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From ecosystem services to benefits of the Baltic Sea – indicators and threats

Janne Helin, Janne Artell & Heini Ahtiainen

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Nordic Council of Ministers
Ved Stranden 18
DK-1061 København K
Phone (+45) 3396 0200
Fax (+45) 3396 0202

Nordic Council
Ved Stranden 18
DK-1061 København K
Phone (+45) 3396 0400
Fax (+45) 3311 1870

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Content

Preface

This report is an outcome of the Nordic Workshop on Economic Analysis of the State of the Baltic Sea (NorWEBS), which was held in Helsinki 19.11.2009 to 20.11.2009. This work received financial support from the Nordic Council of Ministers. The workshop was preceeded by a survey assessing ecological indicators for economic valuation. The survey was sent to economists and marine experts in countries bordering the Baltic Sea. The survey results along with notes on the discussions in the workshop provide the backbone of this report. The report reflects these sources with additional insights from the ecosystem valuation literature.

We would like to give acknowledgements to all the participants of the workshop for their efforts. Possible mistakes in reporting are our own. Special thanks go to the editorial team and Jens Perus who patiently saw after the whole process despite the delays.

Helsinki, 28.4.2010
Janne Helin, coordinator

Summary

The value of the Baltic Sea manifests through a multitude of human activities that rely on the sea. The most significant threats to the welfare of the Baltic are eutrophication, oil spills and invasive species. The key question is how much resources should be allocated for protecting the ecosystem services the Baltic provides. In order to establish the optimal protection policies, we require information on the benefits. We propose a framework for deriving the combined benefits from the Baltic Sea ecosystem services. We extend the existing ecological information of the ecosystem services with economic considerations on valuation of these services. The choice of the indicator depends on the environmental problem in question. We define a set of indicators, which captures the linking of the ecological processes and people's perceptions together based on the environmental threats assessed by a Baltic Sea expert panel. The appropriate valuation method will account for the cultural differences between the surrounding nations and for the ecological interdependencies underlying the benefits. For the purpose of aggregation of benefits there is a need to focus on cultural and provisioning services to avoid double-counting. The regulating and supporting services should be modelled in such way that their significance is represented in the value of the provisioning and cultural services.

1. Introduction

The state of the Baltic Sea is adversely affected by economic activities, which in turn leads to a decrease in human well-being. The need to evaluate the benefits of protecting the Baltic Sea arises from the limited resources of the society in general to deal with the ecosystem service degradation. When we cannot solve all the problems and eliminate all the risks, we need to be able to assess which issues should be solved first. The key question is not what the total value of the Baltic Sea is, but how much resources should be allocated for protecting the services it provides. Hence, we are interested in services that are both beneficial for people and vulnerable to outside pressures.

Ecosystem services can be defined as "…*conditions and processes through which natural ecosystems, and the species which make them up, sustain and fulfill human life*."(Daily 1997). Furthermore, ecosystem services can be classified as either supporting, regulating, provisioning or cultural (Millennium Ecosystem Assessment, MA 2005). Abiotic services that are not easily damaged by anthropogenic activities have been considered as a fifth class, "geosystem services" (Huhtala et al. 2009). Ecosystem services of the Baltic Sea are reviewed by Garpe (2008) in a recent qualitative study. In addition, Söderqvist and Hasselström (2008) examined the existing information regarding the economic value of the Baltic Sea ecosystem services, identified knowledge gaps and suggested further research based on the gaps. These reports, although providing useful background information, do not give detailed instructions on how to value the benefits delivered by the ecosystem services.

Indications of societal ecosystem service priorities can be observed from the fundamental principles of the Helsinki convention (HELCOM 1992), which call for preventative measures when human health, living resources and marine ecosystems, amenities or other legitimate uses would be harmed. The main emphasis in the convention is given for prevention of harmful substances, such as DDT and PCB, which consequently have been banned.

More recently the focus of Helsinki Commission has shifted towards the ecosystem approach emphasizing good ecological status of the sea, and has led to setting objectives like clear water and termination of excessive algae blooms (HELCOM 2007). Adaptation of such objectives steps closer to feasible value-based protection plans, as the driving force and the ecological response to pressure can be measured and linked to ecosystem services such as recreational amenities or fishing. In addition to HELCOM, a recent Finnish study (Huhtala et al. 2009) demonstrates that eutrophication is regarded as the most serious threat to the Baltic Sea amongst the administration and researchers.

Eutrophication of the Baltic Sea is a complex process affecting many ecosystem services of the sea. Economic studies have concentrated on the cultural services, mainly recreation. However, the use values like the value of recreation depend on the underlying ecosystem processes and services. To capture these indirect values, which are not apparent to public or captured via market mechanisms, we need to be able to model the fundamental nutrient cycles within the Baltic Sea. Ecological models have been developed for this purpose and can already simulate the nutrient fluxes in time and space (Kiirikki et al. 2006). The biophysical description of these cycles is not, however, sufficient to establish the value of ecosystem services; the economic consequences need to be quantified despite the impacts on human activity result from a complex web of interactions.

While eutrophication is a publicly recognized problem in the Baltic Sea, the threat of invasive alien species is seen as the most potential risk by the experts (Huhtala et al. 2009). More than 120 alien species have been found in the Baltic Sea (Baltic Sea Alien Species Database 2009), but information on the effects of these species on Baltic Sea ecosystem is scarce. As the effects to the ecosystem are uncertain and, thus far, limited in the Baltic Sea, a systematic estimation of the impacts to the services requires considerable modelling effort. The risk assessment of ballast water mediated species introductions (Leppäkoski & Gollasch 2006) covers wide range of variables affecting the invasion probability to the Baltic Sea, but the economic analysis of the impacts calls for further studies.

Alongside the increased risk of inadvertent alien species introduction, maritime transport poses potential large scale changes to the ecosystem services in the form of accidents involving oil. Maritime transportation was considered a serious problem by experts, only second to eutrophication in terms of current issues of the protection of the Baltic Sea (Huhtala et al. 2009). The risk of a large scale oil accident to happen has been estimated as high as once per twenty years (NorWEBS 2009). Again, estimating the loss of recreational value seems plausible based on existing knowledge, while the indirect damage occurring through the supporting and regulating services is more difficult to quantify.

Overall, it seems that a more systematic approach on valuing the ecosystem services of the Baltic Sea is required. We aim to extend the existing ecological information of the services with economic considerations on valuation of these services. A framework consisting of both, economic and ecological, aspects can provide new insights on the protection priorities of the Baltic Sea. Economic valuation will provide an important tool as several impacts need to be compared in commensurate terms and aggregated (MA 2005). The existing gaps in the ecological knowledge do not eliminate the need to establish economic analysis. Under constantly changing environmental conditions, ecological information will always be imperfect. This requires that the uncertainties need to be reflected in a transparent fashion in conducting the economic analysis.

Economic valuation methods can be categorized into market-based methods, cost-based methods, revealed preference methods and stated preference methods (Champ et al. 2003). The value of ecosystem goods or services that are bought and sold in markets can be estimated, at least partly, through their market price. Cost-based methods include avoided damage costs, replacement costs and provision costs of ecosystem services. Revealed preference methods elicit the value of goods through consumer behaviour in markets. Stated preference methods are based on surveys that directly ask people their willingness to pay for changes in the state of the environment.

Economic valuation typically distinguishes between use and non-use values. Use values can be further classified into direct use value and option value. Non-use values consist of existence value, bequest value and altruistic value, and according to their name, are not related to the direct use of ecosystem services. Only stated preference methods are able to capture non-use values.

In valuation, indicators are needed to link the ecological processes to people's perceptions. These indicators need to be both meaningful and understandable to people and adequate in describing the ecological state. The indicators differ depending on the environmental problems, and are discussed in more detail in the sections devoted to eutrophication, oil spills and invasive alien species.

In the following chapters we attempt to cover the benefits provided by the ecosystem services under the three most significant threats identified by Finnish marine and economic experts, namely eutrophication, oil spills (maritime traffic) and invasive alien species. Furthermore, we present survey results from an expert questionnaire on economic valuation and marine/coastal ecosystems conducted in all of the littoral countries of the Baltic Sea to find out if the priorities in Finland represent the concerns more generally (Appendix 1). The survey results are complemented by the results from a follow-up two-day-workshop financed by the Nordic Council of Ministers held in Helsinki, Finland between the 19th and 20th of November 2009. Our results indicate that while national concerns differ from country to country, concern is shared between the countries about the three identified problems. Based on the discussions in the workshop we propose a set of indicators to assess values from ecosystem services under threat from eutrophication, large-scale oil spills, and invasive species.

2. Eutrophication

The adverse effects of eutrophication are recognized as one of the largest threats to the Baltic Sea ecosystem (HELCOM 2009a). These effects have also direct impacts on human activities, like water recreation and commercial fishing. Thus, policies reducing eutrophication will have an effect on public welfare. To evaluate the economic feasibility of such policies, monetary effects of both the costs and benefits are required. To compare the costs and benefits in commensurate units it is necessary to link the nutrient concentrations in the sea, the units for which abatement costs are calculated, to benefits from nutrient reductions. The link from nutrient concentrations to benefits is intuitively straightforward, but for economic analysis we need more exact knowledge of how changes in nutrient concentrations affect through ecosystem services, ultimately, human welfare. There have been few attempts on valuing specific ecosystem services and their changes in the Baltic Sea (e.g. Sandström 1996, Söderqvist & Scharin 2000, Kosenius 2009), but these studies are predominantly country-specific case-studies where more encompassing estimates are needed for the valuation of the Baltic Sea.

The most obvious monetary link from eutrophication to human welfare is through acting markets, where the benefits from ecosystem services are already traded in money. For example, fishing industry may suffer from loss of catch due depleted oxygen and weakened food web. Damages from eutrophication may thus be assessed through calculating the losses of the fishing industry due to increased effort and lost catches. On the other hand, moderate increases in eutrophication may help some commercial fish species, like sander (pike-perch), to thrive, making the ex ante estimation of losses less straightforward (Lappalainen 2002).

A more challenging task in the monetary valuation of eutrophication damages is in giving value to the non-marketed amenities that the sea ecosystem provides to the general public. These amenities include, but are not limited to recreational possibilities like swimming, diving, fishing, boating and wild life watching and more indirect values such as scenery and knowledge of a healthy bird population supported by the sea.

As the public does not observe directly the nutrient concentrations in the sea, we require indicators that signify a perceptible level of eutrophication and are directly related to the nutrient levels present. While, for example, the Water Framework Directive (WFD) (European Commission 2000) and the Marine Strategy Framework Directive (MSD) (European Commission 2008) employ a water quality index, they are specifically aimed to describe the general ecological status of the water body. Although these indeces define water quality, they may not describe what is good quality in terms of recreational purposes. On the other hand, the choice of a single indicator of water quality, like water clarity, even though simple, may not be representative enough to describe the nutrient status in the water. These reasons explain why the choice of suitable indicators to describe water quality for the general public is not irrelevant.

Looking from top to bottom, i.e. the benefit-side of things, the best indicator of eutrophication is such that it is easily observed and for which changes are easily explained. For people to state their willingness to pay (WTP) for reduced eutrophication, it is vital that an understandable and as exact as possible scenario is presented to them. For example, while chlorophyll-a and water clarity are described by valuation literature and both marine experts and social scientists (NorWEBS 2009) as good candidates for simple eutrophication indicators, small incremental changes in either of the indicators may well not be intelligible to non-experts. Thus, the scenario setting in a WTP survey requires large enough changes in the levels of eutrophication for people to be able to posit a value for the proposed policy. The NorWEBS workshop (NorWEBS 2009) discussions suggest that a more holistic descriptor of water quality and eutrophication should be employed in the WTP scenario setting, especially if non-use values are of interest. As an example of a holistic scenario-setting a Norwegian valuation study was presented (Magnussen 2009), where water quality levels were introduced to the respondents using photographs, short verbal explanations, and pictograms representing recreational usability status. The WFD criteria for the ecological status were suggested as a starting point for credible scenario setting. It was also recognized that this approach has its limitations from a modeling perspective.

From the standpoint of a practical cost-benefit analysis the indicator for eutrophication must be something that can be modeled. There can be one or two linking factors between nutrient concentrations and human perception of eutrophication. The Finnish Environment Institute (FEI) has employed a SYKE-EIA 3D-model (Korpinen 2009, Kiirikki et al. 2006) to describe the effects from changing nutrient concentrations in the whole Baltic Sea (excluding the Danish straits and the Kattegat). The sea is modeled and results presented in five times five kilometer grid cells with 17 vertical layers, taking biological, geological and chemical issues into account. The model output gives estimates for phytoplankton biomass, including blue-green algae biomass, and nutrient levels with a five-year forecasting ability. The algae biomass may be converted into chlorophyll-a levels, which may be further be converted to water clarity. The conversions entail a certain level of uncertainties as we approach the more perceptible indicators of eutrophication. For example, water clarity is much affected by other organic or humus matter than the levels of chlorophyll-a. Thus the challenge for the evaluator of benefits is to choose the best balanced indicator – an indicator that is well perceptible and most directly linked to nutrient levels at the same time.

Drawing together the discussion of estimating the benefits from reduced eutrophication looking from either perspective, we can see that perfect middle-ground does not exist. Were we to ask the public's WTP to diminish eutrophication using a very simple indicator like water clarity, we could oversimplify the problem and thus receive a non-informative value for the suggested policy. On the other hand, a holistic measure with a multitude of eutrophication effects would give a very credible scenario for the public to give value to. The downside of this approach would be in applying cost-benefit analysis, which would require modeling of all the effects in relation to nutrient reductions, so that a correct portion of the elicited benefits could be attributed to the nutrient reductions. There are, however, a set of indicators of eutrophication that appealed to both social scientists and marine experts; the level of chlorophyll-a, and the intensity of blue-green algal blooming in the affected parts of the sea. These indicators may be usable in cost-benefit analysis – the 3D-model of the sea can predict the indicators for changes in the influx of nutrients, and the levels of both indicators may be set to perceptible threshold levels either at the level of indicators or as a more holistic combination of the measures.

3. Oil Accidents

The risk of oil spills in the Baltic Sea has grown with increased maritime traffic and oil transportation, especially in the Gulf of Finland. This development is projected to continue in the future (Hietala & Lampela 2007, HELCOM 2009b). Oil spills can, depending on the prevailing conditions, damage the functioning of multiple ecosystem services. These effects may then reduce public welfare, i.e. the benefits provided by these services. This section focuses on large-scale oil spills, although small spills in the Baltic Sea area are frequent and cause continual damages.

The ecosystem services linked to the harmful effects of oil spills include primary production, food web dynamics, and maintenance of habitat, biodiversity, and ecosystem resilience. These ecosystem services, in turn, produce well-being to people in the form of recreational activities, provisioning of food and aesthetic values. Another consideration is that the appreciation of affected waterfront properties and summer houses will diminish as a consequence of oiled shoreline. In addition people may value the existence of the ecosystem and species as such.

To assess the monetary value of the damages from oil spills, or, looking from another angle, the benefits from efficient damage control and reduced risk of oil spills, we need indicators describing the effects of oil spills to the ecosystem, recreation and food production. These indicators should reflect both the damages and also the recovery process over time. The damage assessment becomes essential when there are risks of permanently changing the sea ecosystem. It is also important to take into account the temporal nature of oil accidents – nature will recover over time. Unless we can track the path of recovery over time we cannot place a value for diminishing damages or mitigating actions.

One way of estimating the value of oil spill damages is to base the estimates on costs. The maintenance and investment costs of oil spill response capacity and the cleanup and recovery costs of oil are known fairly well. It should be taken into account that generally the costs do not fully cover the monetary value of oil spill damages or the benefits of preventing them. If damages are assessed based on costs, they are frequently underestimated, as they do not completely take into account e.g. the lost ecosystem values. Cost-based benefit estimates do not enable the comparison of costs and benefits either.

The effects to fishing and tourism industries can be assessed rather straightforwardly using market information on the losses caused by the spill e.g. in the form of decreased fish catches. More complicated methods are required for valuing the damages to recreation and non-use values related to the marine ecosystems. These valuation methods necessitate the use of indicators that capture the extent and duration of the effects.

The indicator determination with regard to oil spills is different compared to the case of eutrophication. The damages depend on the prevailing conditions at the time of the spill, type of released oil, as well as the location and magnitude of the spill. Therefore the effects to ecosystem services are subject to many uncertainties. A convenient way in ex ante valuation is to focus on the most likely spill, although such a scenario may be challenging to construct. The similarity to eutrophication indicators is that the chosen indicators for oil spill effects need to be meaningful to the public, with simple enough descriptions.

Historically, assessments of oil spill damages have been predominantly related to the occurrence of large-scale spills. Carson et al. (2003) used the number of dead birds to indicate non-use damages in the valuation study conducted after the Exxon Valdez oil spill. Regarding the Prestige oil spill damages, Loureiro et al. (2006), and Garza-Gil et al. (2006) have estimated the costs to the fishing and aquaculture industries and to the tourism sector. Valuation studies of oil spills are altogether rare, and practically non-existent for the Baltic Sea. So far only one small-scale study, by Ahtiainen (2007), has estimated the benefits from reducing the harm from future oil spills in the Gulf of Finland from the Finnish point of view.

Indicators for ecosystem damage assessment include the number of dead animals or plants, perhaps most practically the number of dead or oil-covered birds. There is also a possibility that a large spill would cause the extinction of an endangered species or damage the functioning of the whole ecosystem. These irreversible changes are most difficult to depict. Loss in recreational benefits can be described via the duration and extent of beach closures and prohibitions in other recreational activities, like boating.

Monetary valuation of damages can be conducted from the perspective of reducing the probability of oil spills or improving the capacity to combat the effects of a spill. It is also possible to combine these viewpoints in building scenarios for valuation studies. An important consideration is that people tend to prefer preventative measures, which should be taken into account in scenario design. A problem related to risk reduction is that people may have difficulties in understanding and putting value to minuscule reductions in risk. As a solution, it is possible to frame the scenario that focuses on preventing a specific kind of oil spill.

4. Invasive Alien Species

Alien species introduced to coastal and marine ecosystems have both benefits and costs. The invasive alien species are policy relevant especially when the damages caused by the invader exceed the benefits. For example, in the US it has been estimated that the zebra mussel invasion from Europe costs 300–1000 million dollars annually (Pimetel et al. 2005). It can be argued that a policy intervention is required to internalise the damages caused by global trade induced invasive alien species (Perrings et al. 2005). However, *ex-ante* evaluation of effects of invasive alien species is not an easy task.

The brackish water ecosystem of the Baltic Sea has not been welcoming to harmful aquatic invaders and significant economic damage is yet to occur. Nevertheless, ca. 120 alien species have been recorded in the Baltic Sea and around 80 of these have reproductive populations (Baltic Sea Alien Species Database 2009). The harmful species include mussels (*Mytilopsis leucophaeata*), barnacles (*Balanus improvisus*), polyps (*Cordylophora caspia*) and water fleas (*Cercopagis pengoi*). Potential harmful invaders such as toxic dinoflagellate (*Pfiesteria piscicida*), american comb jelly (*Mnemiopsis leidyi*) and asian clam (*Corbicula fluminea*) have also been identified. The brackish water of the sea provides a possibility for both fresh and salt water invasions (Paavola et al. 2005).

Main vectors of alien invasive species in the aquatic environment are marine transport and aquaculture (Leppäkoski and Gollasch 2006). Marine transport mainly concerns the species that can survive in the ballast tanks or attach to the hulls of the ships. For the Baltic Sea, the tanker traffic acts as the biggest vector as large ships with oil leave mainly the Russian ports and come back with ballast that is expelled in, or on the way, to the ports. Thus, ports of the Baltic Sea provide first indication of the arrival new species capable of surviving both the in the ballast tanks and in the brackish water of the Baltic Sea. Monitoring guidelines for ports and marinas for alien invasive species have been presented in Campbell et al. (2007).

Once the presence of potentially harmful alien invasive species has been established at some port visited for example by the big oil tankers from Russia, it is logical to calculate the probabilities of the species to end up in the ballast and survive in the tanks till the discharge of the ballast in the Baltic. Of the affecting factors, at least time can be readily estimated from the distance and the typical speeds of the given size class of vessels or from the port registries (Leppäkoski and Gollasch 2006).

The survival of the introduced species will depend on the biological characteristics of the species and of the environmental conditions in the Baltic Sea. Assessing the environmental conditions in the Baltic Sea should be feasible based on some indicators (Paavola et al. 2005). Combined with the information on the shipping volumes to and from the key Baltic ports, a basic risk assessment can be compiled (for examples at the Baltic Sea see Gollasch & Leppäkoski 1999, Leppäkoski and Gollasch 2006).

If the ports represent “hot spots” for alien species, it is possible to conceive a containment and control policy, but in practice the alien species have been detected only once they have been established and become a nuisance for some ecosystem service in the Baltic Sea. Hence, the Finnish expert opinion seems to perceive the invasions as irreversible events (NorWEBS 2009). Indeed, eliminating alien invasive species has proven to be such difficult task that successes have not been reported to the knowledge of the authors. Irreversibility of invasion means that option values may be lost, where the option refers to the value of the possibility to use a resource or service in the future.

Due to differences in the recipient and donor ecosystems, assessing the economic value of damages caused even by the documented species is subject to uncertainties. Lack of peer-reviewed damage estimates of invasive species in the Baltic Sea or coastal/marine regions of the world in general illustrates that further empirical research is needed. Nevertheless, at least the scope of the damage can be perceived by case studies of other marine/coastal ecosystems. In case of the American comb jelly, an alien invader to the Baltic Sea, the damages annually worth of 250 millions USD have been estimated for Black Sea. World Wildlife Fund (WWF) estimates that the annual costs of not adapting the International Maritime Organization (IMO) Ballast Water Convention could be as high as 7 billion USD per year globally (WWF 2009).

Ecosystem services of the Baltic Sea vulnerable to known or potentially invasive species have been recently discussed (Garpe 2008). However, the quantification of effects remains as a challenge to both ecologists and economists. As invasive species have been claimed to be the second biggest factor of biodiversity loss in general (Vitousek et al. 1997, UNEP 2006), it is reasonable to expect that also the biodiversity related ecosystem services of the Baltic Sea will be affected. The effects on biodiversity depend on the success of the alien invader in the new habitat. It is quite possible that the introduced species will be able outcompete some native species completely, and hence alter the food web and decrease the biodiversity, although the current evidence in the Baltic Sea supports the opposite hypothesis (Gollasch & Leppäkoski 1999).

The habitat itself might be changed due some invasive ‘engineering’ species, which can lead to larger shifts in the ecosystem and ultimately decrease the benefits that people derive from them (Wallentinus and Nyberg 2007). The specific example of the Baltic Sea, however, is the enhancement of an ecosystem service, denitrification cycle, by *Marenzelleria* (Wallentinus and Nyberg 2007). Other examples of invasive ‘engineering’ species are the Bay barnacle and Conrad’s false mussel, which both cause biofouling in addition the changes in regulating and supporting services of the Baltic Sea.

While, the ecological modelling capacity seems to be still inadequate to deal with all the effects of invasive alien species on the regulating (e.g. mitigation of eutrophication) and supporting services (e.g. habitat and biodiversity) , it is fruitful to estimate economic effects on the more direct cultural and provisioning ecosystem services such as fisheries, transport and recreation. Even though each invasive alien species is unique as argued in Huhtala et al. (2009), the effects of invasive species on some ecosystem services can be similar. For example, species that clog industrial water intake pipes and attach to ship hulls cause direct damage that may be calculated through the increased fuel, preventive and clean-up costs incurred. For the alien invasive species already established in the Baltic, the comparison should be done between the status quo and the scenario with only native biofouling. Similarly, future invasions should be compared with the status quo.

In case of the services such as food provision, the evaluation of damages *ex-ante* would require modeling of food webs to the extent that the effect of alien invasive species on the main Baltic fisheries can be estimated. Fisheries models should provide quantitative estimates for the economic significance of other ecosystem services such as food web dynamics and resilience. Existing models can already account for ecosystem change and include some degree of food web dynamics (for example Rahikainen et al. 2003). Commercial catch data and fisheries models could even provide an early warning system of changes in the ecosystem services (Uusitalo et al. 2005). Damages to fishing industry can occur in different ways, and do not always relate directly to the amount of fish stock in the sea, as demonstrated by the example of fish hook flea. The fish hook flea increases cleaning time for both the professional and recreational fishing gear and hence increases costs of fishing (NorWEBS 2009).

For directly consumed cultural services, like recreation, giving monetary value to damages by invasive species that prevent or degrade the quality of the activity can be accounted in a similar fashion to an oil spill that closes beaches for some duration. For recreation activities that are directly affected by increased costs, like cleaning up biofouling species from recreational vessels, the increased costs serve as an additional estimate of damages. This approach leaves out the non-use values, like the existence value for Baltic herring, or the existence value of functioning of intermediary ecosystem services. Non-use monetary values can be elicited by specific valuating techniques, but the obtained values may overlap use values, and thus should not be attempted to assess in completely separate studies.

Once the value of damage caused by invasive alien species has been estimated, it can be compared with the costs reducing the likelihood of invasion. Treatment of ballast water is one of the concrete measures to decrease this risk. The alien invasive species can be eradicated from the ballast water by methods of bioactive substances, UV light, filtering or heating (NorWEBS 2009). The costs of these measures should be assessed. One option to decrease the amount of ballast water is to arrange more cargo to be transported, but again the costs need to be evaluated.

From an economic point of view, it can be argued that the ratification and implementation of *International Convention for Control and Management of Ships' Ballast Water and Sediments* (IMO 2004) should only proceed if the benefits exceed the costs of doing so. Furthermore, the assessment should be based on well documented scientific studies, which include methodologically sound economics.

5. Conclusions

The economic value is a commensurable measure which allows different kinds of ecosystem services and different types of pressures on the Baltic Sea to be compared and aggregated. The aggregation is not a simple task as the sea is connected to many human activities, which are often inter-related and substitutable. Understanding how anthropogenic pressures such as eutrophication, oil spills and invasive alien species affect the services, and ultimately the benefits, requires knowledge of the ecological processes that provide the services. These underlying processes can be seen as supporting and regulating ecosystem services as the Millennium Ecosystem Assessment demonstrates. However, for the purpose of aggregation of benefits we need to focus on the intermediate and final services, which produce human well-being (Fisher et al. 2009). Including the underlying ecological processes as evaluated services will lead to double-counting of benefits (Boyd & Banzhaf 2007). Instead, the regulating and supporting services (processes) will need to be modelled in such way that their significance is represented quantitatively in the quality of the provisioning and cultural services, i.e. in the benefits of these more direct services.

The benefits flow from several interdependent services which relate to many cultural factors[1] in addition to the ecological processes. To quantify the value of a beneficial service, we must have data on people and of their behaviour. In the case of the Baltic Sea, we assume that the majority of the benefits are enjoyed by countries around the sea and that we can grasp the scope of the Baltic policy issues by studying these countries. Strictly there are also benefits for tourists from other countries. However, even when assessing the benefits only in the nine surrounding countries, we should consider whether the cultural values of the sea differ from country to country.

As listed by Garpe (2008), the Baltic Sea relates to cultural ecosystem services of recreation, scenery, legacy of the sea, inspiration for art and advertisement, maintenance of cultural heritage and contribution to science and education. We consider recreation and scenery more vulnerable to eutrophication, oil spills or invasive species. Thus they should have a higher priority in quantification of benefits than inspiration for art and advertisement, contribution to science and education and maintenance of cultural heritage. Moreover, these issues are so entwined to the cultural conventions,

[1] The Millenium Ecosystem Assessment distinguishes between provisional and cultural ecosystem services. This distinction can be useful for example when considering differences between the evaluation of public and private goods, but from the societal standpoint also provisional services are derived from culture, e.g. the Baltic Herring as part of the modern Finnish diet stems from the culture to eat it, while the roach consumption is not generally part of the culture.

labour and capital that the effect of marine environmental quality would seem less important than for recreation or scenery.

To facilitate the analysis further, the threatened services can be divided between private and public goods. This is an important distinction for benefit calculus as private goods can be given value by markets, while public goods require indirect methods. In this respect, we consider the provisioning services as private goods and cultural services mainly as public goods. One exception in the category of provisioning services is the provision of genetic resources, which includes also public good characteristics.

In figure 1 we have modified the classification of Garpe (2008) and Millenium Ecosystem Assessement (2005) to illustrate how the previous ecosystem service studies of the Baltic Sea can be extended to the field economic valuation. Following Boyd & Banzhaf (2007) and Fisher et al. (2009), more systematic economic analysis is facilitated by defining the ecosystem services as something provided strictly by nature. Nevertheless, we retain the regulating and supporting services of MA classification and Garpe (2008) to link complex ecosystem services to benefits perceived important by specific users of evaluations, in this case the Baltic Sea research community. Establishing this link is one of the legitimate and meaningful reasons for benefit evaluation (Fisher et al. 2009). Due complexity of the system we do not depict all the connections of services or all the interdependencies between the benefits.

Forcing simple connecting indicators between the benefits and final/intermediate ecosystem services was only partially successful in the case of our expert panel on the economic analysis of the Baltic Sea (NorWEBS 2009) Complexity of the ecosystem of entire sea requires extensive ecological information and a conceptual frame of linking the identified threats to services and benefits would have been essential to facilitate discussion on economic evaluation of the Baltic Sea. Hence, we propose to estimate the benefits of the Baltic Sea by modelling the ecosystem services by the 3D geophysical model (Kiirikki et al 2006) and the value of ecosystem benefits by adding revealed preference elicited value to the market price based changes in the productivity.

When the final services are defined in broad terms e.g. “clean water”, the way to measure the benefit needs to be clarified. The definition of what constitutes as clean or good quality is dependent on the benefit category, even though the service they rely on is the same. The indicators help to quantify the benefits when the benefit itself is not unambiguous. The consensus of the expert panel called for using at least both the water clarity and algae biomass (specifically blue-green algae) as eutrophication related indicator of clean water and length and duration of polluted coast-line and oil tarred birds as indicators related to oil spills. For invasive alien species no indicator could be singled out, although the use of

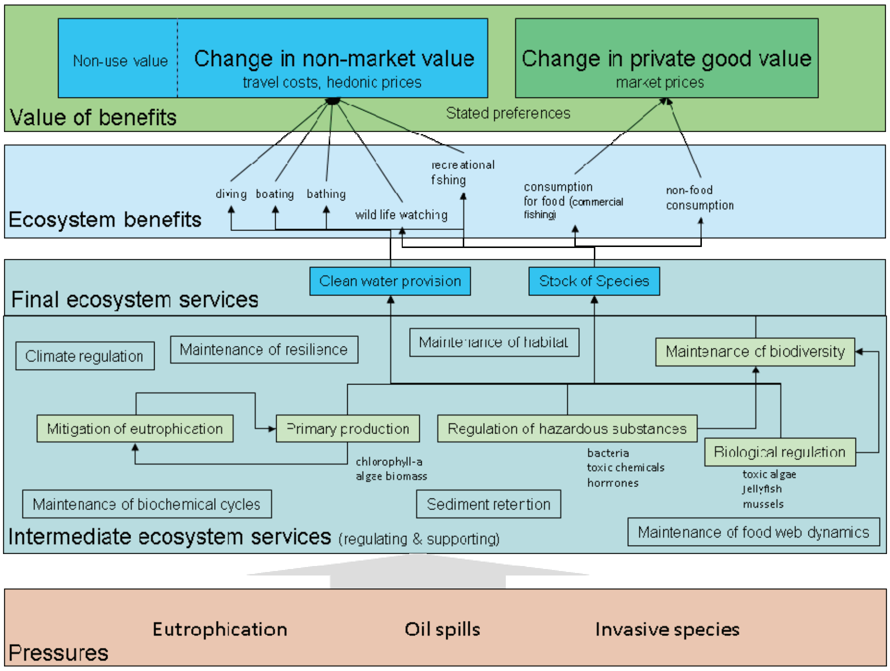

Figure 1. Ecosystem services and valuation of the benefits they provide. Ecosystem services are interlinked. To evaluate economic value of complex natural processes indicators are needed to approximate the effect of more fundamental ecological functions to services that provide the benefits for people.

indicator species for certain groups of invasive species was discussed. Further research will be needed to specify the relevant ranges for the valuation of different benefit categories, i.e. the algae concentration for pleasant sailing is different from the one for swimming.

The provision of both public and private goods means that estimating the monetary value for these benefits requires different methods – for marketed goods, like fish, we can use existing prices to reflect benefits, while for non-market goods, like water recreation, we need to elicit the value through specific valuation methods. While the NorWEBS workshop aimed at bridging the gap between ecosystem services and the estimation of monetary value of these benefits, no conclusion can be drawn on the preferred valuation methods for further studies based on the workshop. Considering the wide range of services the Baltic Sea provides we argue that no single valuation method will represent the values adequately. Therefore, a combination of both stated and revealed preference methods is needed to supplement the market value estimates. Recreational values can be elicited using revealed preference methods based on actual behaviour, and hypothetical scenarios of oil spills and invasive species emergence can be assessed using stated preference methods. Using different methods does not complicate research as such, since data is mostly collected through surveys. Joint-methodological surveys allow the comparison and summation of estimated values across the same sample of individuals, and also make the aggregation of values more reliable. Survey design must, however, be carefully thought and coherent to reap the rewards.

We propose that the values for swimming, fishing and boating trips will be estimated using travel costs related to the trips. As the travel cost method does not capture the value of living by the sea, these value estimates should be amended by including the environmental quality (for example the cleanliness of beach from algae mat or oil) capitalized into property prices with hedonic property price methods. The non-use values, and willingness to pay to decrease the risk of invasive species introduction and catastrophic oil spills we propose to be assessed using the choice experiment method. By focusing on the willingness-to-pay for risk reduction, we may avoid double counting of damages, and gain also policy relevant information on the public opinion of preventive resource allocation. Additionally the valuation needs to take substitution effects into account, which, if omitted, will inflate value estimates. The Baltic Sea is not without its substitutes; people can recreate in inland waters, or participate in other forms of recreation if the quality of the sea degrades enough.

Both revealed and stated preference techniques include issues that need to be taken into account. In the travel cost method approach we need to be careful not to double-count benefits. If overlapping exists between valued benefits we cannot simply add up the monetary benefits as the total economic value of the Baltic Sea. For example, fishermen may take the opportunity to go boating or swimming at the same occasion. The possibility to make joint purpose trips makes the summation of benefits more difficult. This may, however, be taken into account in research once recognized. The same logic works also when using multiple methods; we need to design the research so that there is as little overlapping as possible, since decomposing value estimates may prove very difficult.

The problems with stated preference techniques relate mainly to the construction of scenarios, and eliciting unbiased information. Scenarios should be built as understandable and credible as possible, else the estimated public's willingness-to-pay may be for something the researcher has not intended. Since the method does not subject the respondents to real budgetary constraints, we need to take care that elicited willingness to pay measures do not carry "good-will" contributions - money that would not be paid in a real situation. The choice experiment method allows for simultaneous comparison of multiple attributes, like the chance of invasive species emergence, a major oil spill or eutrophication levels. However, the method relies on using attributes that occur independently of each other. Thus, the challenge in using the choice experiment method in valuing the Baltic Sea environment is to use attributes that are understandable, as independent as possible from each other, and that have distinctly identifiable threshold levels that the researcher may present to a respondent from the general public. Invasive species and oil spills could be presented as a risk of occurrence to the respondent, but would require a careful explanation as to what the ramifications from these events would be.

If non-use values will be assessed in a choice experiment, there are at least two considerations that require attention. First, estimating existence values is challenging. From the standpoint of our discussions, we need to understand what is the benefit, the end-product that the public gives value to. Is it the seal population in the Baltic Sea, or is it the healthy food web that supports the current ecosystem? While it may feel redundant to elicit value for the existence of the food web, asking a similar question about the existence of the seal population is not ultimately so different . Dividing the ecosystem services into small - perhaps more understandable - parts carries the risk of counting the non-use benefits multiple times over. If we were to ask willingness to pay for the existence of several important species in the sea separately, we would most likely find out that people would not like or afford to pay the amount of money they have stated in the end. It may thus be more appropriate to construct the scenarios used in non-use value studies for a more general type of existence value, like the existence of a fully functional ecosystem, of the Baltic Sea, rather than specific species.

A second consideration is the common assumption that non-use values are constant in time. However, non-use values like all values can change over time, e.g. the value of healthy seal population can change despite that the population remains unchanged. Values, especially when asked from the public, are as much an image of the culture as they are an image of the current media coverage. The countries around the Baltic Sea have different cultures and values toward the sea. Cultures also change – the continuing greening of both the political and social atmosphere has an effect on environmental values. This means that a valuation study with WTP measures from ten years ago may well be in need of an update. We thus propose that a decennial report on values should be established, if the costs and benefits of Baltic Sea protection are to be tracked and evaluated over time.

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Sammanfattning

Östersjöns värde visar sig i alla de mänskliga aktiviteter där man förlitar sig på havet. De största hoten mot ett friskt Östersjön är övergödning, oljeutsläpp och invasiva arter. Den avgörande frågan är hur mycket resurser som ska avsättas för att skydda de ekosystemtjänster som Östersjön tillhandahåller. För att kunna ta fram optimala skyddsprinciper behöver vi veta mer om vilken nyttan är. Vi föreslår ett ramverk för att härleda den kombinerade nyttan med de tjänster som Östersjöns ekosystem tillhandahåller. Vi utökar den befintliga miljöinformationen om ekosystemets tjänster med ekonomiska analyser av tjänsternas värdering. Valet av indikator beror på det aktuella miljöproblemet. Vi definierar en uppsättning indikatorer som omfattar miljöprocessernas sammanhang och människors uppfattning. De baseras på de miljöhot som en expertpanel för Östersjön har utvärderat. En lämplig utvärderingsmetod bör ta kulturella skillnader mellan Östersjöländerna och nyttans underliggande ömsesidiga miljöberoenden med i beräkningen. Då fördelarna ska läggas samman måste man fokusera på kulturella tjänster och försörjningstjänster så att de inte räknas dubbelt. De reglerande och stödjande tjänsterna ska modelleras på ett sådant sätt att värdet på försörjningstjänsterna och de kulturella tjänsterna avspeglar deras betydelse.

Appendix

NorWEBS –survey

The Nordic Workshop on Economic analysis of the state of the Baltic Sea (NorWEBS) survey was sent to 37 marine ecosystem experts and economists in all the littoral countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden) and Norway in November 2009. The survey elicited information on the problems affecting the Baltic Sea, indicators of these problems, links between scientific measures and observable quality changes, and national special interests to provide input to valuation studies. The survey had 15 questions on three subjects: eutrophication, oil accidents and invasive species. The response rates were 52% (13/25) and 25% (3/12) for workshop participants and non-participants respectively. The discussion in the NorWEBS workshop in Helsinki 19.11.2009 to 20.11.2009 was based on these answers.

The main results from the survey indicated that the best indicators for both predicting eutrophication and explaining the results to the public were considered to be water transparency and the blooming of blue-green algae. The economists were especially in favour of the water clarity measure, whereas marine experts suggested additionally the use of the levels of chlorophyll-a (chl-a) to describe eutrophication. All three indicators were suggested to be easily observable by the public and be dependent on the nutrient concentrations in the sea, and thus can be modelled. The weakness of water clarity was observed to be its dependence on not only nutrients but also humus concentrations, which causes uncertainty in modelling. The respondents did not generally recognize existing studies with transfer functions from nutrient concentrations to these indicators. Data availability on the indicators was, however, abundant, at least for water clarity and chl-a levels. There was a call for using holistic measures for water quality, including eutrophication, but it remained unsure how to isolate the effects of single indicators to a holistic measure.

For oil accidents all experts found it difficult to speculate how to assess the extent and duration of damages to both recreational use and ecosystem from a large scale oil spill on the coast-line of their respective countries. Damages to recreational use of the sea were still considered easier to determine compared to ecosystem damages. Economists put weight in their answers to the expertise of marine biologists. It was also suggested that we should learn from previous oil spills, with Exxon Valdez spill as an example. As publicly observable recovery indicators, the condition of sea bird communities was the most suggested indicator for ecosystem values. Many other indicators were also suggested, including sea vegetation, plankton, or other characteristic site specific species. Damages to recreation were suggested to be measured as the number of days that recreation is not possible. There was little knowledge on existing data relating to these indicators – monitoring data for possible indicators was with small coverage or has not yet started. For bird species there exists time series data on population, which may be usable. For recreational damage estimation it was suggested that national recreation inventory data could be used if it exists.

The least understood problem of all three problems examined in the survey was recognized to be the invasive species. The threat in itself was considered to be multifaceted, as there are many different potential invading species with different and uncertain effects on the Baltic Sea ecosystem. The public's knowledge of the problem was considered lacking as serious outbreaks have not, with luck, yet occurred. The only measure currently identified to reduce the risk of invasive species introduction was identified to be the yet-to-be-ratified Ballast Water Convention of the IMO for which the experts could not assess costs.

National concerns that were left out from the survey were included mostly dynamic issues with continuous pressure like overfishing, water pollution, off-shore activities like pipelines and wind mills, erosion of beaches and marine debris.