From silent knowledge to spatial information – mapping blue growth scenarios for maritime spatial planning

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Abstract

Maritime Spatial Planning (MSP) is an effective tool for conciliating human activities and environmental values, building on spatial data and geoinformation technologies. However, socio-economic information is distinctly underrepresented in the rapidly growing supply of spatial information. The spatial distribution of current and future activities and opinions has traditionally been the silent information of scientists, local actors and the public. Moreover, future projections and policies exist in qualitative, non-spatial formats, incompatible with quantitative biophysical spatial data layers. This article aims at promoting the generation and application of spatial socio-economic information for the purposes of MSP. We examine one workflow of converting the socio-economic knowledge of individual experts to spatial data, and further to refined spatial knowledge. We illustrate how participatory mapping, data interpretation and core geocomputing methods may be used to generate data, and discuss the main issues related to their generation and use. The results suggest that participatory mapping can provide valuable data for the MSP process, helping in filling the gap of missing socio-economic information. The process is highly subjective: the presentation of background information, the framing of the questions and the interpretation of the spatial data may have notable influence on the generated information. Furthermore, both the technology of the data collection and applied analysis methods have distinct effects on spatial information and its validity.

Keywords:

Maritime spatial planning

Participatory mapping

Socio-economic mapping

Cross-border

Baltic Sea

1 Introduction

Maritime Spatial Planning (MSP) is an effective tool for building strategies and guiding actions that aim at conciliating human activities and environmental values (European Commission 2014). In the European Union, MSP is formally guided by the Water Framework Directive, the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive (European Commission 2000, 2008, 2014; Oen et al. 2016). MSP is based on a holistic ecosystem approach to marine resources management, implying considerations of environmental, social and economic aspects as part of the decision-making processes (Ehler & Douvere 2009; Ehler 2014; IOC-UNESCO & DG MARE 2017). It is characteristic of spatial planning that stakeholder participation is applied to incorporate local and specialized knowledge (Lebel et al. 2005; Rodríguez et al. 2006; Patel et al. 2007; Bennett et al. 2009).

The MSP process requires diverse spatial information, as well as effective visualization of current activities and planning options on maps. Recent advances in geoinformation technologies have made it possible to conveniently obtain, analyze and visualize large amounts of spatial data. Spatial data and knowledge about the biophysical environment of coastal and marine areas are often quantitative, well represented and easily taken into consideration in the MSP process. However, the socio-economic knowledge representing spatial dimensions of cultural, social and economic activities are of limited availability (St. Martin & Hall-Arber 2008; Klain & Chan 2012; Levine et al. 2015).

Stakeholder participation is an important process in generating the spatial dimensions of socio-economic information in MSP (Pomeroy & Douvere 2008; Reed 2008; Gopnik et al. 2012; Levine et al. 2015; Brown et al. 2016; Howard 2018). Participatory methods have been used in land-use planning and terrestrial environmental management for decades as tools for mapping stakeholder knowledge (Reed 2008). Along with the development of geographical information systems (GIS), also participatory GIS (PGIS), public participation GIS (PPGIS) and volunteered geographic information (VGI) methods have been increasingly utilized in data generation processes to support the empowerment and social justice of local and indigenous communities (e.g. Rambaldi et al. 2006; Fagerholm & Käyhkö 2009; Brown & Kyttä 2014; Brown & Fagerholm 2015; Garcia-Nieto et al. 2015; Brown et al. 2016). However, there are fundamental differences in the marine spatial planning and terrestrial land-use planning, such as the property rights, environments, resources and patterns of resource use and the large size of the territorial and international marine areas included in MSP (Kerr et al. 2014).

The principles of MSP require to consult stakeholders along with authorities and the public (European Commission 2014). In this study, we point out the need to discuss the appropriate use of participatory mapping of socio-economic data in MSP, and the limits and conditions related to its application. Methods based on participatory mapping have been utilized in studies concerning conservation, management and planning of marine areas, including different types of stakeholder groups. Those stakeholder groups are the managers and users of the marine space, and resources have been included in participatory mapping, e.g. authorities, scientists, entrepreneurs, representatives of business support organizations and non-governmental organizations (e.g. Schlossberg & Shuford 2005; Gopnik et al. 2012; Collie et al. 2013; Brown & Kyttä 2014; Sullivan et al. 2015; Brown et al. 2016; Oen et al. 2016).

Stakeholder groups are involved in different stages of coastal and maritime planning, for example to collect information on the marine ecosystem services, marine-related values, or the socio-spatial aspects of the human activities (e.g. Scholz et al. 2004; Klain & Chan 2012; Yates & Schoeman 2013; Le Cornu et al. 2014; Levine & Feinholz 2015; Brown et al. 2016; Reilly et al. 2016; Strickland-Munro et al. 2016; Kafas et al. 2017; Moore et al. 2017). Not all socio-economic knowledge can be easily comprehended with maps, and deliberative approach must be allowed in the planning process alongside with GIS methods (Klain & Chan 2012; Brown & Kyttä 2014). Some aspects of socio-economic information are challenging to conceptualize on a map. Many socio-economic data are inherently non-spatial, and therefore challenging to relate to spatial biophysical information. Those data that are spatial often have vague spatial references. For instance, tourist services can be readily located based on a postal address or physical infrastructure, which are always located on land. However, the distribution of their activities (resource area) and their impact area on the adjacent sea remain obscure.

The main aim of this study is to examine the process of transferring the silent socio-economic knowledge into spatial data for the purposes of MSP. Our case study explores a workflow starting from the diverse knowledge and opinions of participants, through spatial data layers, and ending in a spatial representation of the participants' views. The technical process involves mapping of socio-economic elements, data interpretation and analysis. Moreover, the possibilities and challenges related to the special characteristics of socio-economic knowledge and the marine space are discussed, taking into account the multi-sector and cross-boundary aspects of MSP. The discussion is illustrated with a cross-border case study from the Gulf of Finland in the Baltic Sea, which utilized online queries and workshops as methods to obtain views of participants on future development of marine business activities (Pöntynen & Erkkilä-Välimäki 2018).

Our approach to socio-economic issues is based on the concepts of blue economy and blue growth, which are strategic initiatives closely linked to MSP with the aim to create sustainable economic growth of marine related businesses (European Commission 2012; Elliot 2013; European Commission 2014; Pascual 2014; Eikeset et al. 2018; Soma et al. 2018). Human activities and blue economy sectors co-exist in the Gulf of Finland, causing potential for conflicts and synergies while aiming at both sustainable development and growth of blue economies. The case study developed alternative future scenarios for the regional blue economy sectors as part of the MSP project (Pöntynen & Erkkilä-Välimäki 2018), which required taking into account complex, multilevel, and long-term aspects of socio-economic development. We emphasized the knowledge connected to the economic activities in the coastal and marine areas. However, they are closely interlinked with social knowledge, especially considering sectors such as fishing, tourism, culture and leisure activities, which use the coastal and sea areas more freely than businesses in fixed locations. As the study area is larger and the socio-economic aspects of maritime activities are on a more general level than in participatory mapping on smaller communities, the holistic approach of MSP requires the consideration of these issues also in international marine areas.

2 Methods and case description

2.1 Project description and study area

Our case study on the Gulf of Finland in the Baltic Sea collected spatial socio-economic knowledge of experts with participatory mapping methods. The study was carried out as part of the MSP development project "Plan4Blue", which enhances MSP collaboration between Finnish and Estonian MSP stakeholders, and outlines alternative future scenarios and visions of sea use for the sustainable blue economies for the year 2050 (Pöntynen & Erkkilä-Välimäki 2018).

The scenario building process was based on the Delphi method (Dalkey & Helmer 1963) and deliberative workshops. In the first two rounds of the Delphi study, as well as in the first workshop, Delphi panelists and workshop participants mapped future locations and activities of blue economy sectors in the study area. The resulting spatial data were used along with other quantitative and qualitative data to produce future images and pathways for four main sectors of marine economic activities, i.e. energy sector, maritime cluster, blue bioeconomy and subsea resources, as well as tourism, culture and services for leisure activities (Pöntynen & Erkkilä-Välimäki 2018, Figure 1).

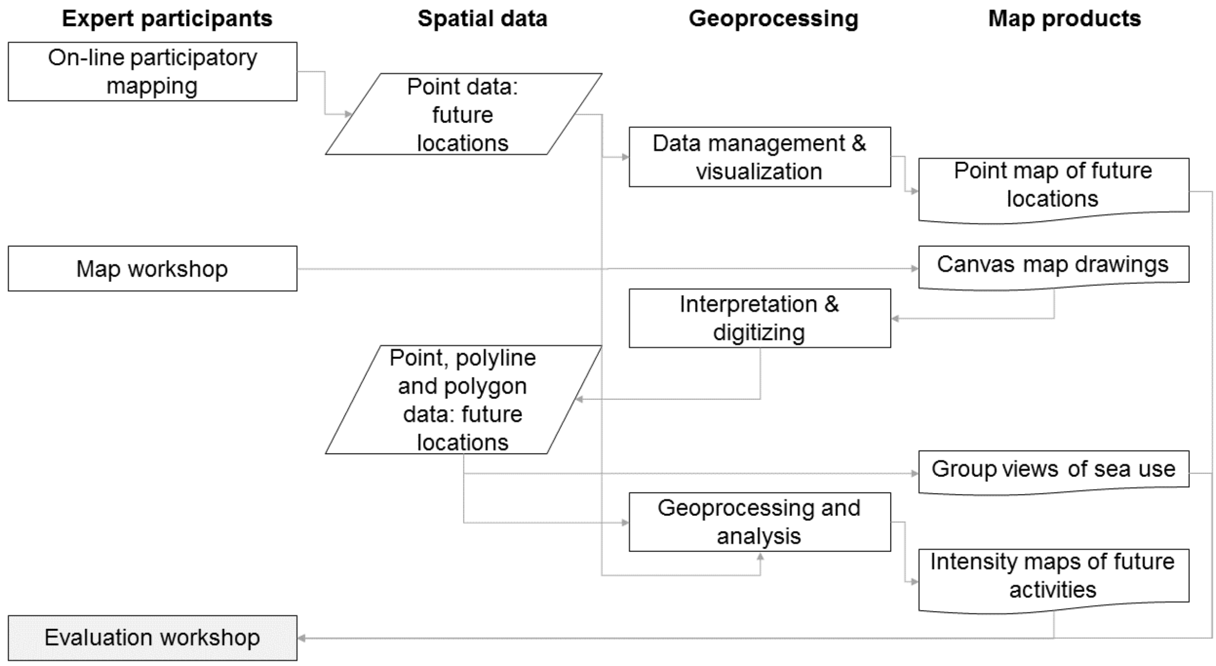

Figure 1. The participatory mapping process in the case study.

The participatory mapping methods were tested as part of a larger process, allowing the outcomes and value of the participatory mapping to be examined (Pöntynen & Erkkilä-Välimäki 2018, Figure 1). The resulting input data were managed to produce spatial growth scenarios in the four sectors of marine economic activities, and evaluated by the expert group (Pöntynen & Erkkilä-Välimäki 2018, Figure 1).

The case study area, Finnish and Estonian waters in the Gulf of Finland (Figure 2), is one of the most heavily used areas of the Baltic Sea, and is has a long history of human activities, emphasizing the need for effective long-term spatial planning across the region (HELCOM 2018). Established environmental and cultural conservation areas together with military areas set the framework for MSP in this area, influencing the usability of sea space for other purposes, such as blue businesses (Figure 2).

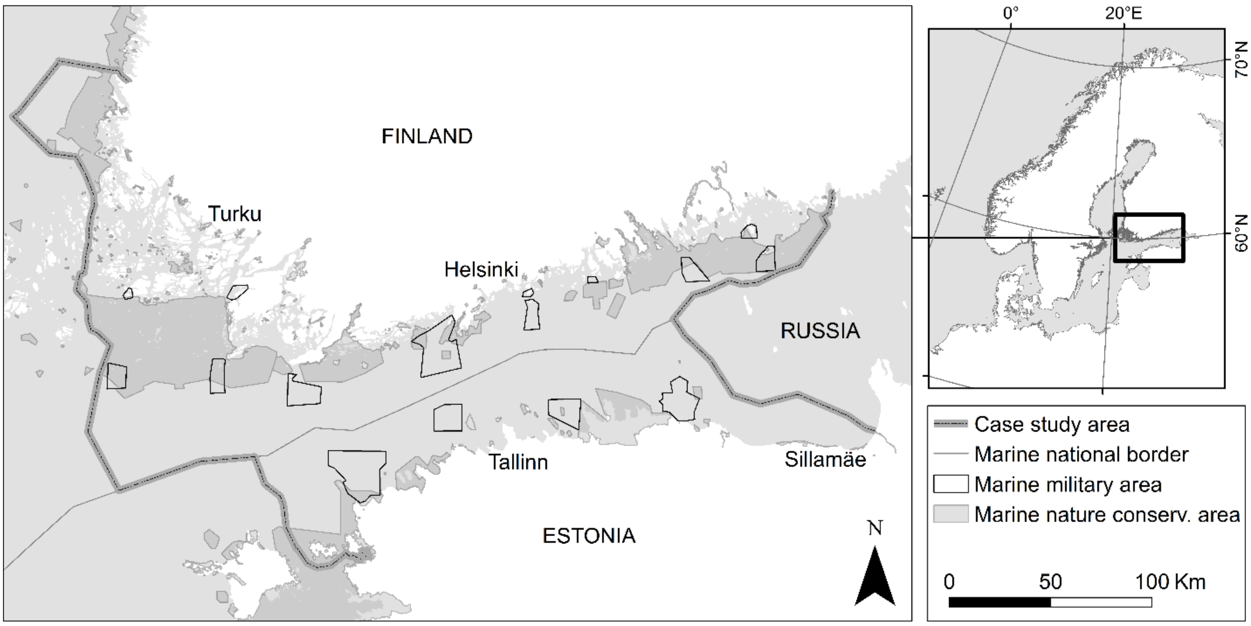

Figure 2. Location of the case study area, Gulf of Finland, in the eastern Baltic Sea region. The area spans over the marine border between Finland and Estonia. Carefully selected background information laid the basis of the mapping process of the future sea uses. These included military, Natura 2000 and national nature conservation areas that restrict other uses of marine space. Data sources: Estonian Environment Agency, European Environment Agency, Finnish Transport Agency, HELCOM, IMO, National Land Survey of Finland, UNESCO.

2.2 Participants and preparation

The participatory mapping process began with identifying and recruiting participants and selecting background information (Pöntynen & Erkkilä-Välimäki 2018). The multidisciplinary and cross-border project team determined the principles for the inclusion of participants in the participatory process, aiming at balancing the distribution of participants between different economic sectors and geographical areas. The team decided to include experts that have concrete interests or activities in the coastal and sea areas either regarding business or sea-use planning. Thus, academics were not largely invited despite their considerable expertise. Representatives of blue economy sectors were mostly affiliated with business-support organizations, associations or groups, thus representing the general views of certain industry rather than a single company.

The project team identified 132 prospective participants from Finland and Estonia, and they were personally invited to take part in the entire process. Out of these, 55 accepted the invitation, and they were invited to the map workshop. In addition, the invitation to the map workshop was distributed more widely, utilizing applicable mailing lists, notice boards and personal contacts. 43 participants answered the online participatory mapping, and 30 people attended the workshop in addition to the workshop organizers (Pöntynen & Erkkilä-Välimäki 2018). The two methods reached partly different participants, since the online questionnaire was more dominated by the public authorities (over private sector, academy and NGOs), but had a more even representation from the two countries than the map workshop (Pöntynen & Erkkilä-Välimäki 2018).

The online participatory mapping was integrated in a Delphi questionnaire (Pöntynen & Erkkilä-Välimäki 2018), including both spatial and non-spatial questionnaire elements. The map workshop was arranged as part of a broader stakeholder workshop (for details, see Pöntynen & Erkkilä-Välimäki 2018). Background information for both mapping processes included spatial and non-spatial documents. Spatial information was presented for the participants in as map documents and key spatial data appearing in the online participatory mapping interface. The amount of background information was optimized to give participants enough stimulus and spatial references, but not to overwhelm them with excessive information.

The multidisciplinary and cross-border project team identified eight map types as the optimal amount and variety of background maps presenting environmental, societal and economic background data to participants (Nylén & Tolvanen 2017):

- Base map (similar to Figure 2)
- Spatial restrictions (military areas, deep water navigation areas, national nature conservation areas, Natura 2000 sites and UNESCO world heritage sites)
- Overlap map of restrictions (areas with no restrictions and the interaction between military areas, deep water navigation areas, national nature conservation areas, Natura 2000 sites and UNESCO world heritage sites; Nylén & Tolvanen 2017)
- Marine traffic
- Human impact (population density and the Baltic Sea Impact Index, HELCOM 2010)
- Blue business (companies located based on registered address)
- Nature values on the sea (Herkül et al. 2017; Aps et al. 2018)
- Environmental risk profile (Herkül et al. 2017; Aps et al. 2018)

In addition to the background map documents, Open street map data and spatial data of maritime businesses were available for participants in the online participatory mapping interface. The maritime business data were based on the registered postal addresses of those private companies in Finland and Estonia that belonged to the "blue economy sector" (e.g. shipping, fishery, tourism; Orbis database, version 2017). To guide and classify the responses, the blue business sectors were classified into four main blue economy sectors, each of which was further divided into 4–11 subsectors (for details, see Pöntynen & Erkkilä-Välimäki 2018, Table 2.1).

2.3 Online participatory mapping

Online mapping was tested as an individual-based mapping method, with no interaction between anonymous Delphi panelists. An online-based method allowed equal accessibility over national borders and from all parts of the case study area. The questionnaire was sent as two equivalent language versions, Finnish and Estonian (both including an English translation), to facilitate participation across national borders. The Delphi panelists from Finland and Estonia were asked to familiarize themselves with the background information, and answer spatial and non-spatial questions on their views of sea use in 2050. The participants were asked to point approximate locations in the coastal and sea area, where they expected the activities of four blue economy sectors to increase, decrease, claim new areas, or be totally banned by 2050. The point data, representing the future locations with previously mentioned attributes of four blue economy sectors resulting from the online mapping, was checked and managed to create four spatial point data layers.

The questionnaire was conducted using HARAVA, a map-based survey tool that integrates responses with spatial data. HARAVA is a national PPGIS software, commissioned by government of Finland for use of e.g. local governments (Brown & Kyttä 2014).

2.4 Mapping in the workshop

The workshop allowed interaction between participants and enabled a broader selection of map items, i.e. points, polylines and polygons, as well as more flexible use of qualitative attributes and descriptions. The 30 participants attending the workshop were first asked to familiarize themselves with the background information. Then they were divided into three working groups (versatility in the backgrounds of the participants was ensured), each lead by two project team members as moderators. An adaptation of the World Café method (Brown & Isaacs 2005) was applied to allow the working groups to comment each other's work (Pöntynen & Erkkilä-Välimäki 2018).

The groups were advised to indicate their visions of sea use in 2050 using different methods, such as drawing or placing Lego bricks on canvas maps ("Lego serious play", Roos et al. 2004; Hinthorne & Schneider 2012). The markings on the map were discussed freely, but the group work was guided and documented by the moderators. English was selected as the language of the map workshop to allow interaction between Finnish and Estonian participants. The documents included photographs of the canvas maps, attached text descriptions, and map workshop reports written by the moderators.

2.5 Geoprocessing

Our case study illustrates a representative selection of possibilities for processing and visualizing expert mapping data for the purposes of MSP. The selection of the methods in this case reflect the purposes of the MSP case study project, while the possibilities and needs of individual MSP processes are not limited to these.

We harmonized the structures of all mapping data attributes to promote flexible grouping, reclassification and visualization of the data (see Roose et al. 2017 for details of spatial data management). The results of the map workshop were then converted into spatial data by interpreting and digitizing the markings. This was a highly interactive process involving the GIS experts and the moderators of the map workshop, and requiring substantial subjective interpretation of the working groups' intentions. The markings were classified into subsectors and types of change, and digitized as points, polylines and polygons. The resulting data included spatial point, polyline and polygon layers of each four sectors, and each three working groups. The design of the attribute tables allowed the layers to be easily merged by group or sector (Roose et al. 2017).

In addition to the original detailed expert mapping data, the case study project called for a simplified spatial quantification of socio-economic pressure. This allowed a general inspection of spatial interaction between e.g. nature values and socio-economic pressures. Moreover, the expert mapping data were originally in two formats: spatial point data originating from the online mapping, and point, polyline and polygon data from the map workshop. To combine the data sources, and to facilitate the illustration of single-sector distributions as well as multi-sector examination and comparison, the original data were sampled with a regular grid to produce intensity surfaces.

All available data indicating increase or claim of new area were sampled with a regular 10 km * 10 km grid. The resulting value of each grid cell was the number of map items entirely or partially inside the cell. The very few indications of decrease or total ban of business activities were excluded from the analysis. Each map item type (point, polyline and polygon) was examined separately due to their different characteristics (e.g. one polyline item being potentially counted into multiple grid cells while one point item being counted only once), and since the respondents of the online questionnaire were limited to indicating their visions using points. The number of point, polyline and polygon map items were calculated separately for each blue economy sector. In addition, the total number of map items was counted, separately for each sector, and for the blue businesses combined. Finally, the number of overlapping sectors (0–4) was calculated.

2.6 Visualization

Based on the outputs of the online mapping, we created point maps of each blue economy sector in 2050. The structure of the attribute data allowed the spatial data to be grouped or filtered in several ways to, for example, highlight or hide details related to subsectors (Roose et al. 2017). The output data of the map workshop allowed the visualization of the views of each working group or each blue economy sector separately. The structure of the attribute data was again designed to enable the visualization of several spatial data combinations efficiently (Roose et al. 2017). Single-sector distributions of expert mapping results were visualized based on the intensity surfaces (10 km grid), combining the two data sources (online and workshop). In addition to the total number of map items indicated for each sector, each map item type (point, polyline and polygon) was visualized as a separate map panel. Multi-sector comparison was facilitated by visualizing each single-sector intensity surface in a figure of four map panels. The distribution of total intensity of anticipated sea use was visualized as the total number of map items and the number overlapping blue economy sectors.

2.7 Use of spatial data and maps

To exemplify the potential use, as well as the benefits and issues related to the use of the socio-economic data, the outputs were distributed for internal project use, and external expert evaluation. Spatial data were used internally in the project as input layers in further geoprocessing, and in the production of maps for reporting and presentations. Map visualizations of the spatial data were used in further stakeholder workshops for evaluating and discussing the expert views.

3 Results and discussion

The case study demonstrates the applicability of participatory mapping in generating spatial data for MSP on the expert views of future sea use. As shown by previous research, online participatory mapping (e.g. McCall 2003; St. Martin & Hall-Arber 2008; Simão et al. 2009; McCall & Dunn 2012) and group work with maps (Palacios-Agundez et al. 2013) succeed in involving experts in spatial planning. The resulting data can present both the “missing layers” of socio-economic resource and impact areas (St. Martin & Hall-Arber 2008), as well as the spatial dimensions of future sea use scenarios. The detailed original expert mapping data and individual views provide important information into the MSP process. In addition, spatial data from different sources can be harmonized into useful spatial data products, such as intensity maps of future sea use, as long as the origin and restrictions of the data are appreciated. This will give new insights into the spatial patterns of synergies and conflicts in the use of marine space.

The case study exemplifies how point data can be used to visualize the locations of future activities based on participants’ views (Figure 3). These data overcome the restrictions of official data products by locating activities and resources on sea areas instead of e.g. postal addresses of companies on land. Based on the case study, the main restriction in simple point data may be the lack of proper and flexible attribute information, such as the explanations of the participant's intentions. Thus, it may be difficult to interpret why the participant had indicated certain locations. In gathering of spatial data of complex socio-economic issues, the context and the background of selected locations should be documented as well.

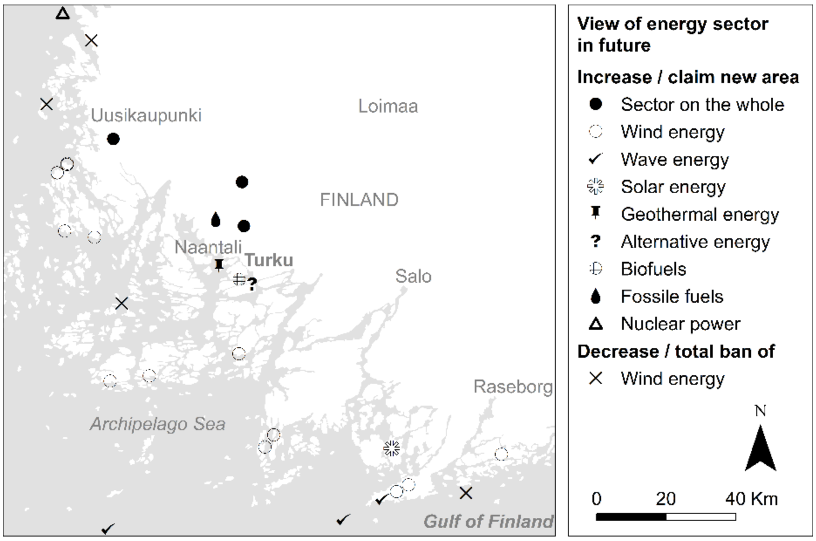

Figure 3. An example of spatial point data retrieved from online mapping. This is the view of one workshop group of the energy sector in one part of the case study area (Roose et al. 2017).

Outputs of a face-to-face map workshop allow the visualization of the sea use visions of multidisciplinary expert groups (Figure 4), and the comparison between the resulting maps of different working groups. The outputs also enable the examination of spatial interactions of sea uses by combining the expert visions with other spatial data, such as nature conservation areas or the environmental vulnerability patterns (Herkül et al. 2017; Aps et al. 2018). Based on the case study, a map workshop may produce more comprehensive understanding of the socio-economic issues than an online questionnaire, as the discussions between work group members and their reasoning regarding each map marking can be documented by the moderators for later analysis.

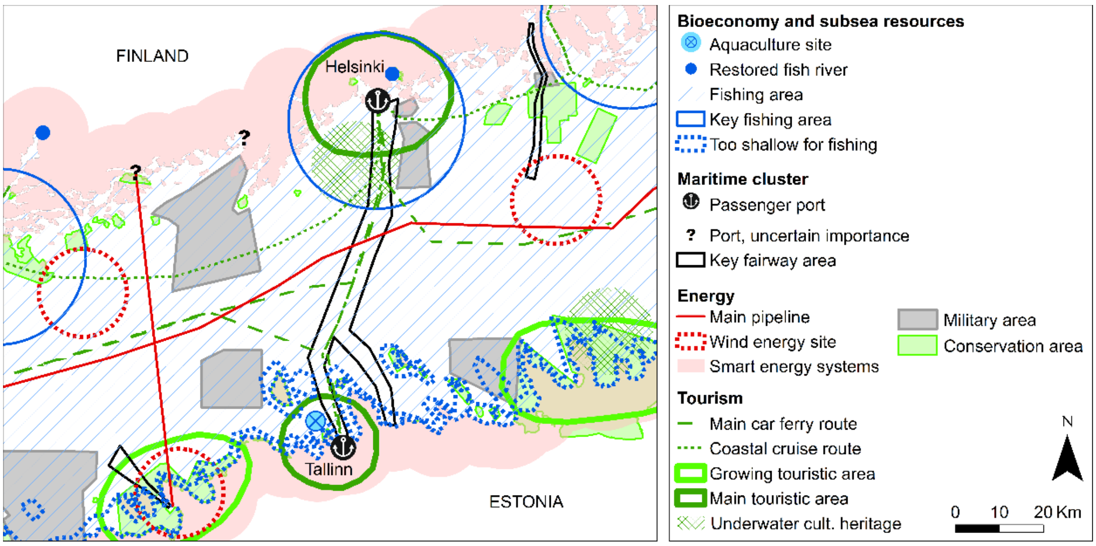

Figure 4. An example of spatial data retrieved from a map workshop. This is the view of one workshop group (11 map workshop participants) of the sea use in one part of the case study area (Roose et al. 2017).

The results of different expert mapping processes can be combined, for example, as single-sector intensity surfaces of the expected future use of sea space (Figure 5). The case study illustrates how original data sampled with a regular grid can be utilized as a representation of the general spatial patterns of the expert views. This simplified representation may be a useful addition to the individual views and details in MSP. Moreover, the results demonstrate how the analysis identifies spatial patterns that smoothly cross administrative borders (Figure 5). Different map item types and data sources need to be taken into account when visualizing and examining the results. This can be done, for example, by presenting the distributions of map item types separately, and with appropriate captions (Figure 5).

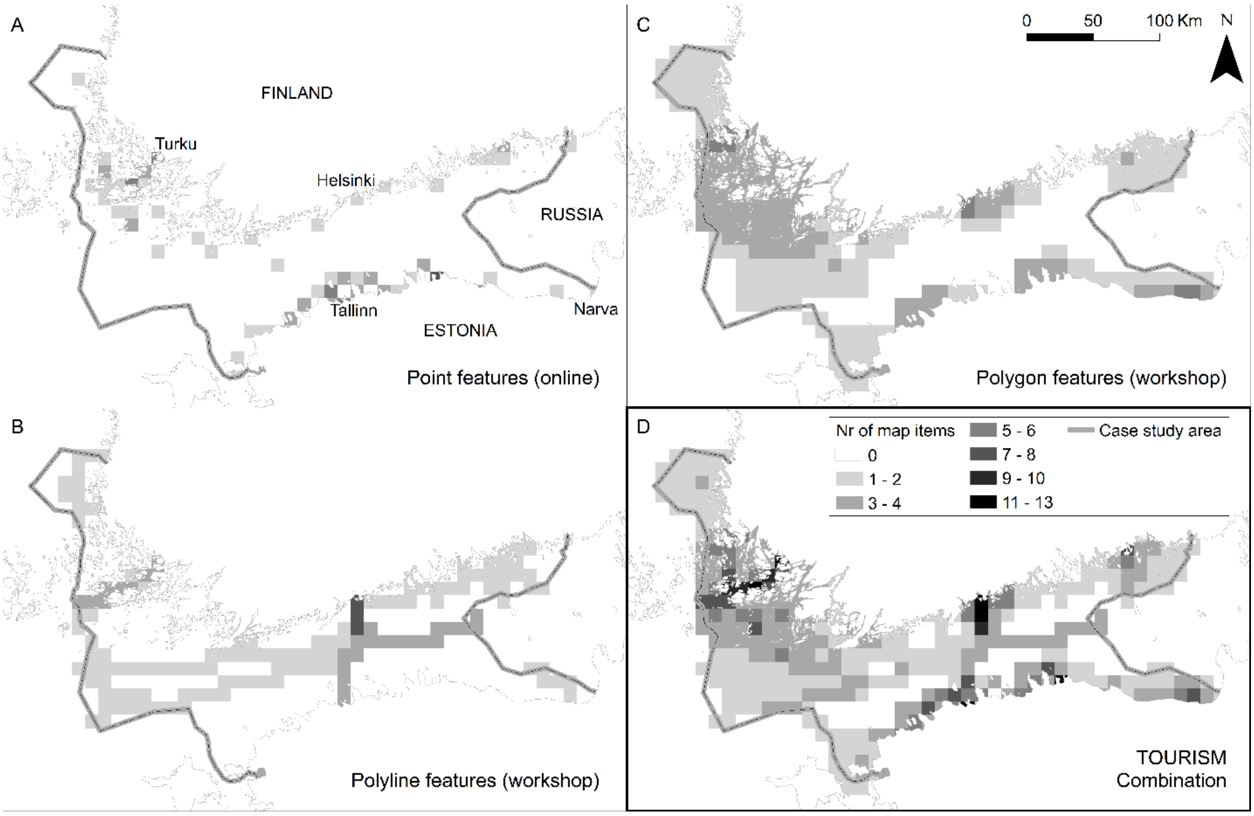

Figure 5. An example of a single-sector visualization of expert mapping data, combined from different mapping processes as intensity surfaces. This is the view of one expert participant group (eight online participatory mapping and 30 map workshop participants) of the future distribution of tourism in the case study area (Roose et al. 2017). The distribution of point, polyline and polygon map items are shown separately in subfigures A–C and combined in subfigure D. When examining subfigure D, note that the three map item types (subfigures A–C) cannot be directly compared due to their topological differences and the fact that they originate from two different mapping processes (polylines and polygons only from the map workshop).

In addition, MSP may benefit from comparing the expected patterns of blue economy sectors by examining the intensity surfaces of multiple sectors side by side (Figure 6). The multi-sector patterns can be further combined into a representation of the expected total sea use intensity across sectors (Figure 7A). The complexity of sea use expectations can examined by mapping the number of overlapping sectors (Figure 7B). In combination with the detailed original expert mapping data, these and many other geoprocessing and visualization methods can bring novel information into MSP processes.

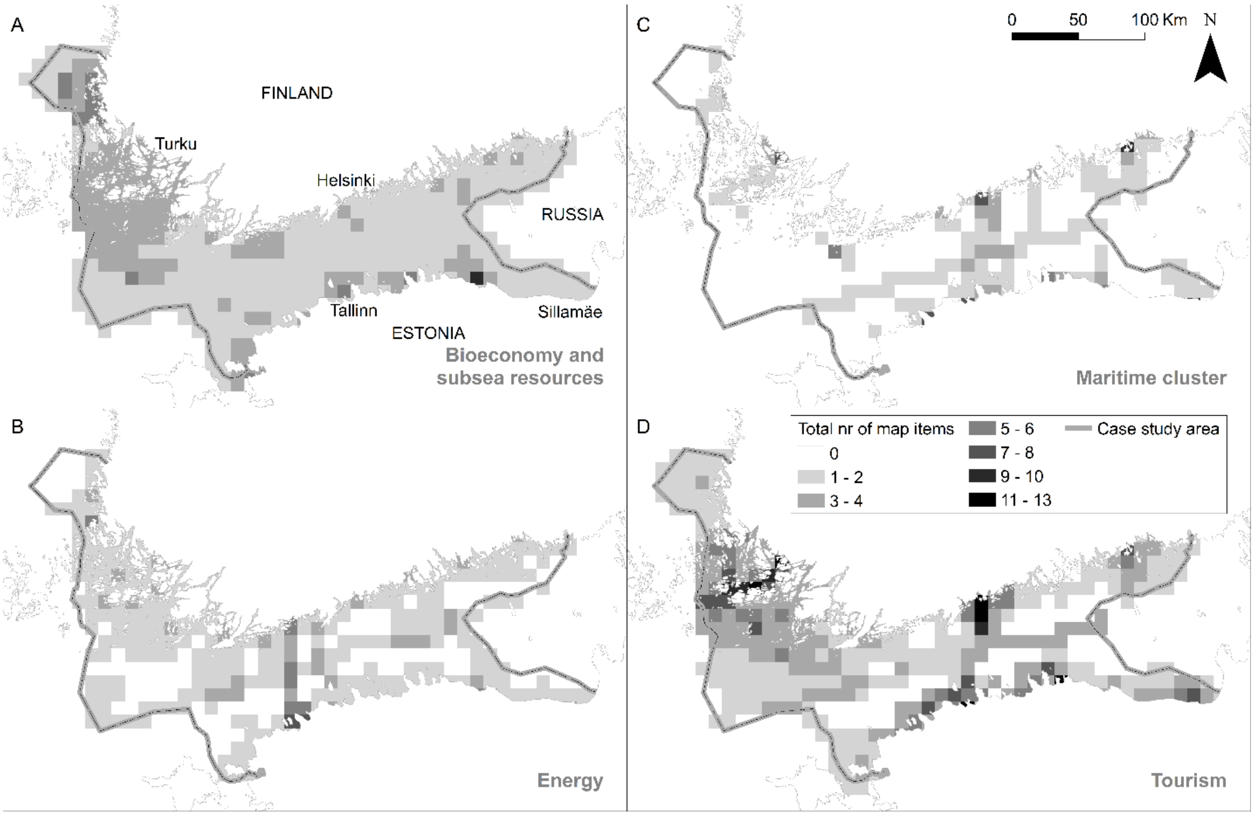

Figure 6. An example of a visualization of expert mapping data as intensity surfaces for comparing blue economy sectors. This is the view of one expert participant group (eight online participatory mapping and 30 map workshop participants) of the future distribution of four main blue economy sectors in the case study area: bioeconomy and subsea resources (subfigure A), energy (B), maritime cluster (C) and tourism (D) (Roose et al. 2017). When examining the figure, note that the total number of map items was calculated by counting together point, polyline and polygon map items in each grid cell (see the Geoprocessing section and Figure 5). The three map item types cannot be directly compared due to their topological differences and the fact that they originate from two different mapping processes (polylines and polygons only from the map workshop).

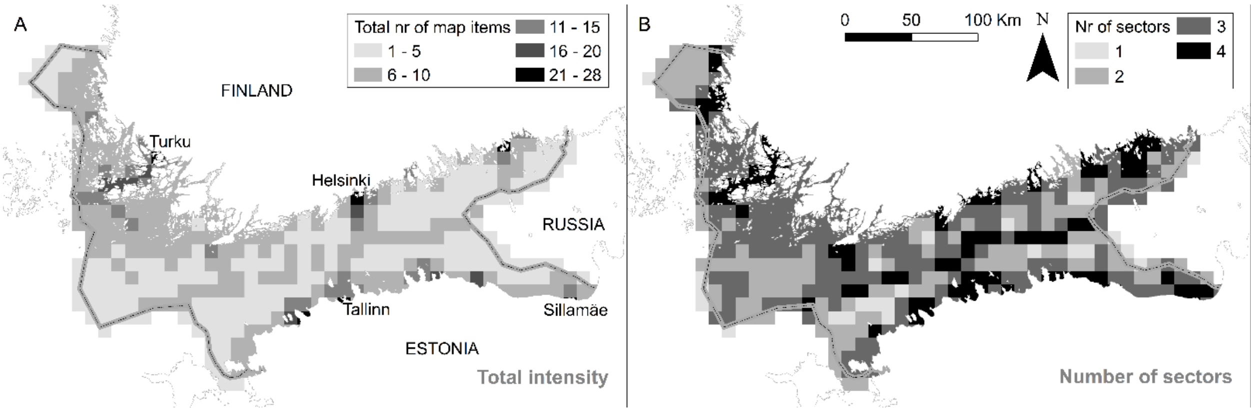

Figure 7. An example of a visualization of expert mapping data as intensity surfaces for examining the expected total intensity of sea use. This is the view of one expert participant group (eight online participatory mapping and 30 map workshop participants) of the future distribution of combined blue businesses (subfigure A) and the number of overlapping sectors (B) in the case study area (Roose et al. 2017). When examining the figure, note that the total number of map items was calculated by counting together point, polyline and polygon map items in each grid cell (see the Geoprocessing section and Figure 5). The three map item types cannot be directly compared due to their topological differences and the fact that they originate from two different mapping processes (polylines and polygons only from the map workshop).

Cross-border MSP is challenging from the spatial data perspective (e.g. Drankier 2012; Jay et al. 2016; Abramic et al. 2018): for instance, there are administrative differences across all types of borders, such as administrative sectors, business sectors, municipality borders, region borders, and particularly national borders. These, with additional historical differences, create multiple discrepancy issues in spatial data collection, management and availability (Abramic et al. 2018). In addition, language differences across national borders set a challenge for the use of existing spatial data. Participatory mapping may facilitate the creation of harmonious transboundary data from experts, in addition to raising overall awareness of cross-border processes (Hjortsø 2004). It also creates trust and connections between MSP stakeholders and planners across borders (Baltic SCOPE 2017). Online mapping methods dispel geographical barriers and allow multiple language versions, giving participants equal opportunities to participate, but require more financial resources and time for translations and analyses. Face-to-face methods are more tied to one place and language, but still allow more interaction and discussions between participants, even with moderate language skills.

The spatial data gathered from participants is open to various interpretations, since it they passed through multiple subjective filters. First, background information is selected, processed and presented subjectively by a group of experts and planners. Questions are formulated and pre-classifications decided by this group for the mapping process (such as classification into blue economy sectors and subsectors or future scenarios). Second, the mapping task is taken up by the experts with their personal background, and they are influenced by the provided, either verbal or spatial, background information. Third, knowledge is converted into map items subjectively by the experts, restricted by their own abilities and the technical limitations of the selected mapping tool. Fourth, the spatial output data are subjectively processed to a spatial data product, by making decisions about attribute classes, inclusion and exclusion of map items, and potential conversions to other types of map items or surfaces. Fifth, the joint map products of the experts or the dispersion of expert views is subjectively interpreted from the spatial data product with more or less appreciation of the limitations of the data.

Available map geometry (map item) types have a notable effect on the choices made by the participant. Although standard geoprocessing methods allow transformations between geometry types (e.g. polygon to point) and modifications to the spatial characteristics of the map items (e.g. buffering), careless data management may result in a loss of the original meaning of the data. As an example, if one group of participants locates potential wind energy sites using points, and another one by using polygons, they transform compatible knowledge into incompatible data. If the point locations are interpreted as representations of larger areas, and are transformed into polygon map items with buffering, the appearance of the two data sets will converge but the processing will have created artefacts. Since the interpreter cannot know the size of the area represented by each point, drawn by different participants, the geoprocessing will necessarily create areas with wrong spatial extents. As one participant may use one point and another several points to represent a larger suitable location, geoprocessing will falsely multiply some potential locations. These difficult choices at the processing stage are easily forgotten when the output product is used in the decision-making.

Subjectivity of the mapping process is challenging for the interpretation, even if all participants use similar map geometries in their markings. For example, participants may represent similarly-sized areas with polygons of different sizes and different amount of detail in the outline. Participants may use one or several points to draw a larger area. Based on the case study, this emphasizes the need for verbal explanations and reasoning from the participants. Thus, map markings alone rarely provide enough information about the socio-economic phenomena, but help in setting their spatial dimensions when accompanied with adequate verbal explanations.

The two above-mentioned challenges related to subjectivity in the processing and reporting of the expert mapping data can be taken into account by increasing the amount of guidance and facilitation in the participatory process (Schuman 1996; Hjortsø 2004). For example, an experienced moderator may give specific instructions to calibrate the work of individuals. Representation from all stakeholder groups helps to initiate the collective planning process using most suitable map item types in the markings (Schuman 1996; Hjortsø 2004). However, increasing the amount of control may decrease the innovativeness and originality of the results.

As the number of participants increases, individual inputs and details disappear, but the robustness of a "consensus view" strengthens. With a larger number of participants, the data processing phase creates more "artefacts", since simplifications and compromises are inevitably made. Due to the growing amount of artefacts, the resulting data cannot be used for detailed (i.e. high spatial resolution) interpretations. However, the voices of a number of individuals and socio-economic sectors can be refined into a summary of expert views. The mapping methods also enable the combination of views from multiple jurisdictional areas, thereby fading border issues and discrepancy issues in the pre-existing data.

One possible result of the mapping of socio-economic knowledge is a set of spatial scenarios of socio-economic activities. Due to the special characteristics of the process, the result may be very different from the future projections of many biophysical distributions. For example, the climate envelope modeling approach produces detailed species distribution projections with high spatial resolution (e.g. Pearson & Dawson 2003; Araujo et al. 2006). Although the same input data related limitations apply to the interpretation of these projections, the differences to the socio-economic projections are substantial.

Due to the subjective nature of the mapping process, the selection and final composition of the stakeholders is influential for the outcome of the collective mapping process (Wollenberg et al. 2000; Kok et al. 2007; Brown 2017). The composition of the group dictates the emphases, volume and level of detail of the spatial data. Moreover, it determines the geometric structure of the resulting spatial data, if several map item type alternatives are given. Careful framing of the questions, good instructions and an experienced moderator in a face-to-face mapping process have a notable influence on the quality of the outputs. Most important, however, is to understand that the very aim of participatory mapping is to obtain the view of a certain group of people, instead of an objective "truth". This subjectivity and the composition of stakeholder groups need to be recognized if participatory mapping is used as part of the official MSP processes. When the participatory mapping effort aims to collect layman opinions instead of expert opinions, the spatial extent of the queried area would need to be smaller, scaled to the range of everyday life.

The case study demonstrates how the selection of the mapping method influences the outcome in many ways. Compared to face-to-face methods, the use of an online method has potential to collect more responses, improve the evenness of representation from different parts of the planning area, and enable anonymity and equivalent language versions (e.g. Denscombe 2009; Brown 2017). However, online-based methods are sensitive to technical usability issues that may reduce participation. Face-to-face methods allow a larger flexibility in the outputs and facilitate interaction in the participant group (although also an interactive online mapping interface enables a certain degree of interaction). Face-to-face methods allow more guidance and a possibility to document information in non-spatial formats, such as the reasoning and motivations of the participants. These can be later interpreted into map items, if possible. Some aspects of the socio-economic information are difficult to conceptualize as map items, and thus require these attached explanations. This flexibility, in combination with the support from a moderator, is particularly valuable in a complex and multilevel process, such as the expert consultation process in MSP. The language of the group work has an influence on the participation across national borders.

The participatory-based socio-economic spatial data are valuable and highly subjective, which is both an inherent characteristic of this information, and also a challenge for processing and reporting the data. The data should therefore always be used in a way that appreciates their origin, and includes explanations of reasoning and motivations of the participants. The producers of the data have the responsibility to document and inform the end-users about the possibilities and restrictions of the data. When published or used as input data in further analyses, the origin of the mapping data should always be clearly documented, and influence the interpretation and message tracing back to the data.

4 Conclusion

In this paper, we illustrate how participatory mapping, data interpretation and core geocomputing methods may be used to generate socio-economic data, and discuss the main issues related to their generation and use. The results suggest that participatory mapping can provide valuable data for the MSP process, filling some gaps of missing socio-economic information. In the context of a complex and multilevel process, such as MSP, the benefits of face-to-face and moderator-lead mapping methods are highlighted, since they allow discussion and flexible (also non-spatial) documentation of the results. The mapping process is highly subjective: the presentation of background information, the framing of the questions and the interpretation of the raw data may have notable influence on the generated data. Furthermore, the selection of the data collection technology and applied analysis methods shape the generated spatial information and its validity.

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Supporting information

See Pöntynen & Erkkilä-Välimäki (2018) for detailed description of the case study.

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