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Integrating Bayesian Network Models for Oil Spill Risk Assessment: Linking Economic Decision-Making with Biological Impact Modeling in the Gulf of Finland

INTRODUCTION

Effective decision-making in oil spill preparedness requires interdisciplinary knowledge. However, assessments of these issues tend to focus on either economic or environmental dimensions, often leading to oversimplified treatment of the other. To answer this problem, we integrate two different published Bayesian network models assessing economic and biological aspects of oil spill impacts. The baseline model by Helle et al. (2015) performs a probabilistic cost benefit analysis for two oil combating measures, where environmental benefits of oil combating are assessed through estimation of environmental damages. To improve the estimation of biological impacts we integrate a part of the model by Lecklin et al. (2011) assessing oil spill impacts on vulnerable aquatic and coastal biota in the Gulf of Finland, thereby providing a biologically robust representation of environmental damage.

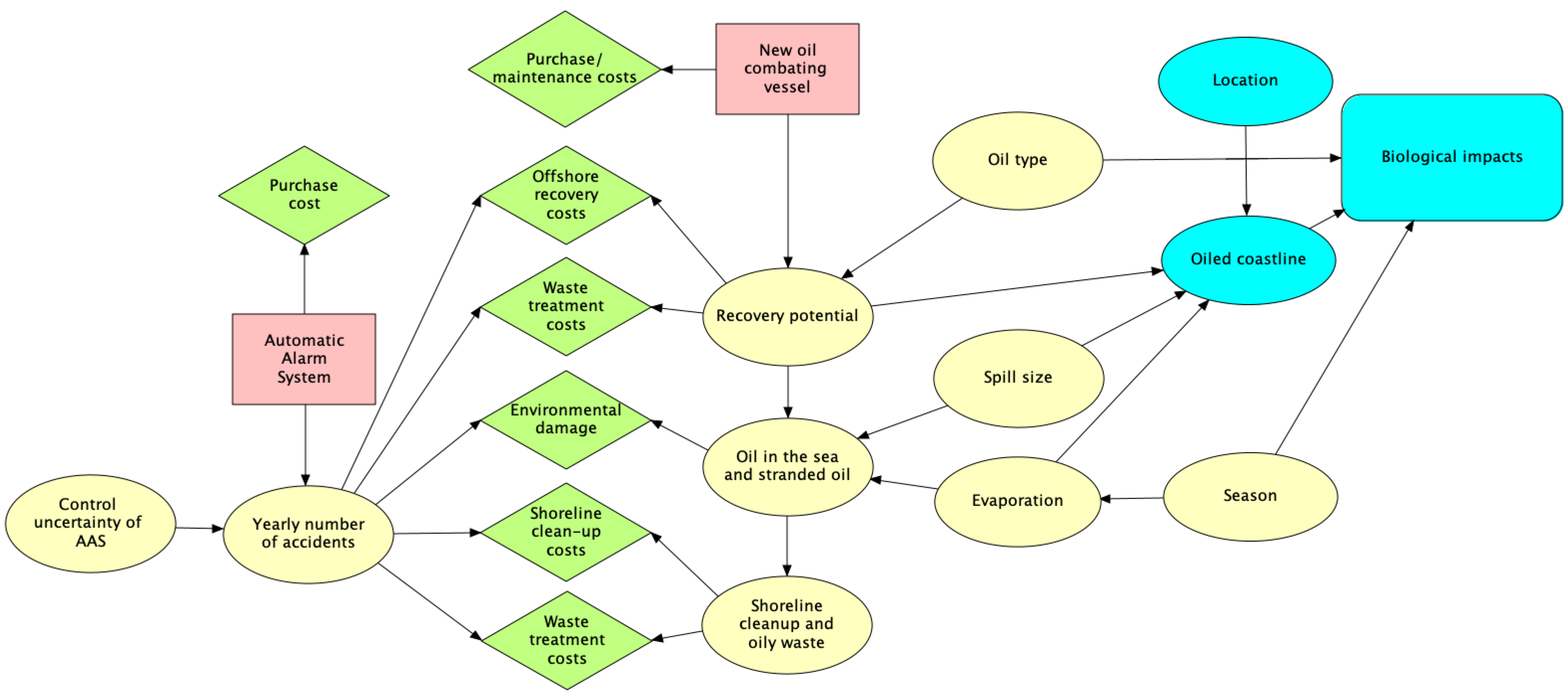

Figure 1. Simplified illustration of the integrated model. The blue part is integrated from Lecklin et al. (2011)

METHODS

We decided to treat the model by Helle et al. (Model 1) as the base for the integrated model in which the biological impact model of Lecklin et al. (Model 2) is integrated. The animal and plant group sub models in Model 2 all receive information from three nodes: *Time of accident, Oil type* and *Oiled coastline*. Model 1 has corresponding nodes for *Time of accident,* called *Season,* and *Oil type* and their states correspond those in Model 2. We needed to recreate the node *Oiled coastline* in Model 1 and its corresponding parent nodes. In Model 2, *Oiled coastline* has parent nodes *Evaporation, Location, Oil amount in water and Recovery efficiency*. Model 1 has a corresponding node for *Evaporation* but we needed to create the node *Location*. Model 1 has similar counterparts for *Oil amount in water*, called *Spill size*, and for *Recovery efficiency*, called *Recovery potential*. *Spill size* has more states than *Oil amount in water* and *Recovery potential*'s states are in tonnes of oil instead of percentages like the states of *Recovery efficiency*. Due to these differences, we could not import the conditional probability table (CPT) of *Oiled coastline* in Model 2 directly to Model 1. To create the CPT of *Oiled coastline* in Model 1, we used several logistic regression models. Separate models were created for the different *Oiled coastline* states. The models used the probabilities of *Oiled coastline* states as response variables and states of the parent nodes as predictors. We converted the *Recovery efficiency* node's states to tonnes of oil to correspond with Model 1's *Recovery potential*. Using the estimated parameters of the regression models, we predicted the probabilities for the *Oiled coastline* node's CPT in Model 1. Then we integrated the biological impact model to the nodes *Oil type, Oiled coastline* and *Season* (Figure 1).

PRELIMIMINARY RESULTS AND NEXT STEPS

For the results, the change in environmental damage is compared to different states of organism recovery or endangerment after 10 years after the accident. Without additional information (i.e., locking evidence on population recovery) the baseline estimate for environmental damage is -15,3 M€. If known, that all the groups of organisms recover, this decreases the estimate for environmental damages to -12,4M €, which compared to the baseline value of environmental damage is 2,8 million euros less. Thus, based on this model version, ensuring that all the groups of organisms can fully recover in 10 years could be valued to be up to 2,8M €.If at least one group of organisms is threatened or endangered, the estimate for environmental damages decreases to -21,6M €, which valuates the increased environmental damage to 6,4 million euros. The worst scenario is to observe all groups of organisms threatened or endangered. If this is the case, according to this model version the environmental damage rises to -202,9M €, which valuates the negative change in environmental conditions to be -189,7 million euros.

The environmental damage estimate is based on a contingent valuation survey on Finnish citizens to value improvements in recovery efficiency. Thus, straightforward valuations of the mentioned organism groups can't be made. For improvement, WTP study for preventing oil pollution impacts on specific groups of organisms would be a less uncertain estimate and would also allow for deriving value functions from the integrated part of the system.

REFERENCES

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