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Deliverable D.T3.7.1 First versions of case options maps

Workflow for optimizing sea use with priority maps

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SYKE.FI/PROJECTS/PLAN4BLUE

SUMMARY

The maps presented in this report have been produced for illustration purposes only. They are partly fictional and do not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project.

This report describes a preliminary workflow for the Maritime Spatial Planning process from the spatial analysis perspective. The workflow represents the views of the GIS experts of the Plan4Blue project and is based on experiences from the project and scientific literature. The cross-border and cross-sectoral project team of the Plan4Blue project and involved experts have influenced the development and refining of this workflow. The description of the workflow is illustrated with partly fictional maps from the Plan4Blue project area, to exemplify the types of ideal spatial data and ideal map presentations for Maritime Spatial Planning.

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INTRODUCTION

This report aims at facilitating Maritime Spatial Planning (MSP) from the spatial analysis perspective by describing a workflow for analysing the spatial interactions of marine activities and optimizing sea use. It describes the steps from setting the planning aims, through identification of spatial data requirements and collection of ideal data, to analysing priority areas, spatial interactions of activities and optimizing sea use to conciliate multiple objectives. In addition, the report highlights the division of work and the roles of the states and EU, planners and scientists in the process.

The need for clear and unambiguous spatial data and maps for the basis of the MSP process is urgent. At the same time, making justified and well-documented map representations is laborious and relies on the quality of input data. One of the major challenges of the MSP process is access to good quality data (Calado et al. 2010). Maps communicate strong visual messages and releasing inappropriate map presentations, accompanied by insufficient documentation, may lead to biased conclusions in the decision-making process. For example, maps may be used without considering the associated disclaimers on the origin and resolution of the input data and they could presented out of their context. This highlights the need for caution in releasing maps representing intermediate planning stages and project results. The MSP development should prioritize perfecting the spatial analysis and sea use optimization process, as well as the acquisition of high-quality input data.

Scientists and planners need to make a clear division of responsibility in the decision-making process. This requires that scientists are given resources to work with good-quality data. The scientists are responsible for the quality and documentation of the data and maps. At the same time, they need to be aware of that drawing maps is subjective and involves making decisions. Planners are responsible for using the information handed to them in the appropriate way, respecting the documentation of the data and maps.

The description of the workflow for optimizing sea use with priority maps is illustrated with the three Plan4Blue cases, “Natura 2000”, “Fishery” and “Marine traffic”, which represent the activities or sea uses that need to be conciliated in the MSP process. **The maps presented in this report have been produced for illustration purposes only. They are partly fictional and do not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project.**

The workflow consists of four stages, each involving appropriate actors (Figure 1):

1. Producing priority maps for activities

- Guiding and funding MSP (states and EU)
- Determining activities (planners)
- Identifying data requirements, including content and quality criteria (scientists)
- Commissioning data and channelling funding (planners)
- Producing data (scientists)
- Determining priority areas for activities: *priority maps* (scientists)

2. Identifying the interactions of activities

- Conflicts, synergies, neutral relationship (planners)

3. Identifying the spatial interactions of activities

- Identifying the conflict areas (other activities cannot exist in the same area with the priority activity) (scientists)
- Identifying the overlap areas (other activities are limited by the priority activity) (scientists)

4. Optimizing sea use

- Utilizing spatial optimization tools (scientists)
- Allocate sea space for activities (planners)
- Execute plans, adapt legislation (states and EU)

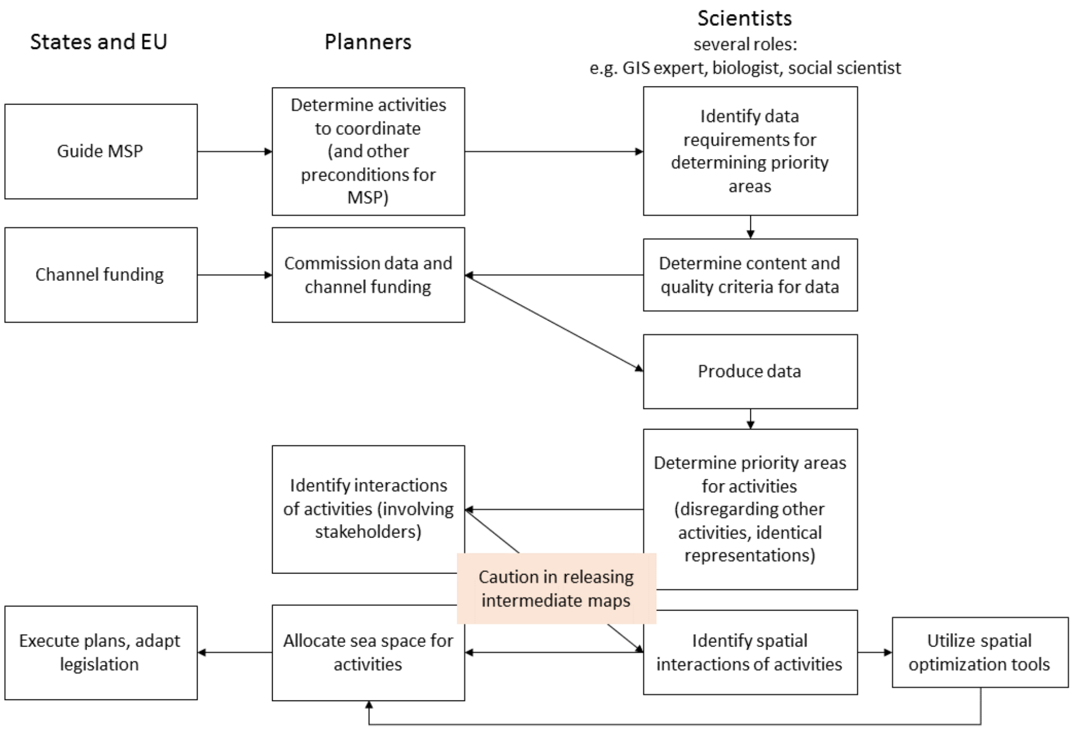


Figure 1. Workflow for optimizing sea use with priority maps.

1. PRIORITY MAPS FOR ACTIVITIES

Priority maps of activities represent the most recommendable areas for the activities. Recommended areas are identified without considering the activity's interactions with other activities. For example, the recommended areas for conservation are based on nature values only and the potentially overlapping requirements of marine traffic (e.g. distribution of existing ship routes) are not considered at this stage. The priority surfaces may be classified into binomial "prioritized" or "not prioritized" areas, into several classes (e.g. "highly recommended" > "recommended" > "potential" > "not recommended") or apply a continuous scale (e.g. from 0 to 1). To facilitate further steps in the sea use optimization process, identical representations of the priority surfaces of all activities are highly encouraged, for example by using the same classification and identical spatial grid.

1.1. Determining activities

The planners determine the framework of the MSP process, including the activities considered in the allocation of sea use and the scale and other preconditions of the planning (Figure 1). This report identifies seven activities typically considered in MSP, including nature conservation, (professional) fishery, (merchant) marine traffic, defence, energy production, aquaculture and leisure. In this report, energy is considered as energy production, excluding power lines. In addition to fish farming, the analysis of aquaculture includes the emerging farming of molluscs, crustaceans and aquatic plants. Leisure consists of tourism and leisure fishing.

1.2. Identifying data requirements

Essential input data for outlining the priority areas for each activity have to be identified with care by scientists (Figure 1). Typically, the decision-making process is complicated by the large and expanding amount of data, most of them irrelevant or sub-optimal from quality, scale or content perspectives. The input data have to be identified based on two main criteria; relevancy and the level of processing. **It has to be accepted that the ideal**

data may not exist yet and that it needs to be produced in order to make well-informed decisions on sea use. It is therefore advisable to identify the essential data types from the basis of the planning objectives, instead of letting existing data set the scene for the MSP process.

The relevancy of all input data has to be evaluated in terms of content, and the spatial and temporal coverage and resolution of the data. For example, when a synthesis of nature values is considered to be essential background data for outlining priority areas for nature conservation, the calculation of the "nature values" data should be based on appropriate selection of taxa and include all types of nature values (incl. biological, geological and geomorphological). The input data should cover the entire planning area, with appropriate spatial and temporal (e.g. seasons) resolutions throughout the area, i.e. without a need to make extensive assumptions in the spatial modelling process.

When the input data are released for planners, stakeholders and the general public, they should be interpreted (processed) by the scientists into **meaningful values**. In other words, the visualizations should reflect the importance of features in the MSP context. For example, the relative importance of ship routes in the Baltic Sea scale is more useful for the general public than the number of ships sailing through the routes per day. Nevertheless, the input data should be well documented for the users of the derived priority maps.

Two types of essential input data can be identified. First, data indicating the **current spatial extent** of an activity are needed. Second, the process requires data that can be used to **identify optimal or potential areas** for the activities. These data may include, for example, the properties of the natural environment, existing human made infrastructure, socio-economic interests or projected impacts of climate change.

For example, nature conservation, marine traffic and defence are allocated in specified areas, outlined according to contemporary knowledge. Established locations reflect the present knowledge about optimal locations for the activities and relocating them may laborious or irrational. However, the present day outlines are not static, and they have to be revised if needed.

Optimal areas for nature conservation may also be identified by examining the natural values without considering the present day establishment of nature conservation areas. Fishery is not strictly restricted to specific areas, but optimal areas may be indirectly examined based on information of the natural environment (e.g. catch per area, estimations of sustainability of stocks, spawning areas) or infrastructure (e.g. locations of fishing harbours).

Locations of the units of aquaculture have been mainly established based on land ownership instead of natural values. However, these locations reflect the optimal locations at the local scale, and investments for necessary infrastructure have already been made. Thus, evaluating the optimal areas for aquaculture requires a holistic approach, including the current situation, infrastructure and natural values. There are no extensive areas used or reserved for energy production, but it has been identified as an emerging industry. Thus, there is an opportunity to influence the distribution of the energy production by for example analysing the wind and wave conditions, bathymetry, natural values and existing infrastructure (e.g. powerlines and cables).

1.3. Producing data

Optimally, producing input data for the priority maps is a **research-lead project**, and the outcomes are documented following scientific principles (Figure 1). The data production is preceded by the first two steps of the workflow, funded by the states and EU and guided by planning objectives. The production of the spatial data may consist of a coherent set of co-operating projects. This ensures that the data are collected by experts from respective fields, and that the methods are comparable. The requirement of comparability includes, for example, the spatial and temporal coverage and resolution of raw data, and the extent, resolution and classification of output spatial data layers and maps. Thus, the optimal outputs of this step are high-quality spatial datasets (Figure 2).

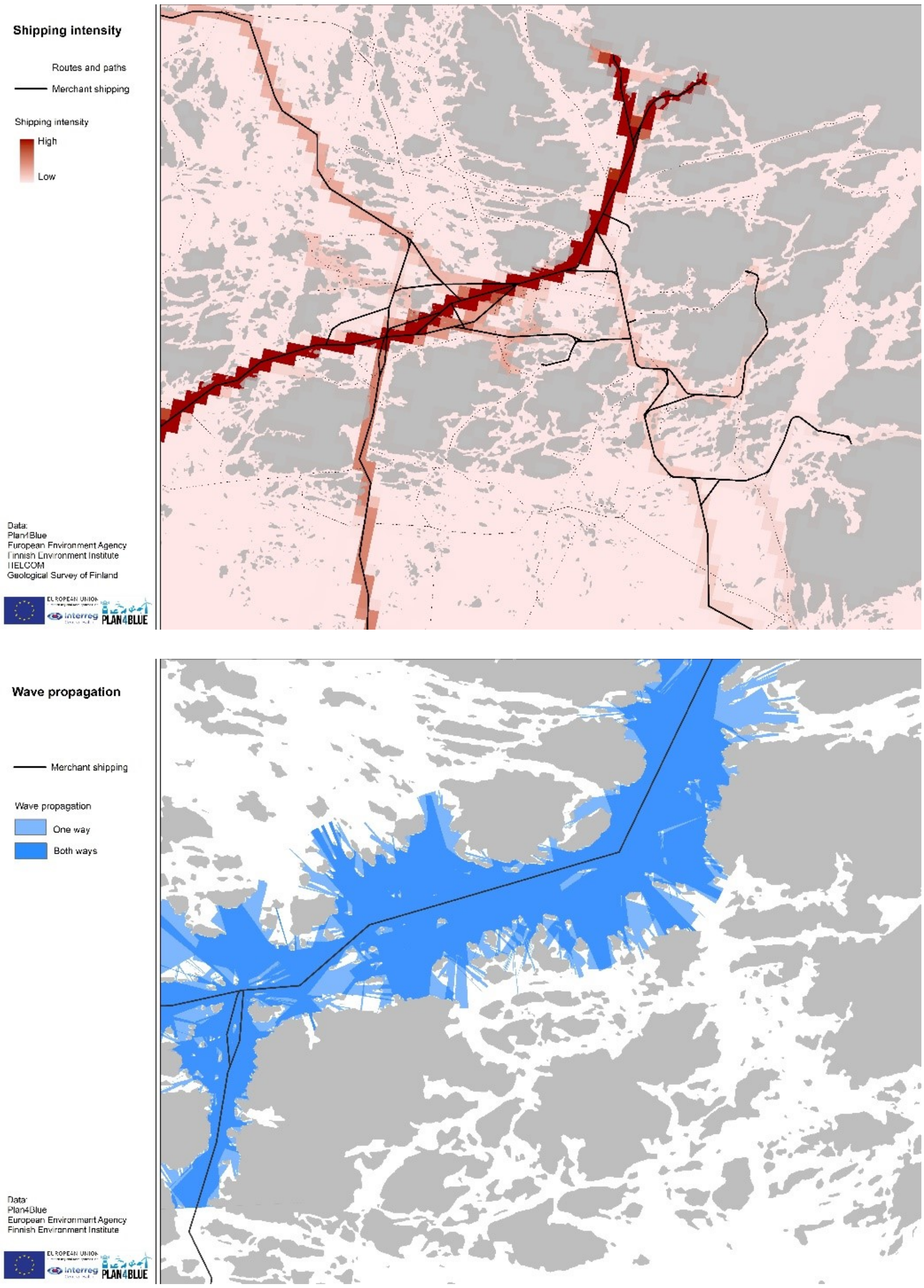


Figure 2. Examples of input datasets for identifying priority maps and their visualization. ***The maps presented in this report have been produced for illustration purposes only. They are partly fictional and do not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project.***

1.4. Determining priority areas for activities: priority maps

Input data are analysed by the scientists and used **to identify priority areas** for each activity, disregarding other (potentially competing) activities (Figure 1). Typically, these areas include the current establishment of the activities and other potential areas for the activity, based on spatial analysis of the input data. Illustrations of these workflows is given in Figure 3. For example, the priority areas for nature conservation may be based on the current nature conservation areas and other potential areas with high nature values. The optimal outputs of this step are high-quality spatial **datasets of priority areas with standard spatial extents and formats** (Figure 4, Figure 5). For example, in the Baltic Sea case, the standard spatial format for the priority and conflicts maps could be the European Environment Agency's indexed rectangular grid with a spatial resolution of 1x1 km (Figure4, Figure 5). The use of a regular and common grid in priority maps and for example in planning options maps is justified for topological reasons. The format of input data is less relevant.

This step of the process is also influenced by subjectivity issues. There are several ways to analyse spatial information and with these choices the analyst influences the outcomes. For example, multiple parameters need to be set when applying even simple spatial analysis methods. The selection of the method and settings should be carefully reviewed and the results evaluated, following strict scientific guidelines. The scientists have to make decisions on visualizing numerical data. The choices of colours, symbols and scales should be appropriate for highlighting essential information. The choices need to be made responsibly and as objectively as possible, since map visualisation is a powerful tool in influencing the message.

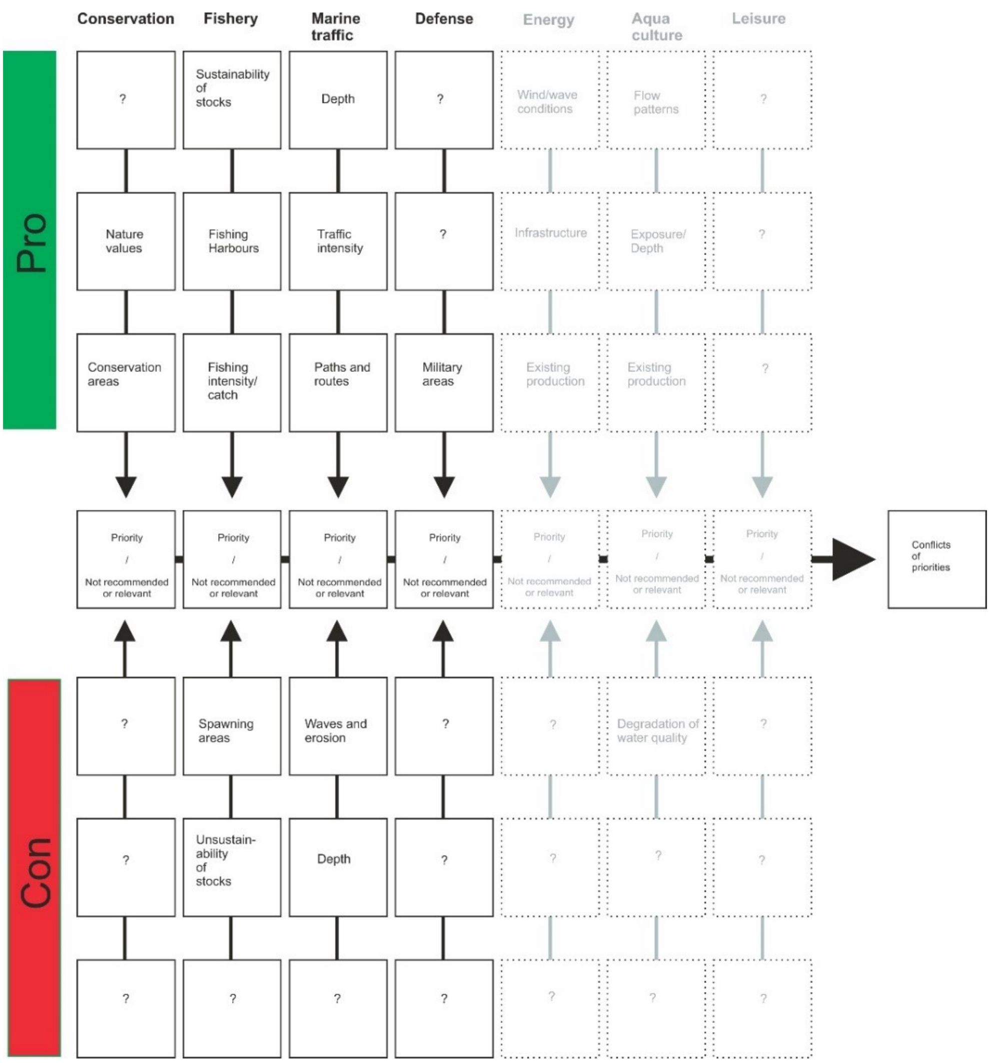
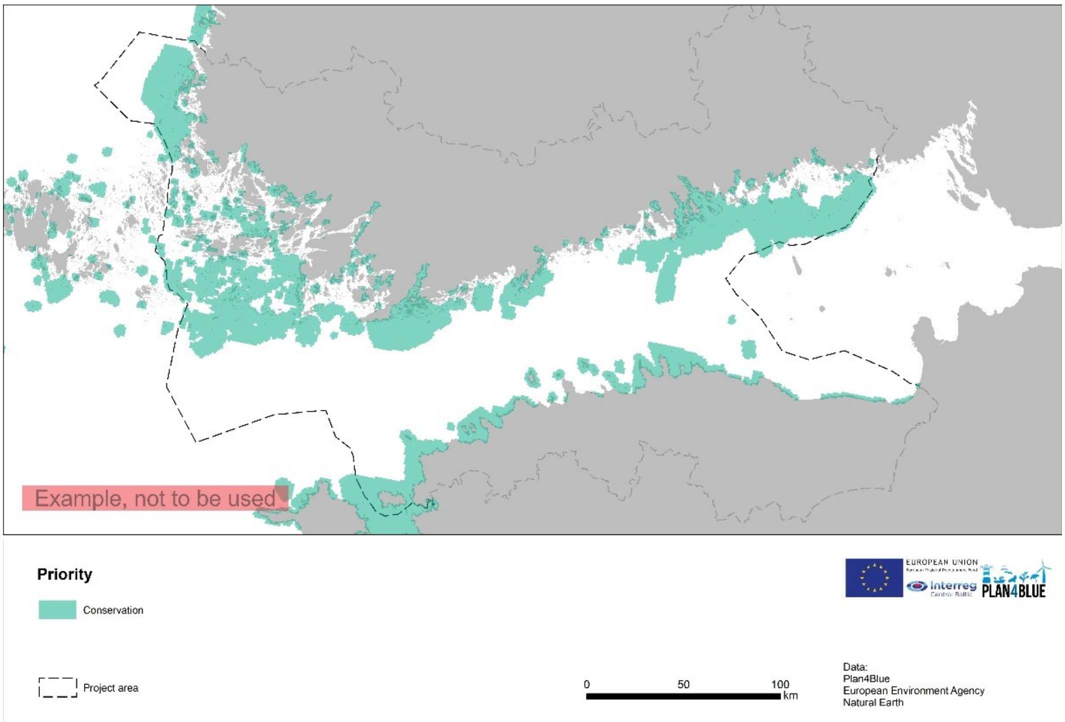


Figure 3. An examples of the process the deriving priority areas for activities from relevant input data. The priority areas are defined without considering the interactions between activities. The priority maps are then overlaid to examine the spatial dimensions of conflicts and synergies of the activities. ***This chart has been produced for illustration purposes only. It is a simplification of the phenomena and does not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project.***

1.5 The Plan4Blue example

As an example, the priority areas for nature conservation were identified as the Natura 2000 sites (for simplicity, other conservation area types were ignored in this example). The existing conservation areas reflect the present view on the distribution of high natural values. The current outlines of Natura 2000 areas formed the basis for the priority map of nature conservation. To account for the potentially important “buffer zone” around the Natura 2000 sites, where other activities should be regulated more strictly, 500-meter buffers around the Natura areas were included in the nature conservation areas.



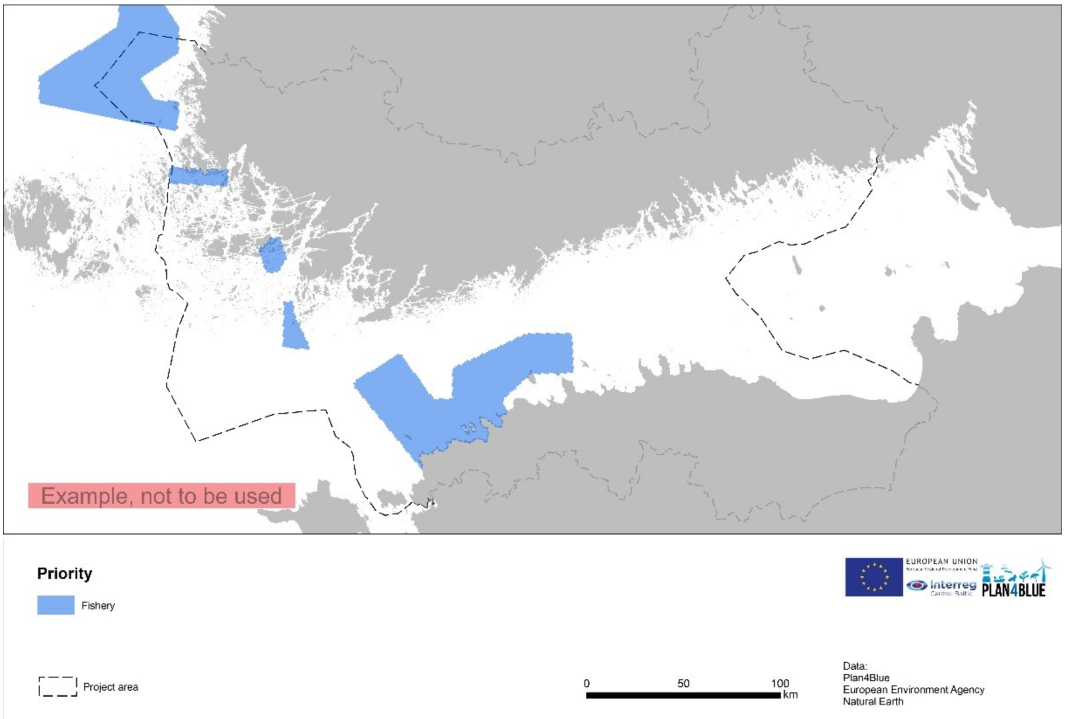
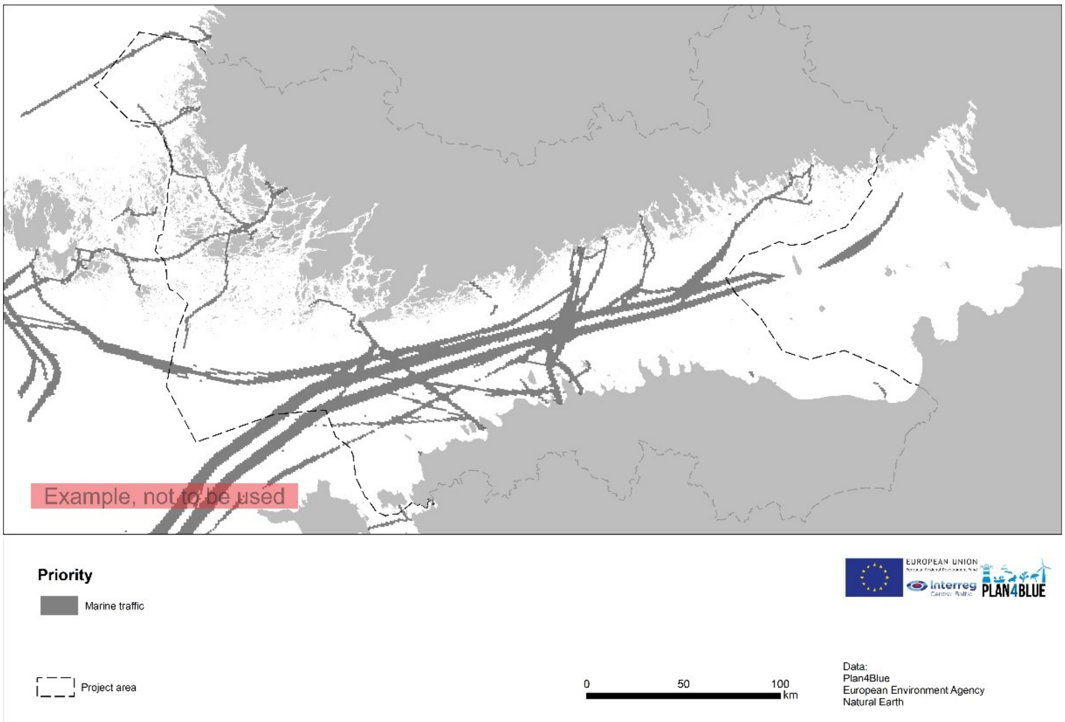


Figure 4. Fictional examples of priority maps. **The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders.**



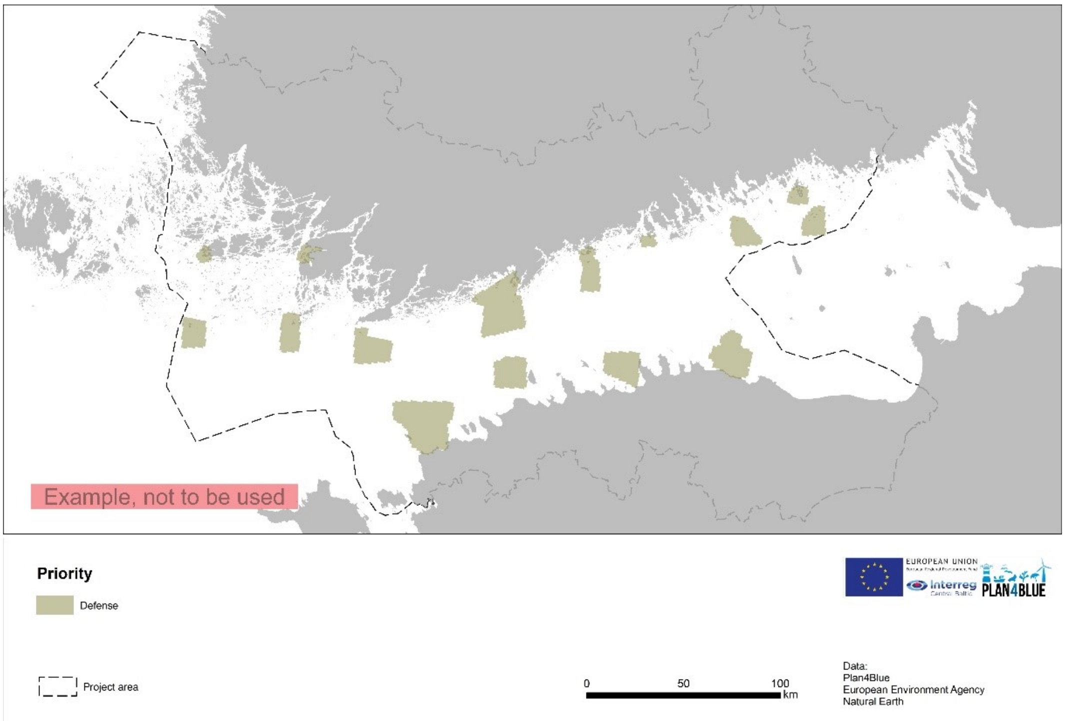


Figure 5. Fictional examples of priority maps. ***The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders.***

Priority areas for fishery were identified based on the current knowledge of important fishing grounds. The important fishing grounds were digitized based on HELCOM data “Fishing effort all gear types”, covering years 2009-2013 (HELCOM maps and data service 2018). The mean for five year period was calculated for gear type “midwater trawl”. Priority areas for marine traffic were identified based on the current shipping density. The distribution of shipping density was based on the HELCOM dataset “2016 all ship type AIS shipping density” (HELCOM maps and data service 2018). Areas where the number of passing ships exceeded 500/yr were identified as the priority areas for marine traffic. Priority areas for defence were based on the public data by the Land Survey of Finland (General map 1:1 M 2017) and the Estonian Land Board (2017). The priority areas presented in this report have been created solely for the purposes of illustrating the described workflow and map types and they are not based on thorough analysis.

2. INTERACTION OF ACTIVITIES

At this stage, planners take charge for the identification of the interactions of activities when competing for the use of sea space. The identification should optimally be done in communication between researchers, planners and stakeholders. The interactions of two co-existing activities may be classified into several categories:

- “Exclusion”: one activity is excluded by the other
- “Competition”: activities are impeded by each other
- “Amensalism”: one activity impedes the other, but is not influenced itself
- “Neutralism”: activities can co-exist without influencing each other
- “Commensalism”: one activity gains from the co-existence, the other is not influenced
- “Mutualism”: both activities gain from the co-existence

For the purposes of this workflow description, three types of activities are considered: “exclusion” where the prioritized activity excludes the other activity, “competition” where the prioritized activity limits the other activity and “neutralism” where the prioritized activity co-exists with the other activity in the same area without influencing each other.

The prioritized activity may also gain from the co-existence with the other activity, e.g. fishery may utilize the infrastructure of aquaculture and vice versa. The interaction isn’t necessarily symmetric. For example, if fishery is prioritized, marine traffic could be allowed in the same area (potentially with limitations). However, if marine traffic is prioritized, fishery may be excluded. Figure 6 illustrates possible two-way interactions between the prioritized activity and other activities.

	PRIORITY						
ACTIVITY	Conservation	Fishery	Marine traffic	Defense	Energy	Aquaculture	Leisure
Conservation		2	2	2			
Fishery	2		1	1			
Marine traffic	2	2		2			
Defense	2	2	2				
Energy							
Aquaculture							
Leisure				Example, not to be used			

Figure 6. Examples of interactions between two co-existing marine activities. The interactions are classified into 1=exclusion, 2=competition and 3=neutralism. ***This chart has been produced for illustration purposes only and it does not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project.***

3. SPATIAL INTERACTION OF ACTIVITIES

3.1. Procedure

The interactions of co-existing activities (Figure 6) are transformed into spatial data by researchers at this stage. When the input layers, the priority maps, have been produced into a standard spatial grid format with identical classifications, standard spatial analysis methods are used to determine the spatial dimensions of the interactions. For example, overlay analyses determine the areas where the prioritized activity would exclude one competing activity, where it will only limit a second activity and where the priority activity will neutrally co-exist with a third activity. This results in a set of clear and self-explanatory interaction maps that can be used in further analyses and to support the decision-making process.

3.2. Example: Fictional interaction maps for the Plan4Blue project

The examples of priority areas (e.g. Figure 4, Figure 5) and the interaction chart (Figure 6) have been produced for illustration purposes only. They are simplifications of the phenomena and do not represent the real situation or established view of the researchers, planners or stakeholders involved in the Plan4Blue project. Therefore, the interaction maps shown are also merely illustrations and should not be used for example for planning purposes. However, the type of the spatial elements are realistic (priority areas of marine traffic form lines, nature conservation and fishery cover large coastal and offshore areas, and military areas regularly shaped polygons), and thus some general observations on the use of the interaction maps can be made.

3.2.1 Marine traffic as the priority

Figure 7 shows examples of interaction maps with marine traffic as the prioritized activity. Potential exclusion of fishery by marine traffic is depicted in subfigure A, and areas where marine traffic limits other activities are shown in subfigure B (Figure 7). These fictional analyses are based on the assumptions that shipping routes run unavoidably through the potential areas of other activities and marine traffic effectively excludes other activities in the immediate vicinity of the routes. Marine traffic has indirect effects in nature conservation, energy production, aquaculture and leisure activities by creating waves and causing erosion even at a certain distance from the shipping routes. The results of the analyses are highly dependent on for example the selection of small ship routes into the shipping priority areas and the adjustment of the “safe distance” around the shipping routes.

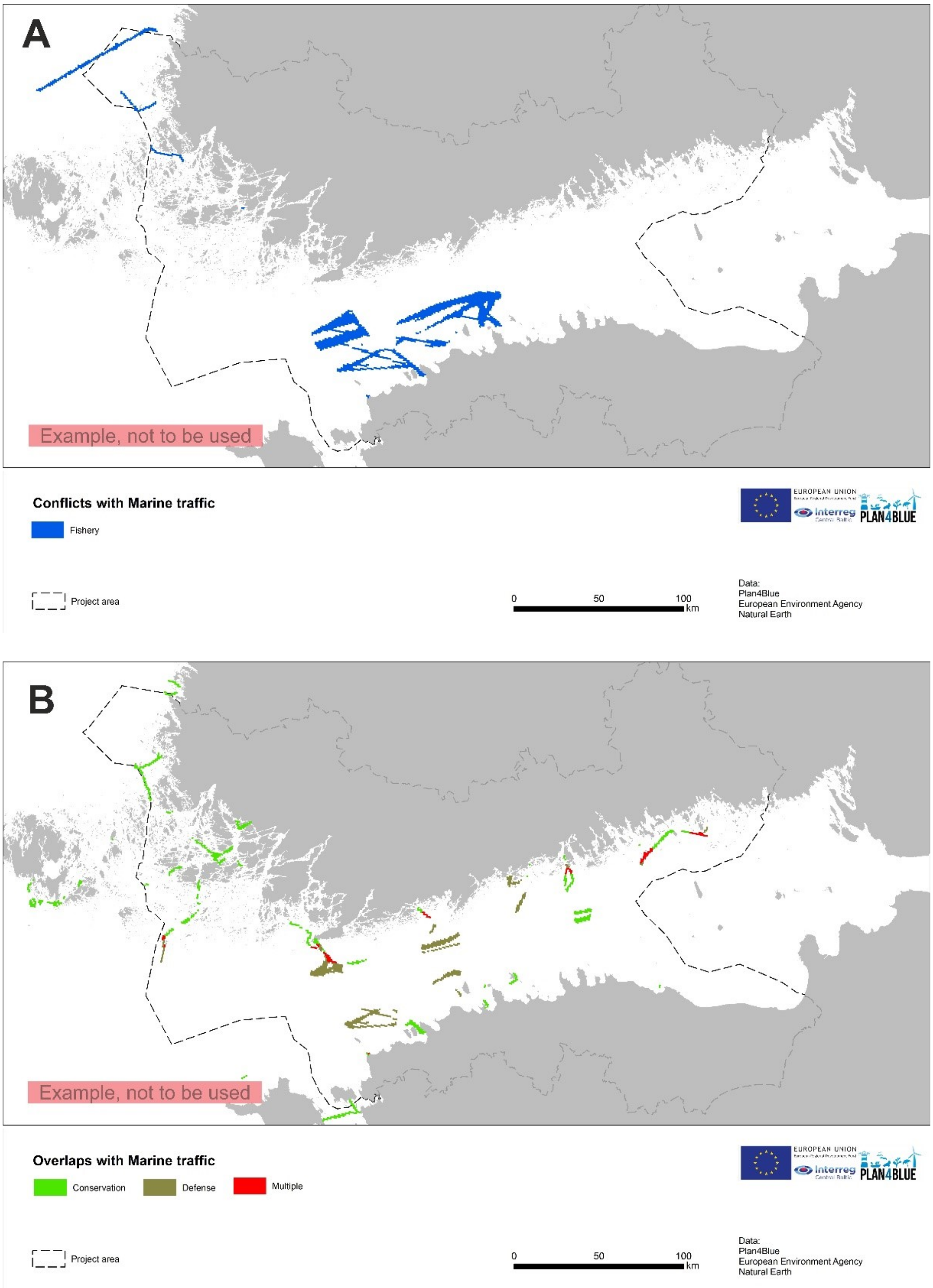


Figure 7. Examples of interaction maps. These maps show the interaction of the prioritized activity "marine traffic" with fishery (exclusion: the other activity must be banned; subfigure A) and three other activities (competition: other activities may be limited; subfigure B). ***The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders.***

3.2.2 Nature conservation as the priority

Figure 8 shows an example of spatial interactions of nature conservation with other activities. The illustrative analyses are based on the assumptions that nature conservation covers large areas near the coast, and depending on the objectives of the conservation action, it usually limits other activities. Since conservation areas are scattered, conflicts with other activities cannot be avoided. The outlines of the interaction areas for conservation are not strict; the activities causing e.g. water quality degradation, wave erosion or noise may have influence on the conservation areas from a distance. The results of the analyses could be focused by examining the nature conservation objectives of each site in relation with the impacts of other activities. For example, energy production, defence and leisure activities may not have conflicts with nature conservation in sites where the objective is biodiversity or geodiversity conservation.

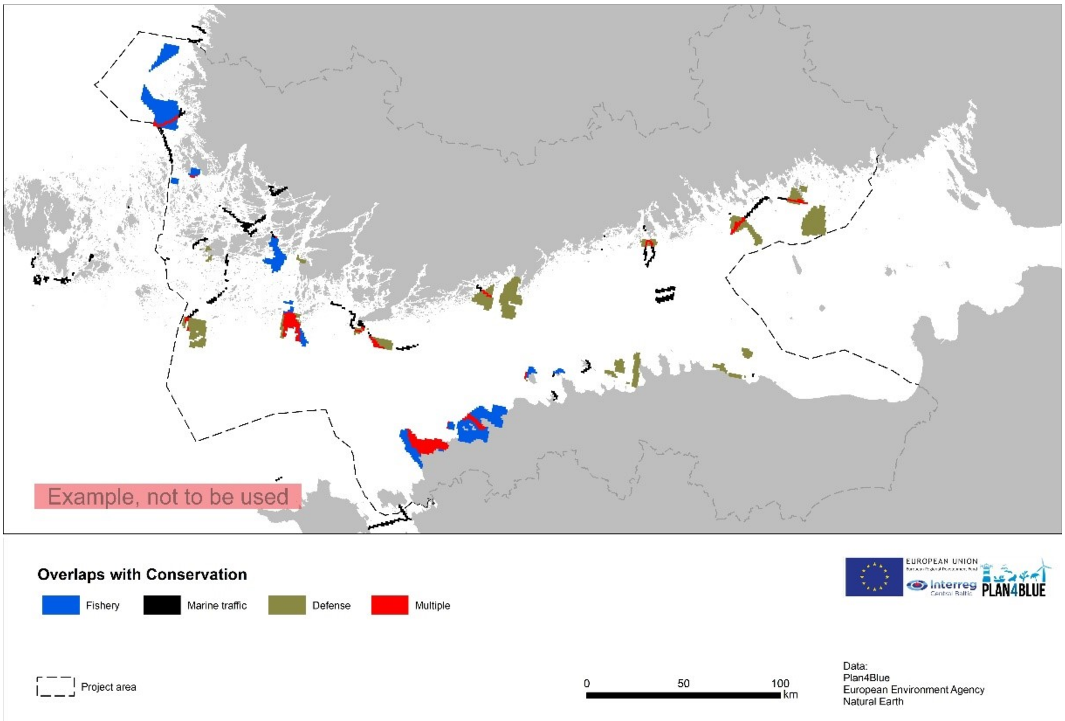


Figure 8. Example of an interaction map. This map shows the interaction of the prioritized activity "nature conservation" with four other activities (competition: other activities may be limited). ***The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders.***

3.2.3 Fishery as the priority

Figure 9 shows an example of the spatial interactions of fishery with other activities. The illustrative analyses are based on following assumptions: the main gear in offshore fishing is midwater trawling. According to AIS data, major fishing grounds are extensive and they are located in the north-western parts of the Estonian coast and on the coastal zone of the northern Archipelago Sea. In principle, fishery may not exclude other activities, but allocating areas solely for fishery may still be justified. Areas dedicated to fisheries would likely cause maritime traffic to move elsewhere, and conservation, defense and energy production should be adjusted not to have mutual interests or overlapping functions in the same area. Aquaculture or leisure activities are typically not influenced by fishery, and in some cases co-existence of these activities may be mutually beneficial.

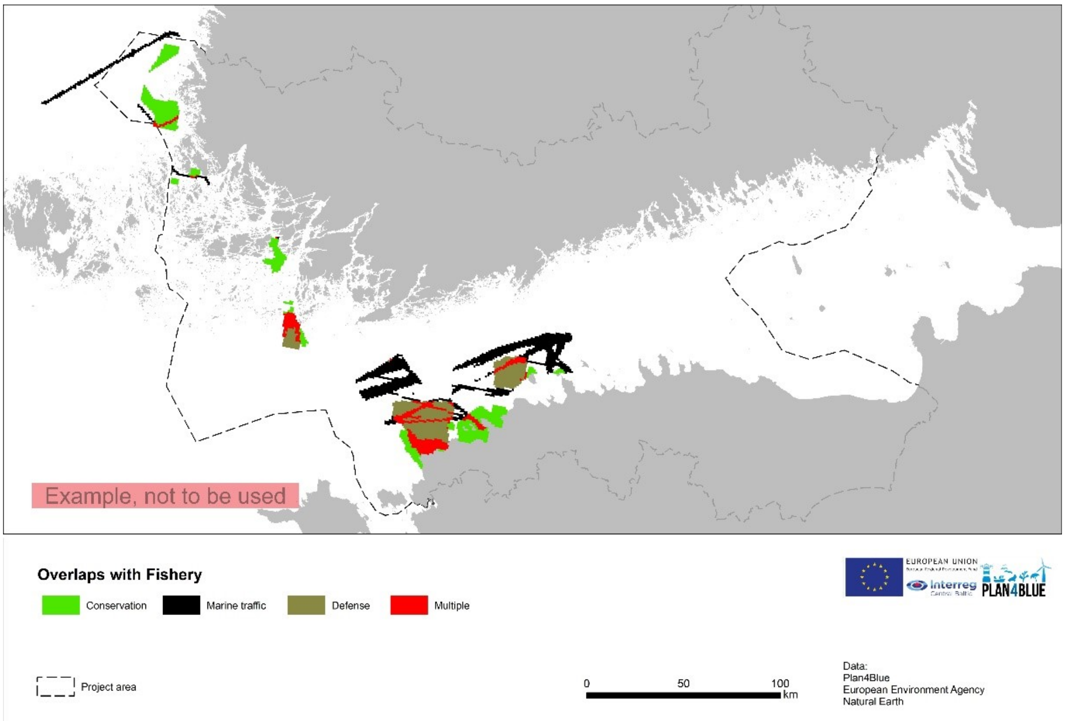


Figure 9. Example of an interaction map. This map shows the interaction of the prioritized activity "fishery" with four other activities (competition: other activities may be limited). ***The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders.***

3.2.4 Defence as the priority

Figure 10 shows an example of the spatial interactions of defence with other activities. The illustrative analyses are based on the following assumptions: Military areas typically form a chain of regularly shaped areas along the coasts of the Gulf of Finland. In this example, defence is considered to be in conflict with fishery. The military areas tend to overlap with nature conservation areas, with neutral or positive effects. The exclusion of other activities in the military areas has increased their nature values over time.

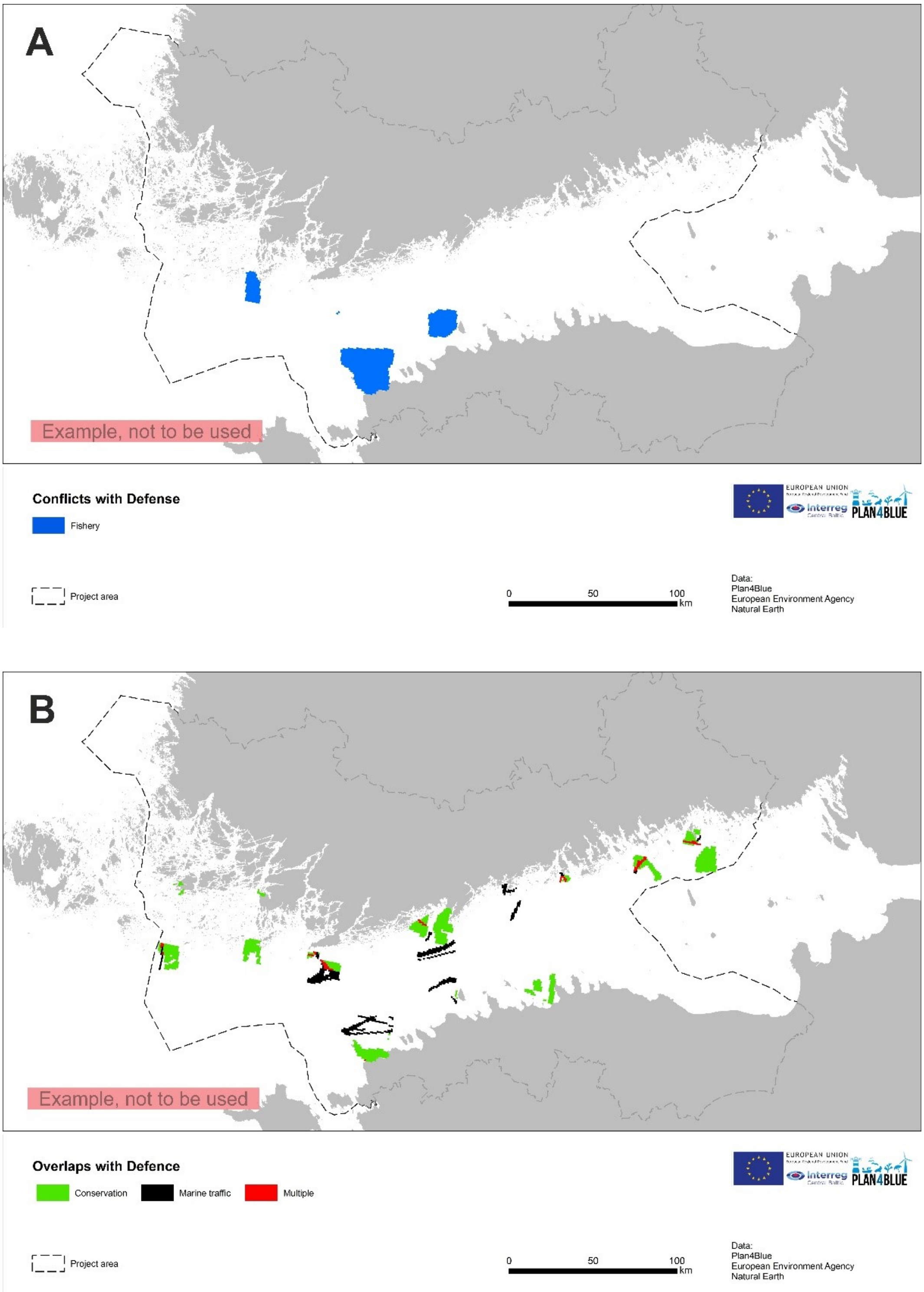


Figure 10. Examples of the interaction of the prioritized activity “defence” with fishery (exclusion: the other activity must be banned; subfigure A) and three other activities (competition with marine traffic and other activities and mutualism with nature conservation; subfigure B). ***The maps represented in this report are partly fictional and they do not represent the real situation or established view of the researchers, planners or stakeholders***

4. OPTIMIZING SEA USE

Optimizing sea use means arranging marine activities spatially in a way that minimizes spatial conflicts of competing activities and maximizes spatial synergies between activities, while maintaining the pressure on the natural environment on a sustainable level. Typically, the optimization is an iterative process, conducted by the planners and stakeholders. Careful pre-processing of the spatial data into meaningful information and harmonious map presentations is the key for successful sea use optimization.

An effective approach for optimizing sea use would be to determine the first versions of planning options based on spatial optimization modelling. It would be based on the clear identification of activities, good-quality input data, harmonious quantitative priority maps, identification of the interactions of activities and the quantitative results of spatial interaction analyses (Figure 1). The most efficient management options are unlikely to be considered, much less adopted, without the use of model-based optimization (Rassweiler et al. 2014). The proposals of optimized sea use resulting from the modelling (under the given preconditions, e.g. smallest continuous area, connectivity or mandatory areas for selected activity) would be the basis for discussions by planners and stakeholders. Scenarios of future development could be examined by making adjustments to the initial priority maps and calculating corresponding interaction maps. Using these and re-adjusted preconditions could then be used in the spatial optimization modelling to view the adjusted results.

Spatial optimization could be performed in practise by utilizing Decision Support Tools (DST). DSTs are software-based intermediaries that provide support to evidence-based decision making process (Rose et al. 2016). DST’s may be used for various stages of the MSP process, but typically they are used for data storage and information transfer and they may have analysis tools incorporated. The aim of the DSTs is to manage and arrange the extensive amount of data, and they aim at helping to undertake the decision making in a more systematic and objective manner (Pınarbaşı et al. 2017).

Most of the web-based DST software have been created as part of MSP projects. They tend to be short-lived after the project ends, but their major purpose is not to offer a durable solution for MSP data management, but to test and demonstrate the concepts, techniques and appropriate contents. Government institutions have produced more stable DSTs since they are able to ensure the maintenance and updates of the technical environment. Despite a various DST’s developed for MSP related tasks, their use in real MSP processes has been limited (Pınarbaşı et al. 2017). This might partly be due to unawareness of the existing DTS’s, but the contents and functionalities of the DST’s may not answer the need of planners.

Overall, the reliability of source data is key to the whole planning process. It is wise not to take shortcuts when preparing the fundamental spatial data for MSP – the possible shortcomings will propagate in the workflow. This leads to distorted information for the decision making at the other end of the process. Compromises are inevitable, but in these cases, the consequences must be managed as well as possible.

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