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1. PUBLISHABLE SUMMARY

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

Recent large accidents with oil spills in the marine environment have shown that there is a need for better oil spill response technology, capacity and knowledge on how to balance the efficiency of the response with its environmental impact. In context of a large spill, today, there are limited ways of predicting and measuring the evolution of the pollution. There is also a need for a design of an appropriate response, combining the right mixture of oil spill response methods.There is a need for on-line monitoring of oil and for integrated oil spill response technologies, based on the environmental impact. It is of special importance because off-shore oil exploration is nowadays being performed in harsher environments, such as the Arctic or deep sea. Also climate change and reduction in sea ice coverage in the Arctic are opening up for the northern shipping routes, and thus creating a higher risk for oil accidents in the Arctic. It is important for environmental health and human quality of life that any unintended oil spills can be monitored on-line and cleaned up effectively. This is important for companies involved in offshore activities in the Arctic and for oil spill response authorities and their cross-border collaboration bodies. The overall objectives of the project are to:

• explore the true environmental impacts and benefits of a suite of marine oil spill response technologies in cold climates and ice-infested areas in the northern Atlantic Ocean and the Baltic Sea. The response methods considered include mechanical collection of oil in water and below ice, in situ burning, use of chemical dispersants, natural biodegradation and combinations of these;

• assess in particular the impacts on fish, mussels, crustaceans and macro algae of naturally and chemically dispersed oil, in situ burning residues and non-collected oil using highly sensitive biomarker methods, and to develop specific methods for the rapid detection of the effects of oil pollution on biota;

• improve the observation and predictions of oil movements in the sea using novel on-line sensors on vessels, fixed structures or gliders, and smart data transfer to operational awareness systems;

• develop a strategic Net Environmental Benefit Analysis tool (sNEBA) for oil spill response strategy decision making in cold climates and ice-infested areas.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

The first period of the project has included much field and laboratory work. This includes developing on-line monitoring oil detection systems on different platforms. We have tested oil sensors installed in SmartBuoys, FerryBox and underwater (autonomous) vehicles such as gliders. On-line data transfer worked well and no deviating observations indicating an oil spill were observed. Comparison to laboratory analyses showed that signals from interfering compounds should be corrected for, and that the calibration of instruments in a harmonized way is desirable. FerryBox data is available on http://on-line.msi.ttu.ee/GRACEferry/. Furthermore, a biosensor for oil using hatched zebrafish embryos is being developed and it was found that they could tolerate Baltic Sea water. Currently the first prototype of the system is in production. Biodegradation of oil and dispersed oil in ice, water and sediment has been studied in laboratory scale. Preliminary results show that oil in the water phase and in ice can be degraded well at low temperatures, and the limiting factor is the accommodation of oil

into the water phase. Also the key microbial species and metabolic pathways which are associated with oil biodegradation are studied by sequencing of the DNA in the samples and by comparing to relevant databases. This work is still in progress. A pilot scale test with electrokinetic treatment of petroleum hydrocarbon contaminated sediment was initiated in a coastal bay of the Baltic Sea. GRACE also studied how dissolved oil components can affect marine fauna, like copepods, and mussels in the Northern Atlantic and the Baltic Sea. The establishment of latitudinal and seasonal baselines of the biomarkers allows distinguishing contaminant effects from a healthy state. Most of the field sampling has been completed and the laboratory analyses of the biomarkers are in good progress. Experiments where biota is exposed to oil were performed at either high concentration for acute toxicity tests or at sub-lethal concentrations in order to study measurable effects on the different biomarkers in these organisms and in laboratory model organisms. Preliminary results have shown that the effects of the water-dissolved components of oil have less effect at lower temperatures, and that chemically dispersed oil in general shows higher effects. GRACE obtained permission from the Greenland authorities to perform controlled pilot tests on in situ burning and field experiments with mimicked stranded oil on tiles placed in the tidal zone in the coastal waters of Greenland. The tests were performed according to the plan. As a mitigation measure, oil spill and in situ burning experiment were performed behind a barrier boom. After the pilot scale oil spill field experiment and subsequent in-situ burning the burn residues were collected. Environmental effects and exposure of the marine environment is monitored using blue mussels and this work is still ongoing. Mechanical oil response equipment for oil collection under ice is being designed and a test tank for testing has been built. The concept chosen for further development is an under ice vehicle. The work on a strategic Net Environmental Benefit Analysis (sNEBA) decision tool is in progress, together with making accessible both existing knowledge and results from novel, innovative research and development on spill response technologies, along with decision chain development using fuzzy logic methodology. Simulating oil spill scenarios in the Baffin Bay and the Baltic Sea, serves as a starting point for evaluating the type of platform to be used in the final sNEBA tool.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

The GRACE project has performed unique field tests for on-line monitoring of oil and this will be complemented with testing of satellite communication of the data streams. The results of the ongoing novel electrokinetic sediment remediation field experiment will be finalized and new information on the genetic level of the microbial communities' ability to degrade oil compounds will be obtained. The impact of oil and dispersed oil on different relevant trophic levels of biota will be completed. This work will lead towards a novel establishment of adverse outcome links that should report an exposure and possible adverse outcome already on a molecular basis in biota. The results from the unique in situ burning experiment in Greenland and the environmental impacts will be reported. A novel under ice vehicle prototype for oil recovery under ice will be built and tested. The strategic Net Environmental Benefit Analysis (sNEBA) decision tool will be finalized and launched. Information about GRACE and the first results have been disseminated through the GRACE web pages, press releases, presentations at international cross-border working groups and to a number of seminars and conferences. This has already resulted in contacts from many stakeholders interested in the results of the project. An exploitation plan has been produced and prospects for companies involved in on-line monitoring technology and oil recovery and remediation technology looks promising.

Address (URL) of the project's public website

www.grace-oil-project.eu