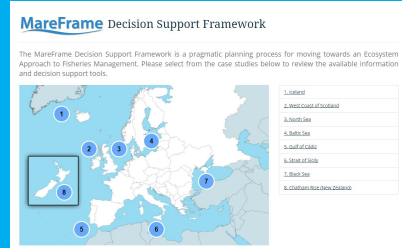


MAREFRAME TOOLBOX SUPPORTING INFORMED MULTI-ATTRIBUTE FISHERIES MANAGEMENT DECISIONS

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Decision support platform for EBFM

The online MareFrame platform for Ecosystem Based Fisheries Management (EBFM) contains software for structuring a decision problem and for calculating the preferred choices. It also provides guidelines for how to use the associated Decision Support Tools (DST) to explore, compare and evaluate alternative decisions or planning alternatives.

MareFrame DST features 2 alternative approaches for contextualizing the decision problem: 1) Multi-Criteria Decision Analysis and 2) Bayesian Influence Diagram. Both approaches synthesize outputs from ecosystem models with subjective values perceived by stakeholders. In addition, a visualization tool generates an interactive graphical representation of the expected outcomes of alternative management choices.

The toolbox is accessible via URL <http://mareframe.mapix.com/>. It is open access and runs in all major browsers. No log in or third-party software is required to access and run the decision support tools. The home screen of the DST shows the 8 MareFrame case studies and provides links to the respective management choices and underlying models.

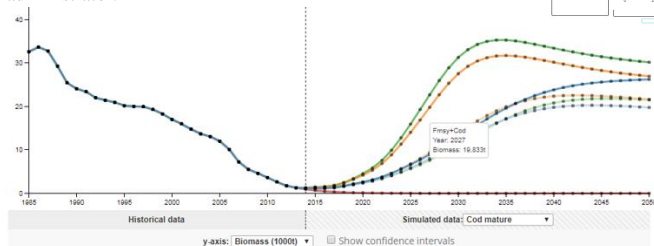
The DST is generic, and users can design and implement a decision analysis for whatsoever purpose. Decision models can be saved as a local file in user's computer.

Visualization tool

In order to balance concerns among the many sub-objectives in a decision problem it is necessary to have information on the expected consequences of alternatives. The interactive tool contains 4 main features: a timeline for indicators, a scatterplot, a traffic light panel, as well as the option to compare various scenarios. Users can monitor all the indicators which have been estimated with ecosystem models.

An information box is displaying the forecasted quantity for each alternative choice by hovering the mouse on any line in the graph (figure below). It is also possible to make comparisons among the predictions from alternative ecosystem models.

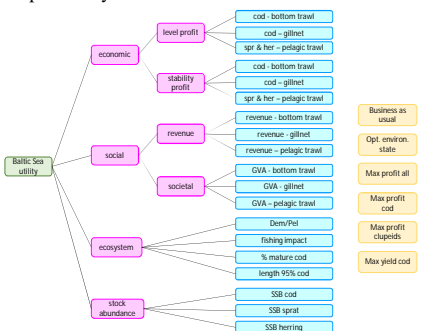
The user cannot add new or revise any of the data or estimates underlying the scenario visualization tool. The estimates must be uploaded by the web-administrator.



Multi-Criteria Decision Analysis

Multi-Criteria Decision Analysis (MCDA) is concerned with structuring and solving decision and planning problems involving multiple criteria. These problems consist of a finite number of alternative solutions which reflect the identified case study objectives and concerns. The solutions are alternative management strategies that have been developed in a co-creation process with the stakeholders. Each of the alternative strategies is evaluated by its performance in multiple criteria. Typically, there does not exist a unique optimal solution for EBFM problems and it is necessary to use decision maker's preferences to differentiate between solutions. The aim of using MCDA is finding a set of viable alternatives, rather than pursuing the best alternative for a decision maker.

A complete application comprises four components: the decision tree, the composite analysis graph, the consequences table, and the sensitivity analysis. The decision tree highlights the issues that are regarded important by the stakeholders.



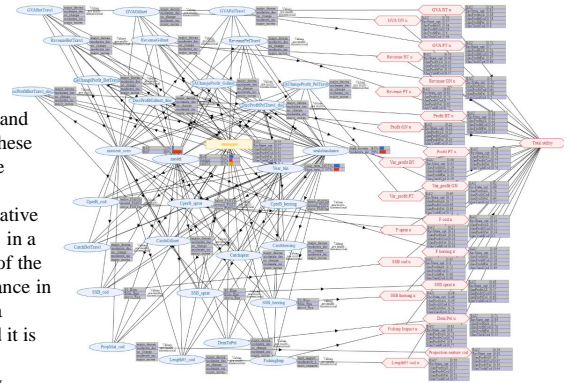
A hierarchical value tree indicating the objectives, indicators (criteria), and management alternatives.

Stakeholders need to define value functions for the performance indicators and provide weights across priorities. Then, the DST returns a weighted sum of scores indicating the best choices.



On the top: the composite analysis graph, the consequences table, and the sensitivity analysis of the MCDA tool.

On the left: timeline of the expected cod stock biomass under alternative management choices in a MareFrame case study.

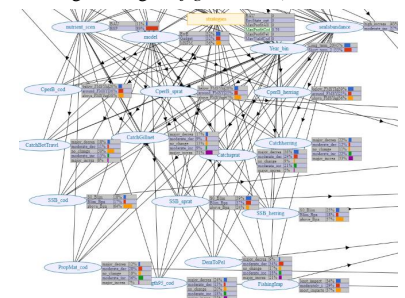


A Bayesian Belief Net consists of uncertain variables (blue nodes). By adding variables that can be controlled (managerial decisions, yellow) and variables that measure utility or loss (preferences, red) related to uncertain variables, the impact and utility of the management measures can be evaluated.

Bayesian Influence Diagram (BID)

Decision problems are structured into graphic cause-effect relationships which permit examining how a decision affects subjective utility. It is also possible to examine how a change in information in one variable affects status of the other ones. The DST allows users to 1) apply her own preferences in BID populated by the case study information or 2) update a pristine influence diagram and assign new knowledge in it.

The strategic management targets are typically set for 10–20 years in large scale environmental problems. Forecasts about the expected consequences of decisions are essential. They will be uncertain because of the stochasticity of natural systems and limitation of the knowledge. Bayesian approaches are particularly well suited to cope with uncertainty in knowledge and advising the decision makers with the probability of achieving the targets (figure below).



The DST features a functionality to calculate value of new information. It is high if the information is anticipated to help in differentiating between the expected consequences of alternative management actions.

Technical solutions

The applications use the following open source components: The jQuery framework for general HTML document traversal and event handling. The Bootstrap framework for the layout of the tools. The D3.js JavaScript library for data visualization. Easels for the value tree elements and connections and for value function design. Google Charts is used for MCA tables and graphs. The CreateJS framework for the MCA model interface.

The source code for the MareFrame BID is available at: <https://github.com/fofnl/mareframe-bbn-mca-v515>

- <https://jquery.com/>
- <https://developers.google.com/chart/>
- <http://www.createjs.com/>
- <http://getbootstrap.com/>
- <https://d3js.org/>

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