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**TECHNOLOGY DEVELOPMENT:**

**New Tool Available to Assess Offshore Drilling Mud Discharges**

~ Dr. Charles Hannah is a DFO research scientist at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia.

The potential environmental impact of discharged drilling muds is an ongoing issue for offshore petroleum operators, regulators, government agencies and environmentalists. Sound scientific assessments of the fate and impacts for different discharge scenarios can provide a basis for prudent decisions that minimize adverse impacts. Dispersion models can be an effective tool in this process.

A benthic boundary layer transport (bblt) model has been developed by DFO scientists to predict the transport and dispersion of suspended particulate drill

waste (primarily barite and bentonite) on the continental shelf. For the purposes of the model, the benthic boundary layer is considered to be the lower layer of the ocean whose dynamics are affected by the sea floor.

The first version of the bblt model was released by DFO in 1995. Both industry and DFO have since used the model for the preparation and review of Environmental Assessments. With further refinement, Version 7.0 of the bblt model was released in April 2004. This new version features a graphical user interface, which is written in JAVA so that it can be

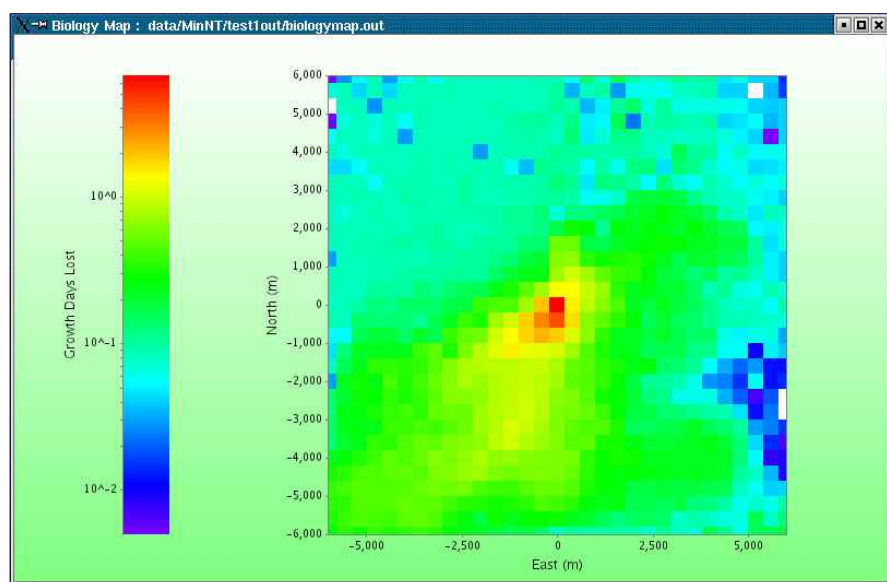
installed on computers running either Linux or Microsoft Windows. This new version allows scientists who may not be experts in modelling to use the software as a tool in their analysis.

Previous laboratory studies conducted at the Bedford Institute of Oceanography have linked detrimental sublethal effects in sea scallops with both barite and bentonite. Simulations for the North Triumph drilling site near Sable Island have recently been run with the latest version of the bblt model, which includes a dose-response module for contaminant impacts. Results suggest that the potential impact of drilling mud discharges on scallop growth is of the order of a few days of lost growth over spatial scales of a few kilometres, depending on environmental parameters.

This is an exciting step in predictive modelling of environmental effects of the offshore oil and gas activities. This development of this software was made possible with the support of Natural Resources Canada's Program of Energy Research and Development (PERD). ♦

Version 7.0 of the bblt can be downloaded at no cost from the following web site:

[http://www.mar.dfompo.gc.ca/science/ocean/coastal\\_hydrodynamics/WEBbbltgui/bbltgui.html](http://www.mar.dfompo.gc.ca/science/ocean/coastal_hydrodynamics/WEBbbltgui/bbltgui.html)



Results from bblt simulations of the fate and effects of drilling discharges at the North Triumph drilling site.

# Energy R&D Forum

Over 200 participants gathered at the first Nova Scotia Energy Research and Development Forum on May 13-14, 2004.

The Forum, which was held on the campus of St. Francis-Xavier University in Antigonish, Nova Scotia,

Atlantic Canada, the Forum combined networking opportunities with presentations by leading energy research experts. DFO scientists from the Bedford Institute of Oceanography (Will Perrie, Kenneth Lee, Ted Potter) and the Northwest Atlantic Fisheries Centre (Jack Lawson, Jerry Payne) were among those who delivered presentations on the subject of "Energy and the Oceans Environment", a session organized by COOGER and chaired by Dr. Kenneth Lee. ♦



Rosalie Allen Jarvis (COOGER) with Jeff Garnhum (NS Dept. of Energy) and Charles Martin (ACOA) at the first Nova Scotia Energy Research and Development Forum at St. Francis-Xavier University.

brought together researchers, managers and policy-makers from industry, universities and government to share information about the research conducted in Nova Scotia's energy sector and to discuss emerging research priorities.

Hosted by Nova Scotia's Department of Energy, Atlantic Canada Opportunities Agency and Petroleum Research

More information about the Nova Scotia Energy Research and Development Forum can be obtained online:

<http://www.energyresearch.ca/forum2004>

## REAL PEOPLE

### Dounia Hamoutene

COOGER would not be possible without the dedication of Fisheries and Oceans Canada employees who work each day to ensure its success.

Equipped with an international perspective, Dr. Dounia Hamoutene has called Newfoundland home since 1998. Following her research at Memorial University of Newfoundland and the completion of a post-doctoral fellowship with Dr. Jerry Payne, Dounia joined DFO's Northwest Atlantic Fisheries Centre in 2002 as a research scientist. Her research focuses on aquatic toxicity and, specifically, on sublethal effects of the toxic compounds released through offshore oil and gas activities.

Originally from Algeria, Dounia completed her Ph.D. in 1995 at the Université Aix-Marseille II in France, where her research focused on the environmental monitoring applications of *Posidonia oceanica* (a marine, flowering plant that provides important habitat in the Mediterranean Sea). Her extensive research experience with pollution

and biomonitoring programs in the Mediterranean region is now being applied to offshore oil and gas toxicity issues. This has included



toxicological studies on the physiological effects of drilling fluids, produced water, crude oil and oil dispersants. While her recent work has primarily used snow crab

as a test species, past work investigated impacts on other commercial species of interest, including mussels and lobster.

"While significant advances have been made in environmental effects research related to offshore petroleum development, many questions remain unanswered," says Dounia. "It is the responsibility of researchers to identify and address the gaps in scientific understanding. It is also imperative to put these scientific issues in perspective when communicating results to decision makers and the public."

COOGER relies on the scientific expertise of researchers like Dounia to delve into the unknown and develop research objectives that support DFO's priorities of understanding the oceans and protecting the marine environment. ♦

# Chemical Dispersion Increases Oil Bioavailability to Marine Fish Larvae

~ Dr. Catherine Couillard is a DFO research scientist at the Maurice Lamontagne Institute in Mont-Joli, Quebec.

**Chemical dispersants effectively reduce** the concentration of surface oil by transporting it into the water column as small droplets, where they are rapidly diluted and biodegraded. However, there is concern that chemical dispersants may increase the bioavailability of the high molecular weight polycyclic aromatic hydrocarbons (PAH), which are toxic to early life stages of fish at low concentrations.

**In this study**, mummichog (*Fundulus heteroclitus*), one of the most abundant of fish in tidal marshes on the east coast of North America, was selected as the test species due to its known sensitivity to petroleum hydrocarbons. Changes in the activity of the cytochrome P450 1A (CYP1A) enzyme 7-ethoxyresorufin-O-deethylase (EROD) were used as an indicator (i.e., biomarker) of exposure to high molecular weight PAH.

**Newly-hatched mummichogs** were exposed to water-accommodated fractions of crude oil or chemically dispersed crude oil, with the following results:

-□ Chemical dispersion increased both the

total PAH concentrations and the proportion of high molecular weight PAH in water-accommodated fraction of crude oil.

-□ Mummichog larvae exposed to water-accommodated fractions of dispersed crude oil had higher mortality rates and lower body length compared to larvae exposed to water-accommodated fractions of crude oil prepared with similar oil loading.

-□ Chemically-dispersed petroleum high molecular weight PAH were bioavailable and were taken up by fish larvae, as indicated by higher levels of activity of EROD.

-□ The no-observed-effect concentration for effects on body length and EROD activity was below the lowest concentrations evaluated.

**This study suggests** that the application of oil dispersants may increase the hazard for marine larval fish due to an increase in the concentration of total PAH, but also in the relative proportion of high molecular weight PAH. Increased exposure of fish

larvae to CYP1A-inducing substances may enhance the risk for CYP1A-mediated toxicity as PAHs may be transformed into more toxic forms.

**Thus, it is recommended** that dispersant use guidelines take into account the possibility of added risks of toxic effects on

early life stages of fish due to enhanced exposure to high molecular weight PAH. Measurements of concentrations of oil in the water column alone do not provide adequate information for risk assessment. Integrated use of biomarkers is necessary to assess PAH bioavailability and toxic effects of complex petroleum PAH mixtures. In order to better assess the risks associated with chemical dispersion of petroleum oil at sea, further studies should be conducted in a more environmentally realistic system (e.g., mesocosms with controlled dilution and/or sea trials) and should investigate delayed biological effects. ♦



PAH concentration in larval mummichogs was assessed following exposure to dispersed and undispersed crude oil.

Couillard, C.M., K. Lee, B. Légaré and S. Saint-Pierre. (2003) Comparative toxicity of water-accommodated fractions of oil and dispersed oil to marine fish larvae. In: Hedley, K., S. Roe and A.J. Niimi (eds). *Proceedings of the 30th Aquatic Toxicity Workshop, Ottawa, Ontario, September 28 - October 1, 2003. Can. Tech. Rep. Fish. Aquat. Sci.* 2510. pp 16-17.

## Norwegian Perspective of Oil and Gas



Per Gerhard Grini (OG21, Norway) at the Bedford Institute of Oceanography (BIO).

On April 1, 2004, Per Grini presented a seminar at BIO on the topic of Norway's approach to the quantifying environmental risk associated with offshore oil and gas discharges. Norway's current "zero (harmful) discharge" regime was discussed, as were recent environmental effect studies on the Norwegian

Continental Shelf and technology development for reducing discharges to sea and emissions to air. COOGER cosponsored the presentation, along with Atlantic Canada Opportunities Agency (ACOA) and Petroleum Research Atlantic Canada (PRAC). ♦



## Recent COOGER Publications

- Bancroft, D., R.A. Lake, S.L. Marshall and K. Lee. (2003) An overview of marine environmental research pertaining to West Coast offshore oil and gas development. *Can. Tech. Rep.* 2480: iii + 45p.
- Clarke, L.M.J., C.W. Khan, P. Akhtar, P.V. Hodson, K. Lee, Z. Wang and J.W. Short. (2004) Comparative toxicity of four crude oils to the early life stages of rainbow trout (*Oncorhynchus mykiss*). *In: Proceedings of the 27th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Edmonton, Alberta, Canada, June 8-10, 2004.* Environmental Science and Technology Division, Environment Canada, Ottawa, Ontario, Canada. pp 785-792.
- Hamoutene, D., J.F. Payne, A. Rahimtula and K. Lee. (2004) Effect of water soluble fractions of diesel and an oil dispersant (Corexit 9527) on immune responses in mussels. *Bulletin of Environmental Contamination Toxicology* 72: 1260-1267.
- Hannah, C.G., A. Drozdowski, D.K. Muschenheim, J.W. Loder, S. Belford and M. MacNeil. (2003) Evaluation of drilling mud dispersion models at SOEI Tier I sites: Part 1 North Triumph, Fall 1999. *Can. Tech. Rep. Hydrog. Ocean Sci.* 232:v+51 p.
- Kepkay, P.E., J.B.C. Bugden, K. Lee and P. Stoffyn-Egli. (2003) Application of ultraviolet fluorescence (UVF) spectroscopy to monitor oil-mineral aggregate (OMA) formation. *Spill Science and Technology Bulletin* 8: 101-108.
- Khan, C.W., S.D. Ramachandran, L.M.J. Clarke, P.V. Hodson, B.P. Hollebone and Z. Wang. (2004) EROD activity (CYP1A) inducing compounds in fractionated crude oil. *In: Proceedings of the 27th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Edmonton, Alberta, Canada, June 8-10, 2004.* Environmental Science and Technology Division, Environment Canada, Ottawa, Ontario, Canada. pp 773-785.
- Khelifa, A., P. Stoffyn-Egli, K. Lee and P.S. Hill. (2003) Characteristics of oil droplets stabilized by oil-mineral aggregation. *In: Proceedings of the 2003 International Oil Spill Conference, Vancouver, British Columbia, Canada, April 7-10, 2003.* American Petroleum Institute Publication No. 14730B. pp. 963-970.
- King, T.L. and K. Lee. (2004) Assessment of sediment quality based on toxic equivalent benzo[a]pyrene concentrations. *In: Proceedings of the 27th Arctic and Marine Oilspill Program (AMOP), Edmonton, Alberta, Canada, June 8-10, 2004.* Environmental Science and Technology Division, Environment Canada, Ottawa, Ontario, Canada. pp. 793-806.
- Lee, K., R.C. Prince, C.W. Greer, K.G. Doe, J.E.H. Wilson, S.E. Cobanli, G.D. Wohlgeschaffen, D. Alroumi, T.L. King and G.H. Tremblay. (2003) Composition and toxicity of residual bunker C fuel oil in intertidal sediments after 30 years. *Spill Science and Technology Bulletin* 8: 187-199.
- Lee, K., P. Stoffyn-Egli, G.H. Tremblay, E.H. Owens, G.A. Sergy, C.C. Guénette and R.C. Prince. (2003) Oil-mineral aggregate formation on oiled beaches: Natural attenuation and sediment relocation. *Spill Science and Technology Bulletin* 8: 285-296.
- Owens, E.H. and K. Lee. (2003) Interaction of oil and mineral fines on shorelines: Review and assessment. *Marine Pollution Bulletin* 47: 397-405.
- Payne, J.F., A. Mathieu and T.K. Collier. (2003) Ecotoxicological studies focusing on marine and freshwater fish. *In: Polycyclic Aromatic Hydrocarbons: An Ecotoxicological Perspective.* Douben, E.T. (ed). John Wiley & Sons Ltd. pp. 191-224.
- Prince, R.C., R.E. Bare, R.M. Garrett, M.J. Grossman, C.E. Haith, L.G. Keim, K. Lee, G.J. Holtom, P. Lambert, G.A. Sergy, E.H. Owens and C.C. Guénette. (2003) Bioremediation of stranded oil on an arctic shoreline. *Spill Science and Technology Bulletin* 8: 297-302.
- Ramachandran, S.D., C.W. Khan, P.V. Hodson, K. Lee and T.L. King. (2004) Role of droplets in promoting uptake of PAHs by fish exposed to chemically dispersed crude oil. *In: Proceedings of the 27th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Edmonton, Alberta, Canada, June 8-10, 2004.* Environmental Science and Technology Division, Environment Canada, Ottawa, Ontario, Canada. pp 765-772.
- Schratzberger, M., F. Daniel, C.M. Wall, R. Kilbride, S.J. Macnaughton, S.E. Boyd, H.L. Rees, K. Lee and R.P.J. Swannell. (2003) Response of estuarine meio- and macrofauna to in situ bioremediation of oil-contaminated sediment. *Marine Pollution Bulletin* 46: 430-443.
- Sergy, G.A., C.C. Guénette, E.H. Owens, R.C. Prince and K. Lee (2003) In-situ treatment of oiled sediment shorelines. *Spill Science and Technology Bulletin* 8: 237-244.
- Stoffyn-Egli, P. and K. Lee. (2003) Formation and characterization of oil-mineral aggregates. *Spill Science and Technology Bulletin* 8: 31-44.



## Reviewing the Offshore Moratorium in British Columbia

On April 20, 2004, the Royal Society of Canada released a report of the Expert Panel on science issues related to offshore oil and gas activities off the coast of British Columbia. The report was prepared in response to the Government of British Columbia's request that the Government of Canada consider lifting the federal moratorium on oil and gas activities offshore of British Columbia. On behalf of the Government of Canada, the Minister of Natural Resources appointed the Expert Panel to conduct the review to identify science gaps related to possible oil and gas activity offshore British Columbia, to determine public opinion as to whether or not the federal moratorium should be lifted for selected areas, and to consult with aboriginal groups to ensure that issues of unique interest to First Nations are fully explored.

The Expert Panel determined that, provided an adequate regulatory regime is put in place, there are no science gaps that need to be filled before lifting the moratoria on oil and gas development. In addition, it was suggested that lifting the moratoria would perhaps enhance the opportunity to fill many of the science gaps through shared-cost partnerships involving industry participation. However, it was advised that the present restriction, on tanker traffic in transit along the West Coast of North America being prohibited from entering the coastal zone, be maintained. ♦

For more information, including a complete description of gaps in scientific understanding, please visit the Royal Society of Canada web site:

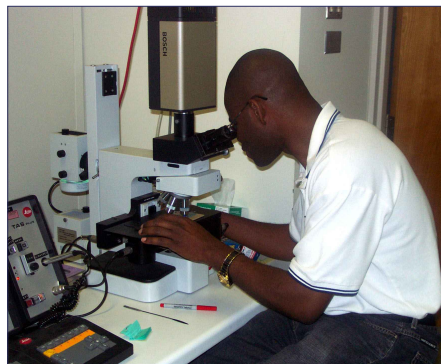
[http://www.rsc.ca/BC\\_offshore/indexEN.html](http://www.rsc.ca/BC_offshore/indexEN.html)

To address emerging concerns of the public and the private sector (both the fishing and petroleum industries) on Canada's West Coast, Dr. Kenneth Lee (COOGER) recently provided overviews of DFO's research on the assessment of potential environmental impacts of offshore petroleum activity. This included invited presentations at a workshop, hosted by the B.C. Seafood Alliance, focused specifically on seismic operations, and a special session at the 23rd International conference on Offshore Mechanics and Arctic Engineering entitled, "Engineering BC's Offshore Development: Challenges and Opportunities".

## Effects of Sediment Size and Concentration on Formation of Oil-Mineral Aggregates

~ Lukman Ajjolaiya recently completed his Masters degree from Dalhousie University's Department of Chemical Engineering under the supervision of Drs. Rafiq Islam (Dalhousie University, Department of Chemical Engineering), Paul Hill (Dalhousie University, Department of Oceanography), Ali Khelifa (COOGER) and Kenneth Lee (COOGER).

The natural dispersion and degradation of oil spilled in aquatic environments has been linked to the interaction between fine mineral particles, such as clays, and oil droplets in the formation of oil-mineral aggregates (OMA). A scientific understanding of the variables that determine the extent of OMA formation is required to determine the ecological significance of this process. In this regard, Mr. Ajjolaiya conducted a detailed labora-



tory study to gauge the effects of sediment size and concentration on OMA formation. Results of his research suggest that the contribution of OMA formation to oil dispersion after an accidental spill can be high (i.e., more than 70%). This evidence has improved our understanding of the natural recovery processes that occur following oil spills and will aid in the development of active oil spill countermeasures, such as surf-washing. ♦

Partnering with universities is an important component of COOGER's approach to promote multidisciplinary research and training to address environmental concerns associated with the development of Canada's offshore oil and gas industry.



## COOGER Recognized for Role in Technology Transfer



Dr. Yvan Hardy (Natural Resources Canada) presents Dr. Kenneth Lee (COOGER) with the FPTT Leadership in Technology Transfer Award.

On June 17, 2004, Dr. Kenneth Lee (COOGER) was recognized for his exemplary leadership in the development and transfer of innovative technologies and strategies to alleviate the damage of oil spills and enhance recovery of the affected natural habitat. The Federal Partners in Technology Transfer (FPTT) presented Dr. Lee with the prestigious Leadership in Technology Transfer Award, which was sponsored by The Impact Group and Research Money Inc. The award was bestowed for Dr. Lee's collaborative efforts over the last 15 years to develop methods and operational guidelines for strategies related to oil spill bioremediation (enhanced contaminant degradation based on natural microbial processes) and monitoring of habitat recovery. ♦

### ABOUT US

## What is COOGER?

In November 2002, Fisheries and Oceans Canada (DFO) established the Centre for Offshore Oil and Gas Environmental Research (COOGER) to co-ordinate the department's nation-wide research into the environmental and oceanographic impacts of offshore petroleum exploration, production and transportation.

This national research centre – based at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia – seeks to improve scientific knowledge, identify priority research needs, and co-ordinate and implement collaborative research efforts.

Through a national approach to science coordination, COOGER aims to optimize current and future research initiatives and to build upon existing regional research expertise and infrastructure. COOGER addresses the departmental mandate and industry need of ensuring safe and environmentally sound management of offshore oil and gas operations.

COOGER strives to improve the quality of science by fostering research collaborations with other government research agencies, universities and industry, thus minimizing research duplication. Furthermore, it will seek out new funds to support research

on offshore oil and gas environmental issues. COOGER research findings will be available for use by external partners and DFO resource managers.

COOGER also facilitates the opportunity to share experiences and to foster collaboration at the international level. COOGER looks forward to learning from the past experiences of other key countries to avoid reinventing the wheel in Canada. It is recognized within COOGER that the potential to design and conduct large-scale research projects by sharing expertise and resources in an international setting is almost limitless. ♦

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COOGER Update is a bilingual newsletter published by Fisheries and Oceans Canada to provide information on emerging issues and research activities coordinated by the Centre for Offshore Oil and Gas Environmental Research. Published three times a year, it is also available electronically on the COOGER web site. ♦

