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Practical tools to support marine spatial planning: A review and some prototype tools

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ABSTRACT

Marine planners use spatial data to assess planning options. They need analytical approaches, methods, applications and practical software tools to enable assessment of the relationships between human uses and ecosystem components. Here the results of a two-stage process, aimed at developing practical and GIS-based tools for direct use by planners, are presented. First, some available tools for use in the early stages of plan development were reviewed; for example, to identify interaction between activities to reduce potential conflicts or assist in zone delineation, methods to facilitate a risk assessment of the cumulative effect of human pressures and tools offering decision support. Second, a stakeholder workshop was organised to identify routine marine planning tasks and the technical tools required to support those tasks. From the 39 practical tools reviewed, mostly published in peer-reviewed literature between 1998 and 2009, the majority have been applied in the marine environment in Europe, USA and Australia. It was observed that many of the tools are designed to be used by scientists, programmers or strategic planners with only a few that could be used by case officers (regulators). Together with the results of the stakeholder workshop a suite of prototype tools were developed that offer utility to marine planners. Thus the developed tools provide a solid basis for future development as they are a result of a transparent and participatory process.

1. Introduction

Worldwide marine spatial planning (MSP) is advocated as a promising tool to support the implementation of ecosystem-based marine management [1,2]. Marine spatial planning is defined as a public process of analysing and allocating the spatial and temporal distribution of current and future human activities in marine areas, to achieve ecological, economic, and social objectives that usually have been specified through a political process [3,4]. Moreover ecosystem-based MSP explicitly incorporates ecological principles which articulate the scientifically recognised attributes of healthy, functioning ecosystems into a decision-making framework [5]. Among the most important drivers for MSP in Europe are the Maritime Policy or 'Blue Book' [6] issued by the European Commission in the context of the EU Thematic Strategy and European legislation on nature conservation such as the Birds Directive [7] and the Habitats Directive [8]. Examples of national MSP implementation are the recent UK Acts to deliver a new marine planning system, which will enable the development of marine plans where the protection of the seas and the ability to balance pressures on them will be enhanced [9,10].

There is a growing body of literature regarding the underlying concepts of MSP [5,11,12], the processes involved in its implementation [13–15] and practical experiences [16–19]. Practical guidance for the development of spatial plans often describes a sequence of tasks within a planning framework. A prominent example is provided by the United Nations Educational, Scientific and Cultural Organisation, where worldwide MSP examples have been described and synthesised in a good practice guide for MSP [20]. Ten steps depict the cyclic process comprising scoping, setting of goals and objectives, initial assessment, plan development and implementation with strong stakeholder participation throughout, and a final adoption of the implemented plan, based on a performance assessment (see also [13]).

Whilst there is conceptual guidance for MSP, practical tools to support the implementation of the various steps are still scarce [5,21]. In general, such tools are manifold and can comprise frameworks, meetings, methods or technical solutions (see examples in EBM network toolbox; www.ebmtools.org). Furthermore, not all steps of such a planning process require underpinning science. Thus the main scientific input is required for the initial assessment, the development of spatial management scenarios and for plan performance assessment. Specifically, scientific

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information is the building block for the key tasks of data collection, analysis and the development and evaluation of spatial management options.

More precisely, the marine planning process requires an integrated assessment of (*i*) multiple objectives, (*ii*) conflicts and synergies of marine uses, (*iii*) the risk of cumulative effects of human activities, (*iv*) spatial zoning or management options, and (*v*) scenario testing. For this integrated assessment, marine planners and case officers (regulators) need practical tools which ultimately support marine planning in practice. These tools include risk assessment tools, forecasting and modelling tools and other decision support tools such as simulation models to facilitate 'what if' questions/scenarios from which planning options can be developed.

Inherent within the concept of marine planning is the requirement to process and analyse information with a spatial component and so there are obvious benefits to implementing marine planning within a Geographic Information System (GIS) framework. Practical tools should not only be useful in the preparation of the plans themselves, but may also assist regulators and case officers to put a plan into effect when making routine licensing decisions.

A process that has led to the development of some prototype planning tools designed to address this need for practical, easy to use tools to support the plan development by planners and decision makers, is described here. This three-part process comprised a review of existing planning tools, a stakeholder workshop on tool requirements for routine planning tasks, and the development of GIS-based tools. Only tools relevant to the initial development of plans (including examples from terrestrial planning) and the assessment and analysis of options were reviewed. Three categories of possible practical tools for MSP were distinguished: those that could be used for (*i*) identifying spatial interactions between activities; (*ii*) risk assessment of cumulative effects of human pressures (CEA); and (*iii*) decision support (DSS). In the second step, an expert workshop to determine the requirements for practical tools to support routine planning tasks was held. Based on the review and workshop results a suite of prototype tools, driven by spatial data and designed to simplify or automate routine procedures, was developed, thereby allowing maximum utility without the need for high levels of GIS technical expertise. These tools were developed using Visual Basic (http://vb.net/uk/index.html) within the Visual Studio development environment and were designed to be used with the ESRI ArcGIS software. The resulting toolbar provides additional functionality when enabled within an ArcGIS map document.

2. Material and methods

2.1. Review of practical planning tools

For each tool category available or published, practical solutions were reviewed and assessed against standardised criteria to ensure comparability. As the objective of this initiative was to evaluate the capability and practicality of a certain tool to aid the routine tasks of marine planners the aim of the tool and the associated references was reported. Further, the tools were classified using the following criteria: potential users (programmer, scientist, strategic planner, case officer, public), data requirements, purchase cost (commercial > £100, commercial ≤ £100), last update (date), marine use (yes/no), and location used (scale, country, case study). Since the results of this review have been used to define the gaps and consequently the needs for the development of prototype planning tools, a comprehensive assessment of the advantages and disadvantages of the use of a certain tool was not included. The background and reasoning for the review process for each tool category are briefly described below.

2.1.1. Spatial interaction between activities

Allocating space to particular activities within a marine environment poses challenges that are more problematic than in land-based planning. In the marine environment conflicts between users are more common and boundaries are more difficult to identify and enforce [3,4]. Spatial zoning can be used to separate potentially conflicting activities and may result in a particular sector being granted near-exclusive use of specific areas of the sea [22]. However, zoning often occurs following the development of a spatial plan, effectively becoming one of the tools used to implement the plan and usually as a component of a more comprehensive management strategy. An understanding of the extent and intensity of existing activities is necessary before zones can be established. Furthermore, zoning, or the development of spatial management options, requires that management objectives be clearly defined in conjunction with the indicators to assess achievement of those objectives. All of this information must be presented in a format that is easy to understand both by users of the marine environment and by those with a management remit [23]. A wide range of variables must be taken into account e.g., data describing the physical and biological characteristics of the area; user activity within the area; user values and perceptions; and an appreciation of conflicts between competing users and between users and the environment [13].

In land use management, current approaches for defining and assessing spatial management options encompass, for instance, multi criteria analyses (MCA) or spatial optimisation techniques such as Pareto optimality (see [24,25] and references therein). While the former approach requires a weighting of management objectives, for example using stakeholder opinions, the latter eliminates the need for a prior specification of weights and represents a more complex and computationally intensive approach. Multi criteria analysis comprises a series of methods allowing a comparison between alternative outcomes based on multiple factors. It includes techniques for structuring objectives, performing sensitivity analysis and enhancing presentation and visualisation of results [26,27]. Development of the criteria layers used to drive the MCA is an important component and can provide useful insight into conflicting activities within an area. Multi criteria analysis has been applied as an aid to zoning within marine protected areas [28], across national borders [23], in coastal areas [29] and for broad-scale marine management [17], with the sources of the criteria layers being many and varied. Only technical tools that facilitate the implementation of MCA in the context of zone delineation were reviewed, as the aim was to identify the gaps in exploratory tools to assist in the quantification of current activities, prior to the establishment of zones or spatial management options.

2.1.2. Cumulative effect assessment

Currently, the management of marine resources often follows a sector by sector approach, where each human activity, such as fisheries, energy production or shipping, is managed independently [30]. This sectoral approach to marine management makes it difficult to assess cumulative effects of multiple human activities and their associated pressures. Cumulative effects or impacts can be described as the combined effect of multiple activities over space and time [31]. A cumulative effect assessment (CEA) forms a part of a strategic environmental assessment and environmental impact assessment, where adverse effects on a resource or valued ecosystem component are assessed. Components of a CEA may