* software, and is divided into 8 sections. Beyond this introduction, there is:

- DSF Process: A description of the overall process in which the *DSF interface* will be used
- Case Studies and Management Scenarios: A list of case studies and identified management scenarios that are implemented in the *DSF interface*
- West Coast of Scotland Case Study: sample detailed description of one of the case studies
- Decision Support Approaches: A general description of the approaches to decision support implemented in the *DSF interface*; Multi-Criteria Analysis and Bayesian Belief Networks
- Description of the DSF interface: The screens and user interaction in the *DSF interface*
- Technical implementation: How the *DSF interface* is technically implemented

Finally, there is a short conclusion and a section with references.

## 2. The MareFrame Decision Support Framework

The MareFrame Decision Support Framework (DSF) is a pragmatic planning process that aims at facilitating a transition towards Ecosystem Approach to Fisheries Management (EAFM).

For each case study, the DSF focuses on developing a management proposal that addresses fisheries and ecosystem concerns through a co-construction process. This involves collaboration between stakeholders and researchers about problem definition and the development of a suitable management approach.

The DSF involves:

- a) Formulation of case specific management problems
- b) Cooperative formulation of a limited number of scenarios representing competing management approaches
- c) Quantitative evaluation of likely impacts of each approach/scenario
- d) User interface based decision support for presenting and evaluating scenarios while eliciting relative priorities
- e) Selection and adaptation of favoured approach as basis for management plan proposal

The *DSF interface* facilitates parts of this process. The *DSF interface* provides a window to the modelled outputs of each management scenario in each case study, and equips stakeholders with the tools to compare management scenarios using their own preferences. The interface allows users undertake a detailed and transparent evaluation of the relative merits and drawbacks of the management scenarios.

Moreover, using the *DSF interface* in stakeholder meetings (decision support workshops) provides an opportunity for discussing how to improve the most promising approaches through further modifications.

In addition, tailor made models have been developed for two case studies (the North Sea and the SWW waters) that allow users to explore likely outcomes of management actions in an interactive mode.



### 3. Case Studies and Management Scenarios

The seven MareFrame case studies have different objectives and different sets of alternative management scenarios. Below these are listed as they stand at the time of writing.

#### Icelandic case

Overall objective: Propose an EAFM approach to achieve goals of the Fisheries Management Act that optimizes yield under a multispecies approach and addresses environmental concerns.

Management scenarios:

1. Business as usual: Current  $F$ 's, single species MSY
2. Multispecies Maximum Economic Yield or Multispecies Maximum Sustainable Yield
3. Changes in fleet composition giving consideration regional employment
4. Conservation scenario: Optimal fisheries while reducing negative impact on sensitive ecosystem elements. (e.g. reduce capelin catches)
5. Optimized fisheries considering the impact of the mackerel stock on the Icelandic ecosystems

#### Baltic case

Overall objective: The most advantageous yield under multispecies approach that is robust to environmental changes.

Management scenarios:

1. Business as usual: Current  $F$ 's, single species Maximum Sustainable Yield. Central Baltic herring, sprat and eastern Baltic cod.
2. Multispecies Maximum Economic Yield or Multispecies Maximum Sustainable Yield
3. Management approach to mitigate adverse environmental impact on cod and pelagic fish stocks
4. Conservation scenario: Optimal fisheries while reducing negative impact on sensitive ecosystem elements.
5. Optimized fisheries considering the impact of the seal predation and parasites on key commercial stocks in the Baltic

#### North Sea case

Overall objective: Optimising yield under a multispecies approach and adapting to landing obligations. Integrate EAF in the formulation.

Management scenarios:

1. Business as usual: Current  $F$ 's
2. Multispecies Maximum Economic Yield or Multispecies Maximum Sustainable Yield
3. Single species Maximum Sustainable Yield
4. Conservation scenario: Optimal fisheries while reducing negative impact on sensitive ecosystem elements
5. Optimized fisheries under the additional constraints of the landing obligation



For the North Sea case study, John Pope (WP5) has developed a model for mixed fisheries, which will be available in addition to an evaluation of alternative management scenarios based on Multi Criteria Analysis (MCA; see below). The model allows users to explore estimated effects (in terms of landings and SSB of key stocks) of changes in effort allocated to different fleet segments between different fleets and TACs. Once it is fully developed (end of July), this interactive model will appear on the North Sea case study page in the DSF interface.

## West Coast of Scotland case

Overall objective: to achieve an advantageous and economically and sustainable fisheries through a multispecies approach that addresses environmental concerns.

Management scenarios:

1. Business as usual: Maximum Sustainable Yield approach (without landing obligation)
2. Maximum Sustainable Yield approach while addressing obligation through improvements in selectivity
3. Multispecies Maximum Economical Yield
4. Maximum Sustainable Yield approach while reducing seal populations to mid-1980 levels
5. Multispecies Maximum Economic Yield based on reducing seal populations to mid-1980-levels and through feasible selectivity improvements

## Gulf of Cádiz case

Overall objective: Adaptive management plan for the anchovy fisheries giving consideration to impacts of environmental forcing.

Management scenarios:

1. Business as usual: Economic and biological traits under non-adaptive and non-environmentally driven TAC (fixed)
2. Economic and biological traits under increased/decreased TACs (fixed)
3. Economic and biological traits under present climate conditions: adaptive and environmentally driven TAC
4. Economic and biological traits under climate change
5. Multispecies Maximum Sustainable Yield for the purse seine fleet.

For this case study, Javier Ruiz and Margarita Rincon (WP5) are developing an interactive model that enables users to make adjustment to identified management scenarios, including: changes in TAC for the target species; changes in the proportion of annual revenue to be included in a an insurance scheme; risk pooling approach to even out variable income streams forms resource highly subjected to environmental variation; and presence or absence of a harvest control rule that takes environmental drivers into account.



## Strait of Sicily case

Overall objective: The most advantageous yield for hake and shrimp fisheries considering environmental change and the multinational aspects of these fisheries.

Management scenarios:

1. Business as usual: Non adaptive effort and capacity control and MPAs
2. Multispecies Maximum Economic Yield or Multispecies Maximum Sustainable Yield through selectivity measures and area closures
3. Rebuilding key commercial stocks shrimp, hake and mullet to (single stock) MSY levels.
4. Conservation scenario: Optimal fisheries while reducing negative impact on sensitive ecosystem elements (hotspots).
5. Improve economic performance of trawl fisheries, considering e.g. fuel costs

## Black Sea case

Overall objective: Restoring the turbot to productive levels through an EAFM approach.

Management scenarios:

1. Business as usual
2. Multispecies Maximum Economic Yield or Multispecies Maximum Sustainable Yield. Turbot, sprat, whiting.
3. Robust management under uncertain stock structure (Romanian vs. NW Black Sea)
4. Conservation scenario: Optimal fisheries while reducing negative impact on sensitive ecosystem elements
5. Optimized fisheries considering the impact of climate change and/or pollution
6. Cost efficient enforcement

## 4. West Coast of Scotland Case Study

The case study concerns Ecosystem based management context in the waters west of Scotland, geographically defined as ICES's statistical area VIa.

The overall objective of the case study is to achieve an advantageous and economically and sustainable fisheries through a multispecies approach that addresses environmental concerns.

### Management Scenarios

The following 5 management scenarios have been identified

1. Business as usual: Maximum Sustainable Yield approach (without landing obligation)  
The purpose of this scenario is to establish a baseline for comparing the alternative management approaches that represented by the other listed scenarios: What might happen if management was to proceed as before the 2014 CFP reform?





2. **Maximum Sustainable Yield approach while addressing obligation through improvements in selectivity**  
The purpose of this scenario is to establish a baseline for comparing the alternative management approaches that represented by the other listed scenarios: What would happen if management was to proceed according to CFP as revised CFP in 2014?
3. **Multispecies Maximum Economical Yield**  
By changing the balance between the main commercial species and fisheries involved (including the balance between whitefish and Norwegian lobster), this scenario proposes an approach to achieve the maximum economically yield.
4. **Maximum Sustainable Yield approach while reducing seal populations to mid-1980 levels**  
The purpose of this scenario is to assess the potential impact of increased seals populations in combination with the requirements of the coming landing obligation and of achieving MSY for commercial stocks.
5. **Multispecies Maximum Economic Yield based on reducing seal populations to mid- 1980- levels and through feasible selectivity improvements.**  
The purpose of this scenario is suggest an approach to achieve maximum economically yield by changing the balance between the main commercial species and fisheries involved (including the balance between whitefish and Norwegian lobster) in combination with improved selectivity measures to address the landing obligation and a reduction of the seal populations to the levels estimated to be present in the 1980s.

## Management problem

The main problem that has identified by stakeholders and researchers is that the spawning stock biomass of cod and whiting have declined to the lowest levels seen in available data series. This is in spite of fisheries management measures aiming to achieve recovery. Such measures include a cod recovery plan (2009) and a zero TAC for cod (except for a 1.5% bycatch limit) that has been in place since 2012. The bycatch limit applies only to landed fish and does not constrain discards of cod. The discards mainly stem from mixed demersal trawl fisheries and for Norway lobster, respectively. In addition, it has been suggested that seal predation on small cod individuals could impair recovery of the cod stock (Cook et. al., 2015). From 2016, the main commercial species will be subjected to an “obligation to land all catches”, which may involve severe negative consequences for the industry (at least in in the short term) due to the so-called “choke species problem”.

## Management setting

The governance of marine resources and the environment in the Vla area is complex and involves institutional arrangements and agencies at both national (UK and Scotland) and international (EU) levels. The fisheries are managed under the Common Fisheries Policy while environmental aspects are mainly managed under the Marine Strategy Framework Directive. UK and Scotland are responsible for implementing fisheries and environmental management measures in the near shore areas. The fisheries in Vla are dominated by Scotland although other countries such (mainly France and Ireland) also are participating.



## Main objectives and criteria

A management proposal for the case study will be evaluated in relation to a set of objectives and criteria (see the list below). Some criteria are derived from the main policies that apply to the case study (the CFP and the MSFD). For instance, the CFP requires that the spawning stock biomass (SSB) of any commercial fish stock should be at or above the level consistent with a Maximum Sustainable Yield (MSY) no later than the year 2020.

Objectives for the management plan proposal	Candidate operational objectives and indicators
Recovery of the cod stock	<ul style="list-style-type: none"> <li>• Cod SSB <math>\geq</math> 22.000 t (Bpa<sup>4</sup>) by the end of the planning period</li> </ul>
Recovery of the whiting stock	<ul style="list-style-type: none"> <li>• Whiting SSB <math>\geq</math> = 22 000 t (Bpa) by the end of planning period</li> </ul>
Ensure strong economic performance of demersal fisheries	<ul style="list-style-type: none"> <li>• An optimum combination of Multispecies Maximum Economic Yields of key demersal species is suggested</li> <li>• An optimum balance between shrimp and whitefish is suggested</li> </ul>
Healthy commercial fish stocks	<ul style="list-style-type: none"> <li>• All commercial stocks <math>\geq</math> Blim<sup>5</sup> by end of planning period</li> <li>• All commercial stocks <math>\leq</math> Flim by end of planning period</li> <li>• At least 75% commercial stocks <math>\geq</math> SBB MSY or:</li> <li>• 95% commercial stocks <math>\geq</math> SSB MMSY (if defined) by end of planning period</li> </ul>
Maintain foodweb integrity	<ul style="list-style-type: none"> <li>• The Large Fish Indicator (relative weight of large fish in catches) <math>&gt;</math> 0,4 by end of planning period</li> <li>• Mean trophic level <math>\geq</math> value in starting year by end of planning period</li> </ul>

<sup>4</sup> Bpa is the precautionary spawning stock biomass level defined by ICES. The risk of impaired recruitment is estimated to be low when the SSB is above Bpa.

<sup>5</sup> Blim is the critical spawning stock biomass reference point defined by ICES. The stock is estimated to be at risk of suffering from impaired recruitment when the SSB is below Blim.



## More information

The ecosystem model that informs this scenario analysis is Ecopath with Ecosim (<http://www.ecopath.org/>). More information about this model is available in (Christensen and Walters, 2004). The model has earlier been applied to the West of Scotland area (Alexander et. al 2014).

The potential impact of Grey seal predation on recovery of cod stocks west of Scotland is analysed by Cook et al (2015).

More information of the ecological context of this case study is available in [MareFrame report D5.1](#)

More information on the case study and the preparation of decision support is available in [MareFrame report D6.1](#).

## 5. Decision Support Approaches

The *DSF interface* implements two distinct approaches to decision support: Multi-Criteria Analysis and Bayesian Belief Networks. Either or both apply to each case study. Below is a general description of the two approaches.

### Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) is concerned with structuring and solving decision and planning problems involving multiple criteria (Keeney & Raiffa 1976, Huang et al. 2011). These problems consist of a finite number of alternatives, explicitly known in the beginning of the solution process. In MareFrame, the management scenarios that have been developed in a co-creation process with the stakeholders make the finite set of alternatives. Each of them is evaluated by its performance in multiple criteria. Typically, there does not exist a unique optimal solution for such problems and it is necessary to use decision maker's preferences to differentiate between solutions. The aim of using MCA is finding a set of viable alternatives, rather than pursuing the best alternative for a decision maker. MCA has been applied earlier to support planning of ecosystem based fisheries management<sup>6</sup>.

Thus, there are different interpretations to solving the decision problem. It could correspond to choosing the best alternative from a set of available alternatives (where the interpretation of "best" is "the most preferred alternative" of a decision maker). Another interpretation of solving could be to choose a small set of good alternatives, or grouping alternatives into different preference sets.

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<sup>6</sup> <https://www.liv.ac.uk/mefepo/> (last visited 27.05.2015)



## Bayesian Belief Networks

A Bayesian Belief Network (BBN) is a probabilistic graphical model that represents the conditional dependencies of a set of random variables (Pollino and Henderson 2010). In a BBN, each node represents a variable in the dependency model and the connecting arcs represent the causal relationships between these variables. Each node or variable may take one of a number of possible states or values. The belief in, or certainty of, each of these states is determined from the belief in each possible state of every node directly connected to it and its relationship with each of these nodes. The belief in each state of a node is updated whenever the belief in each state of any directly connected node changes. For example, a Bayesian network could represent the probabilistic relationships between diseases and symptoms. Given symptoms, the network can compute the probabilities of the presence of various diseases.

The strength of the BBN approach arises from the limited scientific understanding of complex ecosystem, including bio-economic components. The reasons for that include parameter uncertainty, model inadequacy, process variability, and code uncertainty (O'Hagan & Oakley 2004). BBN approach has a capacity to consider such uncertainties while providing support for rational decision-making (Jensen 2001).

Some of the advantages of BBNs are that they provide mathematically rigorous method to express uncertainty in knowledge, and probability as a measure of uncertainty is intuitive. BBNs are quantitative and enable using several types of data simultaneously: data sets, expert knowledge, parameter estimates in literature, and modelling outputs. BBNs can also easily include multidisciplinary knowledge and, therefore, suit for evaluating the multidisciplinary large-scale environmental management challenges. In addition, the effect of the managers' risk attitude (risk averse, risk neutral, risk prone) can be included and analysed in a BBN, and they are graphic models that enable linking several components and their management options in one model. Importantly, stakeholder perspectives can be included through participatory modelling, and BBNs can be helpful in communicating uncertainty to stakeholders (Spiegelhalter et al. 1993, Kuikka et al. 1999, Barton et al. 2012).

One of the drawbacks of using BBNs is that using probabilistic approaches in risk assessment and management modelling is typically more time-demanding than the more traditional methods with point estimate output (e.g. expected mean), and critically, there are no stochastic versions of the MareFrame related ecosystem models available, so far, to produce probability distributions as an input for BBN.

## 6. Description of the DSF interface

The user accesses the *DSF interface* via the main MareFrame project website<sup>7</sup> using a standard web browser. The *DSF interface* uses standard web technology and there is no requirement to install any plug-ins. The following sections present the main components of the *DSF interface* in the order they appear for a user.

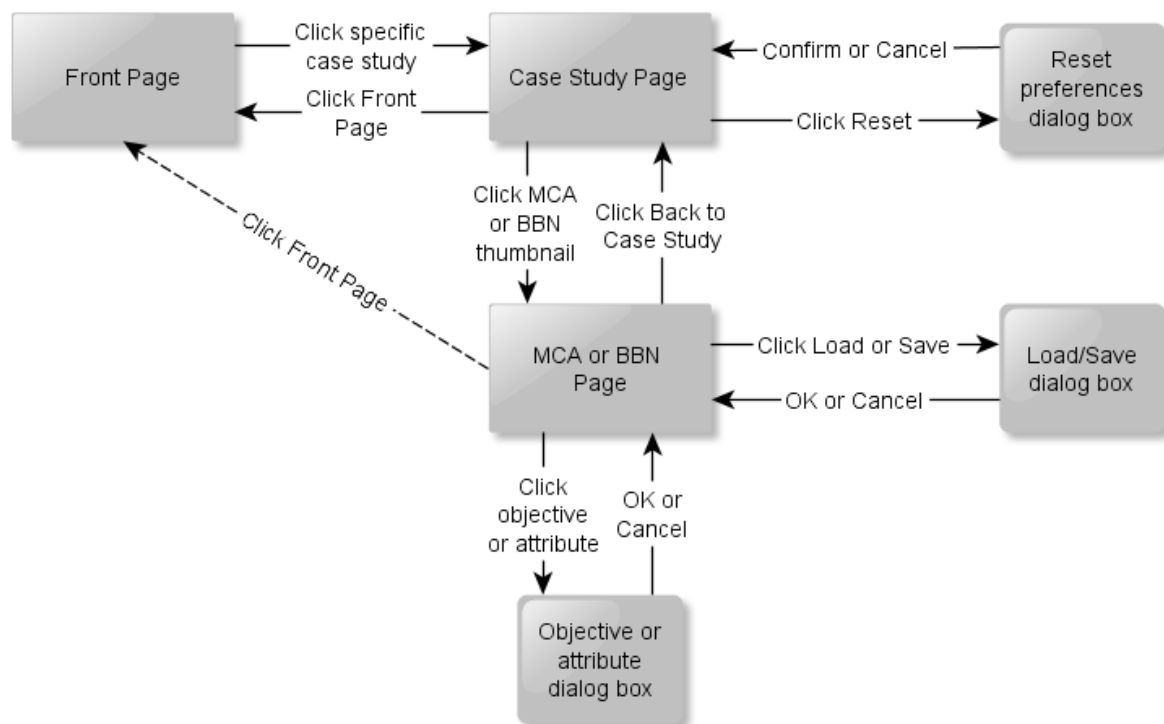


Figure 1 Main pages and links in the DSF Interface

<sup>7</sup> <http://www.mareframe-fp7.org/>

## Front Page

The main screen of the *DSF interface* shows the seven MareFrame case studies visible as numbered circles on a map of Europe. Moreover, the case studies are listed to the right of the map.

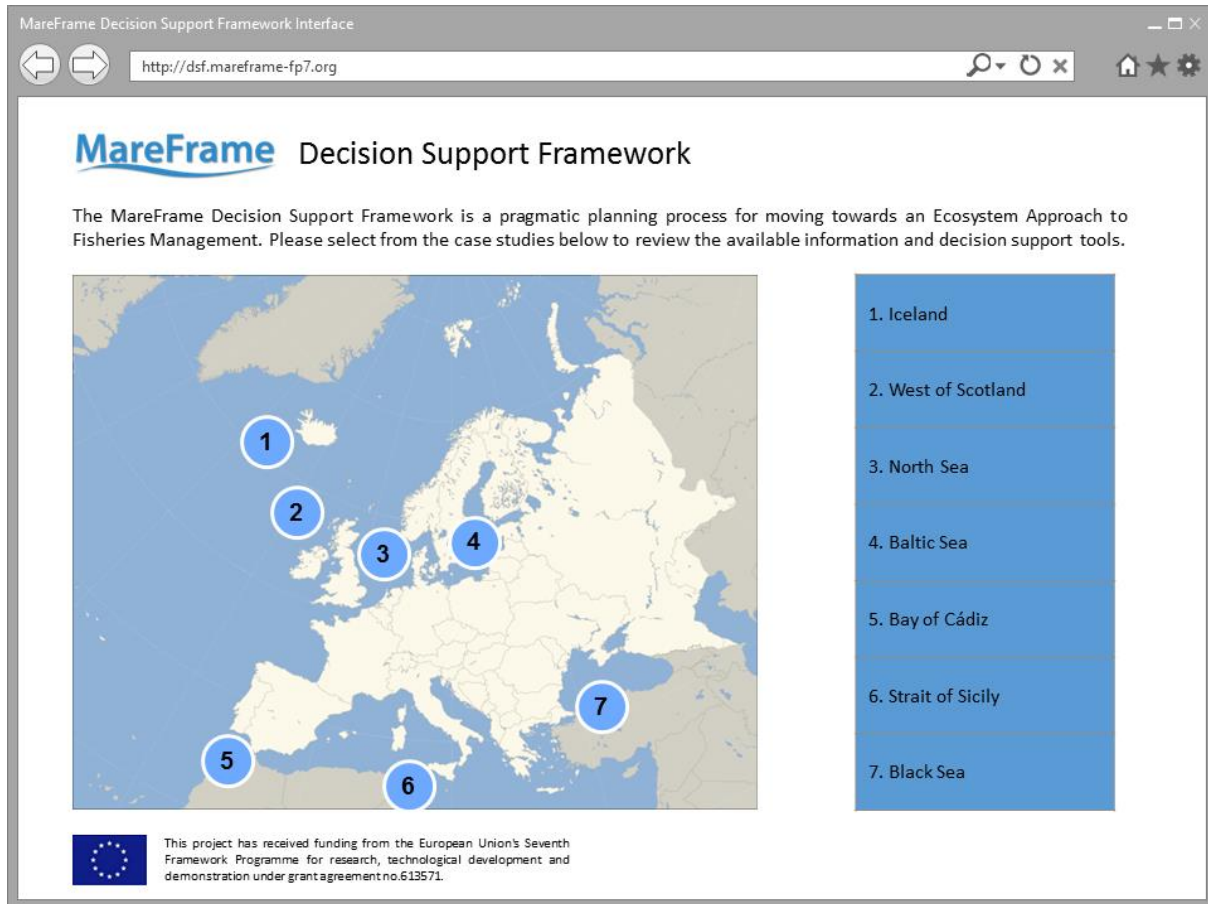


Figure 2 DSF interface Main Page

Hovering over one of the numbered circles or the list of case studies, the user can see a brief textual description of the case study.

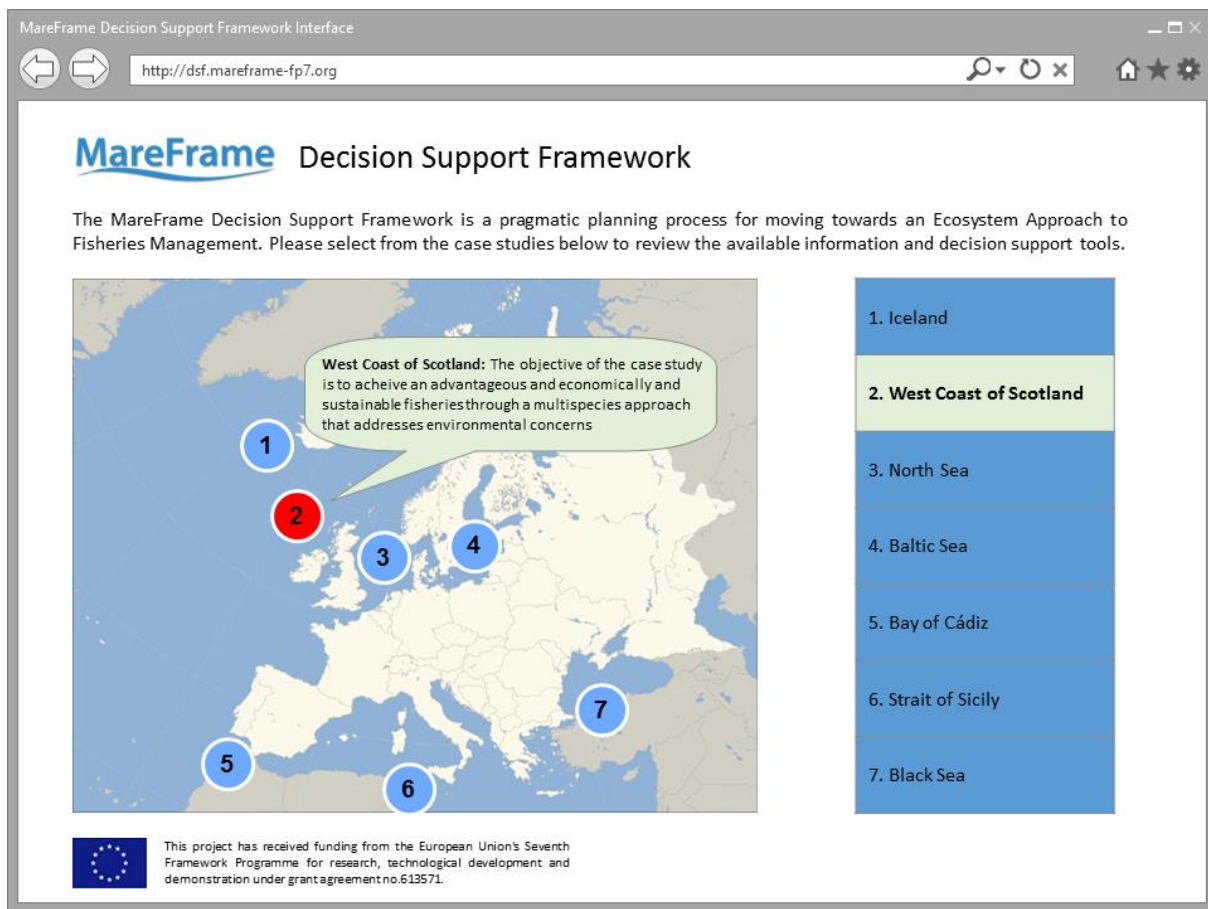


Figure 3 Hovering over a case study area shows a brief description of the case study

Clicking on the area, the user gets the Case Study Page for that particular case study.

## Case Study Page

The Case Study Page provides the user with an overview of the case study information and available decision support tools.

The first time the user gets to the Case Study Page, the user sees:

- a header with a map of Europe, which is a link back to the Front Page
- the case study title
- the case study objective
- the management problem
- the management setting
- the main objectives and criteria
- a miniature version of the Multi-Criteria Analysis (MCA) and/or Bayesian Belief Network (BBN) that have been created for the case study
- the management scenarios for the case study
- the output from the ecosystem models



MareFrame Decision Support Framework Interface – West Coast of Scotland

http://dsf.mareframe-fp7.org/west-coast-of-scotland

## MareFrame Decision Support Framework

The MareFrame Decision Support Framework is a pragmatic planning process for moving towards an Ecosystem Approach to Fisheries Management. Click on the map of Europe to the left to see all case studies, or explore the current case study below.

### Case Study: West Coast of Scotland

**Objective:** to achieve an advantageous and economically and sustainable fisheries through a multispecies approach that addresses environmental concerns.

**Management problem:** The main problem that has been identified by stakeholders and researchers is that the spawning stock biomass of cod and whiting have declined to the lowest levels seen in available data series. This is in spite of fisheries management measures... [Read more](#)

**Management setting:** The governance of marine resource and the environment in the Via area is complex and involves institutional arrangements and agencies at both national (UK and Scotland) and international (EU) levels. The fisheries are managed... [Read more](#)

**Main objectives and criteria:** A management proposal for the case study will be evaluated in relation to a set of objectives and criteria (see the list below). Some criteria are derived from the main policies... [Read more](#)

Objectives for the proposal	Candidate operational indicators
Recovery of the cod stock	Cod SSB >= 22,000t by the end of the planning period
Recovery of the whiting stock	Whiting SSB >= 22,000t by the end of the planning period
<a href="#">Read more...</a>	

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571.

#### Multi-Criteria Analysis

#### Bayesian Belief Network

#### Management Scenarios

- 1. Business as usual: Maximum Sustainable Yield approach (without landing obligation)**  
The purpose of this scenario is to establish a baseline for comparing the alternative management approaches that are represented... [Read more](#)
- 2. Maximum Sustainable Yield approach while addressing obligation through improvements in selectivity.**  
What would happen if management was to proceed according to CFP ... [Read more](#)

#### Ecosystem model output

The ecosystem model that informs this scenario analysis is Ecopath with Ecosim

The potential impact of Grey seal predation on recovery of cod stocks west of Scotland is analysed by Cook et al 2015... [Read more](#)

Figure 4 Sample Case Study Page for West Coast of Scotland

Clicking on the MCA or BBN miniature images, the user gets the either the MCA Page or BBN Page for that case study. See the MCA Page or BBN Page sections for more details.

The user can also chose to go back to the Front Page.

MareFrame Decision Support Framework Interface

http://dsf.mareframe-fp7.org/west-coast-of-scotland

## MareFrame Decision Support Framework

The MareFrame Decision Support Framework is a pragmatic planning process for moving towards an Ecosystem Approach to Fisheries Management. Click on the map of Europe to the left to see all case studies, or explore the current case study below.

### Case Study: West Coast of Scotland

Figure 5 Clicking on the map of Europe takes the user back to the Front Page

Later, when the user has entered preferences in the BBN and/or MCA, the results are visible on the Case Study Page.



Clicking on the Reset button deletes any entered BBN and/or MCA preferences for the current case study – after getting confirmation from the user.

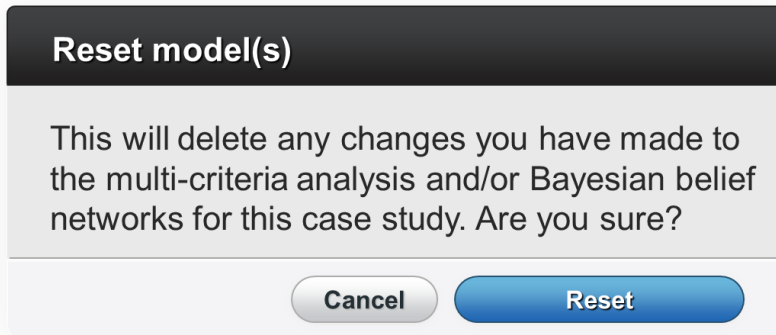


Figure 6 Confirmation dialog box before resetting models

However, the Reset button is not available (greyed out) if the MCA and BBN are in their pristine states.

## Multi-Criteria Analysis Page

The MCA Page shows the multi-criteria analysis for the current case study. The first time the user gets to the MCA Page, the value tree and the preferences are in the default state.

**MareFrame Decision Support Framework**

Case Study: West Coast of Scotland  
 Objective: to achieve an advantageous and economically and sustainable fisheries through a multispecies approach that addresses environmental concerns.

**Multi-Criteria Analysis**

Main objective: Sustainable fisheries

Sub-objectives: Economical, Social, Environmental

Attributes: Attribute 1, Attribute 2, Attribute 3, Attribute 4, Attribute 5

Management scenarios:

1. MSY without landing obligation
2. MSY with improvements in selectivity
3. Multispecies Maximum Economical Yield
4. MSY while reducing seal populations
5. MMEY while reducing seal + imp. selectivity

Rating of attributes					
Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5	
10%	20%	30%	40%	0%	
0%	10%	20%	30%	40%	
40%	0%	10%	20%	30%	
30%	40%	0%	10%	20%	
20%	30%	40%	0%	10%	

Weighing of subobjectives	
<b>Sustainable fisheries</b>	✗
Economical	-
Social	-
Environmental	-
<b>Economical</b>	✓
Attribute 1	50%
Attribute 2	50%
<b>Social</b>	✓
Attribute 3	100%
<b>Environmental</b>	✗
Attribute 4	-
Attribute 5	-

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no.613571.

Figure 7 Sample Multi-Criteria Analysis Page for the West Coast of Scotland case study

The MCA Page contains the following components:

- The case study name and objective
- A value tree consisting of the following columns:
  - o Main objective for the case study
  - o Sub-objectives that relate to the main objective
  - o Attributes that connect the sub-objectives and each of the management scenarios
  - o Management scenarios
- A matrix with rating of each attribute on each management scenario
- A table with weighing of sub-objectives and attributes

Moreover, there is space for a (composite priorities) bar chart showing the user's management scenario preference and a (sensitivity analysis) line chart. These, however, are not visible until the user has entered their weighing.

Clicking on the boxes in the value tree, the user sees a dialog box for that particular box. Clicking on the Main objective box, the user sees a table with the weighing of the sub-objectives.

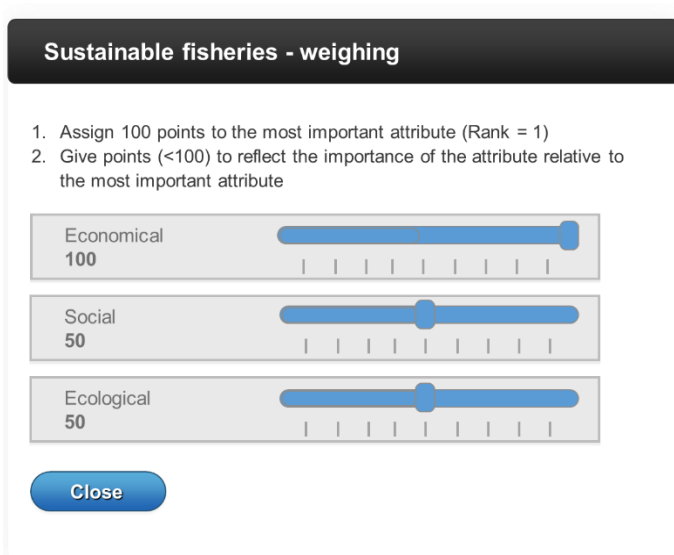


Figure 8 Main objective dialog box with sub-objective weighing

In the main objective dialog box, the user can enter weighing for each sub-objective to indicate their relative importance.

Clicking on a sub-objective box, the user gets a dialog box to enter weighing for each attribute to indicate their relative importance.

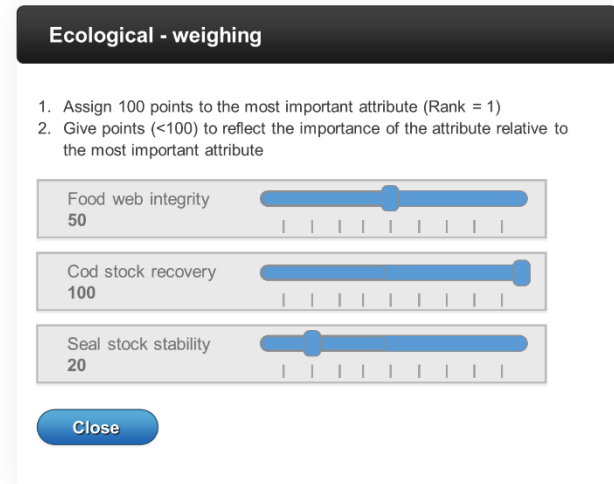


Figure 9 Sub-objective dialog box with attribute weighing

Clicking on an attribute box, the user gets a dialog box to adjust the value function for that attribute.

The attribute box shows a graph with one vertical line rating each of the management scenarios on that attribute. The user can update the Min and Max fields to adjust the scale on the x-axis, and can adjust the unit shown in the Unit field. The scale on the y-axis goes from 0.0 to 1.0.

The default function type is Exponential<sup>8</sup>. Exponential functions start either in the lower or upper left hand corner and always end in the opposite corner. Clicking and dragging the small green box adjusts the exponential graph and updates the X and Y field values.

Clicking Flip Vertical toggles the start point between the lower and upper corner (and opposite for the end point).

Clicking Linearize makes the function a straight line.

Clicking OK saves changes, and clicking Cancel discards the changes in the attribute dialog box.

In both cases, the user returns to the MCA Page, which now also contains:

- A *composite priority* bar chart showing which management scenario is preferred
- A *sensitivity analysis* line chart showing how much changes in the weighting of one sub-objective or how much changes in the scoring on one of the attributes affects one of the management scenarios

<sup>8</sup> In the first version, this is the only type available. In later versions, the ambition is to enable users to use piecewise linear graphs as well



The composite preference bar chart shows one bar for each management scenario. The bar is composed of the weighted result from each of the three sub-objectives, and the highest bar is the preferred management scenario.

Next to the sensitivity analysis chart, there are two selection boxes: Criteria and Sub-criteria. Selecting one of the criteria and one of the sub-criteria updates the chart showing the rating of each of the management scenarios, if this particular sub-criterion had a different weight. The vertical black line shows the current weighing.

All user selections are saved for the duration of the session (in practice until the browser is closed).

Clicking on the Save button saves the MCA to a text file on the user's computer. Clicking on the Load button loads a previously saved MCA from a text file on the user's computer into the system.

Clicking on the Reset button deletes any changes made to the MCA for the current case study – after getting confirmation from the user.

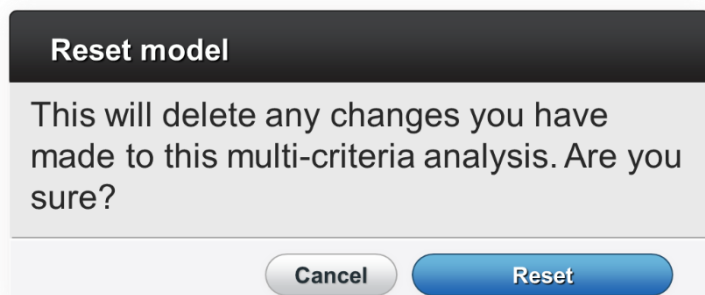


Figure 10 Reset model confirmation dialog

However, the Reset button is not available (greyed out) if the MCA is in its pristine state.

## Bayesian Belief Network Page

In addition to the Multi-Criteria Analysis page, participants in decision support workshops will use the GeNie<sup>9</sup> tool for those case studies where a Bayesian Belief Network model exists. One challenge will be that the workshop participants will have to install the GeNie tool on their laptops.

At the time of writing, it is being considered whether a Bayesian Belief Network page – similar to the Multi-Criteria Analysis page – can be developed within the project scope to avoid having workshop participant installing new software.

If implemented, this Bayesian Belief Network page will work very much like the Multi-Criteria Analysis page with the main functionality of the GeNie tool and other similar Bayesian Belief Network tools.

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<sup>9</sup> <https://dslpitt.org/genie>



## Editing case studies, MCAs and BBNs

Superusers are able to edit the case study descriptions, including all supporting charts and images.

Moreover, superusers can edit the MCAs and BBNs for each case study.

## Future functionality

A number of additional features are planned but not yet developed:

- Registration and creation of a user account
- Piecewise linear graphs when weighing attributes
- User-defined BBNs and MCAs

## 7. Technical implementation

The *DSF interface* is a web based application, programmed in JavaScript. It utilises the following open source components:

- The jQuery framework<sup>10</sup>
- The jQuery-UI framework for the layout of the MCA Tool<sup>11</sup>
- The CreateJS framework for the MCA model interface<sup>12</sup>.
- Google Charts is used for MCA Tool graphs<sup>13</sup>
- GeNie is used for Bayesian Belief Networks<sup>14</sup>

MAPIX hosts and manages the web server where the software runs. The partners are considering a long-term storage and maintenance solution beyond the lifetime of the project.

## 8. Conclusion

An interface for the MareFrame decision support framework has been designed as described in this report. At the time of writing, the interface is operational although not all functionalities have been completed. Priority is given to the work of completing the DSF for each case study in time to make it available for the decision support workshop. These workshops will be held in the period from June 2015 to January 2016. As part of Work Package 7, Tokni and other partners are developing a training tool with the explicit purpose to teach stakeholders to use the DSF interface.

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<sup>10</sup> <https://jquery.com/>

<sup>11</sup> <https://jqueryui.com/>

<sup>12</sup> <http://www.createjs.com/>

<sup>13</sup> <https://developers.google.com/chart/>

<sup>14</sup> <https://dslpitt.org/genie>



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