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On the role of visualisation in fisheries management

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ABSTRACT

Environmental change has focused the attention of scientists, policy makers and the wider public on the uncertainty inherent in interactions between people and the environment. Governance in fisheries is required to involve stakeholder participation and to be more inclusive in its remit, which is no longer limited to ensuring a maximum sustainable yield from a single stock but considers species and habitat interactions, as well as social and economic issues. The increase in scope, complexity and awareness of uncertainty in fisheries management has brought methodological and institutional changes throughout the world. Progress towards comprehensive, explicit and participatory risk management in fisheries depends on effective communication. Graphic design and data visualisation have been underused in fisheries for communicating science to a wider range of stakeholders. In this paper, some of the general aspects of designing visualisations of modelling results are discussed and illustrated with examples from the EU funded MYFISH project. These infographics were tested in stakeholder workshops, and improved through feedback from that process. It is desirable to convey not just modelling results but a sense of how reliable various models are. A survey was developed to judge reliability of different components of fisheries modelling: the quality of data, the quality of knowledge, model validation efforts, and robustness to key uncertainties. The results of these surveys were visualized for ten different models, and presented alongside the main case study.

1. Introduction

In 2014 McInerny et al. [1] called upon scientists across disciplines to rethink the role of visualisation in their work, to engage users and to avoid bias. They argue that visualisation and graphics are powerful tools for communication upon which the success of the relationship between science, policy and wider stakeholders depends. They highlight the current gap in expertise, knowledge and skills related to design and called for development and adoption of better standards for communication both within academia and to outside audiences. This paper describes recent efforts within an EU funded project, MYFISH (http://www.myfishproject.eu/), to improve the use of visualisation in fisheries management.

MYFISH was a project developed through interactions between stakeholders and scientists. Its broad objectives were to discover alternative goals of fishery management, to build models to explore management options and to communicate modelling outcomes effectively to decision makers and stakeholders. This project illustrates a trend in the governance of fisheries to become more open to stakeholder participation.

Within MYFISH there were several regional case studies, which used various types of mathematical models to assess trade-offs under different management options. MYFISH case studies covered the main areas of European fisheries: the North Sea, the Baltic Sea, the Mediterranean Sea and Western Waters that included the Celtic Sea, the Irish Sea, Bay of Biscay and Iberian Sea. In these regions, and globally, the management practices in fisheries have expanded from a focus on yield or surplus production for a single stock to include a complex set of concerns [2,3] from a wider range of stakeholders [4]. With the expansion of objectives for fisheries management to include ecological and socio-economic values, the list of trade-offs has been expanded to include impacts on both society and the environment in the present and, through the concept of sustainability, into the future. The risks most widely considered include the probability of the spawning stock biomass and fishing mortality falling outside of the desired range defined by target and limit reference points. However,

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impacts on non-target species, habitats and fishing income, catch levels and catch variability, along with their associated uncertainties, have also become objectives in scientific assessments [5,6]. While the use of Management Strategy Evaluation [7] requires identification of multiple management objectives [8], visualisation helps to facilitate and structure discussions between scientists and stakeholders [9].

Fisheries are at the interface between science and policy, and with the involvement of multiple stakeholders [10], governance cannot be successful without effective communication. Different stakeholders hold different values with respect to environmental, economic and social goals and it is vital that information about trade-offs is conveyed in a manner that is consistent with a plurality of values and without creating prejudices that might influence decisions. Relating complex scientific information, such as model outcomes, to stakeholders is fraught with difficulties but fisheries can learn from the more general experiences of graphic designers within the field of information visualisation [11–16].

It is important that the design of visualisations is informed by the science on perception of images and tailors these lessons to the specific properties of the data and their intended use [17,18]. The examples of visualisations in fisheries used here reference well-established sources of design theory and the perception of graphical information.

Information design and data visualisation are being developed in many fields to portray not just knowledge but also the uncertainty (and its causes) [18–23]. For example, doctors need to present information about the trade-offs between different risks to patients (e.g. treatment versus no treatment), while meteorologists need to communicate the uncertainty of weather predictions to the public, and climate scientists need to find ways to present complex and uncertain findings to governments, industry and the public [1,24–26]. Specific applications of visualisation in fisheries developed for MYFISH were adapted through consulting a variety of designs from these areas.

In a sub-section of this paper two fisheries related examples are presented which directly influenced the designs developed in MYFISH project. The main task for the designers was to develop a format for displaying the results of modelling in the form of Decision Support Tables (DST). Given the paucity of examples of designer-scientist collaborations within fisheries science, priority has to be given to design experience gained in other fields. Within MYFISH, scientists have collaborated with design professionals to create visualisations of multi-dimensional impacts of management options. These designs have been tested with stakeholder groups and subsequently improved. Using a Western Mediterranean case study, the following sections discuss how different design options can impact the decision making process based on the same modelling results, and conclude with lessons learned from adopting a visualisation approach to communicate with stakeholders.

Finally, an approach to convey (visually) a sense of how reliable these modelling results are is presented. Given a variety of models it is important to enable stakeholders and decision-makers to develop an independent judgment about a model's suitability and plausibility. The difficulty is to condense information about the quality of the data, the relative depth of knowledge, the robustness of the model and the extent to which the model has been validated into a single graphic that can help contextualise modelling results. The model reliability visualisation is based on detailed standardised questionnaires posed to ten modellers working on different case studies. The variety of fishery contexts and models that were included in the questionnaire demonstrate transferability of this methodology. It is a generic way to compare very different models to each other qualitatively. The information about reliability of the model is rarely synthesised systematically or communicated to decision-makers, albeit previous EU projects have begun to tackle this issue. The four point scoring system for the data and knowledge quality is adapted from an EU FP7 project JAKFISH which searched for a common presentation format in which models can be compared.

In this paper, approaches to communicating modelling results and their reliability are presented as starting points for developing a visual language for fisheries science that takes advantage of advances in information design technology and software.

2. Methodology

2.1. Previous applications of design in fisheries

Research on visual perception followed closely on the developments in information design pioneered at the beginning of the 20th Century in Vienna [27]. The greatest contribution to the development of modern visual language came from a Viennese school of designers, in particular Otto and Marie Neurath, who pioneered ISOTYPE – the International System of Typographic Picture Education [27].

The ISOTYPE (icon array) visualisation techniques are still commonly used in information design [28]. Icon arrays have been demonstrated to be extremely effective visual tools when used to compare quantities in the same units [20]. There are few examples of icon array use in fisheries, especially in the academic literature. The majority of examples found were produced by non-governmental organisations (NGOs).

The Pew Trust has used Fig. 1 to depict the impact of growth overfishing. This illustration breaks several rules of what might be considered 'best practice' for fisheries in order to make a point. For example, the size of the fish, which is meant to represent the relative change in the average length, is not drawn to scale. The length of the "Today" fish is half that of the '1962' specimen according to the numbers given (33 in. vs. 16 in.) but this information is pictorially distorted, possibly for greater emphasis. Our perception of change might be subconsciously based on area rather than length of the fish depicted, and therefore the 'Today' fish which has been drawn 11% smaller in length than it should have been could translate into a bias of approximately 21% in terms of the area of the depicted fish.

Another problem with this representation (Fig. 1) is the use of the same icon to refer to both eggs and spawners, thereby creating visual conflation. It is better to be consistent in the use of icons so that audiences only need to learn the design language once [26]. Specifically, each icon should only represent a single meaning. In developing design approaches within MYFISH, the kind of ambiguity found in Fig. 1 was avoided. The same example also raised awareness of how the size icons may affect perceptions of the information. It is good practice to avoid such conflicts in the depictions of relative differences in values.

In addition to finding an example of using icon arrays within fisheries to inform about change over time (Fig. 1), a fisheries example was found that compares two kinds of fleet based on several criteria using a similar visualisation technique (Fig. 2). This visualisation, developed by Archipelagos Institute of Marine Conservation, served as

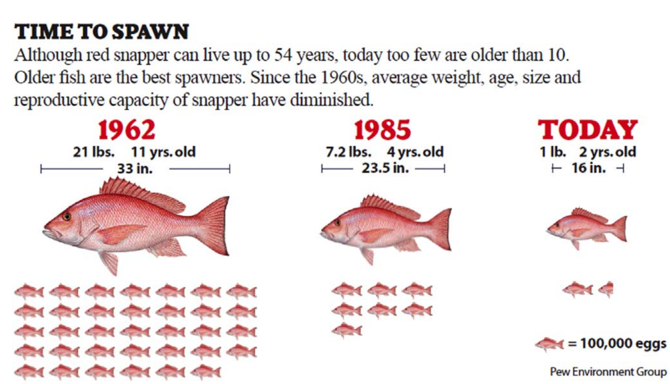

Fig. 1. Time to Spawn. Pew Environment Group uses icon arrays to show how fertility has declined with the average size of the fish in a red snapper fishery. © 2011 The Pew Charitable Trusts.

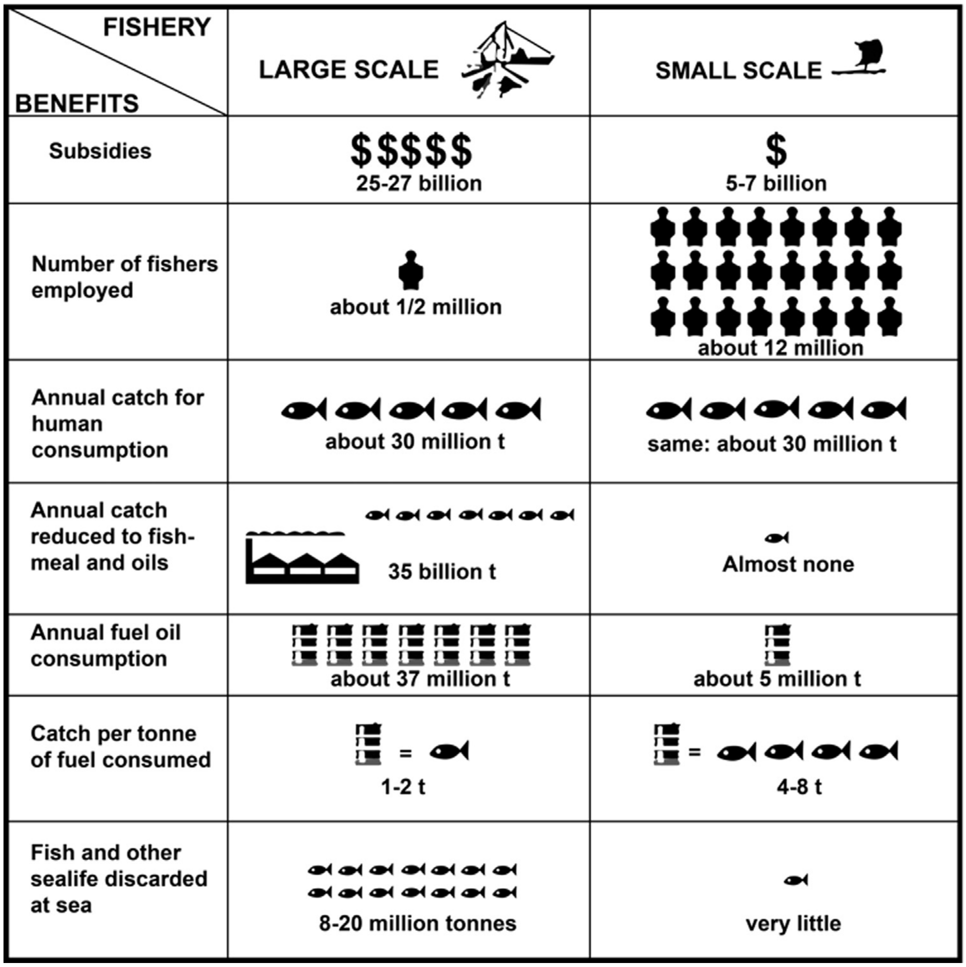

Fig. 2. Large and Small Scale Fisheries. A comparison between two types of fisheries in the Greek seas according to Archipelagos Institute of Marine Conservation.

a prototype for the DSTs developed for MYFISH.

The message is communicated more clearly and attractively than if Fig. 2 contained only numbers. However, as with Fig. 1, there are lessons to be learnt from its presentation. Firstly, the same icons are used to refer to different entities and scales.. The units in terms of catch/discards in tonnes represented by one fish icon change between table rows (varying between million tonnes and tonnes); the changes in sizes of fish icons are confusing, especially since these don't always relate to changes in unit values. This visualisation worked well for some criteria but not for others. For example, the comparisons are very clear for 'subsidies', 'number of fishers employed', 'annual catch for human consumption' and 'annual fuel consumption'. Yet, equating oil drums and fish within the table was not just potentially confusing but also redundant given the information contained in the row 'annual catch for human consumption' and 'annual fuel consumption'. Particularly problematic was using the same fish icon for catch and discards. Not only the signified meaning for the icon changes but it also switches from referencing to something valued positively as 'catch' to something valued negatively as 'discards'. Furthermore, the large variability in values was not captured adequately by the icon design.

For MYFISH, designers combined the lessons learnt from these previous attempts with the insights from graphic design-oriented literature and applied them to a variety fisheries modelling case studies [15,16,26,29]. Following Bertin's work there are thirteen tools that can be used to achieve distinction within a graphic [30]: physical location, size, crispness, resolution, colour values, colour saturation, colour hue, texture, orientation, arrangement and shape. When choosing which tools to use it is important to ensure that graphics remain focused and it is desirable to limit the methods of visualisation to no more than seven of these categories [31]. However, the recommendation is to restrict the number of attributes to as few as is possible without losing important information or impacting comprehension.

The scientific literature also indicates that while a variety of visualisation tools exist they are not all perceived with equal effect [1,32]. Especially relevant to information design is the evidence that humans perceive relative differences better than differences in absolute amounts. Consequently, visualisation techniques should focus on displaying patterns of differences [33]. It is also relevant that humans compare certain parameters of graphics (such as width) better than others (such as area) [33].

The following section details the visualisation approach adopted in one of the project case studies, while variants of this and other approaches were tested in other cases. This case illustrates some progress made in visualising model outputs, but shortcomings are highlighted that need attention in future developments.

2.2. Questionnaires to evaluate model robustness

A generic questionnaire, developed together with modellers, enabled comparisons of models in four categories: data inputs into the models, state of knowledge used in models, tests that modellers performed to assess robustness and other aspects of model performance, and tests to assess the sensitivity to specific sources of uncertainty that are important for many stocks. These four categories that formed the basis for cross-model comparisons are described in Sections 2.2.1–2.2.4. The full Excel-based questionnaire can be found in supplementary materials.

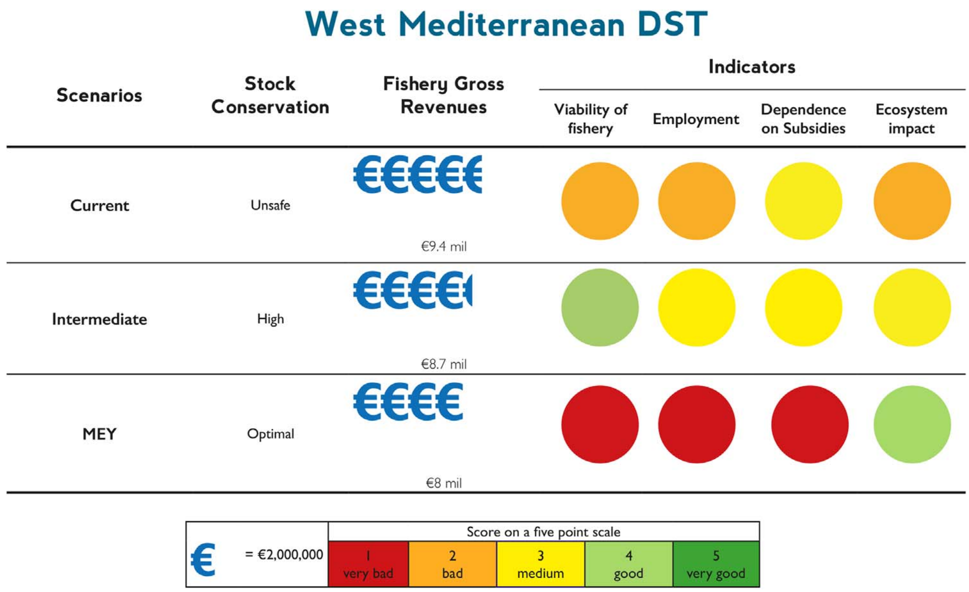

Fig. 3. MYFISH project version of the DST. Stock Conservation status and Fishery Gross Revenues are model based, whereas indicator values reflect subjective views of experts.

Table 1
Western Mediterranean case study.

Options	Stock conservation status	Catch (tonnes)				Fishery gross revenue (millions)	Indicators			
		Red mullet	Hake	Norway lobster	Red shrimp		Fishing sector viability	Employment	Dependence on subsidies	Ecosystem impacts
Current	Unsafe	93	85	32	111	€ 9.4	2	2	3	2
Intermediate	High	94	128	26	125	€ 8.7	4	3	3	3
MEY	Optimum	95	172	19	139	€ 8.0	1	1	1	4

2.2.1. Data inputs

The data inputs category compared the quality of data used in the models, based on qualitative four-level answers which ranged from ‘this source of data was not used’ to ‘this source of data provided good coverage in time and space’. Five sources of data were chosen to be the basis for comparison: fishery independent survey data, recruitment observations, catch data, data on selectivity, and information on bycatch.

2.2.2. State of knowledge

The way models accounted for available knowledge was evaluated within eight four-level questions. The qualitative answers ranged from ‘this knowledge was not represented in the model’ to ‘the model was well informed in this respect.’ The eight processes that the models were expected to account for were: knowledge of a stock-recruitment relationship, understanding of growth, understanding of natural mortality, knowledge of the state of the stock, impact of climate change, the role of stock interactions, understanding of spatial dynamics, and knowledge about implementations of management decisions.

2.2.3. Model testing

The modellers were asked five yes/no questions about how they tested their models. Because the role of the models was to predict trade-offs under different management goals, it was important to assess whether these results were robust under alternative stock assessments, uncertainties in parameter values (Markov Chain Monte Carlo (MCMC) or elasticity analysis), or if results were shown to be robust within Management Strategy Evaluation approach (MSE). Lastly, we asked if models were validated with external data.

2.2.4. Sensitivity to important sources of uncertainty

There are some sources of uncertainty that are important across many case studies. Eleven specific assumptions were identified as generally important in fisheries modelling, and modellers were asked if they had tested their models with respect to some level of uncertainty in each. These were yes/no questions based on whether the modeller had made runs with some alternative versions of these processes to see if modelling results were robust. The 11 categories of assumptions on which models are known to be sensitive concerned natural mortality, selectivity, migration, stock recruitment, assumptions about unfished stock size, growth, prices and costs of fish, effects of climate change, other environmentally forced regime shifts, standardisation of catch statistics, and problems with underreporting.

3. Visualisation

Within the MYFISH project visualisations were produced for nine different case studies and ten different models. These examples can all be found online on the project website [34], which includes a graphical summary of the questionnaire results for ten model comparisons. The design process went through several stages. These are documented in the newsletters published by the project, which are also accessible online [35].

The first round of communicating modelling results took the form of formatting tables of numbers to highlight those quantities that are most important to stakeholders. This textual approach is a common format for presenting results when the task of modelling is to characterise the consequence of aiming for different goals in fisheries under varying management options.

In MYFISH, modelling was aimed to inform decision makers about possible trade-offs, hence the tables of results were referred to as

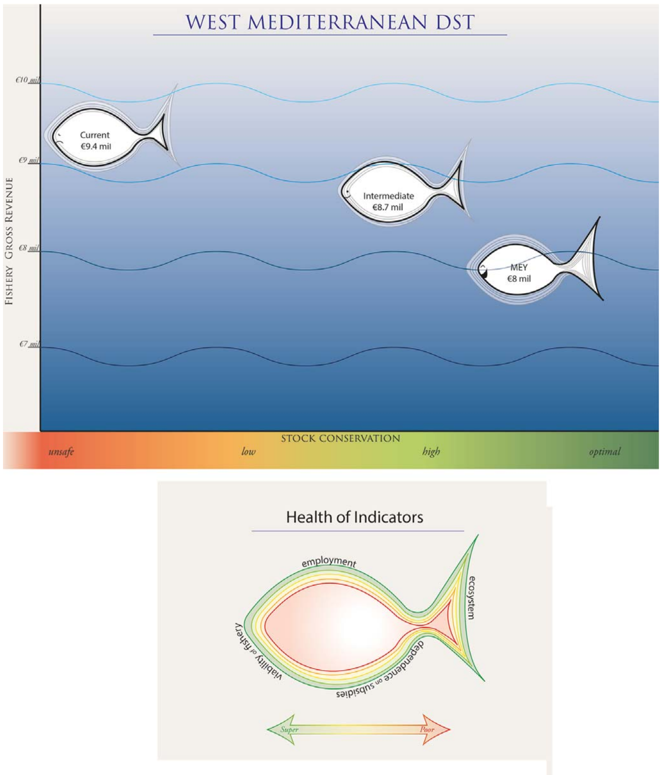

Fig. 4. An alternative visualisation of the DST. The solid dark outline of the body of the fish in the four regions (head, ventral, dorsal or tail) corresponds to expert judgment for the four indicators. Expert opinion on ecosystem impacts is represented by the size of the tail section of the fish, with the bigger tail representing preferred ecosystem outcomes. The facial expression corresponds to stock conservation status.

Decision Support Tables or DSTs. In the first series of workshops that followed the modelling exercise, the stakeholders were presented with two versions of the DSTs, one containing only numbers and the other containing visualisations of the same results using icon arrays (the complete set of examples from this first round of visualisations can be found in the 2nd MYFISH Newsletter [35]).

The goal of the visualisations was to convey complex information in a manner which makes comparison of alternative management scenarios more accessible to stakeholders than might be achieved with a table of numbers. In the first round of design, an overview comparison for key model outputs was the key objective. Several visualisation methods were also tried, including: Colour, Icon arrays, Bar charts, Pie charts and Shading to depict uncertainty.

The feedback regarding the initial visualisations of the DSTs from the stakeholders was encouraging. Because the early visualisations were an exploration of what approaches worked best, our initial designs were inconsistent across case studies. In some case studies fish icons were used to denote landed catch, in others they represent biomass in the sea. Using what was learned from the first round of visualisations, a consistent design language was developed and this was then applied across nine case studies (3rd Newsletter [35]).

Following initial feedback from stakeholders, a more effective design software (Adobe InDesign) was used thereby facilitating improved collaboration with design professionals. In this paper, the implication of design choices are explored for a particular case study. The Western Mediterranean case study focuses on the bottom trawl fishery from the Balearic Islands, which targets the following four stocks, depending on the fishing grounds exploited (determined by the different depth strata of the continental shelf and slope):

- striped red mullet, *Mullus surmuletus* (Shallow Shelf)
- hake, *Merluccius merluccius* (Deep Shelf)
- Norway lobster, *Nephrops norvegicus* (Upper Slope)
- red shrimp, *Aristeus antennatus* (Middle Slope).

The modelling, supplemented with expert elicitation, centred on three scenarios:

1) the current level of exploitation, which is considered unsustainable given that all stocks are over-exploited;
2) an intermediate scenario, in which effort in the fishery is reduced to half way between the current level (scenario 1) and the Maximum Economi8c Yield (MEY) level (scenario 3);
3) the MEY scenario, based on a bio-economic model [36], which is considered socially unfeasible.

The model stipulates that substantial reductions in effort are necessary to achieve MEY (scenario 3), by more than 67% in case of hake. This would have serious immediate consequences for fishermen in terms of employment, economic viability and demand for subsidies. The Decision Support Tables combine information from the bio-economic models with expert opinion. A bio-economic model was used to calculate the ‘stock conservation status’, ‘fishery gross revenue’ and ‘catches by species’ under the three exploitation scenarios. Models predicted that effort reductions under scenarios 2 and 3 would produce stock levels that are ‘high’ and ‘optimal’, respectively (Fig. 3). The difference between ‘high’ and ‘optimal’ stock conservation status is largely due to variability – ‘optimal’ stock conservation status corresponds to lower stock variability associated with reduced exploitation effort at MEY (scenario 3). Expert opinion was then sought regarding the impact on the four indicators under the three scenarios. Indicators were: viability of the fishery as perceived by experts; employment in the long term; dependence on subsidies; and overall ecosystem impacts. The experts scored the values for the indicators on a five-point scale ranging from ‘very bad’ to ‘very good’, expressing subjective opinions independent of modelling results, which they were not shown.

Fig. 3 is the visualised form of the same results as in Table 1, which was first presented to stakeholders, including fishermen, industry representatives and fishery managers. According to these stakeholders, the viability of the fishery depended on economic aspects (such as ability to reduce costs and secure higher prices) rather than biological status of the stocks. Reflecting these priorities, the distribution of catches amongst the different bottom trawl species was omitted in that presentation, focusing on gross revenue as a proxy for economic objectives in the management of this fishery.

Figs. 3 and 4 contain the exact same information but in a different graphical form. The two examples illustrate the importance of visualisation choices. The differences between the two presentation styles may influence stakeholder preferences. For example, the bright red colours in Fig. 3 might deter someone from considering the MEY option, especially for those familiar with the traffic light approach to decision making. In Fig. 4 the traffic light system for representing indicators is replaced by a fish shaped version of the web diagram. The largest outline of the fish represents the ‘very good’ level, while the innermost outline represents ‘very bad’.

The representation in Fig. 4 emphasizes the two dimensions derived from modelling results: profits and conservation - the Y and the X axis, respectively. Options ‘Intermediate’ and ‘MEY’ are positioned close together. In this depiction, these two options are more similar to each other, indicating smaller trade-offs. By contrast, in Fig. 3, the three red circles exaggerate negative aspects of the ‘MEY’ option. From the design point of view, Fig. 3 accentuates differences between the two options compared with Fig. 4. This has the potential to influence decision making.

There are possible advantages for having several visual presentations of the same information provided to stakeholders at one time. Each visualisation emphasizes different aspects of the scientific assessment. By literally seeing the problem as different pictures, stakeholders

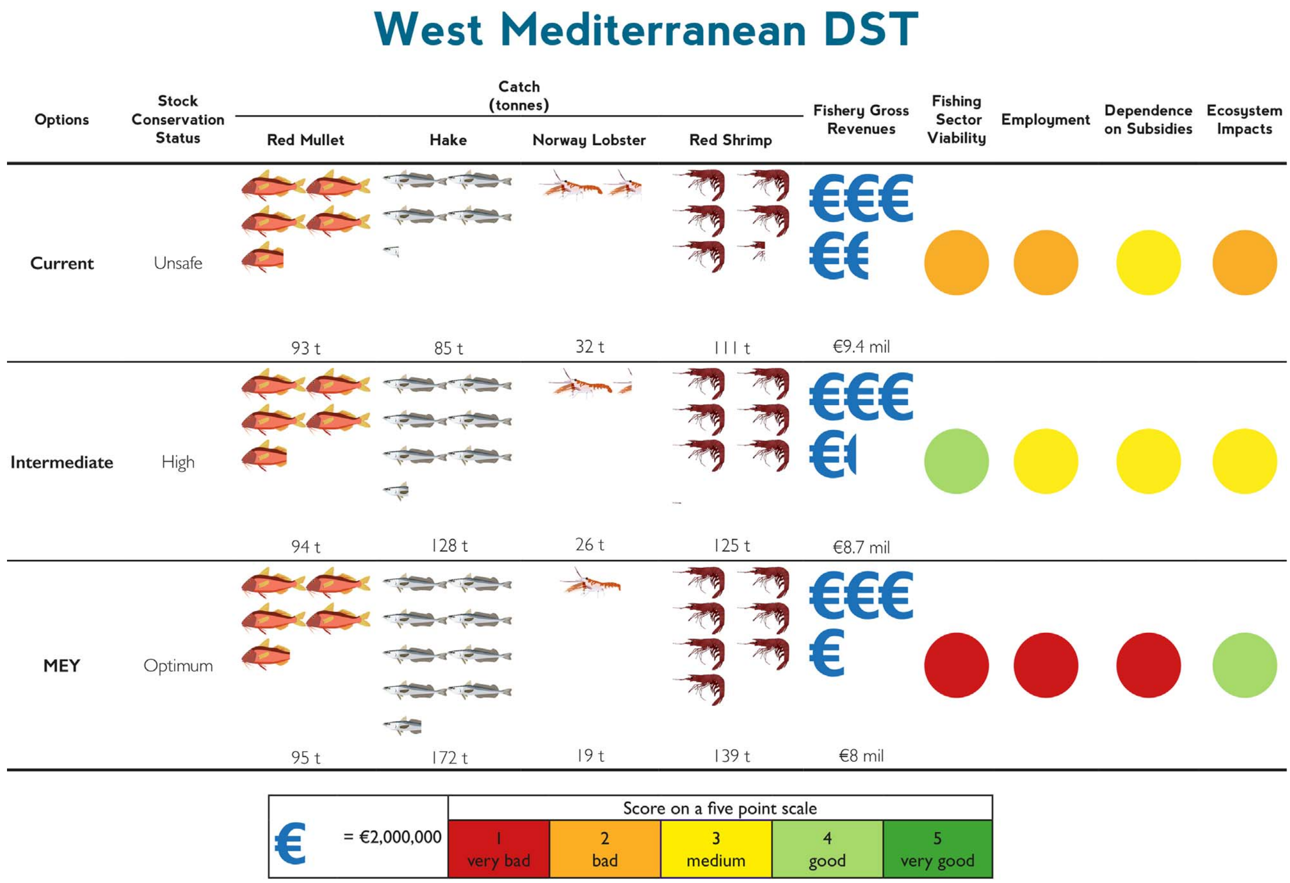

Fig. 5. DST containing additional information on catches. Each species icon corresponds to 20 t of catch.

might become more aware of the differences in perspectives. Diverse visualisations might be a way to encourage a more participatory, transparent and more inclusive process of engagement.

Fig. 5 is similar to Fig. 3 but it contains additional information about catches for each of the four species predicted with the bio-economic model. Including more information complicates decision making, but it could be valuable for different stakeholders. For example, those fishermen that target Norway lobster and shrimp might realize that there is not actually that much difference between the three scenarios as far as their livelihoods are concerned. However, those who are primarily targeting hake might have a greater appreciation of what is at stake for them, as their catches are, by far, the highest under the MEY scenario.

A questionnaire on model reliability was filled out for the Western Mediterranean case study by the modellers, and the results can be seen in comparisons to the other nine models in Fig. 6.

Fig. 6 provides at a glance a comparison of how complete is the data, how comprehensive is the knowledge base for model building, and how extensively the model was tested relative to other case studies. The negative (or uncoloured) space in each column signals the lack of knowledge and data relative to what is attainable in other case studies. Western Mediterranean is one of two models (out of ten) which was evaluated for sensitivity to small parameter changes. But overall, Fig. 6 shows why expert opinion is relatively important for this case study – the knowledge about the important processes controlling the population dynamics is sparse (blue bars), giving important context for interpreting modelling results presented in DSTs.

4. Discussion

In order to incorporate the complexity of a fishery system, the MYFISH project used a wide range of methodologies, exemplifying a trend for more inclusive governance [37]. In an individual case-study, the project may aim to:

- identify the response of fishers to limiting constraints;
- determine the most economically appropriate paths towards Maximum Sustainable Yield (MSY);
- predict likely response of fishers to Long Term Management Plans;
- identify implications on governance appropriate for implementing MSY management.

A range of qualitative and quantitative techniques are employed to achieve these aims, including stakeholder surveys, computational modelling and expert elicitation. This diverse output then must be conveyed to a range of stakeholders and used to inform decision making. In the past, scientific advice to decision makers could have been as simple as a single number such as a Total Allowable Catch. More recently, advances in data collection, analytical techniques and multidisciplinary methodologies produce increasingly complex and multidimensional advice. For example, in Management Strategy Evaluation, where the aim is to find a management procedure that best meets management objectives [8].

Less effort has been expended on developing new ways to communicate this multifaceted scientific advice. Innovation in the way information is communicated has never been a more pressing need [1,8,18]. Visualisation is helpful in linking different facets of knowledge and supports efforts to communicate complex results to stakeholders. Based on experience in MYFISH, visualisation encourages stakeholders to ask questions about results and how they were obtained, enabling stakeholders to engage constructively in a critical role.

Historically, visualisation has been particularly valued for complex datasets for three main reasons. Firstly, it enables large bodies of data to be better understood than through pure text approaches [1,8,11,38].

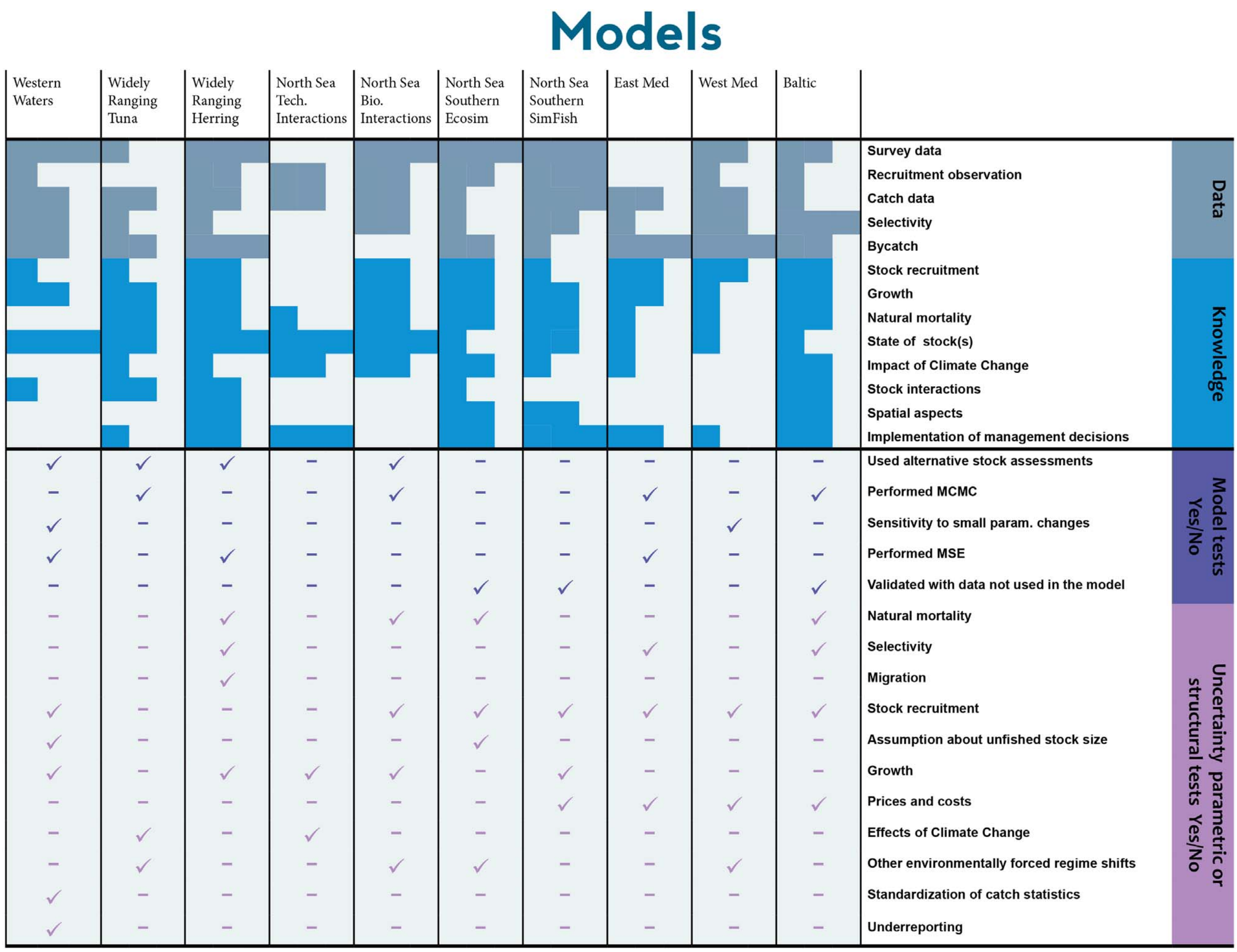

Fig. 6. Model comparisons. Western Mediterranean model relative to other case studies (West Med column).

Secondly, it frees up the cognitive system to look at higher level relationships between the data [38]. Thirdly, it can be designed to highlight specific points of interest [38].

It is important for visualisation to be an inclusive process where various designs are tested and improved with feedback from stakeholders. Consultation with stakeholders should raise awareness of how the presentation of scientific advice influences its interpretation and use in decision making [9,20]. The methodology described here, has been presented at a range of stakeholder venues, from advisory council workshops to scientific symposia where various stakeholders were participating and an EC level policy workshop in Brussels.

Visualisation techniques can either make the issues arising from psychological predispositions for irrational decision-making more problematic or could help alleviate perception biases [20]. No presentation of results is neutral, in a sense that there will always be consequences dependent on the format in which results are presented.

Our observation of fisheries literature indicates that the visualisations are underused if the goal is to enable stakeholders to understand and interpret scientific findings with ease. Not surprisingly, more attractive and comprehensible examples of visualisation are often found in publications of fisheries related NGOs and the media, as engaging the wider audience has been their intention for longer than it has been for fisheries scientists or academia. As fisheries management increasingly includes stakeholder participation in its governance there will be greater emphasis on improving communication and using visualisation techniques to communicate complex information coming from scientific studies. With greater public openness in policy making comes richer diversity of opinions and values, as well as demands and expectations for scientists to support discussions with more broadly based knowledge and more complex analysis [9,10,22,39–41]. No longer is the remit of stock assessment limited to calculating measures necessary to ensure a maximum sustainable yield from a single stock; the models scientists are now asked to build may cover species and habitat interactions, as well as social and economic issues [5,36,37,39–41]. These developments bring more urgency to the task of improving communication methods using experienced designers.

Much of the power of design for information lies in its immediate perceptibility. The graphical vocabulary developed for MYFISH enables a depiction of trade-offs and other criteria for decision making that were highlighted by stakeholders. This improved the stakeholder comprehension of modelling results. Visualisation also facilitates a process of critically questioning the results and the models that produced them. The choices for visualisation were limited by availability of scientific findings and knowledge of stakeholder priorities. Even within individual case studies, the focus on specific aspects of the modelling results shifted depending on the composition of the stakeholder group. For example, a group representing industry might be more interested in predictions regarding fleet composition and catches than an environmental NGO-dominated stakeholder group that might be more concerned with the impacts on fish communities, habitats and endangered species. Considering diverse interests, it was still possible within MYFISH to produce a uniform approach for communicating results of both quantitative (model-based) and qualitative (expert-based) assessments of complex trade-offs under different management options.

It would be desirable to build on the efforts of MYFISH to test and improve a framework based on visualisation for communication between scientist and stakeholders on an EU-wide basis. As far as the authors are aware no studies have been conducted analogous to those done for health risks [20] into what would constitute best practice for visualisation in fisheries. This paper echoes many of the observations made by Spiegelhalter et al. [18] in the hope of attracting greater attention to the issue of graphical risk communication for fisheries management.

Both outside and within academia, there has been a growing social awareness of risk and uncertainty which has led many to advocate a precautionary approach in government policy, especially in the domains of environment and public health [22]. Visualisation of trade-offs under uncertainty helps multiple actors to compare and debate risks; this technique may be particularly suited in the context of Management Strategy Evaluation.

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