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Valuing Marine Ecosystem Services Loss from Oil Spills for Use in Cost-Benefit Analysis of Preventive Measures

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1. **Introduction**

The coastal zones globally are under increasing pressure from often competing human uses, such as aquaculture, sea transport, energy production, conservation, fishing, and recreation (Turner and Schaafsma 2015). Climate change causing sea level rise, warming and acidification, put additional pressures on coastal zones and management (Nicholls and Cazenave 2010). Traditionally; state, regional and local agencies have managed marine and especially coastal resources relatively statically and sector-by-sector, with little consideration for connections between and within human and ecological systems (Holland et al. 2010, Liu et al. 2015). Further, the un-priced, non-market values of coastal resources have often remained implicit or even ignored (Kumar 2010). Overall, this approach has been unsuccessful in managing the coastal zone sustainably, leading to outcomes with lower net benefits to society than would otherwise have been possible (Holland et al. 2010).

Recognizing the need for more effective coastal zone management, efforts to implement ecosystem-based management (EBM) is on the rise (Sanchirico et al. 2013; Samhouri et al. 2014). A core component of EBM is its strong emphasis on ecosystem services (ES), i.e. the myriad of benefits that people and industries obtain from marine and coastal resources (Kumar 2010; Fisher et al. 2009). They include various basic supporting services as well as provisioning services (products) such as fish and other food resources, regulating services (e.g. preventing coastal erosion), and a range of cultural services (e.g. recreation, tourism, spiritual and cultural well-being, and aesthetic benefits) (CICES 2015). In addition, the coast provides many abiotic services such as minerals and energy sources. Implementation of EBM requires a good understanding of how the marine and coastal ecosystems provide ES, how human activities affect these services, and how to reliably assess their value in a particular geographic area. Further, it also involves trade-offs among options for managing human activities, including both conservation and economic development. . The ES framework promotes a more holistic thinking, motivated by the need to develop more integrated approaches to resource management, and to better account for human welfare and livelihoods implications (Egoh et al. 2007, NOU 2013) as well as providing a link to more adaptive management models (Schultz et al. 2015; Börger et al. 2014; Turner and Schaafsma 2015). The field of economics has as its core interest the welfare implications of ES and coastal zone management for people. Economics offers a highly useful conceptual framework for thinking about interactions between humans and other components of the ecosystem in a more holistic manner.

Many, if not most, decisions regarding natural resource management hinges on the question of how people value resources and how those valuations can inform trade-offs in specific decision-making contexts. Using economic methods, especially methods for valuing ES (in monetary terms) and the decision-support tool cost-benefit analysis (CBA) it is possible to examine values associated with many different coastal resources and uses. Making trade-offs explicit improves transparency in decision-making, helps avoid unnecessary conflicts attributable to perceived but weak trade-offs, and focuses debates on finding the most efficient solutions to mitigate real trade-offs and maximise industry values (White et al. 2015). Yet, significant research challenges remain in the refinement of valuation methods, the inclusion of ES values in CBA, and in the amendment of current CBA (and other decision-support) frameworks, for ES valuation to rise from its current promise to wider practical usefulness and actual use in coastal zone management. The aim of this chapter is to present a real world, extensive pilot application valuing the ES loss of oil spills from ships along the Norwegian coast for use in CBA of preventive measures within the realm of the Norwegian Coastal Administration (NCA).

In the remainder of this chapter, section 2 briefly reviews monetary valuation methods for marine ES losses, and section 3 describes the design and results from a contingent valuation (CV) survey valuing different levels of marine ES losses from oil spills. Section 4 concludes with lessons learned from this case study, and the policy implications of including monetary marine ES losses in the CBAs of the NCA.

2. Marine Ecosystem Services Monetary Valuation Methods in Cost-Benefit Analysis

Some marine and coastal ES are traded in markets, and can be valued in monetary terms based on market prices (e.g. farmed fish or tourism). Other ES, especially regulating and cultural ES, typically have no market prices, and can be valued by non-market valuation methods only. These methods include revealed preference (RP) and stated preference (SP) methods. RP methods use observational data on decisions people make in markets to estimate the value of changes in an ES flow, and include among others the travel cost method (TC) method to estimate recreational benefits. SP methods use data generated from surveys eliciting people's contingent preferences in constructed (hypothetical) market scenarios, and include the Contingent Valuation (CV) method, Choice Experiments (CE), and variants of these. The aim of SP methods is to estimate the affected population's willingness-to-pay (WTP), directly or indirectly, to obtain a positive stream of ES or avoid further reduction. A third group of (secondary) valuation methods is Benefit Transfer (BT) (Johnston et al. 2015; Navrud and Ready 2007; Lindhjem and Navrud 2008). BT uses value information from existing studies or data in the literature to transfer to a relevant policy context in need of such information. BT is a much-used method in practice, and may have sufficient precision in some contexts. While the valuation methods have been tried and tested for many years, applications using the ES framework fully are relatively recent (Kumar 2010, Nunes et al. 2014). The literature also calls for more careful validity testing and triangulation of the methods to achieve higher level of precision and credibility, especially for SP methods since these are hypothetical by nature (Kling et al. 2012, Haab et al 2012). In addition, challenges remain in conducting ES valuation studies that are specifically designed for decision-support and CBA, not just awareness raising in general (Kumar 2010), and that deal directly with issues that arise in practical contexts (Börger et al. 2014; Banzhaf et al. 2006). Scientific uncertainty, spatial explicitness and temporal stability of values, definition of affected populations and aggregation over both ES use and non-use values, are important questions also for marine and coastal planning (Luisetti et al. 2011; Raheem et al. 2012; Sanchirico et al. 2013; Marre et al. 2015). Moving research into resolving both the methodological and practical challenges in ES valuation is seen as one of the most important frontiers of ES research (Guerry et al. 2015, TEEB 2010).

Within CBA, costs and benefits to society of alternative scenarios for ES flows compared to a baseline are reviewed, quantified in physical terms, and to the extent possible, valued in monetary terms. If the most important cost and benefit components can be meaningfully valued, all cost and benefit categories can be compared. In many countries, including Norway, there is a formal requirement to conduct CBA of projects and polices with significant impacts (DFØ 2014). As noted, current CBAs rarely include monetary ES values. A growing number of cases suggest that incorporating the right monetary (and non-monetary) ES values into decisions is practical, and can lead to a broader set of desired outcomes (Schaefer et al. 2015; Arkema et al. 2015; Ruckelshaus et al. 2015; TEEB 2010)[1]. Figure 1 illustrates the temporal flow of marine ES, and ES loss/damage due to an external stressor, in this case a marine oil spill. The next section describes the design and results from an extensive pilot Contingent Valuation survey aimed at estimating the monetary welfare loss to the Norwegian population from interim losses in ES services for use in CBAs of local and regional preventive measures.

[1] Non-monetary valuation methods for CBA can also be used to express the welfare effects of hard-to-value ES; and multiple value metrics have also been called for by decision-makers (Ruckelshaus et al. 2015). The methodological toolbox is, however, generally less well developed than for the monetary methods, but include deliberative methods (e.g. citizen's juries, deliberative ES mapping), preference assessment methods (e.g. preference ranking), and time-use studies (Kumar 2010, Martin-Lopez et al. 2012). Integrating monetary and non-monetary values associated with ES into a hybrid CBA framework is both a policy and management need, as well as a research challenge (Gomez-Baggethun and Lopez 2014). Critics further add that for CBA to play a more important role in the policy process, a more explicit focus on distributional issues and stakeholder involvement is needed to better understand who wins and who loses, and resulting underlying conflicts (Nyborg 2012; Turner et al. 2014; Krutilla 2005). There is also increased emphasis on equity issues in the revised Norwegian guidelines on CBA (DFØ 2014). If the CBA framework can be amended in these ways, CBA can be very useful in structuring, reviewing and analysing costs and benefits of ES flows, and as a basis for analysing trade-offs between different ES uses, over time, between geographical areas, and between key stakeholder groups.

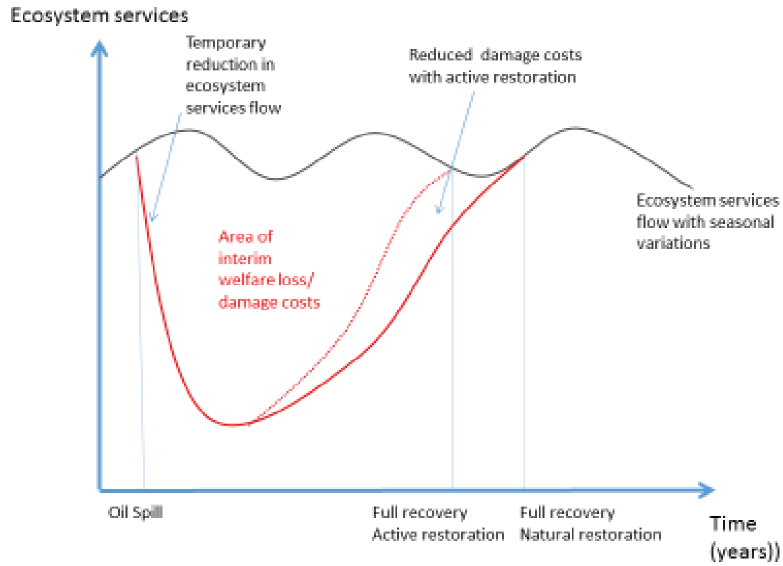


Figure 1. Temporal flow of marine and coastal ecosystem services (ES), and the service loss/damages due to an oil spill; with and without active restoration of the services.

3. Valuing the Benefits of Marine Oil Spill Prevention Measures

Norway has a long coastline with a relatively high number of vessels, and the Norwegian Coastal Administration (NCA) is in charge of implementing preventive measures to reduce the risk of accidents causing oil spills. While the social costs of these measures can be valued by market prices, the social benefits in terms of avoided damages to marine regulating and cultural ES require non-market valuation methods[2]. In order to capture both use and non-use benefits of these ES, SP methods need to be employed. In order to construct a reliable set of unit values for benefit assessment in their CBA manual, NCA decided to fund a comprehensive set of new CV studies covering all of the Norwegian coast. As many of the measures NCA implements are in specific harbours and parts of the coastal fairways, we need to know the WTP of the regional populations rather than some national average as preferences might vary along the coast, and between the coast and inland. In addition to knowing the regional mean WTP for avoiding damages, we also need to

[2] However, benefits from avoided damages to provisioning ES like commercial fisheries, aquaculture and tourism can in principle be valued using market prices.

know how many households in each region experience a welfare loss from damages to marine ES, in order to calculate the aggregate social benefits of these oil spill prevention measures. As we know from SP studies of e.g. Value of a Statistical Life (VSL) that people have difficulties in understanding changes in accident risks (see e.g. Lindhjem et al 2011), these are computed in a separate risk assessment model. Thus, the CV survey asks for respondents´ WTP for avoiding specific damage scenarios occurring with 100 % certainty, and ranging from small through moderate and large to very large damages to marine and coastal ES. The damage scenarios are extrapolations of damages experienced in previous oil spills[3]. The description of damages has been developed through expert and stakeholder workshops, focus groups with households, and careful pretesting of a CV web survey instrument.

Although our CV scenario builds on the experiences from previous CV surveys of major marine oil spills; especially Carson et al (1992, 2003) of the Exxon Valdez oil spill and Loureiro et al (2006) of the Prestige oil spill, these two surveys were conducted for use in natural resource damage assessments of oil spills that had already occurred, whereas the aim of our survey is to establish unit values for a range of ES damages from oil spills for use in CBAs of measures *preventing* oil spills from ships.

In 2013 we carried out a large pilot CV web survey of a total of about 2500 households, in a design aimed at mapping how households´ preferences for marine and coastal ES varied across regions of Norway. Both ES of mainly regional significance in their own region and ES of national significance outside their region were valued. The sampling plan consisted of:

i) **Three regional subsamples**, where respondents in each sample were asked their household annual WTP to avoid damages to marine ES from a typical oil spill incident along the coastline where they lived. The respondents were told that without further measures, an accident would happen "in the next few years"[4] that would result in an oil

[3] In the follow-up main CV survey, damage scenarios are based on extensive oil spill dispersion and ecological modelling.
[4] We did not want respondents to focus too much on the number of years, as we experienced during focus groups that some respondents thought that small spills and damages were more likely than large spills/damages. This is why we were rather vague about when it would happen.

spill that could cause four different levels of environmental damage (from “small” to “very large” damage/loss – see Table 1). Each respondent would face all four damage levels in turn, but with advance disclosure of all four to avoid any surprises for respondents during the valuation exercise. Then they were asked for their household’s annual WTP for a ten year period to avoid each of them - always starting with the small damage. The three regions were: i) Eastern Norway/Oslo Fjord area (one spill site; see detailed map example from the web survey in Figure 3), ii) Western Norway, with Norway´s longest fjords (two spill sites, in the northern and southern part of this region, respectively), and iii) Northern Norway (one spill site, in the iconic area of the Lofoten Islands, see below). Figure 2 provides an overview of the three regions, and four spill sites (i.e. two sites in Western Norway).

ii) **One national subsample,** where respondents were asked their household annual WTP to avoid ES damages from an oil spill in an area which most Norwegians consider to be an iconic area of national importance, and very important for both tourism and fisheries; the Lofoten Islands in Northern Norway. It was the same oil spill scenario as given to the third regional subsample in Northern Norway mentioned above. Note that out of Norway´s 2,2 million households, close to 1/3 in live in Eastern Norway (and most in the counties surrounding the Oslo Fjord), while the Lofoten Islands in the far north are scarcely populated. Many Norwegian households have never visited this area, but most have heard about the Lofoten Islands, and seen them in photos and on TV. This subsample would therefore test whether there are also non-use values for the Lofoten Islands marine ES among households outside of the Northern Norway region. This would be used to determine if the size of the “affected population” is larger than the Northern Norway population, and how the mean WTP varies geographically among households in Norway.

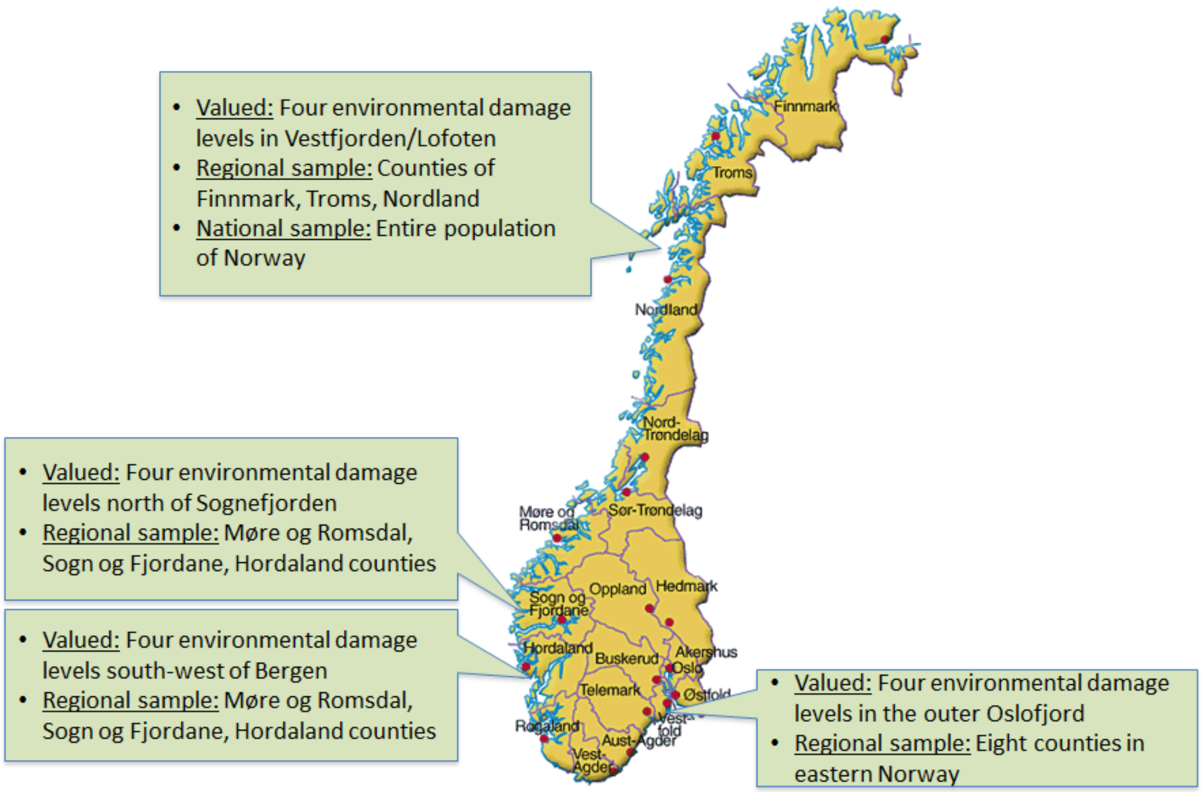


Figure 2. Location of oil spills considered for the regional and national population samples.

The purpose of this extensive pilot CV survey was to develop and test material for use in the final questionnaire, including a damage/loss table (see Table 1) scaling the damage from small through medium and large to very large damage (with traffic light colors to help people distinguishing between the damage categories), and maps showing the spill site and dispersion of the oil for different damage categories (see Figure 3 for an example). The spill sites and dispersion/geographical extent of the damage are based on preliminary inputs from NCA, marine biologists, ornithologists, environmental authorities and other experts; in a workshop and their comments on an early version of the pilot survey instrument.

It was clear from the focus groups and testing that people particularly cared about: i) the death and suffering of birds (not only the share number, but also the vulnerability and rarity of bird species and populations), ii) marine mammals (represented by the seal in Table 1), iii) the extent and severity of damaged coastline for recreation (and return times back to normal use), and iv) damages to other ES and life in the sea in general, including fish and seafood consumption advisories. The ES losses were therefore presented along the four dimensions of “birds”, “seals”, “coastal zone” and “other marine life” in Table 1.

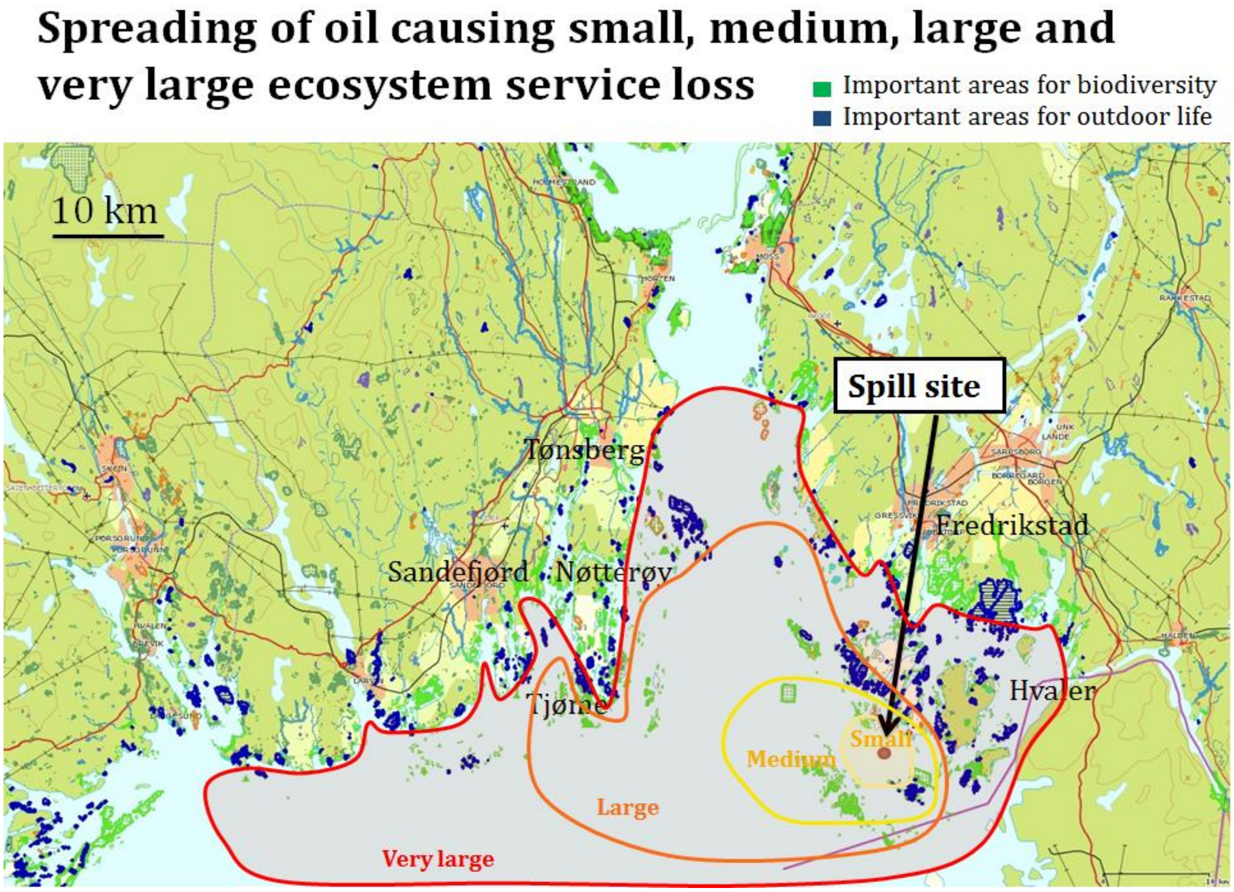


Figure 3. Map showing the Oslo Fjord oil spill site, and the extent of damage for the four damage/loss levels (i.e. small, medium, large, and very large loss), as described in table 1.

Table 1. Damage/loss table used in the Contingent Valuation (CV) survey to describe four different loss levels for different ecosystem services (ES) from an oil spill in the Oslo Fjord area (There are similar region-specific damage tables for other regions with different numbers, but the same color coding) if no preventive measures are undertaken ("without measures" - in light yellow, yellow, orange and red) versus a situation "with measures" which would preserve the current state of marine ES (in green).

	With measures	Without measures			
	Present conditions	**Small loss**	**Medium loss**	**Large loss**	**Very large loss**
Damage to birds					
	The area is an important breeding, migration and wintering ground for seabirds. The bird populations are in good condition.	The bird populations are in good condition. In total **1000** dead birds	The bird populations recover after **1** year In total **7 500** dead birds	The population of common eider is locally endangered. Other bird populations recover after **2** years In total **20 000** dead birds	The common eider and common murre populations are locally endangered. Other bird populations recover after **4** years. In total **50 000** dead birds
Damage to seals					
	Parts of the area are important to seals. The seal population is in good condition	The seal population is in good condition In total **10** dead seals	The seal population is in good condition In total **40** dead seals	The population of harbor seal recovers after 2 years In total **150** dead seals	The population of harbor seal is locally endangered In total **300** dead seals
Damage to coastal zone					
	The area is very important for recreation and outdoor life The area has a large cold-water coral reef, rich marine eelgrass meadows and a valuable natural environment	**5** km of coastal zone consisting of *bare rock shores and beaches* soiled with oil Affects land and water based outdoor life Affected areas can be used as normal after **6** months	**30** km of coastal zone consisting of *bare rock shores and beaches* soiled with oil Affects land and water based outdoor life Affected areas can be used as normal after **1** year	**150** km of coastal zone consisting of *bare rock shores and beaches* soiled with oil Affects land and water based outdoor life Affected areas can be used as normal after **3** years	**400** km of coastal zone consisting of *bare rock shores and beaches* soiled with oil Affects land and water based outdoor life Affected areas can be used as normal after **5** years
Damage to other marine life					
	Fish and shellfish in the area	Can be harvested as before. Safe to eat seafood Spawning areas for fish are unaffected	Can be harvested as before. Safe to eat seafood after **1** year Spawning areas for fish are unaffected	Fish, shellfish, mussels and seaweed should not be eaten until **3** years after the spill Spawning areas for fish are unaffected	Fish, shellfish, mussels and seaweed should not be eaten until **5** years after the spill Spawning areas for fish are unaffected

The pilot survey was conducted by a professional survey firm, which drew random samples of respondents from their internet panel for each region and for the national sample. The net sample size was 622 respondents for the Eastern Norway subsample (the Oslo Fjord spill site), 400 and 402 respondents for the southern and northern spill sites in Western Norway, respectively), and 350 respondents in the Northern Norway subsample (the Lofoten Islands spill site). Finally, there were 751 households in the national subsample valuing the same Lofoten Island spill site. The response rate varied between 17.2 and 20.7 %. This is relatively low, but acceptable for a pilot internet survey. Further, the subsamples were representative of the regional/national population with regards to selected socio-economic characteristics (i.e. age, gender and education level).

The results showed that respondents did understand the material, and generally responded in a rational way. Figure 4 shows that households´ mean, annual WTP over a 10-year period increased with the size of the ES damage/loss as expected from economic theory, i.e. people are willing to pay more to get more in terms of avoiding larger ES losses[5]. Further, households in Northern Norway have significantly higher WTP for avoiding ES losses from a spill in their region, compared to the other regions` WTP to avoid ES losses from a spill in their region. This could be explained by the historically high dependency (due to commercial fisheries[6]) and connectedness to the ocean in Northern Norway compared to the other regions; although some of the same could be said for Western Norway. The results from the national sample valuing ES losses in the Lofoten Islands (see Figure 5) clearly show that there are significant non-use values outside the scarcely populated Northern Norway region. This illustrates the potential underestimation of aggregate benefits in CBA of preventive measures that would arise if we assume that only households in the region where the oil spill and ES loss takes place, as we would aggregate benefits over much fewer households than are actually experiencing a welfare loss. However, this is only true for unique ES of national importance, like the Lofoten Islands, and assuming the same for marine ES of mainly regional importance could greatly overestimate the aggregate benefits in CBAs of avoiding ES losses.

[5] This shows that this CV survey passes the "internal scope" validity test.

[6] Note that we tried in our survey design to focus attention on the non-market ES losses, and away from any potential commercial losses that could result from the oil spill damage scenario. Including the latter losses in this CV survey could potentially lead to double-counting as these losses could be valued separately using market prices of fish and sea food.

Figure 4. Mean willingness-to-pay (WTP) per household per year for a ten year period to avoid marine and coastal ecosystem service (ES) loss/damage from an oil spill in each of the regions; for different loss levels and for each of the regions. (In Norwegian Kroner (NOK); 1€ = 11,64 NOK (Purchase Power Parity (PPP) corrected € at the time of the survey; 2013)

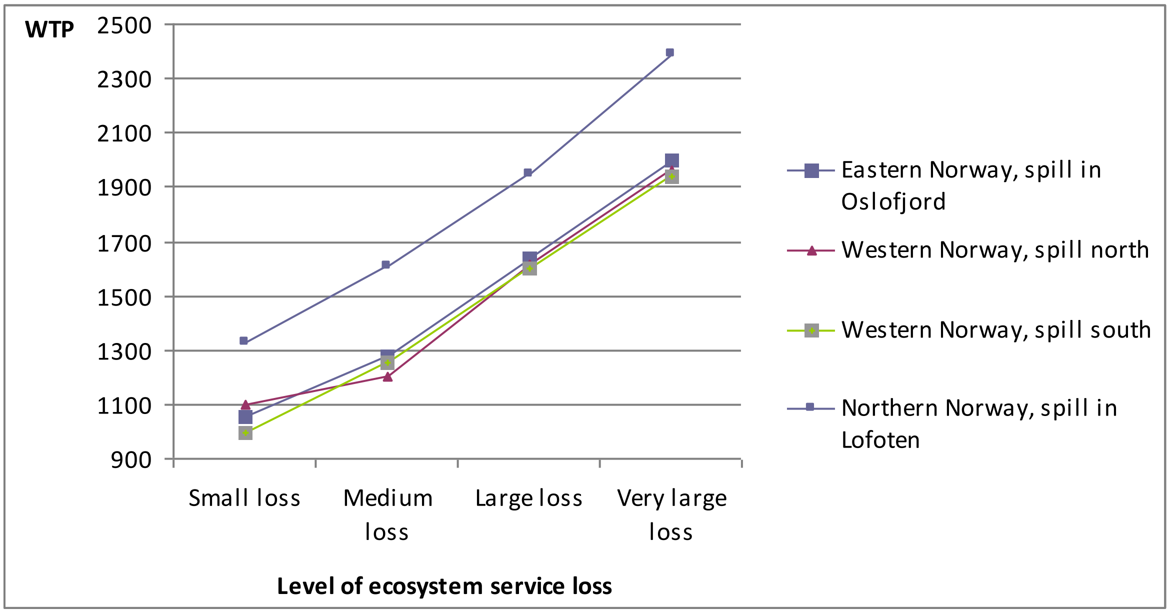
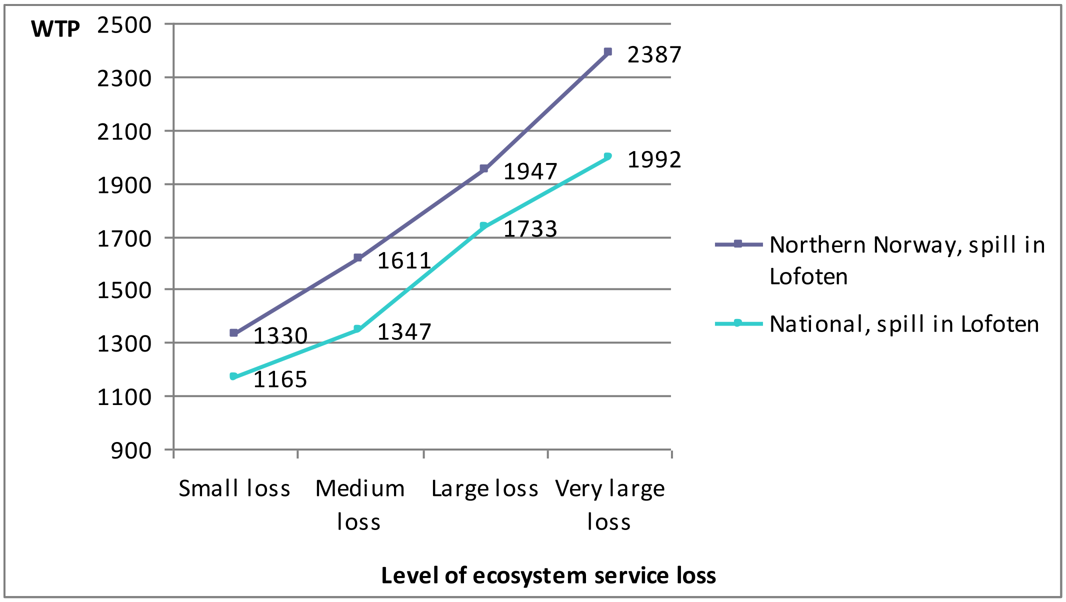


Figure 5. Mean willingness-to-pay (WTP) per household per year for a ten year period to avoid marine and coastal ecosystem service (ES) loss/damage from an oil spill in the Lofoten Islands in the Northern Norway region; for different loss levels and for the national sample (including households from Northern Norway), and the regional Northern Norway sample only. (In Norwegian Kroner (NOK); 1€ = 11,64 NOK (Purchase Power Parity (PPP) corrected € at the time of the survey; 2013)



4. Conclusions, lessons learned and policy implications

This Contingent Valuation (CV) survey of marine and coastal ecosystem services (ES) demonstrates the usefulness of the method to value ES losses, and the importance of easing people's cognitive burden when valuing many levels of complex ES losses through simple, transparent and consistent verbal and visual descriptions. Visual tools like the damage table (Table 1) with photos of each ES, a "traffic light" design to illustrate the different levels of ES loss from no loss (green) to a very large loss (red) seem to work very well. Thus, households´ welfare loss, stated in terms of their mean annual willingness-to-pay (WTP) to avoid these ES losses, increased with the size of the ES loss. This is in accordance with economic theory. This also shows the importance of stating the wildlife loss, both in terms of the number of individuals killed, and the time it will take before the populations are back on their feet. Just stating the number of dead birds etc., and not mentioning that this is an interim loss, could easily lead to overestimation of mean

WTP. The same is true for a payment vehicle based on annual payments, as respondents have been shown in experiments to apply discounting strategies such as hyperbolic discounting, suggesting high mental discount rates in the short-run and low behavioral weight on the future, e.g. Kirby and Hermstein (1995). Thus, in the main survey we will use a one-time payment rather than annual payments for a limited time period or infinity, in order to make sure that we are not overstating mean WTP when aggregating over time.

The final CV scenarios for the planned main survey will be based on detailed oil spill modeling and more detailed ecological assessments for each region. Although the ES loss/damage scenarios in this extensive pilot survey were realistic, they were based on preliminary expert assessments rather than detailed modeling. However, oil dispersion and ecological modeling which has since been run in order to test the validity of this expert assessment, provide ES loss/damage scenarios corresponding surprisingly well with this expert approach.

In addition to designing the CV scenario so as to get realistic estimates of mean WTP per household in the main survey, the importance of getting the size of the affected population/geographical region right could be even more important in order to get the aggregate welfare loss right. We find that losses to unique marine ES of national importance should be aggregated over the national rather than the regional population to account for extensive non-use values of such marine ES. This is especially important if the marine ES is located in sparsely populated areas with few directly affected households, and where aggregating over just the regional population, would then underestimate benefits in CBAs of regional oil spill prevention measures. For ES of local or regional importance the opposite is true, and one should not aggregate over households outside the region as this would easily cause overestimation of aggregate social benefits of avoiding marine ES losses. Hence, getting this balance right demands careful considerations and design of the CV instrument.

The Norwegian Coastal Administration (NCA) is in charge of planning and implementing local and regional preventive measures to avoid oil spills from ships, and they regularly carry out Cost-Benefit Analyses (CBAs) of these measures. However, NCA recognized that their CBAs were incomplete as the monetary assessment of benefits excluded non-market benefits in terms of avoided damages to marine and coastal ES, and therefore decided to fund research into their economic values. The results from this pilot CV survey show that the monetary value of these ES impacts could potentially be large, and affect the outcome of CBAs of preventive measures. Thus, incorporating regional unit values for different levels of marine and coastal ES damages from oil spills in their CBAs will have policy implications in terms of improved ranking of preventive measures in order to maximize public welfare of NCAs current budget. Further, it could also serve to justify increments in their budget for preventive measures to avoid losses in marine and coastal ES.

Aknowledgement

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