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Expert systems for marine resource management

MEECE is an EU FP7 project that has developed a range of tools to help formalize the process of decision-making. These tools are known as Decision Support Tools (DST). Expert Systems are just one example of a Decision Support Tools, which help decision-makers to use data and models in order to solve unstructured problems. Expert systems, also termed knowledge-based systems, are models that mimic the way decisions are reached by experts or formalize the decision-making process. They support a transparent decision-making process that is both communicable and reproducible to a wider audience.

Expert DST are tools that condense a combination of (un)related, large datasets into a digestible and comprehensive form which provides a starting point for decision makers to act upon. DST are commonly used in the management of fisheries but in MEECE they go a step further and now include other human pressures such as pollution and non-indigenous species or an environmental driver, i.e. climate. This fact sheets presents two types of expert DST for selecting a preferred management option for fisheries and another for managing contaminated land.

Choosing a management approach for fisheries in the North Sea

Decision-making in fisheries management is complex and involves uncertainty, multiple objectives and multiple stakeholders. Recent policy documents (e.g. the revised Common Fisheries Policy) emphasize the importance of increased stakeholder participation in the management process. The application of DST helps to structure discussions, improve communication among stakeholders and lead to additional insight on possible solutions to the issues. A framework has been developed for the selection of the preferred management scenario. It combines scientific information based on modelling (MEECE output) with stakeholder preferences (based on EU-funded MEFEPO) to select the preferred management scenarios to achieve the ecological objectives whilst also taking into account the social and economic impacts of the proposed management measures.

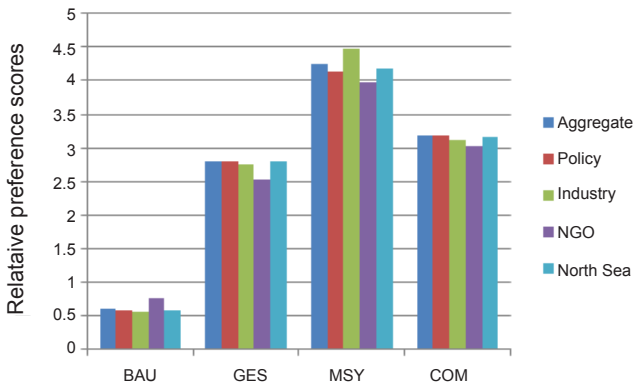

Figure 1. Relative preference scores of four management scenarios based on multi-criteria decision analysis and depending on the stakeholders affiliation.

The stakeholder preferences were sought through informal interviews, a stakeholder workshop and preference questionnaires. Four different management scenarios were considered and applied through different (example) Harvest Control Rules (HCRs). A multi-criteria decision analysis (MCDA) was then used to combine stakeholder preferences with the scientific information to determine the preferred management scenarios to achieve Good Environmental Status. In this North Sea example MSY (Maximum Sustainable Yield) came out as the preferred scenario independent of the composition of the stakeholders.

This approach demonstrated that DST could be used to deliver a preferred management scenario to achieve policy objectives in a formal and transparent process that takes the stakeholders opinion into account and combines this with scientific evidence. It is important to note that this framework relies on the use of a meaningful management scenarios and most importantly reliable information to drive the models.

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An expert system to manage contaminated coastlines

Sediment management is a key issue in marine coastal management due to the large amount of material collected during maintenance dredging from harbours, estuaries and channels. The development of an objective framework to correctly support decision making in planning re-use or remediation of collected materials will improve sustainable environmental management under the framework of Marine Strategy Framework Directive (European Commission, 2008).

MEECE has developed an Expert Decision Support System (DSS) able to objectively integrate chemical and eco-toxicological data into numerical indices to support decision makers in managing contaminated marine coastal sediments and eventually in planning the necessary remediation or rehabilitation activities.

The DSS evaluates chemical data, both as single compounds and as total toxic pressure of the mixture. Chemical concentrations and eco-toxicological high-level effects are combined to determine the level of risk due to exposure to sediments from highly contaminated sites by computing a sediment risk index ranging from 0 (no risk) to 1 (maximum risk). In addition, the system uses results from multi-driver experiments to model the biological response in organisms caused by key pollutants and shifts in other climate change drivers such as temperature and pH.

It is important to include in any management tool the impacts of a changing climate, as the change in temperature will affect the behavior including breakdown, transportation and impact of chemicals; however, changes in temperature affect different chemicals in different ways making generalisations impossible.

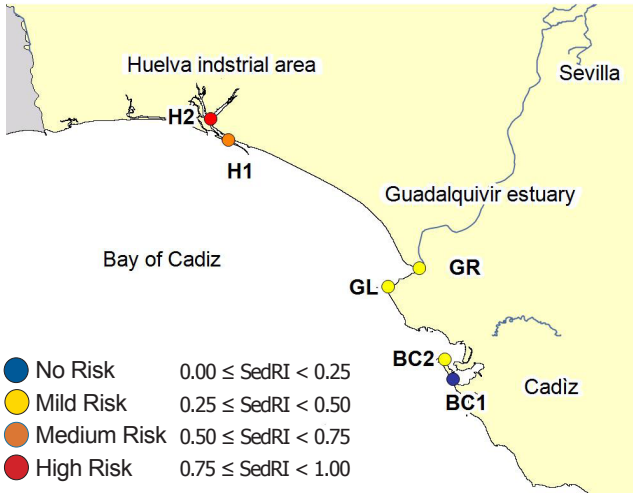

Figure2. The map shows the levels of contamination and ecotoxicological test results on sediments from the Bay of Cadiz (Riba et al 2004) that were then fed into the expert decision support system to create a sediment risk index to classify the sites into risk categories.

The Expert DSS was applied to integrate bibliographic data (Riba et al 2005) from the Bay of Cadiz in order to classify sites along the coast into various risk categories. Sediment samples were collected from different estuarine areas in the region of Cadiz, an area impacted by mining activities and therefore characterized by inorganic contamination. As seen in figure 2 areas of high risk are clearly identified when using this DSS.

Further development

The next steps needed for further development of Expert DSS for marine environmental management include: the definition of a test battery to be applied in marine coastal sediment studies, and the definition of common Environmental Quality Standards for the most diffuse priority pollutants throughout Europe.

Summary of the Decision Support Tools developed by MEECE

1. **Information synthesis:** tools which essentially synthesize monitoring data into meaningful metrics summarizing the structure and function of marine ecosystem state.
2. **Expert systems:** tools that mimic the way decisions are reached by experts.
3. **Scenario planning:** tools involving numerical models which can simulate and predict changes in the state of marine ecosystems in response to different management and climate driven scenarios.

For further information about the Decision Support Tools developed in MEECE please contact GerJan Piet (GerJan.Piet@wur.nl) IMARES, The Netherlands or Alessandro Dagnino (dagnino@unipmn.it) UPiedmont, Italy. Full details and results of this work can be found in Deliverable 5.2 on the main project website, www.meece.eu

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For further details about the MEECE project (www.meece.eu) and its activities please contact: Project Coordinator, Icarus Allen (JIA@pml.ac.uk) or Project Manager, Jessica Heard (jessh@pml.ac.uk).