



Monitoring and Evaluation of Spatially Managed Areas

Deliverable 4.4

Tests of set of management tools: Performance evaluation and validation of the management tools

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1 OVERVIEW OF TOOLS USED IN MESMA

A number of tools that are described in Deliverable 4.1 (Cronin et al., 2012) were used in the MESMA case studies and are evaluated here. Some were developed within MESMA and others are popular tools used for monitoring and evaluating spatially managed areas worldwide or more general tools used in different fields.

Tools that were used and evaluated within MESMA by the case studies include:

Tools for monitoring and evaluating spatially managed areas:

1. Biological Valuation Tool
2. CHASE
3. Marxan
4. Medium Scale Commercial Fisheries Effort (MeSCoFE)
5. SeaTrim
6. Small Scale Coastal Fisheries Pressure (SmaSCoFiP)
7. SPAM
8. VMSBase

And more generally applicable tools including:

1. ArcGIS and ArcGIS with the spatial analyst extension
2. Pedigree Matrix
3. Semi-structured interviews
4. Walker Matrix

The central tool used by all the MESMA case studies was the flexible and generic assessment framework developed in Work Package 2, which facilitates the linkage between the structured assessment, governance analysis, required tools and geodata infrastructure. This framework tool was in turn developed into an online database through which case studies or other users of the MESMA framework can step through electronically (<http://mesma.ucc.ie/emanual/>).

The use of the framework ranged from the observation of a process, either analytically or not, to the development and evaluation of spatially managed scenarios using spatial and temporal resolved data (Stelzenmüller *et al.*, 2013). Those case studies that mainly observed the processes in place (Östergötland [Baltic Sea], Pentland Firth, Puck Bay [Baltic Sea], Southern North Sea) did not extensively use tools as the majority of the work was based on desk study analysis. Most of the case studies that were more involved in the actual evaluation and development of spatial managed scenarios applied a variety of tools (Ionian archipelago, Strait of Sicily, Basque), although certain sub case studies of the 'observing' case study of the Southern North Sea, such as the Dogger Bank and Skagerrak sub case studies did also apply some tools. The limited number of case studies applying tools to monitor and evaluate the spatially managed areas in their region is reflected in the small number of tools that were subsequently evaluated. To supplement the case study tool evaluations, as they don't reflect the wide range of tools available for the monitoring and evaluation of spatially managed areas, an additional literature review of useful tools was undertaken (Chapter 2).

Marxan and the Biological Valuation Tool were the two most popular tools used in the case studies. The use of both tools was stimulated by the organization of two tool workshops by the Institute of Marine Research in Norway (IMR) for Marxan and the University of Gent for the Biological Valuation Tool (see Cronin et al., 2013 for a description of the workshops). Many of the other tools were used by individual case studies and often the institute involved in the case studies were also involved in the development of

the tool i.e. SPAM, SSCFP, MSCFE, CHASE (Helcom). Therefore the evaluations of these tools, although honest, may not be totally subjective.

Other tools have been dealt with separately and more extensively outside this deliverable namely the application of an uncertainty analysis for the generic framework using the Walker Matrix and Pedigree Matrix techniques on which a paper is currently being finalized by Stelzenmüller et al., 2013. A paper is also being written on the comparison of Marxan across different case studies, namely the Barents Sea and the Ionian Archipelago (reference not yet available).

2 TOOL TESTIMONIALS FROM THE LITERATURE

There are extensive papers about tools useful for the evaluation of spatially managed areas available in the literature. A selection is presented here for the most popular tools. These tools are also available through the wiki. Specifically those tools that are thought to be useful for the monitoring and evaluation of spatially managed areas, but were not used by the case studies are described. As it a popular tool used worldwide, Marxan is also included, although it was evaluated by the case studies. Many more papers exist describing a particular application of these tools. However the purpose here was only to review those papers that provided clear commentary on the performance of the tool, specifically comments on the quality, advantages and disadvantages of the tool in question. For some tools, much of the opinion is based on one or two authors' use of the tool and we attempted to give as balanced a view as possible. These testimonials were directly quoted from the papers referenced in order not to re-interpret any of the performance comments. These 'testimonials' are shown in a different font and in italics. The tool reviews from the literature do not reflect the opinion of the MESMA community.

AHP in ArcGIS
<p>Description: AHP 1.1 is an ArcGIS extension which performs a criteria weight determination according to the Analytic Hierarchy Process (AHP) method. It is a powerful tool for the creation of suitability maps (spatial planning, risk mapping and more). ArcGIS Spatial Analyst extension is required in order to use this AHP extension.</p>
<p>URL: http://publicwiki.deltares.nl/display/MESMA/AHP+in+ArcGIS</p>
<p>Literature comments:</p> <ul style="list-style-type: none"> • <i>One of the advantages of the hierarchic analysis is the ability to examine the consistency of the decisions made for determining the weight of the criteria and sub-criteria</i> – Beigbabayi and Mobarki, 2012 • <i>In this paper the application of multicriteria decision making in spatial problems and GIS application is discussed and in resumption AHP is a most applicable tool in this context</i> - Ghamgosar et al., 2011
<p>References:</p> <ol style="list-style-type: none"> 1. Beigbabayi, B. & Mobarki, M.A., (2012). Using AHP Modeling and GIS to evaluate the suitability of site with climatic potential for cultivation of autumn canola in Ardabil Province. <i>Annals of Biological Research</i>, 2012, 3 (5), 2307-2317 (http://scholarsresearchlibrary.com/archive.html) 2. Ghamgosar, M., Haghyghy, M., Mehrdoust, F. & Arshad, N., (2011). Multicriteria decision making based on analytical hierarchy process (AHP) in GIS for Tourism. <i>Middle-East Journal of Scientific Research</i>, 10, 4, 501-507

ARIES
<p>Description: ARIES is a web-based technology offered to users worldwide to assist rapid ecosystem service assessment and valuation (ESAV). Its purpose is to make environmental decisions easier and more effective. ARIES helps discover, understand, and quantify environmental assets and what factors influence their values, in a geographical area and according to needs and priorities set by its users. ARIES can accommodate a range of different use scenarios, including spatial assessments and economic valuations of ecosystem services, optimization of payment schemes for ecosystem services, and spatial policy planning.</p>
<p>URL: http://publicwiki.deltares.nl/display/MESMA/ARIES</p>
<p>Literature comments:</p>

- *ARIES is a web based ecosystem services mapping and valuation tool, which uses probabilistic Bayesian networks to analyse ecosystem service flows from point of supply to place of use and beneficiaries - Crossman et al., 2013*
- *By creating ad-hoc probabilistic models of both provisions and usage of ecosystem services in a region of interest, ARIES helps discover, understand and quantify environmental assets... the results of an ARIES user session is an environmental asset portfolio that describes in depth the spatial distribution of benefits produced in the area – Villa et al., 2009*
- *Improvements under development will enhance its versatility as well as the scientific quality and policy relevance of its output. System improvements include an encoded set of artificial intelligence-based decision rules that enable specific model components to be automatically selected under appropriate circumstances - Villa et al., 2012*
- *To date, the source, sink, use and flow models developed in ARIES have largely been developed from literature reviews and discussions with regional experts. In many cases, the realism of results, including those of the flow models, could be improved by incorporating previously developed biophysical models.. – Villa et al., 2012*

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1. Crossman, N.D., Burkhard, B., Nedkov, S., Willemsen, L., Petz, K., Palomo, I., Drakou, E., Martin-Lopez, B., McPhearson, T., Boyanova, K., Alkemade, R., Egoh, B., Dunbar, M. & Maes, J., (2013). A blueprint for mapping and modeling ecosystem services. *Ecosystem Services*, 4, 4-14
2. Villa, F., Ceroni, M., Bastad, K., Johnson, G.W., & Krivov, S., (2009). Understanding agricultural ecosystem services with ARIES (Artificial Intelligence for Ecosystem Services): Perspectives for assisted policy making. AgSAP Conference 2009, Egmond aan Zee, The Netherlands.
3. Villa, F., Bagstad, K., Johnson, G. & Voigt, B., (2012). Towards a comprehensive approach to quantifying and mapping ecosystem services flows. Basque Centre for Climate Change. BC3 Working Paper Series, 2012-07 http://www.bc3research.org/working_papers/view.html

ATLANTIS

Description: Atlantis is an ecosystem box-model intended for use in management strategy evaluation. The overall structure of Atlantis is based around having multiple alternative sub-models to represent each step in the management strategy and adaptive management cycles. The primary processes considered are consumption, production, waste production, migration, predation, recruitment, habitat dependence, and natural and fishing mortality.

URL: <http://publicwiki.deltares.nl/display/MESMA/Atlantis>

Literature comments:

- *A key strength of Atlantis is its modular construction. Atlantis incorporates multiple alternative sub-models to represent each step in the management strategy and adaptive management cycles – though some steps are more extensively elaborated on than others. -- Link et al., 2010*
- *Atlantis model outputs can encompass a wide range of metrics, often with output files from a model run comprising copious gigabytes or even terabytes of information -- Link et al., 2010*
- *We assert that the model outputs we have shown indeed reasonably approximated the major state variables as measured and observed...that most of our results were reasonable and within levels of tolerance across such an interdisciplinary array of*

considerations is not trivial -- Link et al., 2010

- *For those processes, functional groups or fleets that were not modelled well, the model actually forced us to reevaluate our data and in some cases, when revising or re-estimating those values were found to be more in accord with Atlantis outputs -- Link et al., 2010*
- *Using model outputs to bound potential estimates of biomass until further field estimates can be obtained is one benefit of this approach...having a modelling tool such as this that simultaneously accommodates and evaluates a range of marine processes that are known or even suspected to be important in driving marine ecosystem dynamics is valuable -- Link et al., 2010*
- *This application has the potential for being used in a wide range of management situations, embracing the EBM concept fully -- Link et al., 2010*
- *The value for EBM and related management using a model such as this is that it allows one to simulate across a range of management strategies to determine which have the most likely probability of being robust and hence successful in actual implementation -- Link et al., 2010*
- *This ecosystem model has the ability to synthesize across a wide range of information and simultaneously explore the relative prominence of processes suspected to influence marine ecosystem dynamics. As such, this model has both high heuristic and practical value -- Link et al., 2010*
- *The Atlantis model allows spatial, multispecies projections of stock trends through time, which translate [here] into 15-year forecasts of fleet revenues, economic impacts and jobs – Kaplan and Leonard, 2012 Atlantis is a strategic tool and is not appropriate for use in direct support of tactical management decisions...thus we strongly recommend against setting specific quotas etc. using this modelling approach – Kaplan and Leonard, 2012*

References:

1. Link, J., Fulton, E.A. & Gamble, R.J., (2010). The northeast US application of ATLANTIS: A full system model exploring marine ecosystem dynamics in a living marine resource management context. *Progress in Oceanography*, 57, 214-234
2. Kaplan, I.C. & Leonard, J., (2012). From krill to convenience stores: Forecasting the economic and ecological effects of fisheries management on the US West Coast. *Marine Policy*, 36, 947-954

Desktop GARP

Short description: Desktop GARP is a software package for biodiversity and ecologic research that allows the user to predict and analyse wild species distributions. GARP is a genetic algorithm that creates ecological niche models for species. The models describe environmental conditions under which the species should be able to maintain populations.

URL: <http://publicwiki.deltares.nl/display/MESMA/Desktop+GARP>

Literature comments:

- In Wiley *et al.*, 2003, the authors extended the application to the marine ecosystems and demonstrated its potential usefulness in predicting geographic distributions of littoral and benthic fishes across a major and heterogeneous ocean region

- *GARP has been shown to be robust in the face of various kinds of bias, including bias produced by considering presence data only...GARP models provide an efficient means of modeling species' ecological niche and for projecting those models onto geography in the form of maps* – Wiley et al., 2003
- *We designed this study as a severe test of GARP's ability to model marine fish distributions through niche modeling and projection of models into geographic space. At least for benthic and continental shelf species, GARP succeeded admirably* – Wiley et al., 2003
- *GARP is scalable and its usefulness is limited only by the relatively fine- or coarse-scale nature of the environmental data and the availability of appropriate point data for species* – Wiley et al., 2003
- *At present GARP cannot model volumes of water and thus is limited to benthic or benthic-orientated species and to species of the littoral and epipelagic zones* -- Wiley et al., 2003

References:

1. Wiley., E.O., McNyset, K.M., Peterson, A.T., Robins, C.R., & Steward, A.M. (2003). Predictions in the marine environment using a machine-learning algorithm. *Oceanography*, Vol. 16, No. 4. 8pp

DIVA

Short description: DIVA (Dynamic and Interactive Vulnerability Assessment) is a user-friendly tool that allows its users to produce consistent quantitative information on a range of social, ecological, and economic coastal impact indicators based on user-selected climatic and socio-economic scenarios, as well as coastal adaptation strategies. DIVA was developed within the European-funded project DINAS-COAST (Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones to Climate Change and Sea-Level Rise).

URL: <http://publicwiki.deltares.nl/display/MESMA/DIVA>

Literature comments:

- *This modelling tool enables users to analyse a wide range of mitigation and adaption policies in terms of coastal impacts and vulnerability* – Vafeidis et al., 2008
- *While the DIVA tool is specific to the DINAS-COAST project, the DIVA method can be re-used in other contexts with similar requirements* – Hinkel, 2005
- *Improvements on the current DIVA tool could include a module for coral reefs and atolls, refining the adaptation module and increasing the spatial resolution of the analysis, thus increasing the spatial resolution of the analysis...* – Hinkel, 2005
- *DIVA is a dynamic, interactive and flexible software tool that enables its users to produce quantitative information on a range of coastal vulnerability indicators, for user selected climatic and socio-economic scenarios and adaptation strategies.* – Hinkel and Klein, 2009

References:

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2. Hinkel, J. (2005). DIVA: an iterative method for building modular integrated models. *Advances in Geosciences*, 4, 45-50
3. Hinkel, J., & Klein, R.J.T., (2009). Integrating knowledge to assess coastal vulnerability to sea-level rise: the development of the DIVA tool. *Global Environmental Change*, 19, 384-395

ECOPATH

Short description: Ecopath with Ecosim (EwE) is a free ecological/ecosystem modelling software suite. EwE has three main components: EcoPath - a static, mass-balanced snapshot of the system; EcoSim - a time dynamic simulation module for policy exploration; and EcoSpace - a spatial and temporal dynamic module primarily designed for exploring impact and placement of protected areas.

URL: <http://publicwiki.deltares.nl/display/MESMA/EcoPath>

Literature comments:

Walters *et al.*, 1997 present an approach for using the results of EcoPath assessments to construct dynamic ecosystem models – EcoSim module for EcoPath. A large number of EcoPath trophic flow applications have been published (>60) and the authors ran 40 test simulations. From a bottom up trophic perspective EcoPath has been useful in assessing ecological limits to fish production and in identifying key trophic linkages that are necessary for sustained production.

In scanning EcoPath datasets, the authors have seen some types of prediction that appear to be incorrect or misleading; overestimation of potential productivity for low-fecundity species; indeterminate outcomes of complex food webs and misleading parameter estimates due to the equilibrium assumption of EcoPath.

- *Ecopath has been appreciated by a wide variety of authors as an approach for summarizing available knowledge on a given ecosystem – Walters et al., 1997*
- *EcoSim can be a valuable tool for design in ecosystem-scale adaptive management experiments – Walters et al., 1997*

Blanchard *et al.*, 2002 found that *Ecopath with EcoSim is a useful tool for exploring interactions between marine mammals, their prey and fisheries, however it is, ...particularly sensitive to different vulnerability settings....during the balancing of any EcoPath model there is a danger of employing an overly top down strategy*

Essington, (2007) evaluated the sensitivity of EcoPath predictions to uncertainty in input data and determined the extent to which they were improved via the mass-balance constraint. He used nine published EcoPath models as operational models, added error to input variables and then determined how well EcoPath could uncover the true model structure. He focused on EcoPath's ability to precisely estimate biomass and ecotrophic efficiency. He found that EcoPath error predictions *were approximately as precise as the input variables, except in cases of tightly linked cycles of food web connections when errors become greatly amplified...EcoPath predictions were most sensitive to biomass and production rate input data and only occasionally sensitive to consumption rate and feeding habits data...Results suggest that the precision of EcoPath derived estimates of biomass and ecotrophic efficiency is generally comparable with the precision of the input data.*

- *One of the most beneficial uses of EcoPath with EcoSim is an exploratory, heuristic model that can identify possible unintended alterations of trophic interactions caused by management actions. A second potential use is as a prediction tool, analogous to the manner that single species assessments are routinely used to make policy decisions*

– Essington, 2007

Simulations by Essington, (2007) suggest...*that accurate knowledge about which data types were imprecise did little to improve the prediction accuracy of the model estimates. However... Relatively imprecise models, coupled with a thoughtful exploration of uncertainty can still advise and inform policy decision.*

- *The [EcoPath] approach uses large datasets for the diets of fish but has some drawbacks. It does not include nutrient recycling in the microbial food web. It does not account for the physical exports of plankton that are a concomitant of the physical input of nutrient rich waters, and a dominant feature of shelf ecosystems – Steele and Ruzicka, 2011*
- *Part of the success of EcoPath results from the general applicability of the computer program – it can be used in the analysis of the upper levels of any shelf ecosystems – Steel and Ruzicka, 2011*

Pauly *et al.*, 2000 created a pedigree matrix (see MESMA tool review in Chapter 3 below) for EcoPath input. The major deficiency they found was its assumption of homogenous spatial behaviour. However this was recently improved through the development of EcoSpace (Walters *et al.*, 2000), a dynamic version of EcoPath incorporating all key elements of EcoSim. They found that *EcoSpace still needs much work to make it a useful policy exploration tool for many ecosystems. Case experience suggests in particular that it needs to include representation of orientated migration as well as simple dispersal and a better way to specifying differences in trophic flow among habitat types than is offered by aggregate EcoPath analysis*

In Steenbeek *et al.*, 2013 the EcoSpace with EcoSim (EwE) software was extended via plug-ins to operate with external spatial-temporal data and models. This functionality allows the EcoSpace model to interact with a wide range of spatial data sources, handle GIS data and interact with other spatial ecosystem models

- *Spatial variations in driver variables such as the primary productivity map have significant impacts on the EcoSpace dynamics. However, up to the present study, a continued and major shortcoming of the EcoSpace routine was its lack of facility to read and produce true geospatial data into driver layer -- Steenbeek *et al.*, 2013*

To facilitate comparative studies, Christensen *et al.*, 2009 have developed a two-way bridge between Marxan and EwE enabling exchange of spatial information and of optimization results between the two approaches. The authors made it possible to compare the most widely applied tool for ecosystem modelling, EwE with the most widely applied tool for spatial zoning, Marxan.

- *EcoSpace approach has now grown to a level where it should be seriously considered as a decision support tool for use in EBM or multiple objective marine spatial planning – Christensen *et al.*, 2009*
- *Similar to MARXAN, EcoSpace is both intuitive and flexible enough to be used as part of a stakeholder consultation process -- Christensen *et al.*, 2009*

References:

1. Walters, C., Christensen, V. & Pauly, D., (1997). Structuring dynamic models of exploited ecosystems. *Reviews in Fish Biology and Fisheries*, 7, 2, 139-172
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5. Pauly, D., Christensen, V. & Walters, C., (2000). Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact on fisheries. *ICES Journal of Marine Science*, 57, 697-706
6. Steenbeek, J., Coll, M., Gurney, L., Melin, F., Hoepffner, N., Buszowski, J., & Christensen, V., (2013). Bridging the gap between ecosystem modeling tools and geographic information systems: Driving a food web model with external spatial-temporal data. *Ecological Modelling*, 263, 139-151
7. Christensen, V. & Pauly, D., (1992). ECOPATH-II – a software for balancing steady-state ecosystem models and calculating network characteristics. *Ecological Modelling*, 61, 169-185

ERSEM

Short description: ERSEM (the European Regional Seas Ecosystem Model) is a mature plankton functional type model that was initially developed by a European Framework 3 project. It includes several refinements necessary to correctly represent the key processes of temperate shelf ecosystems; the main ones being some plankton community complexity, the microbial loop, variable nutrient stoichiometry, variable carbon: chlorophyll ratios and a comprehensive description of benthic biochemical and ecological processes.

URL: <http://publicwiki.deltares.nl/display/MESMA/ERSEM>

Literature comments:

- *The ecosystem model appears to have skill for time scales in the order of weeks, except during periods of phytoplankton blooms where a temporal and strength mismatch occurs – Shutler et al., 2011*
- *Previous work highlighted a temporal mismatch between phytoplankton blooms seen in in-situ data and those produced from the POLCOMS-ERSEM model – suggests there is a problem with the ecosystem dynamics such as over or under grazing or nutrient supply – Shutler et al., 2011*
- *The performance of the model physics has been previously evaluated (Holt et al., 2005) and shows good agreement with point data – Shutler et al., 2011*
- *The apparent ability of the model to capture the mean annual chlorophyll-a signal suggests that the model is capable of being used for analyzing and forecasting long term mean variations, though the apparent mean bias is likely to have an impact on the results – Shutler et al., 2011*

References:

1. Shutler, J.D., Smyth, T.J., Saux-Picart, S., Wakelin, S.L., Hyder, P., Orekhov, P., Grant, M.G., Tilstone, G.H. & Allen, J.I., (2011). Evaluating the ability of a hydrodynamic ecosystem model to capture inter- and intra-annual spatial characteristics of chlorophyll-a in the north east Atlantic. *Journal of Marine Systems*, 88, 169-182

Fisheries Library Tools in R
<p>Short description: The Fisheries Library Tools in R (FLR) library is a collection of tools in the R statistical language that facilitates the construction of bio-economic simulation models of fisheries and ecological systems. It is a generic toolbox, but is specifically suited for the construction of simulation models for evaluations of fisheries management strategies. The FLR tool box is under development by researchers across a number of laboratories and universities.</p>
<p>URL: http://publicwiki.deltares.nl/display/MESMA/Fisheries+Library+in+R</p>
<p>Literature comments:</p> <ul style="list-style-type: none"> • <i>FLR benefits from being an open source framework because this allows users to adjust programs for their own specific purposes and to pass on these developments to others – Hillary, 2009</i> • <i>FLR also makes full use of R graphics to display simulation results in ways that are both communicable to managers and stakeholders – yet technically informative for model construction and understanding – Hillary, 2009</i> • <i>The tool presented in Howell and Bogstad, (1998) links a multispecies GADGET operating model to assessment models available from the FLR and management rules to allow a full forward simulation of the interacting stocks in the Barents Sea. This integrated GADGET/FLR model is used to produced medium-term projections.</i> • <i>FLR is a generic toolbox but is specifically suited for the construction of fisheries management strategies – Ibarra-Berastegi et al., 2009</i> • <i>FLR is an open source collection of tools providing a generic modelling framework for constructing a management strategy evaluation – Hamon et al., (no date found)</i> • <i>By using R, FLR improves the transparency of scientific work – Hamon et al (no date found)</i> • <i>The use of predefined classes allows fixing some data formats which are flexible and generic enough to suit most kind of fisheries related data and models – Hamon et al., (no date found)</i> • <i>FLR has proved highly flexible in the study of North Sea roundfish fisheries – Hamon et al., (no date found).</i> • <i>The computing time is still high...however this does not prevent using FLR for complex case studies – Hamon et al., (no date found)</i>
<p>References:</p> <ol style="list-style-type: none"> 1. Hillary, R. (2009). An introduction to FLR fisheries simulation tools. <i>Aquat. Living Resour.</i> 22, 225-232 2. Howell D. & Bogstad, B., (1998). A combined Gadget/FLR model for management strategy evaluations of the Barents Sea Fisheries. <i>ICES Journal of Marine Science</i>, 67, 1998-2004 3. Ibarra-Berastegi, G., Ganzedo, U., Saenz, J., Ezcurra, A., Errasti, I., Elias, A., Barona, A. & Insausti, L., (2009). Linking high education and research using free software: Two experiences with R. <i>Proceedings of the 5th WSEAS/ISAME International Conference on Educational Technologies (Edute' 09)</i> 4. Hamon, K., Ulrich, C., Hoff, A. & Kell, L.T. Evaluation of Management Strategies for the Mixed North Sea Roundfish Fisheries with the FLR framework. (date unknown)

MARXAN
<p>Short description: Marxan can assist with the evaluation of existing reserve systems to identify gaps in biodiversity protection, identify areas to include in new reserve systems, and provide decision support by producing a number of different options that meet both socio-economic and conservation objectives. Marxan has also been used to support multiple-use zoning plans that balance the varied interests of stakeholders.</p>
<p>URL: http://publicwiki.deltares.nl/display/MESMA/MARXAN</p>
<p>Literature comments:</p> <ul style="list-style-type: none"> • <i>Marxan's priority-area map can change between different analyses, and the extent of its near-optimality tends to increase with the number of runs used. Similarly, Marxan's conservation-value map can vary between analyses, although these differences tend to be much smaller because each output is based on a number of runs</i> -- Delavennet <i>et al.</i>, 2012. • <i>The tool has some 'black box' issues, however, these usually stem from lack of understanding of mathematical optimization and a focus on the wrong part of the system</i> – Ball <i>et al.</i>, 2009 • The tool can be used in a range of different marine areas, however calibration and adaptation to local needs (mainly on the spatial scale) is often necessary (see <i>i.e.</i> Ban <i>et al.</i>, 2013; Smith <i>et al.</i>, 2009) • It interacts with a variety of GIS tools and can be plugged in to other softwares such as PANDA (http://publicwiki.deltares.nl/display/MESMA/PANDA) and C-PLAN (http://publicwiki.deltares.nl/display/MESMA/C-PLAN) (Ball <i>et al.</i>, 2009) • <i>Experts including, human use sector representatives, were crucial to identify the limitations of existing human use data for use in Marxan, and data gaps</i> – Ban <i>et al.</i>, 2013 • <i>Studies [with Marxan] emphasized that their results were not meant as a guide to where MPAs should be located, and underscored the importance of comprehensive stakeholder consultation at all stages of future work</i> – Smith <i>et al.</i>, 2009
<p>References:</p> <ol style="list-style-type: none"> 1. Delavennet, J., Metcalfe, K., Smith, R.J., Vaz, S., Martin, C.S., Dupuis, L., Coppin, F. & Carpentier, A., (2012). Systematic conservation planning in the eastern English Channel: comparing the Marxan and Zonation decision-support tools. <i>ICES Journal of Marine Science</i>, 69, 1, 75-83 2. Ball, I.R., Possingham, H.P. & Watts, M.E., (2009). <i>Marxan and Relatives: Software for Spatial Conservation Prioritization</i>. Eds Moilanen, A., K.A. Wilson, and H.P. Possingham. Oxford University Press, Oxford, UK. 3. Ban, N.C., Bodtker, K.M., Nicolson, D., Robb, C.K., Royle, K. & Short, C., (2013). Setting the stage for marine spatial planning: Ecological and social data collation and analyses in Canada's Pacific waters. <i>Marine Policy</i>, 39, 11-20 4. Smith, R.J., Eastwood, P.D., Ota, Y. & Rogers, S.I., (2009). Developing best practice for using Marxan to locate Marine Protected Areas in European Waters. <i>ICES Journal of Marine Science</i>, 66, 188-194

MaxEnt
<p>Short description: Maxent provides a maximum-entropy approach for species habitat modelling. The software takes as input a set of layers or environmental variables (such as elevation, precipitation, etc.), as well as a set of georeferenced occurrence locations, and produces a model of the range of the given species. It is distributed by Princeton University.</p>
<p>URL: http://publicwiki.deltares.nl/display/MESMA/MAXENT</p>
<p>Literature comments:</p> <ul style="list-style-type: none"> • <i>Various studies have proved that Maxent leads to present the best results when ranked against other methods – Martin-Garcia et al., 2013</i> • <i>In Martin-Garcia et al., 2013, the maps generated by Maxent showed the areas with the best predicted conditions for the benthic communities in the study area, and they were congruent with the samples taken and their known distributions</i> • <i>Maxent performs best among different modelling methods and remains effective despite small sample sizes – Martin-Garcia et al., 2013</i> • <i>It has flexibility when handling different kind of species data and responses – Arcos et al., 2013</i> • <i>It is flexible in its ability to accommodate a wide range of data situations, whilst maintaining a high level of predictive performance relative to other methods – Vierod et al., 2013)</i> • <i>It can be used with ArcGIS (Howell et al., 2011)</i> • <i>Maxent requires all environmental data to have the same geographic bounds and cell size (Howell et al., 2011)</i> • <i>Maxent is more suited for species or communities with few presence data and for studies that need restricted distributions– Martin-Garcia et al., 2013</i> • <i>According the Phillips et al., 2006, the advantages of Maxent include the following:</i> <ol style="list-style-type: none"> 1. <i>It requires only presence data, together with environmental information for the whole study area</i> 2. <i>It can utilize both continuous and categorical data and can incorporate interactions between different variables</i> 3. <i>Efficient deterministic algorithms have been developed that are guaranteed to converge to the optimal (maximum entropy) probability distribution</i> 4. <i>The Maxent probability distribution has a concise mathematical definition and is therefore amenable to analysis</i> 5. <i>The output is continuous, allowing fine distinctions to be made between the modelled suitability of different areas</i> 6. <i>Maxent is a generative approach, rather than discriminative, which can be an inherent advantage when the amount of training data is limited</i> • <i>According the Phillips et al., 2006 the drawbacks of Maxent include the following:</i> <ol style="list-style-type: none"> 1. <i>It is not as mature a statistical method as GLM or GAM, so there are fewer guidelines for its use</i> 2. <i>The amount of regularization requires further study as does its effectiveness in avoiding over-fitting compared with other variable selection methods</i>

3. *Special purpose software is required, as Maxent is not available in standard statistical packages*

See Phillips *et al.*, 2006 for more advantages and drawbacks

References:

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ZONATION

Short description: Zonation is a framework for large-scale conservation planning. Zonation can be used for various purposes such as the identification of near-optimal reserve networks, identification of expansions for reserve networks, assessment of proposed reserve networks and priority ranking for conservation decision support. Typical input data of Zonation consists of observed or predicted distributions of biodiversity features. Output of Zonation can be visualized in by two intuitively appealing graphs - the rank priority map and species-specific performance curves.

URL: <http://publicwiki.deltares.nl/display/MESMA/Zonation>

Literature comments:

- *Zonation produces the same conservation-value map for a given set of inputs, based on the same hierarchical ranking output, and also produces the same priority-area map for meeting the specified targets – Delavennet et al., 2012*
- *Zonation is applicable to large-scale high resolution landscape grids having up to tens of millions of grid cells and has been applied to design habitat protection scenarios, evaluate conservation areas, design expansion of conservation areas, target habitat restoration and conservation planning assuming climate change – Sharafi et al., 2012*
- *Using Zonation requires both conceptual understanding about analysis options as well as experience and knowledge on how to establish a sensible workflow, which can be a major obstacle in the use of Zonation, due to the many analysis options available – Lethomaki et al., 2013*



References:













































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3 TOOL EVALUATIONS FROM MESMA CASE STUDIES

The tools used by the different case studies were evaluated within the MESMA project by members of each case study, based on a set list of pre-defined criteria in order to capture the main attributes of each tool. These criteria had to be flexible enough to be applicable to a wide range of different tools, from governance tools to the more technical tools. However, for some tools not all fields are relevant and are therefore left blank. Table 3.1 gives an overview of the tools that were evaluated and a summary of the outcomes. For each of the tools indicated in Table 3.1 more detailed information for each criterion is given in the tables below.

Table 3-1 A overview showing a summary of the tool evaluation. Blank white cells represent an unknown field or not applicable, a  represents a yes per case study. Multiple ticks are present when more than one case study evaluated the tool and a  indicates a data dependent answer

	Accurate	Relevant to question posed	Well validated	Trans-parent?	Generic	Well docu-mented	Used with other tools	Can it be modified	Can it be expanded	Require certain skills	Require certain operating system	Require special libraries	Accept standard data formats	Do what was expected in the case study
Semi-structured interviews														
Walker Matrix														
Pedigree Matrix														
Marxan		  			 	 	 			 			 	

Biological Valuation Tool		 			 		 	 		 			 		
SeaTrim															
ArcGIS															
VMSbase															
SmaSCoFiP															
MeSCoFE															
ArcGIS with spatial analyst															
SPAM															
SLAM															
Chase															

Semi-Structured Interviews	
Case Study	Strait of Sicily
Type	Non-technical, governance tool
Description	Semi-structured interviews, commonly used in governance studies, are based on a list of questions/topics to be discussed with the interviewee. Such list reflects the main themes relevant to the matter of study. It is important to note however that the interviewer may not restrict the interview to a set of pre-determined questions - he/she may wander from the original question to explore any relevant issue raised by the interviewee. Wherever possible and with the consent of the interviewee, interviews may be tape-recorded for further analysis.
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	Yes
Is the tool well validated	Yes – method is widely used in governance studies
Is the tool generic	Yes
Has it good documentation	Yes – socio-economic/governance literature but no formal documentation
Can it be used with other tools	No
Can it be modified	No but it is flexible by its nature
Can it be expanded or improved	Unknown
Does it require certain skills	No, except the ability to conduct interviews smoothly
Does it require a certain operating system	Not applicable
Does it require certain libraries (i.e. in Linux)	Not applicable
Does it accept standard data formats	Not applicable
Did it do what you expected/needed for your case study	Definitely so. Semi-structured interviews have proved a very effective tool to conduct the governance analysis in the Egadi MPA (Case study 6), although none of the interviewers had any previous experience in governance studies. Also the interviewers have been able to maintain a neutral and objective position in order to eliminate any bias due to personal involvement, thus assuring a good and reliable outcome from the survey.

Walker Matrix	
Case Study	Strait of Sicily
Type	Uncertainty analysis tool, communication tool
Description	Squared (or double entrance) matrix for the characterization of the uncertainty associated to the information gathered during the practical run of each step and action of the MESMA framework. Characterization is provided along three axes (or dimensions) defined on conceptual basis by Walker <i>et al.</i> (2003). Scores can be entered as quantitative information, but for MESMA purposes they were transformed to presence/absence (binary) data. The resulting matrix defines where the uncertainty mainly manifests itself along each of the three conceptual axes.
Is it accurate	Accuracy is quite high if the scoring encompasses presence/absence [0, 1] data. However in is difficult to discern where to assign the presence value in some instances, and subjectivity becomes a serious issue here.
Is it relevant to the question posed	Most relevant to the assessment of uncertainty because the conceptual model used is largely accepted and have also become part, as it is or somehow modified, of further classification methods
Is the tool transparent	As far as concepts and definitions are provided, it can be easily checked by any user. Indeed the use of the Walker matrix is intended to enhance the transparency of the MESMA framework, so the tool must be transparent itself.
Is the tool well validated	Good credibility derived from the ample diffusion on literature. Validation for MESMA purposes is still going on and some difficulties arose for certain framework actions in some case studies.
Is the tool generic	Since based on abstract concepts, the tool is largely generic.
Has it good documentation	Literature concerning the theoretical aspects of the tool is enough to be retained as well documented. However, the modified version used within MESMA must be documented yet.
Can it be used with other tools	It can be used with, as well as integrated into, other tools by virtue of its abstract nature.
Can it be modified	At least in principle, the tool can be modified to adapt it to any particular type of information. Flexibility is very large in such sense.

Can it be expanded or improved	It has been already expanded by several authors (e.g. Maxim and van der Sluijs 2011). Such expansion is intended to constitute an improvement but its real value would depend on the specific case and context.
Does it require certain skills	Particular skills are not required as far as abstract concepts can be translated into specific study objects.
Does it require a certain operating system	It does not require any particular operative system.
Does it require certain libraries (i.e. in Linux)	It does not require any particular library
Does it accept standard data formats	Any type of information, in any format, can be processed.
Did it do what you expected/needed for your case study	The tool covered what was needed for the present MESMA framework purposes. However, for a more general use it would be expected to include the social and economic aspects inherent to each case study, possibly through the stakeholders perception. This would directly feed into the (perceived) risk analysis in Step 4 of the MESMA framework.

Pedigree Matrix	
Case Study	Strait of Sicily
Type	Uncertainty analysis tool, communication tool
Description	Squared (or double entrance) matrix for the characterization of the uncertainty associated to the whole run of the MESMA framework. Characterization is provided for five criteria (or dimensions) defined on conceptual basis and properly adapted to the framework scope. Scores were entered within a defined range of [0, 5]. The resulting matrix characterizes the intensity of the associated uncertainty for each of the five criteria.
Is it accurate	The tool is relatively accurate since the score is provided in few classes, therefore dampening to a certain extent the variability among users.
Is it relevant to the question posed	It is highly relevant since it provides a way to synthesize complex information and to convey it to any user in the form of a clear and simple message.
Is the tool transparent	It is as far as the criteria are clearly stated.
Is the tool well validated	The tool has been already tested in many instances with good performance
Is the tool generic	It appears as a very flexible approach that have been applied in a wide array of fields, thus can be retained as highly generic.
Has it good documentation	The use of the tool has been well documentation in scientific and technical literature. The tool itself is described in a number of accessible documents
Can it be used with other tools	It can be used with other tools. In the context of the MESMA framework, it was used together with the (modified) Walker matrix to provide a more complete assessment of the uncertainty associated to the framework run. There seems to be no reason hindering the use of the pedigree matrix with any other tool.
Can it be modified	It can be easily modified since the conceptual criteria are broad and allow ample room to be defined on the most appropriate terms to work out the problem at hand.
Can it be expanded or improved	It can be expanded to include more criteria or larger ranges of scoring. These expansions can be an improvement or not, on depending of the effect of the ratio between the increased detail and the added complexity on the tool performance.
Does it require certain skills	Particular skills are not required as far as abstract

	concepts can be translated into specific study objects.
Does it require a certain operating system	It does not require any particular operative system.
Does it require certain libraries (i.e. in Linux)	It does not require any particular library
Does it accept standard data formats	Any type of information, in any format, can be processed.
Did it do what you expected/needed for your case study	It performed well for the aim of the case study, as expected.

MARXAN (1)	
Case Study	Strait of Sicily
Type	Uncertainty analysis tool, communication tool
Description	Tool to inform decision making by providing a number of maps, based on the information at hand, to be used as starting point in the decision-making process at the stakeholder engagement step. Originally developed for handling conservation questions, it can be used for some other issues
Is it accurate	The tool is as accurate as the information at hand used to feed the software
Is it relevant to the question posed	The relevancy is high for conservation purposes, provided that enough information is available.
Is the tool transparent	The use of the tool enhances transparency in the decision making process, but the tool itself is not transparent. The functioning of the software is illustrated through conceptual analogies, but the software codes were never disclosed. Recently, some of the algorithms have been published.
Is the tool well validated	The tool becomes credible if two conditions are met. First, data should be good enough, in terms of coverage and resolution. Second, credibility increases after a large number of runs, which should include variation in the main parameters as well as the selective inclusion or exclusion of certain information. As far as the resulting variation in the outcomes under these conditions match the user expectations, the tool is credible.
Is the tool generic	The tool is generic within the aim of finding proper areas for conservation purposes. Some other purposes can be handled but it becomes difficult to interpret the outcomes. The tool is not matched for many other purposes.
Has it good documentation	The tool has extensive documentation on how to use it, including tutorials and manuals in major languages other than English. However, little is known about the underlying mechanisms of functioning, and nothing about the software architecture.
Can it be used with other tools	It works with other tools as Zonae Cogito and Quantum GIS, while it does not perform well with other convenient softwares like Ecosim and Ecospace.
Can it be modified	It is not possible to modify the tool itself since the source codes are secret. However, the tool provide ample room for varying the basic parameters.
Can it be expanded or improved	Only the development team can modify the tool,

	<p>therefore only that team can introduce improvements. One of the most important changes is the expansion of the Marxan approach to a heterogeneous landscape, which resulted in Marxan with zones. The later represents a great enhancement but is much more complicated</p>
Does it require certain skills	Definitively yes. The tool has its own terminology, uses its own protocols, etc...
Does it require a certain operating system	Yes, the tool is produced to work on specific operative systems.
Does it require certain libraries (i.e. in Linux)	The tool requires to upload a number of libraries for R.
Does it accept standard data formats	Data must be compiled in a rigidly stated format that can be provided from R and Quantum GIS.
Did it do what you expected/needed for your case study	Not fully tested at the case study level. It appears to be a powerful tool for decision making but it is not so clear to which extent can help in the evaluation of the case study management

MARXAN (2)	
Case Study	Ionian Archipelago
Type	Conservation planning software
Description	<p>Marxan uses a simulated annealing algorithm to find a range of good near-optimal systems of priority areas that meet conservation targets while attempting to minimize socioeconomic costs. Marxan solutions are generated iteratively by randomly changing the status of a single planning unit and assessing the new configuration in terms of achieving Marxan's goal, i.e. minimize cost of the reserve network and the boundary length of the system whilst meeting a set of biodiversity targets.</p>
Is it accurate	<p>Marxan is flexible, transparent, credible, accurate, and generic. It can be applied to a wide range of problems such as reserve design and natural resource management in terrestrial, freshwater, and marine systems. It is efficient, repeatable and provides many good solutions to complex problems, providing a number of options and encouraging stakeholder participation. These features provide users with decision support to achieve an efficient allocation of resources across a range of different uses.</p>
Is it relevant to the question posed	
Is the tool transparent	
Is the tool well validated	
Is the tool generic	
Has it good documentation	<p>Marxan is freely available on the internet http://www.uq.edu.au/marxan/ and is well documented. The user has access to online manual and a number of papers that have used Marxan and illustrate practical examples.</p>
Can it be used with other tools	<p>Marxan can be used with a variety of other tools, some of which are the following; Zonae Cogito Decision Support System, The C-Plan Conservation Planning System, CLUZ- Conservation Land-Use Zoning software, Reserve Design Game, P.A.N.D.A. – Protected Areas Network Design Application for ArcGIS, NatureServe Vista, and The Nature Conservancy – Protected Area Tools (PAT) software.</p> <p>Marxan's recent new editions have improved its computational capabilities. Modifications have been made to the software which resulted in the creation of a new software, i.e. Marxan with Zones. Marxan with zones is novel in that it introduces zoning as a formal consideration of the conservation planning problem. This advancement represents a shift away from the basic reserve design problem towards a multiple zone scheme that supports the efficient allocation of resources across a range of different uses. At its</p>
Can it be modified	
Can it be expanded or improved	

	simplest, the zoning approach can be used to identify two types of zones, with targets being set for each zone type.
Does it require certain skills	
Does it require a certain operating system	
Does it require certain libraries (i.e. in Linux)	
Does it accept standard data formats	Marxan does not require a certain OS or certain libraries. It accepts standard data formats that are built using ArcGIS and Microsoft Office Excel software. While anyone can download and following the manual can apply Marxan, the application of it requires knowledge of the principles of systematic conservation planning. The Pacific Marine Analysis and Research Association (PacMARA) offers a range of Marxan related training courses in various locations around the world. Courses are a mixture of lecture and hands-on activities and are designed to provide users with the basic skills to use Marxan in a conservation planning exercise.
Did it do what you expected/needed for your case study	Marxan was used to identify priority conservation areas in our study region. By setting targets on the biodiversity features we wanted to conserve and by accounting for the economic activities that take place in the region and their spatial distribution we were able to designate a network of marine protected areas for multispecies conservation.

Marxan (3)	
Case Study	Barents Sea
Type	Systematic conservation planning tool
Description	Software program used to support the design of marine and terrestrial reserves worldwide. Using Marxan, conservation planners can identify an efficient system of conservation sites that include a suite of biodiversity targets at a minimal cost. Marxan provides a unique method for designing reserves that is systematic and repeatable
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	Only for those who understand how simulated annealing works
Is the tool well validated	Yes
Is the tool generic	No
Has it good documentation	Very much so, including manuals and good practice books in various languages
Can it be used with other tools	Not easily
Can it be modified	The tool itself can only be modified by the developers. The parameters can be easily changed from run to run
Can it be expanded or improved	Yes
Does it require certain skills	Yes. One needs training to use it, and GIS knowledge is very useful
Does it require a certain operating system	No
Does it require certain libraries (i.e. in Linux)	It depends on the skills of the user, but in principle it does not (GIS extensions can be useful if the GIS skills of the user are limited)
Does it accept standard data formats	Yes
Did it do what you expected/needed for your case study	In progress

Biological Valuation Tool (1)	
Case study	Strait of Sicily
Type	Decision support tool, visualization and mapping tool, uncertainty analysis tool
Description	BVM is a tool aiming to provide information about the spatial distribution of marine biodiversity in the most objective and transparent way. The output is a map that can vary within certain limits on depending of the characteristics of the spatial data used to fed the tool, in terms of type, resolution and coverage. It also consider the adequacy of the spatial coverage and temporal consistency of the data, therefore providing an indirect assessment of the uncertainty associated to such data.
Is it accurate	The tool is as accurate as the coarser data layer used in the assessment.
Is it relevant to the question posed	The tool is highly relevant for the question posed, but the question is very specific
Is the tool transparent	Transparency is the most salient characteristic of this tool.
Is the tool well validated	The tool is relatively new but it has been already validated in a number of cases.
Is the tool generic	BVM is very generic within the limits of its scope, which regards the spatial distribution of marine biodiversity. Any other use seems to be impossible
Has it good documentation	Few literature exits yet but new articles are being produced. It is thought that this tool is not widely available to any user although it is intended to make it freely accessible in the next future.
Can it be used with other tools	BVM makes use of other tools like shapefiles generated by GIS, as well as geographic and taxonomic data provided by on-line servers.
Can it be modified	It can be modified, expanded and improved in every sense since it is completely based on R and other open sources like free on-line data providers.
Can it be expanded or improved	
Does it require certain skills	It requires basic knowledge on R GUI syntax and functioning.
Does it require a certain operating system	In principle, it can work in any computer able to run the appropriate version of R GUI.
Does it require certain libraries (i.e. in Linux)	R libraries need to be updated (or "downdated") to the version used to write the tool script.

Does it accept standard data formats	Data are required in formats that can be considered as standards, like ArcGIS shapefiles.
Did it do what you expected/needed for your case study	Yes, as far as the expectations are in line with the question handled by the tool. It is useful to visualize where the biodiversity and the conservation efforts concentrate, provided that biodiversity conservation was one of the goals for the management regime under evaluation.

Biological Valuation Tool (2)	
Case Study	Strait of Sicily (Maltese waters)
Type	Decision support tool, visualization and mapping tool, uncertainty analysis tool
Description	The Biological Valuation Model (BVM) gives an indication of the value of marine biodiversity by compiling available ecological and biological information for a study area, giving an intrinsic biodiversity value to sub-zones in the study area. As such the modelling approach is thus not related to anthropogenic activities.
Is it accurate	The tool is quite accurate in terms of the results being produced since the questions being asked are quite flexible and these can be deleted, added or modified according to one's case study.
Is it relevant to the question posed	The tool is highly relevant for the question posed, but the question is very specific
Is the tool transparent	
Is the tool well validated	
Is the tool generic	The BVM can be both specific (for example one can choose to work with only two different species) and generic, when the user use all his/her data to have a bigger picture of the situation. The user can choose his/her spatial grid depending on the species (mobile or static), thus making the model more accurate and reliable as one can experiment with different data.
Has it good documentation	Even though this tool is quite recent, there are some papers that document this, briefly explain how one can use this tool and mention some case studies where this tool was tested such as the case of the Belgian coast.
Can it be used with other tools	This tool can be used for better planning and management and can be used with other tools such as certain tools in GIS that can help merge these data and one can then produce queries
Can it be modified	This tool can be modified as the user can add, delete and modify the script according to his/her case study.
Can it be expanded or improved	Not applicable
Does it require certain skills	From experience, a person would require basic knowledge of excel, R script as well as basic knowledge on ArcMap or any open source GIS.
Does it require a certain operating system	In principle, it can work in any computer able to run the appropriate version of R GUI.

Does it require certain libraries (i.e. in Linux)	This tool better works on Windows OS as some programs such as ESRI Arcgis is not fully supported with Mac OS and Linux OS
Does it accept standard data formats	Data are required in formats that can be considered as standards, like ArcGIS shapefiles. Otherwise, the user can opt to use an open source GIS. In order to be able to run the script, the data has to be standardised especially with regards to the coordinates (the script only works with latitude and longitude) and the sample size so that results will comply. Also, field numbers are needed to differentiate rows.
Did it do what you expected/needed for your case study	<p>This tool was used for the Maltese sub case study using the GSA 15 as a boundary and the MEDITS data from 2002 – 2011 (excluding the 2005 data). The grid cell was divided 10km by 10km. This is the first time that the Fisheries Department used this method in the Maltese Islands and it showed very interesting results even though not all the questions could be answered due to limited or no data. Only the five following questions were answered:</p> <ul style="list-style-type: none"> • High counts of many species • High abundance of certain species • High abundance of rare species • Presence of rare species • High species richness <p>Results showed that there is a high biological valuation in the North Eastern part of Malta, whereas there is a very low to low biological valuation to the South Western part. These types of results are very useful for Malta for better management and planning with regards to the high biological data such as closed season, or fishing restricted zone.</p>

SeaTrim	
Case Study	Strait of Sicily
Type	User friendly database programme for data collection, processing and management
Description	<p>The SeaTrim (Software for the Exploratory Analysis of Trawl Information in the Mediterranean) software was conceived with the aim of allowing the efficient recording, managing and analysis of data from experimental bottom-trawl surveys. The format of the MEDITS (Mediterranean Trawl Surveys) program has been selected as the reference.</p> <p>In particular, starting from data on raw catch (nominal local abundance indexes in weight and number) and on biological parameters (length measurements, sex, macroscopic sexual maturity, condition evaluations, etc.), a flow of integrated routines (input and check procedures, import and export, validation and exploratory analyses which range from abundance to biological aspects such as median length, size at maturity, length structure, etc.) can be constructed and utilized also by non- specialists. SeaTrim allows some simple preliminary spatial representation of the data too.</p>
Is it accurate	The tool is quite accurate and credible in terms of the results being produced since all input data are checked for input errors, anomalous measurements and inconsistent records. Moreover, all the implemented analysis methods are statistically valid and widely used in fishery science
Is it relevant to the question posed	Yes
Is the tool transparent	Yes
Is the tool well validated	Yes
Is the tool generic	No
Has it good documentation	SeaTrim is well documented. It has been organized in a hard-printed general manual and an enclosed CD with the software, the corresponding installation procedure, and three related annexes.
Can it be used with other tools	SeaTrim allows to export specific data sets easily usable by other software. In addition, data (from scientific trawl surveys) may be imported from external sources.
Can it be modified	Yes - It is organized as a flow of specific routines which can be modified and improved.
Can it be expanded or improved	Yes - routines can be added which perform new kind of

	data analysis.
Does it require certain skills	No, the software does not require particular skills and only few days are needed to become practical.
Does it require a certain operating system	Windows 98 or successive versions
Does it require certain libraries (i.e. in Linux)	No
Does it accept standard data formats	The data format of the International Trawl Surveys in the Mediterranean (MEDITS) was set as the basic reference interface
Did it do what you expected/needed for your case study	Yes, SeaTrim provided the information layers needed to feed the Biological Valuation Tool, applied for the aims of the CS.

ArcGIS	
Case Study	Strait of Sicily
Type	Generic tool for spatial analysis, data visualization and mapping
Description	ArcGIS is a platform for working with maps and geographic information. It allows to view, manage, analyse, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. It is used by universities, industry, government, and NGOs around the globe.
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	Yes
Is the tool well validated	Yes
Is the tool generic	Yes, however applications may be developed to support specific tasks and activities
Has it good documentation	Yes, the software is provided with a rich library of users guides and GIS tutorials as well as a Web-based Help documentation.
Can it be used with other tools	Yes
Can it be modified	No.
Can it be expanded or improved	Yes, developers can add applications using a choice of languages. Plenty of ready-to-use script and extensions provided by ESRI, or the thousands of GIS users, agencies and organizations worldwide, can be found on the web.
Does it require certain skills	Yes, but numerous opportunities exist to learn GIS technology skills
Does it require a certain operating system	Several platforms are supported
Does it require certain libraries (i.e. in Linux)	Yes, depending on the OS
Does it accept standard data formats	Yes, ArcGIS supports a number of data formats. It is possible to add, work with, and share data files such as CSV, XLS, TXT, KML, WMS, Shapefiles, ERDAS IMAGINE raster files, TIFF and Geo TIFF, JPEG, and many more.
Did it do what you expected/needed for your case study	Yes, ArcGIS allowed to synthesize data from multiple sources and create new geographic layers for the aims of the case study.

VMSbase	
Case Study	Strait of Sicily
Type	Data processing and management, Visualization and mapping
Description	Software platform to import, process, manage, and combine Vessel Monitoring System (VMS) and Logbook data. Useful to evaluate and map fishing effort with a high level of spatio-temporal detail and fine description of effort type
Is it accurate	The tool is as accurate as the information at hand used to feed the software, that is VMS and Logbook data.
Is it relevant to the question posed	The tool is highly relevant for monitoring spatial patterns of fishing effort.
Is the tool transparent	Yes, the tool is fully transparent as its code is open (R environment)
Is the tool well validated	The tool is at its first (alpha) release, so no external tests and feedback provided by users are available
Is the tool generic	No, It is explicitly conceived to process VMS and Logbook data
Has it good documentation	Yes, the tool has documentation on how to use it, following the standard for R packages
Can it be used with other tools	Yes, its outputs can feed GIS tools for further spatial analysis
Can it be modified	Yes, the tool can be modified and new routines implemented since users have full access to code
Can it be expanded or improved	Yes (see previous point)
Does it require certain skills	Yes, a basic level of expertise on R use
Does it require a certain operating system	No, the software runs on Windows, Linux and MacOS platform
Does it require certain libraries (i.e. in Linux)	Yes, the tool depends on a series of other R packages
Does it accept standard data formats	The tool does not require specific data formats. However, ArcGIS maps can be loaded
Did it do what you expected/needed for your case study	Yes, VMSbase provided the spatial information needed to quantify pressure and impact on the ecosystem of the most relevant human activity (trawl fishing) in the case study.

Small Scale Coastal Fisheries Pressure (SmaSCoFiP)	
Case Study	Ionian Archipelago
Type	Fisheries data analysis methodology
Description	The SmaSCoFiP is a methodology developed by Kavadas <i>et al.</i> (unpublished, it was first implemented in the Greek MESMA Framework run) that is useful for the assessment of the fishing pressure of the small scale coastal fishing boats. Due to the lack of information regarding the spatial distribution of coastal fisheries, this methodology is based on combination of geographical data and a Multi-Criteria Decision Analysis process, taking into account various evaluation criteria referring to the suitability of certain areas for coastal fisheries (e.g. bathymetry, distance from coastline, environmental conditions, conflicts with medium scale fisheries, e.t.c.) and the index of registered vessels in the study area's ports.
Is it accurate	This method is considered to provide estimations of moderate accuracy of a variable that cannot be assessed in any other way. It is totally relevant to the question posed as it has been developed for this specifically. The estimation process is transparent in its nature. The credibility of the method has not been assessed, and validation is very hard to achieve. The methodology steps can be considered generic for Mediterranean countries whose coastal fishery fleet has the same characteristics, but small differences might have to be implemented in the steps to achieve better relevance.
Is it relevant to the question posed	
Is the tool transparent	
Is the tool well validated	
Is the tool generic	
Has it good documentation	Documentation for the application of the methodology does not cover all steps of it in detail. It refers to the mindset behind the creation of it, and states out the variables that are taken into consideration, but does not go step by step into explaining how the actual data have to be analysed. The final step of implementation in a GIS system and the subsequent visualization is excluded from the description.
Can it be used with other tools	As it aims to provide advice on how one could derive coastal fisheries pressure data in countries where there is no other way of formal assessment, the methodology is open to modification to implement regional fishing and other local regulations, as well as other parameters that may be important in other areas and can be further improved in terms of standardizing/automating analysis and visualization.
Can it be modified	
Can it be expanded or improved	
Does it require certain skills	Basic GIS fluency is required both for analysing the

Does it require a certain operating system	data and for visualizing the result of the analysis. There is no other specific requirements in terms of OS or libraries, and standard data formats are being used throughout the process of its application.
Does it require certain libraries (i.e. in Linux)	
Does it accept standard data formats	
Did it do what you expected/needed for your case study	SmaSCoFiP was successfully used in the Greek case study and it provided useful data that were used in conflict analysis within the MESMA Framework

Medium Scale Commercial Fisheries Effort (MeSCoFE)	
Case Study	Ionian Archipelago
Type	Fisheries data analysis methodology
Description	The MeSCoFE is a methodology described by Kavadas and Maina (2011) that is useful for the assessment of the fishing effort of trawlers and purse seiners. It is based on analysis of the raw Vessel Monitoring System (VMS) signal of medium scale fishing boats, classifying their activity in three categories, i.e. "fishing", "streaming" and "mooring", with the scope of assessing the actual area fished by each boat as well as their fishing effort (using the actual fishing duration of every boat of known size, tonnage and horse-power).
Is it accurate	This method is considered as the most accurate remote assessment of the actual fishing effort of each fishing vessel. It is relevant to the question posed as it has been developed for this specifically. Transparency is an issue, as VMS data are not freely accessible to the public and cannot be shared with others, since they have been characterized as confidential by the relevant Ministry regulating fisheries. The credibility of the method has not been assessed yet, but validation can be achieved with experiments. The methodology can be considered generic for Mediterranean countries that are using the VMS system for medium and large scale fisheries surveillance but adaptation might be required for its application in other water bodies.
Is it relevant to the question posed	
Is the tool transparent	
Is the tool well validated	
Is the tool generic	
Has it good documentation	Documentation for the application of the methodology does not cover all steps of it in detail. It refers to the mindset behind the creation of it, but does not go step by step into explaining how the actual data have to be analysed. The final step of implementation in a GIS system and the subsequent visualization is excluded from the description.
Can it be used with other tools	As it aims to provide advice on how one could derive fishing effort data from VMS, the methodology is open to modification to implement regional fishing regulations and can be further improved in terms of standardizing/automating analysis and visualization.
Can it be modified	
Can it be expanded or improved	
Does it require certain skills	Basic GIS fluency is required both for analysing the raw VMS data and for visualizing the result of the
Does it require a certain operating system	

Does it require certain libraries (i.e. in Linux)	analysis. There is no other specific requirements in terms of OS or libraries, and standard data formats are being used throughout the process of its application.
Does it accept standard data formats	
Did it do what you expected/needed for your case study	MeSCoFE was successfully used in the Greek case study and it provided useful data that were used in conflict analysis within the MESMA Framework.

ArcGIS 10.1 with the Spatial Analyst Extension	
Sub Case Study [Case Study]	Skaggerak/Dogger Bank [Southern North Sea]
Type	Mapping and spatial analysis
Description	ArcGIS is a stand-alone software package from the software company ESRI. It is a rather expensive tool, but it has almost endless possibilities for applications in terms of geographical analysis.
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	The processes that are used in the software are explained extensively in the help files, with relevant references
Is the tool well validated	Yes. Very much. It is a commercial software product, the company has 3000 employees in the US alone, so there is a big effort behind the software and it is extensively tested, also by the large user community.
Is the tool generic	ArcGIS is only certified to run on the Windows operating system
Has it good documentation	Yes, there is a lot of documentation for ArcGIS. White papers, online help, user forums and so forth.
Can it be used with other tools	There are a lot of extra tools that can be downloaded. The tools are both developed by commercial companies, universities or others from the user community. The format of the used files is quite generic, so you can switch back and forth between ArcGIS and other tools.
Can it be modified	There are different possibilities to modify the program, e.g. VB and python.
Can it be expanded or improved	Same as above
Does it require certain skills	You need to know how to operate ArcGIS and everyday windows usage skills.
Does it require a certain operating system	Yes, Windows
Does it require certain libraries (i.e. in Linux)	Need to have the .NET framework installed
Does it accept standard data formats	Yes, the ArcGIS shapefile format is used by many different programs. You can use standard data formats such as textfiles, excel files, netCDF files and so forth to get data into the software. There is also an interoperability extension that makes it possible to import a large number of formats from other programs.

Did it do what you expected/needed for your case study	Yes, it did everything perfectly. The program can do so much more, it might be overkill for someone who does not have the software already installed and it requires some effort to get used to.

SPAM (Sandeel Population Analysis Model)	
Sub Case Study [Case Study]	Skaggearak/Dogger Bank [Southern North Sea]
Type	Scenario testing tool
Description	<p>SPAM is a spatial explicit process-oriented scenario simulation tool to study the influence of various anthropogenic impacts, as well as environmental and climate changes on sandeel stocks. Sandeel stocks, being mid-trophic in the ecosystem, are sensitive ecosystem indicators. The model has been used in the following contexts:</p> <ul style="list-style-type: none"> • Explore ecological consequences of management policy options on sandeel stocks; • Analyze impact and placement of marine protected areas • Model the effect of anthropogenic/environmental/climate factors on habitat connectivity • Provide scientific basis for pressure indicator evaluation. <p>The model features:</p> <ul style="list-style-type: none"> • Spatially resolved population dynamics based on a sandeel life cycle process model using a high resolution map of potential sandeel habitats • Spatially resolved recruitment processes based on habitat connectivity, calculated from operational hydrodynamical data and individual-based models of sandeel eggs/larvae • Flexible input of spatially resolved impact factors on local population and recruitment processes.
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	Yes
Is the tool well validated	Yes – As usual, the ecosystem state is under-sampled by observations, but the the tool is validated against available stock data, including ICES stock assessment applied as pseudo observations.
Is the tool generic	Yes, the tools can make single-stock impact assessment for other sedentary stocks, if biological parameters for these stocks are supplied
Has it good documentation	Yes – the model is published in several papers and there is a lot of technical documentation in the

	model code
Can it be used with other tools	Yes
Can it be modified	Yes. The code is written object-oriented Python. Code and class structure is relatively simple and transparent and documented in the code.
Can it be expanded or improved	Yes, see remarks above
Does it require certain skills	Modification requires elemental programming skills in the language Python
Does it require a certain operating system	No – it should run on all major platforms (Linux/Mac/MS).
Does it require certain libraries (i.e. in Linux)	Python 2+ and Numpy. This should be available on all major platforms (Linux/Mac/MS).
Does it accept standard data formats	Not applicable
Did it do what you expected/needed for your case study	Definitely so.

SLAM (Sandeel Larval Analysis Model)	
Sub Case Study [Case Study]	Skaggerak/Dogger Bank [Southern North Sea]
Type	Connectivity generation tool
Description	SLAM refers to a particular parameterization of the generic individual-based modelling framework IBMlib, applied to assess marine habitat connectivity. The model has been used for many species in many regions to predict and analyse recruitment variability. Eggs/larvae/juvenile/adults may be modelled. To predict the dynamics of a representative set of eggs/larvae/juvenile/adults the framework solves ordinary/stochastic differential equations, ranging from simple to highly complex, for model state variables. Model state variables are position and condition variables for each member of an ensemble of biological particles.
Is it accurate	Yes
Is it relevant to the question posed	Yes
Is the tool transparent	Yes.
Is the tool well validated	Yes. IBMlib is methodologically well-tested. SLAM is validated against available biological data.
Is the tool generic	Yes, IBMlib is generic, whereas the SLAM parameterisation is particular for the sandeel.
Has it good documentation	Yes – IBMlib is accompanied by a user/programming manual, the model is published in several papers and there is a lot of technical documentation in the model code as well as a developers Wiki.
Can it be used with other tools	Yes
Can it be modified	Yes. The code is written object-oriented in Fortran90 to achieve optimal numerical performance and transparent code structure.
Can it be expanded or improved	Yes
Does it require certain skills	Modification requires moderate programming skills in the language Fortran90
Does it require a certain operating system	No – it should run on all major platforms (Linux/Mac/MS). Installation on MS may require some work, because code compilation is currently facilitated by gmake, which may have some issues on MS.
Does it require certain libraries (i.e. in Linux)	For some input data sets, the netCDF library may be needed, but the code is self-contained. Code compilation is currently facilitated by gmake.

Does it accept standard data formats	Not applicable
Did it do what you expected/needed for your case study	Definitely so.

HELCOM Chemical status tool (CHASE2.0)	
Case Study	Baltic Sea and Southern North Sea
Type	Assessment tool which integrates data on hazardous substances in sediments and biota, as well as biological effects indicators.
Description	<p>The tool was developed specifically for establishing a baseline for the implementation of the Baltic Sea Action Plan (BSAP) and to meet the requirements of the Marine Strategy Framework Directive (MSFD) to establish good environmental status of marine waters.</p> <p>The HELCOM Chemical Status Assessment Tool (CHASE 2.0) integrates data on hazardous substances in sediments and biota as well as well-known biological effects indicators. The tool is based on a substance specific calculation of the 'contamination ratio' being the ratio between monitoring of concentration and the environmental assessment criteria. These ratios are combined within matrices water, sediment, biota and biological effects using a 'one out – all out principle'. Values < 1.0 indicate areas unaffected by hazardous substances, whilst values > 1.0 indicates area affected by hazardous substances.</p> <p>The integrated assessment provides an overall status for the assessed site. The status is assessed according to five classes: bad, poor, moderate, good and high. The classifications of bad, poor and moderate status indicate an environmental state which is "disturbed by hazardous substances". The classifications of good and high status indicate an environmental state "undisturbed by hazardous substances". Thus, this classification system is essentially binomial (undisturbed/disturbed) and is based on the threshold value.</p>
Is it accurate	CHASE is a fairly simple tool and the underlying calculations are transparent and easy to verify. However, the calculated status will depend on the input data and it requires expert judgment to select environmental assessment criteria and evaluate the quality of monitoring data. The tool was specifically developed to carry out this type of assessment and is not generic.
Is it relevant to the question posed	
Is the tool transparent	
Is the tool well validated	
Is the tool generic	
Has it good documentation	

	<p><i>Hazardous substances in the Baltic Sea - An integrated thematic assessment of hazardous substances in the Baltic Sea</i> (Baltic Sea Environment Proceedings No. 120B, HELCOM 2010). The spreadsheet itself is fairly easy to use and should not need any extensive documentation.</p>
Can it be used with other tools	<p>CHASE carries out one step in the assessment process, and other tools will have to be used for visualization on maps etc. The model itself is programmed in VBA and is easy to modify, expand or improve. With some programming skills it can be linked both to databases and GIS tools.</p>
Can it be modified	
Can it be expanded or improved	
Does it require certain skills	<p>CHASE is implemented as an Excel spreadsheet and do not require any programming or technical skills to be used. Data has to be typed into the spreadsheet and the results copied out for use in other programs.</p>
Does it require a certain operating system	
Does it require certain libraries (i.e. in Linux)	
Does it accept standard data formats	
Did it do what you expected/needed for your case study	<p>The tool was developed and used by HELCOM before the case studies started. The current description is based on an using the tool in the North Sea, and a comparison between the results from the Baltic Sea and the North Sea</p>

4 REFERENCES

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