POSEIDON- Produced water monitoring and risk of environmental impact from discharges in the offshore oil and gas industry

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Final Project Report

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1. Progress Towards Objectives/Milestones

Overall objectives of the research project as awarded were as follows:

- Use Memorial University’s new ocean going autonomous underwater vehicle (AUV) to collect ocean environmental monitoring data; to take detailed environmental measurements in the water column; and to validate ocean environmental monitoring and modeling tools.
- Develop models to anticipate, manage and mitigate changes in environmental quality, habitat changes and pollutant effects of produced water discharges from offshore oil and gas platforms.
- Use tank tests to validate hydrodynamic discharge models.
- Train highly qualified personnel in the area of offshore environmental monitoring, risk assessment, and risk management to ensure the sustainability of offshore oil and gas projects.

We made significant progress in achieving the above objectives. We used the Explorer AUV to collect ocean environmental monitoring data, develop a 3-D hydrodynamic model and validate some parameters using the AUV and tank tests. Due to fouling with ghost fishing gear and other logistical problems, the application of the AUV was done at two sites. but we plan to continue AUV applications in near future.

A PDF, a Ph.D. and an M.Eng.student were trained in the areas of modeling, database, and monitoring activities. These trained personnel have been placed in industries in Canada. Another M.Eng. student is in the process of completing his degree and will join the Ph.D. program at Memorial university. Two students (One M.Eng and one Ph.D) are still continuing their work. This delay is due to late recruitment and change in program for one student.

Our integrated modeling, monitoring, and database approach is well recognized in the scientific community. One such example of the recognition is the invitation by Offshore Technology Technical Committee to present a paper in Houston in May 2008 under theme issue of East Coast of Canada – Leading Edge R&D Initiatives

The project has developed a rational and scientific method to assess and manage ecological risk by developing prediction models incorporating uncertainties and identifying mitigation and treatment technologies. Our research in offshore environmental risk management and decision-making is unique in evaluating risks and costs associated in managing produced water discharges by integrating risk assessment methods with treatment technology and associated costs. It has been incorporated into a user-friendly decision support software being developed for the oil and gas industry.

2. Research Team

Principal Investigator, co-investigators, postdocs, and graduate students have had meetings every two weeks to discuss the progress made, problems encountered, and future research plans.

Naia Mohammed joined as PDF and Haibo Niu, Jihad Shanaa, Abdullah Mofarrah, Nahla Mahmoud, and Md. Khaled Chowdhury joined as graduate students on the project.

Niaz joined in October 2006 and worked on the decision support system. He had the opportunity to interact with collaborators and industries. In May 2007, he was offered a job by AMEC in St. John’s in database development and environmental modeling.

Haibo Niu completed his Ph.D. in January 2008. His supervisory team included Tahir Husain, Brian Veitch and Neil Bose. In early 2007, he was offered a research engineer’s position by SNC Lavalin (industrial partner on the project) where he applied hydrodynamic and risk assessment tools for a proposed refinery.
project. Later he joined Dr. Ken Lee's team at COOGER at the Bedford Institute of Oceanography as a visiting NSERC research fellow.

Jihad Shanaa completed his M. Eng. Degree in September 2008. He was co-supervised by Tahir Husain and Neil Bose. His research included sensor identification for AUVs and hydrodynamic modeling. He completed his M.Eng. degree in September 2008. He is now working with the EBA consulting company in Edmonton as an Environmental Engineer.

Abdullah Mofarrah obtained his M.Eng. degree last week on multi-criteria decision-making methodology and offshore produced water treatment technologies. His research was co-supervised by Tahir Husain and Kelly Hawboldt. Abdullah has been accepted into the Ph.D. program at Memorial University.

Md Khaled Chowdhury is in the Ph.D. program. His supervisory team includes Tahir Husain, Kelly Hawboldt, and Brian Veitch. He is in the process of taking the Ph.D. comprehensive examination. His research is on the refinement of ecological risk assessment methodology.

Nahla Mahmoud is working on her M.Eng. thesis on partitioning and dilution of PAHs in produced water. Her research is co-supervised by Tahir Husain, Kelly Hawboldt, and Dounia Hamoutene from DFO.

In addition to the above team, field support on the AUV was provided by Sara Adams, Moqin He, and Ron Lewis. Sara Adams was partially supported from the project.

The research group at Memorial university arranged several meetings with collaborators to review project activities, collaborative research plans, training of students, and funding opportunities. Graduate students had the opportunity to interact with collaborators and industrial partners.

Dr. Lee and and Dr. Eid have been actively involved on the project. Other collaborators also provided technical support from time to time. For example, Dr. Davidson helped Haibo Niu in developing his research plan on coupling of hydrodynamic models with ocean circulation models and he was an external examiner for his Ph.D. comprehensive. Dr. Sadiq provided support to students in fuzzy set logic and multi-criteria decision making. Dr. Payne provided toxicity related information.

3. **Research Results and Knowledge and/or Technology Transfer**

3.1 **Tangible Research Outcomes**

DSS-PRO is a Windows based software program that can aid decision-making concerning produced water treatment and disposal. It incorporates state-of-the-art best treatment technology (considering cost and removal of produced water contaminants) and risks to marine organisms and human beings from consumption of contaminated fish. The system has a rich database containing most produced water pollutants and their important properties that are required in dispersion and risk assessment modeling. The database also contains current produced water regulations and most of the existing treatment technology information with approximate costing that is required in the decision support system.

3.2 **Transferability of Research Results**

DSS-PRO incorporates the research and development outcomes of a multi-year research project done at Memorial University. From a known concentration of produced water contaminants, the system can decide the best available technology (BAT?), and its approximate cost. Based on the extent of treatment, it is possible to estimate risk to fish and marine species and human beings and hence a trade-off between
cost and risk can be developed. It is user friendly and equipped with modern menus, toolbar, status bar and context sensitive help.

It has a user friendly and interactive interface for smooth and sequential data entry of produced water contaminants and dispersion model parameters. Data entry is automatically validated by the system at every step.

3.3 Future Development of Research

Our collaboration with the partners will continue. We plan to launch and license the decision support software through our industrial partner, SNC-Lavalin. The software is being developed and various links on modeling, treatment technologies, and multi-criteria decision-making tools are being implemented through a research contract from DFO. Subject to the availability of funds in future, we also plan to continue working with SNC-Lavalin on the use of AUVs for water quality monitoring in coastal areas.

Our MUN team is working with Dr. Ken Lee and his team on risk assessment and risk management tools. Dr. Niu, who has joined Dr. Lee’s research team in COOGER as a visiting NSERC Fellow, is a strong link in our future research collaboration. We are proposing a research study on modeling and risk management for funding through ESRF.

Since the work is still in progress and two students (Nahla Mahmoud and Khaled Chowdhury) have not yet completed their degree programs and both are doing experimental work, it would be highly appreciated if the project accounts be kept active for another 12 months i.e., up to November 30, 2009. This will help in providing support to these students in their research and assistantship. It will also help in their experimental work and in successful completion of their program.

4. Dissemination of Research Results

4.1 Refereed Journal Articles:


### 4.2 Conference Presentation/Poster:

1. **Shanaa, J.,** Husain, T., Bose, N., Veitch, B., and Hawboldt, K., **2009.** An Innovative Real-time Marine Environmental Monitoring Technique, Offshore Arabia, January 11-13, 2009, Dubai


### 4.3 Other (Including Technical Reports, Non-Refereed Articles, etc.):


4.4 Patent Applications Filed:
