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Development of a methodology for selection and assement of a representative MPA network in the Baltic Sea

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Editors Åsa Andersson Anna-Sara Liman	Date 21 March 2006 Approved by Åsa Andersson

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CONTENTS

0 PREFACE

This report, which is a working document describing a strategy for the development of a methodology for selection and assessment of a representative MPA network in the Baltic Sea, is a result from the BALANCE project (http://www.balance-eu.org).

The following persons have contributed to the report:

- Ulf Bergström, Swedish National Board of Fisheries, Sweden
- Minna Boström, Metsähallitus, Finland
- Darius Daunys, Coastal research and Planning Institute, Lithuania
- Stig A. Helmig, Danish Forest and Nature Agency, Denmark
- Jørgen Leth, Geological Survey of Denmark, Denmark
- Cecilia Lindblad, Swedish Environmental Protection Agnecy, Sweden
- Greger Lindeberg, Geological Survey of Sweden, Sweden
- Steffen Lundsteen, National Environmental Research Institute, Denmark
- Georg Martin, Estonian Marine Institute, Estonia
- Annelie Mattisson, County Administrative Board of Stockholm, Sweden
- Per Nilsson, Göteborg University, TMBL, Sweden
- Anna-Leena Nöjd, Finnish Environment Institute
- Henna Piekäinen, Finnish Environment Institute
- Johnny Reker, Danish Forest and Nature Agency, Denmark
- Solvita Strake, Institute of Aquatic Ecology, Latvia
- Thomas K. Sørensen, Danish Institute for Fisheries Research, Denmark
- Ole Vestergaard, Danish Institute for Fisheries Research, Denmark

The following external experts from The Nature Conservancy (United States) have also contributed: Annette Huggins, Christine Sheppard, Dan Dorfman and Mike Beck.

Please note that this working document is intended for internal use and for progress reporting. The interim strategy will continuously be developed, adjusted and revised within the framework of BALANCE.

Åsa Andersson & Anna-Sara Liman, WP3 Coordinators

WWF Sweden

1 INTRODUCTION

One of the main objectives of BALANCE Work Package 3 is to develop and apply a methodology to assess the representativity of the existing network of marine protected areas (MPAs), identify gaps and select candidate sites for a network of MPAs that represent the full range of marine biodiversity in the Baltic Sea.

This paper will outline a strategy for the process needed to carry out this work. The method proposed in this strategy builds on methods used in other parts of the world and is adjusted to Baltic Sea conditions. It focuses particularly on criteria for selection of a representative network of MPAs, data requirements and the choice of Decision Support Systems.

This strategy will be continuously developed, adjusted and revised throughout the project. Thereby it will be possible to include new information as well as adjust it according to the spatial data that turns out to be available for the analysis. The whole process should be viewed as adaptive, allowing for continuous improvements in both method and outcome.

2 BACKGROUND

2.1 Selection of MPA networks in the Baltic Sea

Marine Protected Areas are increasingly accepted as a tool in conserving marine biological diversity. However, the site designation process has until now been very slow. Site selection in the Baltic Sea has often been undertaken based on knowledge and opinions of experts and authorities and has often been biased towards areas with most information as well as towards specific focal species and unique habitats. Marine areas have generally been selected based on scenic or recreation values or values associated with terrestrial areas such as important bird or seal skerries. Rarely are they selected based on marine values beyond the sea surface. Most existing marine protected areas are also located near the shore.

Moreover, the selection of sites in the Baltic Sea has also often been done on an ad-hoc, site by site basis, with little consideration of national or regional perspectives. The importance of establishing representative and coherent networks of MPAs, aimed at protecting the full range of habitats and species in a region, have however been underlined by a number of international conventions and agreements e.g. World Summit for Sustainable Development (WSSD), Convention on Biological Diversity (CBD), HELCOM recommendation 15/5 on Baltic Sea Protected Areas and the EU Habitats Directive.

Even if the site selection process in the Baltic Sea has been guided by site selection criteria (e.g. the HELCOM guidelines for designating marine and coastal Baltic Sea Protected Areas, BSPA (2003) and criteria in the EU Habitats Directive), a systematic approach is still lacking. A systematic approach to site selection has been recommended by conservation interests as it maximises the chance of creating MPA networks that meet the objectives, ensures a transparent and defensible process and makes efficient use of available resources (Leslie et al. 2003, Margules & Pressey 2000).

The methodology developed during the BALANCE project will therefore strive to be systematic, transparent, flexible, ecologically based and scientifically defensible using the best available data and taking other user interests into account. The methodology will also include the use of Decision Support Systems. The main reason for using decision support tools is that a systematic site selection process often requires consideration of large amounts of spatial data and an enormous number of possible combinations of sites, a task that is virtually impossible without computer support. Decision Support Systems have been successfully used in other parts of the world and have shown to improve both efficiency and transparency of the site selection process (Stewart et al. 2003). In this project existing methods will be adjusted to Baltic Sea conditions.

It is important to underline that the MPA-planning process involves more steps than just identifying and selecting candidate sites for protection e.g. negotiations with stakeholders, development of management plans etc. This means that this strategy only covers a small part of the overall MPA-planning process.

2.2 Available options regarding decision support systems

Decision support systems can be used for a number of applications in the marine environment such as evaluating MPA networks, zoning and selecting sites for protection. There are a number of decision support software and methods available for these purposes and the choice of tool largely depend on the objectives and needs of the project. (Evans et al. 2004) Most of these tools are computer-based with the main function being systematic comparison of sites and combinations of sites. A GIS or other spatial databases can be used in combination with the site selection software for storing and visual interpretation of data. Two alternative approaches for selection of sites are presented below, the scoring method and the sitting algorithmic approach.

A. The scoring method is based on the assigning of scores to each potential site based on pre-defined criteria. The sites are ranked based on cumulative scores for these criteria and those sites with the highest total scores are added to the MPA network. The advantage of the scoring approach is that it is easily explained and requires little technical expertise (Evans et al. 2004). One assumption regarding scoring is that sites having the highest score will best enhance the network, but this may not always be the case. Sometimes two sites considered independently may be better than when considered together. The scoring method also has restricted possibilities to incorporate spatial considerations. The outcome of a scoring process does not give any details about the values contributing to the score and thereby does not produce a transparent result. (Evans et al. 2004)

B. The siting algorithmic approach provides a mathematical way of finding MPA network solutions. This approach aims at minimising the area of the MPA network, while at the same time fulfilling the conservation objectives. (Stewart & Possingham 2002) This was first described by Kirkpatric (1983), as the 'minimum representation problem' and was then formulated as a mathematical programme by Possingham et al. (2000). Selection algorithms use a measure of the extent to which a site or a set of sites contribute with complementary underrepresented features to an existing set of sites if added to the network. (Evans et al. 2004) There are two main categories of sitting algorithms, exact optimisation and non exact optimisation algorithms.

Exact optimisation algorithms are designed to find a single optimal answer to meet the defined conservation objectives. However, the risk of not finding an answer to the MPA selection problem increases with an increasing number of conservation features. This makes exact optimisation appropriate for small-scale analyses where the selection problem is more restricted, but less appropriate for large-scale MPA site selection. (Evans et al. 2004)

Non exact optimisation methods are designed to find multiple solutions that are all near optimal, maximising efficiency of representation in terms of the number and/or area of selected sites. The non exact optimisation algorithm simulated annealing has been considered superior to other algorithms in finding solutions minimising the number of sites and total area selected. (Possingham et al. 2000, Ball & Possingham 2000) The simulated annealing selection process starts with a random set of sites. Solutions are then iteratively explored through random changes of sites. At every step in the iteration the new set of sites is compared with the previous set. The best set is accepted. (Possingham et al. 2000) The number of iterations is defined in advance. More iterations deliver a more efficient network in terms of number of sites and total area included in the network.

For designing MPA networks, the algorithmic approaches are generally better than the scoring methods because they are more systematic and take efficiency into account. The advantage of non exact optimisation, e.g. simulated annealing, compared to exact optimisation is that it delivers multiple solutions. This is an advantage when presenting results to stakeholders for further development, agreement and implementation. Simulated annealing can also incorporate spatial constraints such as connectivity (Evans et al. 2004). However, like several other mathematical selection systems it does not deal with temporal dynamics (Evans et al. 2004). It is also important to remember that the outcome from any Decision Support System is only as good as the data input and the criteria used for selecting the network (Possingham et al. 2000).

2.3 MARXAN - Marine reserve design using spatially explicit annealing

Based on this review and consultation with experienced users of Decision Support Systems we have decided to use the software MARXAN[1] (Ball & Possingham 2000) as the main tool for site selection in the BALANCE project. MARXAN is an interactive GIS-based tool that is publicly available. The software is an implementation of the non-exact optimisation algorithm simulated annealing, which was described above. However optimisation using alternative algorithms is also possible in MARXAN. It has been widely and successfully used to assist planners to identify and select areas for marine conservation, i.e. by the Great Barrier Reef Marine Park Authority, Living Oceans Society (LOS), WWF Canada and The Nature Conservancy (TNC).

MARXAN is a software designed to find spatially explicit solutions to MPA network design. Several parameters can be included in the selection process i.e. representation of conservation features, replication of sites, minimum distance between sites, socio-economic factors etc. The relative cost for selecting a set of sites is calculated using an objective function. The set of sites fulfilling the conservation objectives at the lowest possible cost is identified. Factors contributing to a higher cost are i.e. the total area and boundary length, costs imposed for failing to meet conservation targets and the presence of factors making a site unsuitable for protection.

[1] For more information about MARXAN and to download the software visit the MARXAN web page at the Ecology Centre at the University of Queensland (http://www.ecology.uq.edu.au/MARXAN.htm)

3 STRATEGY

This part of the paper will outline the strategy regarding the development and application of a methodology to assess the representativity of the existing MPA network, identify gaps and select candidate sites for a MPA network that represent the full range of marine biodiversity in the Baltic Sea.

3.1 Over all objective of the MPA network

Networks of marine protected areas can have a variety of aims and objectives such as conservation and protection of biodiversity, protection and management of fishery resources, etc. Therefore, when selecting a network of marine protected areas it is critical to clearly define the over all objective for this specific network. Different site selection criteria will be applied depending on the objective of the network.

The establishment of MPA networks in the Baltic Sea is to a large extent governed by a number of international conventions and agreements signed by the Baltic Sea countries, i.e. EU Habitats Directive, HELCOM recommendation 15/5, OSPAR/HELCOM Ministerial Declaration, Convention on Biological Diversity and World Summit on Sustainable Development. The conventions and agreements identify specific aims of MPA networks with a focus on biodiversity conservation.

This project will work towards the implementation of the conventions and agreements and specifically evaluate the existing Baltic Sea MPA networks (Natura 2000 and BSPA). The overall objective of the MPA network will be in line with these, aiming at biodiversity conservation, which includes maintaining and/or restoring habitats, species and ecosystems, with the focus to maximise representation of marine biodiversity.

The main aim is to identify candidate sites for a representative network of marine protected areas, which includes the whole range of marine landscapes, habitats, species and ecological processes in the Baltic Sea. The identified network should be as efficient as possible i.e. attempting to minimise the cost and impact on other interests. Management of natural resources, e.g. to increase the catch of commercial fish species are therefore not considered as the primary objective. However, protection of spawning grounds and nursery areas for fish can have a positive impact on populations of commercial fish species.

3.2 Study area

The evaluation and identification of a Baltic Sea MPA network will operate on two geographic scales:

A) Baltic Sea - based on the marine landscape information provided by work package 2.
B) Pilot areas (fig. 1) - based on the detailed habitat information provided by work package 2. The pilot areas are:

1. Northern Kattegat & Eastern Skagerrak
2. The Bornholm Deep & Pomeranian Bay
3. Turku-Åland-Stockholm
4. Gulf of Riga & Lithuanian coast

In the analysis these two levels will be treated separately as the analysis on the entire Baltic Sea level will focus primarily on representation of marine landscapes, while the analysis in the pilot areas will focus on more detailed habitat representation. The analysis might be carried out in all pilot areas or only in some of them depending on data availability. The focus habitats in the pilot areas are: benthic inshore and offshore habitats and fish nursery areas (pilot area 1), offshore pelagic habitats and reef habitats (pilot area 2), inshore benthic habitats and fish nursery areas (pilot area 3) and inshore benthic habitats (pilot area 4).

The study areas cover the marine/brackish water extending land wards to the mean water level. The exact boundaries for the study areas, the entire Baltic Sea and the pilot areas respectively, will be defined by BALANCE work package 2. The study areas will thereafter be divided into a number of planning units. Planning units are the potential building blocks of the MPA network. They are the units from which the MARXAN-software can choose to select sites. The scale of the analysis and data resolution largely defines the choice of the planning unit size (Leslie et al. 2003). Since this analysis will be carried out on two different geographical scales, the planning units will also be of two different sizes. Furthermore, planning units may have to be of different sizes in coastal and offshore areas (smaller and larger planning units respectively), since it is reasonable to believe that data on coastal areas will be more detailed.

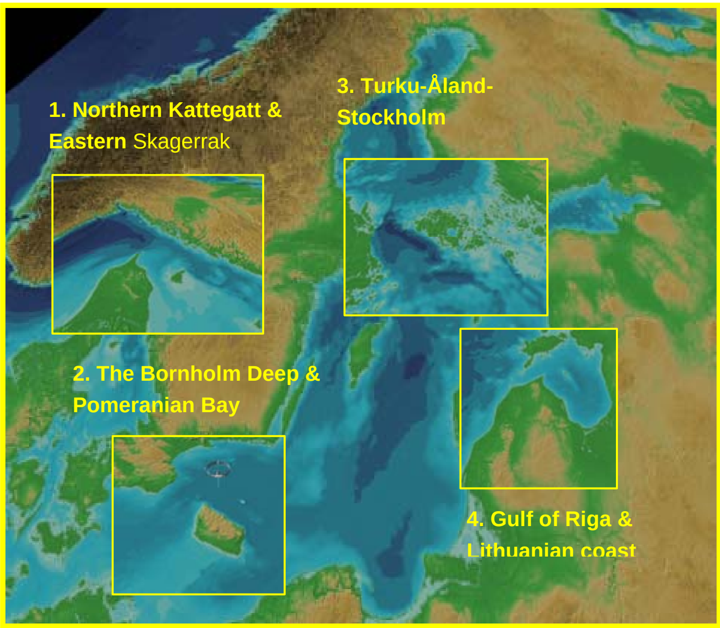

Figure 1. Pilot areas in the Baltic Sea, identified for the BALANCE project.

3.3 *Criteria for selection of a representative MPA network*

When establishing a representative network of MPAs it is critical to define which species, habitats and ecological processes that adequately represent the marine environment in the region and for which the MPA network should be designed, here referred to as the conservation features. It is also important to specify the amount of each feature that needs to be captured in the MPA network to ensure adequate protection, here referred to as the conservation target.

Ideally the conservation features and targets should be set based on good knowledge of the biology and ecology of the Baltic Sea e.g. on information on the status of the habitats and species and the adequate level of protection needed for each of these to ensure long term persistence. In many cases detailed knowledge is missing and the criteria need to be set based on best available knowledge and the precautionary principle.

In addition to scientific (biological/ecological) criteria, there are also political criteria that guide the establishment of MPA networks in the Baltic Sea countries e.g. in the EU Habitats Directive and in HELCOM recommendation 15/5 on Baltic Sea Protected Areas. In the BALANCE project the conservation features and targets will therefore be identified based on both scientific and political criteria.

A draft list of conservation features and conservation targets was identified during the first milestone of the BALANCE-project, July-December 2005, based on a literature review, experiences from similar projects and a workshop with representatives from partners in the BALANCE project. During milestone 2 (January-July 2006) these criteria will be further refined. External expertise, e.g. scientists, authorities, and NGOs, will be invited to give input to the selected conservation features and targets e.g. through a questionnaire. The criteria will be revised based on this input as well as on data availability.

3.3.1 *Conservation features*

In this project we will follow the “coarse filter” and “fine filter” approach for selection of conservation features used in many other similar projects (Beck et al. 2003, Ardron 2004). The “coarse filter” is expected to capture the full range of biodiversity in the study area by including all different ecosystems, marine landscapes and habitats. One shortcoming with this approach is that smaller, but ecologically valuable areas may be overlooked (Ardron 2004). The “fine filter” is therefore expected to ensure inclusion of more specific species, habitats and features that are important to include in the network, but that may slip through the “coarse filter” (Beck et al. 2003). Features included in the fine filter can be e.g. keystone species that have a disproportionate effect on ecosystems relative to their abundance (Power et al. 1995 in Beck et al. 2003); rare, unique, threatened and endangered species and habitats; and/or distinctive features such as upwellings and benthic topographical complexity.

The conservation features have been divided into the following categories: marine landscape representation (seascapes), habitat representation, species of special interest and special elements (Tab.1). A complete list of the conservation features was identified during milestone 1.

Tabel 1. Categories and conservation features proposed to be included in the analysis on both Baltic Sea and Pilot Area level. If spatial data for some of the features turn out to be missing or scarce these conservation features might need to be excluded from the analysis either on the Baltic Sea level, Pilot Area level or both.

	Feature category	**Subcategories**
Coarse filter	Marine landscape representation (seascapes)	Work Package 2 – marine landscapes
	Habitat representation	Work Package 2 – marine habitats Natura 2000 EUNIS Shoreline type
Fine filter	Species of special interest	Kelp belts (Laminaria sp.) Furcellaria belts (Fuecellaria lumbricalis) Bladder wrack belts (Fucus vesiculosus) Eelgrass beds (Zostera marina) Stoneworth beds (Charophyta) Blue mussel beds (Mytilus edulis) Horse mussel (Modiolus modiolus) Maerl beds (Phymatolithon calcareum) Oyster beds (Ostrea edulis) Lophelia reefs (Lophelia pertusa) Marine mammals Fish species Sea birds
	Special elements	Rare, unique, threatened and endangered species and habitats. Distinctive features (e.g. frontal systems, upwellings)
No data areas		

Marine landscape and habitat representation – Coarse filter

The aim of the coarse filter category is to make sure that the full variation of marine biodiversity in the Baltic Sea is captured in the network. The marine landscape map, developed by work package 2, will be used as the basis for the analysis on the entire Baltic Sea level. Representation of all the marine landscapes aim at securing that the full variation of physical (physiographic/oceanographic) factors in the Baltic Sea are captured in the network. Critical physical factors that are not used to define the work package 2 landscapes might be included as separate conservation features in the analysis if sufficient data is available. This will be decided when the physical factors to be included in the marine landscapes have been clarified.

Even though the physical variation in the marine landscapes can be seen as a surrogate for the variation in biodiversity, available spatial information on marine habitats will also be included to make sure that the full biological/ecological variation is captured. Natura 2000 and EUNIS are two habitat systems that are (or will be) defined and agreed by all EU countries and data should therefore be consistent for the entire Baltic Sea. Moreover, according to the Habitats Directive the habitats listed in HD Annex 1 should be represented in the European network of protected areas. Therefore, all Natura 2000 and EUNIS (category 2) habitat types, which include a marine component (below the sea surface), are proposed to be included in this analysis. We would like to underline that where there is an overlap between the Natura 2000 and the EUNIS habitat types, this overlap will be avoided in the analysis e.g. by only including those EUNIS habitats that are not covered by Natura 2000 or vice versa. Shoreline types are also proposed to be included as a conservation feature to cover the link between the terrestrial and marine environment. Overlap between the shoreline types and the other habitat categories will be avoided as far as possible.

For the corresponding analysis on pilot area level also additional data layers with more detailed resolution will be included. The habitat maps developed by work package 2 will be the basis for this analysis. EUNIS habitat level 3 might also be used if data is available.

Species of special interest & Special elements – Fine filter
The fine filter features proposed for this analysis include habitat-forming species like algae belts, sea grass meadows, mussel beds and coral reefs. These species, and the habitat they form, are of crucial importance for the Baltic Sea biodiversity and their representation in the MPA network need to be secured. The proposed fine filter features also include important areas for marine mammals, fish species and sea birds e.g. wintering, feeding, breeding, nursery and refugee areas. This category also comprises rare, unique, threatened and endangered species and habitats and distinctive features like frontal systems and upwellings. Because of their rarity, uniqueness etc, such species or features are unlikely to be covered by a pure representation approach and therefor need to be included separately to secure their future persistence. The fine filter features will be included in both levels of the analysis depending on available data. Relevant features need to be identified separately for each pilot area during the project. This will be done by WWF Denmark (pilot area 1 & 2), CORPI and EMI (pilot area 3 & 4).

No data areas
To avoid the analysis to bias the site selection towards areas with best data availability it might also be necessary to include areas with “no data” or “very scarce data” as a separate feature. By doing this also sites with insufficient spatial information will be represented to a certain amount. This will increase the probability that also marine values not yet discovered will be included in the MPA network. The use of this approach will be further considered during the coming milestones.

The draft list of conservation features will need to be revised and updated continuously through out the project e.g. based on what data turn out to be available. If spatial data for some features are missing or scarce these conservation features might need to be excluded from the analysis. In some cases it might be possible to find surrogates for those features. Based on the data available it might also be needed to split some conservation features into many different classes e.g. sandbanks below and over 20 meters respectively, or lump them into fewer classes e.g. algae belts instead of bladder wrack, kelp and Furcellaria (Beck et al. 2003).

3.3.2 *Conservation targets*

One of the most difficult tasks is to decide how much of the above mentioned conservation features that should be captured in the selected network. There is no easy answer! Scientifically defendable levels of representation for each separate conservation feature are not defined at this time. Therefore we propose to apply a range of target levels (e.g. 20, 60%…etc) to explore the different outcomes.

Four basic scenarios have been proposed both for the entire Baltic Sea and the pilot areas. The proposed target levels in these basic scenarios are to a large extent based on political frameworks, but biological and ecological considerations are, and will be further, included based on expert consultation, especially in scenario 4. The EC Habitats Directive is the political framework that has primarily been considered, but also the World Parks Congress (WPC), Convention on Biological Diversity (CBD) and HELCOM. Consistency with the political targets will hopefully increase the potential for implementation of the final outcome of the project.

Based on the 4 basic scenarios a number of different scenarios will be explored e.g. by increasing or decreasing the target levels, including existing MPAs, including socio-economic factors etc (this is further described below).

Basic scenarios*:*

1. Work Package 2 Marine landscape/Habitat representation scenario
In this basic scenario the targets will be set to ensure that at least 20% of all the work package 2 marine landscape types (for the Baltic Sea analysis) and the work package 2 habitat types (for the pilot areas) are included in the selected sets of candidate MPAs.

Motive: This scenario will be used to evaluate if all marine landscapes (for the entire Baltic Sea) and habitats (for the pilot areas) are sufficiently covered in the existing MPA networks. Many marine studies have suggested that ecologically functional marine reserves will need to cover at least 20% of a region if the biodiversity of that region is to be fully conserved (Roberts & Mason, unpublished, Groves et al. 2002). The World Parks Congress in Durban 2003 also recommended that "marine protected area networks should be extensive and include strictly protected areas that amount to at least 20-30% of each habitat" (IUCN 2003). Some countries have already taken action to attain these levels of protection. In the Great Barrier Reef zoning plan the target levels were e.g. set to cover at least 20% of each biogeographic region (Great Barrier Reef Marine Park Authority 2005). Even higher levels, 20-50% of a region, have been suggested when an additional objective is to sustain fisheries and maximise catches (Roberts & Hawkins 2000, Roberts & Mason unpublished). One example is the California Channel Island where 30-50% of all representative habitats in each biogeographic region were recommended to be protected to achieve both conservation and fisheries goals (Airame et al. 2003).

2. Natura 2000 (HD) representation scenario
In this basic scenario the targets will be set to ensure that at least 20% of the listed habitats and species in the Habitats Directive as well as at least 60% of the "priority habitats in the Habitats Directive" are included in the selected set of candidate MPAs.

Motive: When evaluating the countries contribution to the Natura 2000 network the European Commission are using 20% and 60% coverage as a guiding principle for sufficient protection. The higher figure is used for priority species and habitats. Since one of the objectives of this analysis is to evaluate the existing Natura 2000 network, we propose to apply the same guiding principle in this scenario.

3. Overall representation scenario
In this basic scenario the targets will be set to ensure that at least 20% of all conservation features as well as >60% of the "priority habitats in the Habitats Directive" are included in the selected sets of MPAs.

Motive: Since the habitat types and species listed in the annexes to the Habitats Directive do not cover the full variety of biodiversity in the Baltic Sea, it is necessary to include also other species, habitats and features in the analysis, to create a representative network of MPAs. In this scenario all conservation features listed in table 1 will be included. As mentioned in scenario 1, a number of scientific reports from different parts of the world refer to at least 20% of a region as the level of MPA-coverage needed for efficient biodiversity protection. This basic scenario will therefore use a 20% target as the minimum representation level for all conservation features.

4. Expert scenario
The target levels in this scenario should be based on expert advice about sufficient protection for each of the conservation features. This means that the target levels should be set individually for each conservation feature. Some habitats and species might need greater protection than others. Factors to be considered when setting these targets are e.g. if the feature is stationary or mobile, has a large or small distribution, is rare globally or just regionally, is endemic or of high ecological importance (Ardron pers.com.). It is also necessary to consider threats to or presumed losses of the conservation feature and limitations in distribution of data (Beck et al. 2003). To identify the relevant target level for each conservation feature we propose to consult relevant experts to make a relative ranking of the listed conservation features in a number of target classes.

The described scenarios will be modified and revised during the coming milestones e.g. based on the outcome of preliminary analyses and on data availability. The target levels in the basic scenarios will e.g. be increased (and decreased) to explore different network solutions, such as variation in the total coverage and distribution of the selected networks of candidate MPAs. Targets might also need to be adjusted for individual conservation features e.g. to be set lower for features with a large distribution and higher for features with small distribution.

3.3.3 Modifying criteria

Stratification
The Baltic Sea is naturally divided into different water basins separated by shallow thresholds and the biodiveristy distribution is strongly depending on the salinity gradient from Bothnian Bay to Skagerrak. Because of this the study area will be divided into a number of biogeographic regions: Gulf of Bothnia, Bothnian Bay, Gulf of Finland, Gulf of Riga, Baltic Proper, Kattegatt and Skagerrak. The ecological differences between these regions must be taken into account when establishing a network of MPAs. Therefore, in the analysis on the entire Baltic Sea level we will make sure that all the biodiversity targets are met in each biogeographic region where the conservation feature occurs. This will ensure that ecosystems, habitats and species are represented across their natural range of variation. It will also ensure replication i.e. that all features are represented more than once. Stratification will ensure protection of unknown biodiver-

sity, possible genetic variation on species or community level and variation in ecosystems as well as distribute the sites to spread risk (Beck et al. 2003).

The 4 pilot areas will be analysed separately as they cover very different habitat types and therefore are not comparable. If the individual pilot areas contain different ecological entities they might also need to be divided into stratification units. This need to be decided later depending on the outcome of the habitat mapping in work package 2.

We will explore each scenario both with and without stratification to understand if and to what extent this effects the site selection.

Relative importance of meeting conservation targets
The relative importance of not reaching the target for conservation features can be included in the MARXAN analysis by using a “penalty value”. Targets for features with higher penalty values are generally met before similarly distributed features with lower penalty values (Ardron 2004). The penalty factors in this analysis should therefore be set to reflect both the relative importance of the features and the relative confidence in the data sets. Higher values will therefore e.g. be set to rare, threatened and endangered species or habitats as well as to features that play important ecological roles e.g. key species. Lower values will probably be set to features represented by data of poor quality and low reliability. It is also possible that widespread species and habitats will be given a lower penalty than unusual species, since fully meeting these targets is less critical. A relative scoring of penalty values for the conservation features will be done through expert consultation.

Fragmentation
More fragmented MPA networks generally cover less total area of protection than more clumped solutions to meet the same conservation targets. However, more clumped solutions are often more manageable and probably more ecologically viable (Roberts et al. 2003) The level of fragmentation in a selected MPA network can be adjusted, in MARXAN, by using a “Boundary Length Modifier (BLM)” (Ball & Possingham 2000). We will therefore explore a range of different values of the boundary length modifier to find network solutions with realistic and manageable levels of fragmentation. This will be done in close contact with relevant experts and management authorities.

Connectivity
Aspects of connectivity in an MPA network can be included in a number of ways, in the MARXAN-analysis. Generally data availability and knowledge of the connectivity between habitats and ecosystems limits the use of these parameters. If, and how this will be included in the project need to be decided later on based on available data as well as on knowledge about connectivity among habitats in the Baltic Sea obtained from the BALANCE work on Blue corridors.

Socio-economic factors
A network of MPAs must meet the biodiversity conservation objectives, but to be realistic and accepted by stakeholders it is also important to consider socio-economic factors making the sites more or less suitable for conservation.

A list of socio-economic factors considered to have a potential impact on an areas suitability for MPA establishment where identified during milestone 1(Tab. 2). It is not realistic to include all these factors, but the aim is to include those factors that have largest impact in the entire Baltic Sea and in the pilot areas respectively. The factors to be included will be identified in close contact with relevant stakeholders, experts and authorities and based on data availability.

Socio-economic factors can be included in the analysis in different ways. Sites, which are considered unsuitable for conservation, e.g. major ports or shipping lanes, can be totally excluded ("locked out") from the selection. Sites critical for the MPA network can, in a similar way, be forced into the network ("locked in"). Another option is to steer the selection towards preferable sites (e.g. reference sites) and away from non-preferable sites (e.g. areas with high toxic levels) by assigning different costs to the sites. We will explore scenarios both with and without including socio-economic factors to be able to evaluate how these change the results.

Table 2. Socio-economic factors that might be included in the analysis (identified during milestone 1). The factors to be included will be identified in close contact with relevant stakeholders, experts and authorities and based on data availability.

Density of human population	Major shipping lanes
Cables and pipeline	Port facilities
Toxic levels	Oil transport
Nutrient levels	Fisheries
Military areas	Aqua-culture
Tourism density	Sand- and gravel extraction
Research sites	Dumping grounds (toxics, dredged material)
Reference sites	Wind farms (existing objects)
Cultural heritage sites	Other marine constructions
Ditched areas	Roads close to the shoreline
Dredged areas	Noise levels
Artificial coastline	Marine Protected Areas

Existing MPAs

One of the socio-economic factors that will be included in the analysis is the existing network of MPAs (Natura 2000 sites and Baltic Sea Protected Areas, BSPAs). A gap-analysis will be carried out with the main aim to: 1) identify species, habitats and marine landscapes that are not sufficiently protected in the existing MPA networks and, 2) identify candidate sites suitable to fill these gaps.

This will be done by "locking in" the existing MPAs as described above. If all conservation targets are fully met within the existing network there will be no gap in representation and no other sites need to be added. But, if there are gaps, the analysis will provide information on which habitats, species and features that are not sufficiently protected and additional complementary sites will be selected until the targets for all conservation features are met. We will explore scenarios both with and without locking in existing protected areas to be able to evaluate how well existing areas help meet the biodiversity conservation targets.

For the gap analysis within BALANCE the assumption is that all existing MPAs (Natura 2000 and BSPAs) are effectively managed i.e. that governments have implemented regulations that are effectively protecting habitats and species in these areas. We are aware that this is not the case e.g. for most Natura 2000 sites where management plans are still to be developed.

3.4 Outcome and analysis of the result

For each of the above mentioned scenarios MARXAN will be run a large number of times and result in a number of different network solutions, all meeting the identified conservation targets. The number of alternative network solutions is the advantage of this approach as it allows for a great flexibility e.g. when considering other user interests.

By looking at how often a particular planning unit is selected, it is possible to get an indication of its utility in the overall network design. A planning unit that is repeatedly chosen likely represent areas that are either irreplaceable or most useful in the development of optimal reserve network solutions that best meet the targets, using a minimum of area (Ardron, 2004).

The project will select and present a number of alternative MPA network solutions. These will be presented at two workshops, one for the entire Baltic Sea and one for the pilot areas. Based on the input from these workshops the method will be adjusted and the analysis revised. The final outcomes of the project can there after be further developed and presented to stakeholders as a basis for further development of the MPA network and as part of a Baltic Sea wide spatial-planning process. Based on comments and input from stakeholders their requirements can be taken into account and the analysis can be revised and re-run. The process of analysis and stakeholder involvement can be repeated several times with the aim to identify an MPA network that can be accepted by both stakeholders and conservationists. Moreover, when more detailed spatial data become available these new data layers can easily be added into a new MARXAN analysis to further refine the site selection.

3.5 Data requirements

Data used in this analysis should preferably be GIS based for example *raster* data, *vector* data or *spreadsheet* databases. The data can be quantitative amounts or simply presence-absence data. In cases where spatial data is not available, direct expert input may be an alternative way to gather data. This can be done by sending gridded maps to experts, to gather presence-absence data based on best available knowledge. The information will be collected so that it can be spatially analysed.

The basic data sets, which will be used to evaluate representativity in the Baltic Sea region are:

1) Landscape maps covering the entire Baltic Sea. Compiled by work package 2 during milestone 2.
2) Habitat maps covering pilot area 1-4. Compiled and modelled by work package 2 during milestone 3.
3) Existing spatial data for the Baltic Sea area compiled by work package 1.
4) Data compiled by partners in work package 3, probably mostly biological data for pilot area 1-4. Existing spatial data will be compiled and expert input will be used to get information about conservation features when existing data sets are missing.

A list of data requirements for evaluation of representativity has been provided to work package 1, 2 and 4 (Annex 2). The compilation of data by these work package need to be carried out in close contact with work package 3 to ensure that data meet the requirements such as appropriate geographical coverage, format, resolution and associated attributes.

All data sets will be evaluated/screened before incorporated in the analysis to decide weather they meet the requirements of the analysis. Factors that will be considered are e.g. resolution of scale, how recently the data was surveyed and weather the data is empirical or modelled. It is also important that data covers, and are consistent for, most of the study area or at least for the stratification units. For species data it is especially important to consider whether the data is collected as opportunistic observations or by systematic sampling. Systematic sampling will have equal observation efforts over the whole study area and is therefore more desirable. If only observation data is available, this should be used only for the most critical of the species. (pers. com. Hussein Alidina)

Data sets that fulfil the requirements on coverage and quality will be compiled and formatted using a series of geographic information system processing steps to create suitable data layers. The scale of the analysis wills as far as possible aim to be appropriate for the species and processes being protected.

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Annex 1: Data requirements

Data request to Work Package 1		**Baltic Sea**	**Pilot Area 1-4**
Geographical Data			
Coastline Baltic Sea area		x	x
Nautical Charts		x	x
	Low resolution	x	x
	High resolution	x	x
EEZ /territorial water		x	
Bothnian Bay		x	
Bothnian Sea		x	
Gulf of Finland		x	
Baltic Proper		x	
Gulf of Riga		x	
Kattegat		x	
Skagerak		x	
BioGeoPhysical Data			
Batymetric data		x	x
Salinity data		x	x
Shoreline data		x	x
Geological data		x	x
Bottom substrate (sediment type)		x	x
Temperature data		x	x
	Surface temperature	x	x
	Bottom temperature	x	x
Ice cover data		x	x
Hydrodynamics data		x	x
	Currents	x	x
	Exposure	x	x
Frontal systems data		x	x
Upwellings		x	x
Land-uplift data		x	x
Vertical stratification data		x	x
Light penetration data / Photic zone		x	x
Oxygen content		x	x
Nutrient levels		x	x
Coastal/Offshore waters		x	x
Species Data			
Important areas for marine mammals			
	Harbour Porpoise	x	x
	Grey Seal	x	x
	Ringed Seal	x	x
	Harbour Seal	x	x
Important Bird Areas		x	x
Distribution of algae belts			
	Kelp	x	x
	Furcellaria	x	x
	Bladder wrack	x	x
Distribution of sea grass beds			
	Stoneworths	x	x
	Eelgrass	x	x
Distribution of other habitat forming species			
	Blue mussel beds	x	x
	Horse mussel beds	x	x
	Maerl beds	x	x
	Oyster beds	x	x
	Coral reefs	x	x
Important areas for fish			
	Cod	x	x
	Herring	x	x
Socio-Economic Data			
Marine and coastal protected areas			
	Natura 2000 sites Habitats Directive	x	x
	Natura 2000 sites Birds Directive	x	x
	Helcom Baltic Sea Protected Areas	x	x
Major port facilities data		x	x
Major shipping lanes data (waterways)		x	x
Data on density of human population		x	x
Fisheries data		x	x
Oil transports data		x	x
Sand and gravel extraction data		x	x
Aquaculture		x	x
Cables and Pipelines		x	x
Dredged areas		x	x
Dumping grounds		x	x
Ditched areas		x	x
Roads close to the shoreline		x	x
Artificial shoreline		x	x
Wind farms (existing)		x	x
Ailen species		x	x
Nutrient levels		x	x
Toxic levels data		x	x
Military areas		x	x
Other marine constructions		x	x
Tourism density		x	x
Research sites		x	x
Monitoring sites		x	x
Cultural heritage sites		x	x
Data request to Work Package 2		**Baltic Sea**	**Pilot Area**
Marine Landscapes			
WP2 Landscape Maps		x	
Marine Habitats			
WP2 Habitat Maps			x
Natura 2000 Habitats distribution			
	Sandbanks which are slightly covered by sea water all the time	x	x
	Estuaries	x	x
	Mudflats and sandflats not covered by seawater at low tide	x	x
	Coastal lagoons ('priority habitat HD)	x	x
	Large shallow inlets and bays	x	x
	Reefs	x	x
	Baltic esker island with sandy, rocky and shingle beach vegetation and sublitoral vegetation	x	x
	Boreal Baltic narrow inlets	x	x
	Submarine structures made by leaking gases	x	x
	Submerged or partially submerged sea caves	x	x
EUNIS habitats level 2 distribution			
	Littoral rock and other hard substrate	x	x
	Littoral sediment	x	x
	Infralittoral rock and other hard substrata	x	x
	Circa littoral rock and other hard substrata	x	x
	Sublittoral sediment	x	x
	Deep-Sea bed	x	x
	Pelagic water column	x	x
	Ice associated marine habitats	x	x
EUNIS habitat complex level 2 distribution			
	Estuaries	x	x
	Saline coastal lagoons	x	x
	Brackish coastal lagoons	x	x
Other important habitats (feeding, breeding and nursery areas)			
	Habitats for relevant fish species		x*
	Habitats for relevant bird species		
	Habitats for relevant mammal species		
	Relevant HELCOM redlist biotopes and biotopes complex		

*Need to be further specified for each pilot area separately.

About the **BALANCE** project:

This report is a product of the BSR INTERREG IIIB project "BALANCE".

The BALANCE project aims to provide a transnational marine management template based on zoning, which can assist stakeholders in planning and implementing effective management solutions for sustainable use and protection of our valuable marine landscapes and unique natural heritage. The template will be based on data sharing, mapping of marine landscapes and habitats, development of the blue corridor concept, information on key stakeholder interests and development of a cross-sectoral and transnational Baltic zoning approach. BALANCE thus provides a transnational solution to a transnational problem.

The BALANCE partnership is composed of the following institutions based in 10 countries: The Danish Forest and Nature Agency (Lead), The Geological Survey of Denmark and Greenland, The National Environmental Research Institute, The Danish Institute for Fisheries Research, WWF Denmark, WWF Germany, Institute of Aquatic Ecology at University of Latvia, Estonian Marine Institute at University of Tartu, Coastal Research and Planning Institute at Klaipeda University, Metsähallitus Natural Heritage Service, The Finnish Environment Institute, The Geological Survey of Finland, WWF Finland, The Swedish Environmental Protection Agency, The National Board of Fisheries – Department of Research and Development, The Geological Survey of Sweden, County Administrative Board of Stockholm, Department of Marine Ecology at Gothenburg University and WWF Sweden.

The following institutes contribute as consultants to the partnership: The Geological Survey of Norway, Norwegian Institute for Water Research, DHI Water and Environment, The Leibniz Institute of Marine Sciences, The Sea Fisheries Institute, The Finnish Game and Fisheries Research Institute, Metria Miljöanalys and The Nature Conservancy.

For more information please see www.balance-eu.org and http://maps.sgu.se/Portal.

The **BALANCE Report Series** included at the 1st of March 2006

BALANCE Interim Report No. 1 "Delineation of the BALANCE Pilot Areas".
BALANCE Interim Report No. 2 "Development of a methodology for selection and assessment of a representative MPA network in the Baltic Sea – An interim strategy".
BALANCE Interim Report No. 3 "Feasibility of hyperspectral remote sensing for mapping benthic macroalgal cover in turbid coastal waters of the Baltic Sea".