THE COOGER UPDATE

Centre for Offshore Oil and Gas Environmental Research

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HIBERNIA PROJECT:

# Monitoring Environmental Effects Associated with Produced Water Discharges

~ Dr. Kenneth Lee is the Executive Dirctor of COOGER at the Bedford Institute of Oceanography in Darmouth, Nova Scotia.

**Canada remains** dependent on oil and gas for much of its energy requirements. To meet anticipated future demands, there has been a rapid increase in offshore oil and gas exploration, production and transport during the last decade. Advances in science and technology (S&T) will extend and diversify Canada's oil and gas production in offshore regions. Scientific information is required for environmental risk assessments which support the authorization of new developments across the country. Multi-disciplinary research studies are needed to address emerging concerns such as the potential for detrimental ecosystem effects from exploratory seismic operations and the ocean discharge of production water. With the development of Canada's offshore oil and gas reserves, there is concern that current industry practices may cause contamination and ill effects on fish and fish habitat due to large volumes of produced and displacement waters discharged into the ocean. This is of primary concern to regulators and the environmental community, since produced waters typically contain high concentrations of potential contaminants.

**Produced water** is the water that is extracted along with oil and gas in the drilling process. The largest volume waste stream from oil and gas production activities, it consists of: formation water (naturally occurring in the geological formation); injection water that is injected into the formation during extraction; and other technological waters (i.e., treatment chemicals such as emulsion breakers, corrosion inhibitors, biocides, etc). The formation-water component of production water is, in effect, a brine which derives its salinity from the major ions found in seawater. However, depending on the nature of the formation from which they are withdrawn, they also contain a number of metal and organic constituents of environmental interest including: 1) hydrolysis metals, 2) heavy metals, 3) organic chemicals including petroleum hydrocarbons, 4) nutrients, 5) radionuclides, and 6) treating chemicals.

**In offshore operations**, most produced water is typically discharged to the ocean. Emerging evidence from the North Sea investigations suggest that offshore production water discharges may impact

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the biota (invertebrates, fish and larvae) at greater distances from operational platforms than originally envisaged. In addition, laboratory studies by North Sea investigators also suggested that offshore production water discharges may have impacted the reproductive success of commercial fish species. In Canada, with the anticipated growth of our offshore oil and gas industry, concern has arisen over the potential for acute and chronic toxicity responses due to expected increases of production water discharges in the future.

**Both regulators** and habitat/resource managers are requesting research to provide facts to identify acceptable disposal limits to support changes to our regulatory waste treatment guidelines to protect the quality of our ocean's environment. As the composition of produced water from different sources and formations can vary by orders of magnitude on a constituent-specific basis, a region specific research program is warranted. To meet this need, two major oceanographic expeditions to the Hibernia platform were conducted with the *CCGS Hudson* in 2005 and 2006 under the PERD research program "*Ecological Risk of Produced Water Discharges from East Coast Oil and Gas Operations*". **Preliminary results** from our studies have provided strong evidence that produced water contaminants may alter the health of living organisms (e.g., MFO enzyme levels are lower in fish larvae downstream of discharge sites) and be transported to, and concentrated within, the benthic environment and the surface microlayer. Environmental effects monitoring (EEM) techniques are under development to provide an early warning of produced water discharge impacts in case mitigative measures (e.g., alteration of process controls, re-injection, etc...) must be taken. With support from the Environmental Studies Research Fund (ESRF) COOGER will host an international workshop on the subject of produced water discharges in the marine environment in 2007. Data from the DFO field program is being used for the development of ecosystem models within collaborative programs with the academic sector (Trent University, Memorial University, Concordia University) to predict the environmental risk of produced water discharges within the waters of Atlantic Canada. Preliminary project findings and recommendations from the workshop will be used for the revision of Canada's regulatory Offshore Waste Treatment Guideline document slated for 2007; and the identification of future priority research needs. ♦

*Azetsu-Scott, K., P. Yeats, G. Wohlgeschaffen, J. Dalziel, S. Niven. and K. Lee (2006) Precipitation of Heavy Metals in Produced Water Influence on Contaminant Transport and Toxicity, Marine Environmental Research, 63 : 146-147.*

*Lee, K., Azetsu-Scott, S.E. Cobanli, J. Dalziel, S. Niven, G. Wohlgeschaffen and P. Yeats (2005) Overview of potential impacts from produced water discharges in Atlantic Canada. In: Offshore Oil and Gas Environmental Effects Monitoring (Approaches and Technologies), S. Armsworthy, P.J. Cranford and K. Lee (eds.). Battelle Press, Columbus, Ohio. pp. 319-342.*

*Querbach, K., G. Maillet, P.J. Cranford, C. Taggart, K. Lee and J. Grant (2005) Potential effects of produced water discharges on the early life stages of three resource species. In: Offshore Oil and Gas Environmental Effects Monitoring (Approaches and Technologies), S. Armsworthy, P.J. Cranford and K. Lee (eds.). Battelle Press, Columbus, Ohio. pp. 343-372.*

# Biological Effects of Produced Water on Marine Fish

~ Dr. Les Burridge is a DFO Research Scientist at the St. Andrew's Biological Station in St. Andrew's New Brunswick.

**Research into the biological effects** of produced water from offshore oil production rigs has attracted considerable attention. In northern waters, investigations have been conducted using 'model' fish such as the mummichog as well as commercially important species such as cod and flounder. It is difficult to generalise about the responses of these fish since the chemical constituents of produced water are largely dependent on its source and vary signifcantly over the life of the rig. Despite the site specificity of produced water, general characteristics include elevated salinity, elevated concentrations of metals, and the presence of a suite of alkyl phenols. The dilution factor *in situ* results in little, if any, elevation of these compounds relative to receiving waters within meters of the outflow. The responses of fish to salinity and metals have been characterised and are generally considered to be of low risk under the conditions of exposure on the Grand Banks. Nonetheless, recent studies of the effects of alkylphenols (from a number of sources) have shown that low levels of these compounds can affect the endocrine systems of aquatic species.

**Scientists at DFO** have been studying the lethal and sublethal consequences of exposure to produced water from the Hibernia oil rig. Drs. Jerry Payne (DFO, St. Johns) and Simon Courtenay (DFO, Moncton) have investigated acute responses of cod, cunner, herring and mummichogs after exposure to dilutions of produced water. Dr. Payne's results show that vitellogenin (a precursor of egg yolk protein and an indicator of endocrine effects) is not elevated in male cunners exposed to production water compared to unexposed fish. Dr. Courtenay's work has shown that activity of mixed function oxygenases (MFOs) are not increased in livers from mummichogs exposed to production water. Dr Payne has noted that MFO activity is induced in cod. Induction of MFO activity indicates that the fish's detoxification systems have been activated by exposure to a contaminant.

**These studies** have been conducted in the lab with water delivered from the Hibernia site. Recently Dr. Les Burridge of DFO (St. Andrews) took live mummichogs on board the CCGS Hudson on a COOGER research survey to Hibernia. The purpose of his work was to determine if these experimental fish could be transported with minimal difficulty and used in on-board experiments with production water.

**The fish survived** 'life at sea' without any apparent problems. Twenty four hour acute lethality studies were conducted with mummichogs and produced water from the Hibernia rig. Not surprisingly, concentrated produced water (>45%) is lethal to fish but the risk of fish being exposed to such high concentrations is considered very low; however, fish exposed to lower concentrations of produced water showed behavioural responses to exposure: rapid, uncoordinated movements and disorientation. Mummichogs are a resilient species of fish in terms of handling and ease of care. Perhaps in the future experiments can be conducted at sea utilizing species native to the Grand Banks such as Atlantic cod.

Mummichogs swim in aerated produced water solution upon the CCGS Hudson.

**Dr Burridge hopes** to continue his work with produced water and marine fish in his lab. Production water from the Hibernia rig will be used in experiments with juvenile Atlantic cod. This year's plans include determination of dose-response (lethal and sublethal) relationships for 2006 production water and juvenile Atlantic cod. He also hopes to describe biochemical responses/effects of chronic exposure to low concentrations of produced water in juvenile Atlantic cod. Endpoints of interest include growth, MFO activity, indicators of endocrine disruption (vitellogenin production), and generalized stress responses such as production of Heat Shock Proteins (HSPs). ♦

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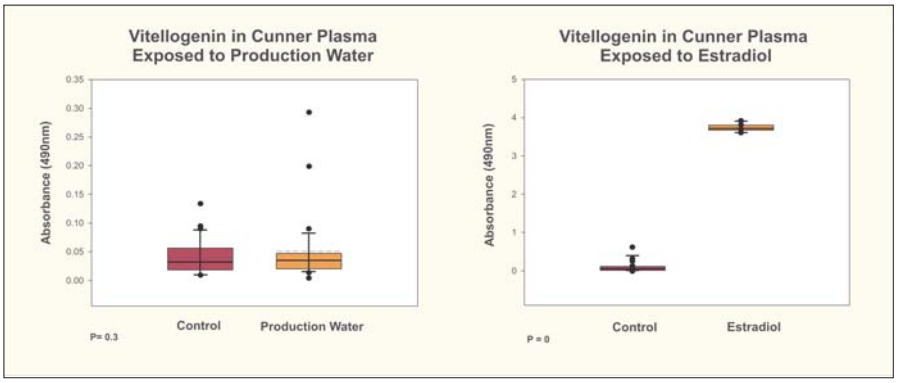
For more information concerning the St. Andrew's Biological Station please visit http://www.mar.dfo-mpo.gc.ca/sabs. Please contact Dr. Burridge via e-mail at BurridgeL@mar.dfo-mpo.gc.ca.

# Does Produced Water Cause Endocrine Disruption in Fish?

~ Jerry Payne is a DFO Research Scientist and Catherine Andrews is a Reseach Technician with the Oceans Sciences Center in St. John's Newfoundland.

**Considerable interest has arisen** recently concerning the potential of some chemicals to act as endocrine disruptors, potentially resulting in adverse effects on reproduction and/or other fish functions. One of the best known examples is the "estrogenic" effect, characterized by feminization of male fish with production of an intersex condition, whereby male gonads are found to contain both eggs and sperm. A prelude to the physiologically obvious expression of intersex is the appearance of relatively large concentrations of yolk protein or vitellogenin in blood.




**A weak estrogenic potential** has been linked to phenols having long alkyl chains, and while phenolic compounds common in petroleum are principally "short chain", it is not surprising that the issue of endocrine disruption would arise in connection with the discharge of production water. As the result of laboratory studies, Norwegian researchers first put the issue in the political spotlight noting that some pure compounds possibly had the potential to induce intersex in fish; however, those studies were of little ecological relevance.

**A chronic toxicity study** has recently been carried out with cunners (*Tautogolabrus adspersus*) exposed to production water from the Hibernia oil field. The experiment simulated chronic conditions of exposure to which fish might be subjected within a few hundred meters of the rig. Vitellogenin was readily induced in fish exposed to estradiol, but no evidence was obtained for vitellogenin induction in the blood or liver tissue of cunners exposed to production water for up to 3 months. Likewise, there was no evidence for any of a large variety of histopathological lesions examined in liver and gill. However some slight but statistically significant effects were noted in blood cells. Further studies will focus on economically important codfish and plaice. Such studies will provide an extra "back-up" for the EEM programs on the Grand Banks where all 3 producers have included early warning indicators of effects on fish health in their monitoring programs. ♦

# Effects of Hibernia Produced Water on the Embryonic Development of the Estuarine Mummichog

~ Monica Boudreau is a Marine Environmental Quality Technician with the Gulf Fisheries Centre in Moncton, New Brunswick. Dr. Simon Courtenay is a Research Scientist with Fisheries and Oceans Canada at the Canadian Rivers Institute, Fredericton, New Brunswick, and Dr. Kenneth Lee is the Executive Director of COOGER at the Bedord Insitutue of Oceanography in Darmouth, Nova Scotia.

**Produced water,** geological water released during the drilling and extraction process of oil and gas, contains a wide variety of contaminants including metals, petroleum hydrocarbons and alkylphenols. All of these constituents are known to be harmful to the sensitive early-life stages of fish. In June 2006, produced water collected by Les Burridge from the Hibernia platform (off the coast of Atlantic Canada) was brought back to the Gulf Fisheries Center (GFC; Moncton, NB) to determine its toxicity to the development of mummichog (*Fundulus heteroclitus*) embryos. Mummichog was selected for this study as a model fish species because it is one of the most abundant fish species found in our estuaries. They adapt very well to life in captivity, where they spawn readily during their spawning season (May to July) or can be prompted to spawn by temperature and photoperiod manipulation during winter months. Mummichog embryos are ideal for early-life developmental studies because they are relatively large and have a clear chorion which permits observation of the developing embryo. For these reasons, mummichogs have been used extensively in marine toxicity assays for nearly a century.

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**Eggs for our bioassay** were obtained by capturing adult mummichog by beach seine in the Kouchibouguac estuary in Grand-Barachois NB (40 km North-East of Moncton). Eggs were artificially fertilised and placed in Pyrex Petri dishes with 50 mL of test solution per dish, which was renewed every 2 days. Tested concentrations of produced water were 1, 10 and 66% along with a water control. The 66% treatment was the highest concentration included because produced water salinity was approximately 48 ppt and had to be reduced to 30 ppt to effectively rear mummichog embryos.

**During our bioassay** we measured the following end-points: heart rates, days to hatch, length of embryos at hatch, morphological abnormalities and survival. Preliminary results indicate that 1% and 10% concentrations increases the number of days for embryos to hatch and reduced their length-at-hatch. Embryos exposed to 1% had a reduced heart rate but this was not evident in the 10% group. Survival was reduced in the 10% treatment. At 66% produced water, all embryos failed to hatch; they had reduced heart rates and numerous morphological abnormalities. The morphological abnormalities were similar to those produced in our laboratory in a recent study with orimulsion and No.6 fuel oil. They included pericardial edema (accumulation of fluids in the pericardial sac), haemorrhaging (accumulation of blood outside the blood vessel), hemostasis (accumulation of blood inside the blood vessel), a white precipitate at the base of the pericardial edema and vertebral abnormalities. Such abnormalities may be associated with the cardiac dysfunction observed in our embryos. Most embryos had non-pigmented blood with different degrees of incomplete formation of the heart chambers, including tube hearts (tubular heart structure with no chambers). All embryos in the 66% treatment were underdeveloped compared to control embryos.

**The results of our study** indicate that produced water from the Hibernia platform was harmful to mummichog embryos at even the lowest concentration tested. Such negative effects during embryonic development could reduce subsequent growth, survival and reproduction, resulting in potential population level effects. Mummichogs will probably never encounter produced water naturally, as they are not found offshore where oil and gas are extracted, but effects seen in this model species may well be seen in other fish species. That said though, previous work in our lab and others has shown species differences in response to hydrocarbon exposure. For this reason, this fall we will be testing the generality of the responses seen in mummichog through bioassays with Atlantic herring embryos exposed to produced water. Stay tuned!

For more information concerning research at the Gulf Fisheries Centre vistit http://www.glf.dfo-mpo.gc.ca. You can contact Monica Boudreau via e-mail at boudreaumx@dfo-mpo.gc.ca

# Is Microbial Community Structure Altered by Produced Water?

~ Dr. Charles Greer is the Group Leader of the Environmental Microbiology Group, Biotechnology Research Institute – NRC, Montreal, Quebec; Dr. Bill Li is a Research Scientist at the Bedford Institute of Oceanography (DFO) and Dr. Kenneth Lee is the Executive Director of COOGER.

**Produced water** (formation water from the subsurface reservoir and waste treatment chemicals from the process stream) is currently discharged from offshore oil and gas installations in Canadian waters directly into the sea. As produced water may contain a variety of organic and inorganic contaminants of environmental concern, there is a need to assess its potential impact, if any, on the environment. Based on acute toxicity data and the modeling of plume dispersion, it would appear that produced water discharges would pose little environmental risk. Nonetheless, as the discharge stream is continuous and expected to increase over time, the focus is now on long-term "chronic impacts" from exposure to low concentrations of contaminants. Data is needed for the development of environmental assessment models to evaluate the cumulative risk of produced water discharges associated with the anticipated expansion of Canada's offshore oil and gas industry.

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**In an effort to identify** direct environmental effects associated with the release of produced waters and to delineate its potential "impact zone", the microbial community in and around the Hibernia oil production platform, off the coast of Newfoundland, is being characterized. The natural microbial flora of seawater is the first, and simplest, of the living organisms that will come into contact with produced waters. The ecological significance of bacteria on primary processes in the ocean such as carbon fixation, nutrient cycling, and contaminant biodegradation/ biotransformation has now been recognized. It is hypothesized that microorganisms will feel the initial impact of produced water discharges, and it is they who will be the most rapid to respond to such impacts. The activity of specific microorganisms will also be an indicator for the degradation and transformation of released contaminants. Using a variety of molecular methods, the DNA fingerprint of the entire microbial community is being developed and profiled. Any detectable changes will be examined in more detail to determine whether they are directly linked to the release of produced water. This collaborative study involving Dr. Greer (genomics), Dr. Bill Li (bacterial counts) and Dr. Ken Lee (bacterial productivity), will be the first of its kind to examine the effects of produced waters on the structure and function of the microbial community and to determine the utility of its measurement as a means to monitor environmental change. This information will be used to update Canadian regulatory limits for produced water discharges. ♦

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For more information concerning the Biotechnology Research Institute please vist http://www.bri.nrc-cnrc.gc.ca. Please contact Dr. Greer via e-mail at charles.greer@cnrc-nrc.gc.ca.

# INTERNATIONAL PRODUCED WATER CONFERENCE:

## *Environmental Risks and Advances in Mitigation Technologies, St. John's Newfoundland, October 17-18, 2007,St. John's Delta Hotel and Conference Centre*

## Technical Program

**1. COMPOSITION/CHARACTERIZATION**
- Definitions for produced water, formation water, and treatment water are needed
- What are the constituents of concern within the produced water stream?
  - Organics : saturated and aromatic hydrocarbons, phenols, organic acids
  - Inorganics: metals
  - NORM (naturally occurring radioactive material)
  - Procuction and produced water treatment chemicals

**2. FATE/TRANSPORT**
- Plume dilution/dispersion
- Sheen
- Weathering
- Metal speciation
- Hydrodynamics (nearfield/farfield)
- Oceanographic considerations
- Transport processes to the surface microlayer, water column, sediments
- Modeling of fate, transport, and ecological risks

**3. BIOLOGICAL EFFECTS**
- Acute vs. chronic Toxicity
- Trophic level dynamics
- Bioaccumulation
- Tainting
- Controlled lab and field (ecological) studies
- Fisheries impacts
- Seabird and marine mammal impacts
- Cumulative effects

**4. MONITORING TECHNOLOGIES**
- Environmental Effects Monitoring (EEM)
- Case studies
- Current technologies and advances

**5. PRODUCED WATER MANAGEMENT: REMEDIATION/MITIGATION**
- Volume reduction
- Re-injection
- BAT "Best Available Technologies" treating contaminants of concern
- Improvements in produced water treatment technology

**6. NUMERICAL/PREDICTIVE MODELLING**
- Life cycle analysis
- Fugacity and Transport
- Food chain
- Case studies
- Risk assessment/management
- Decision support system

**7. FUTURE DIRECTIONS**
- Emerging issues/challenges (including industry and regulator perspectives)
- Policy/regulations
- Identification R&D
- Improved monitoring

**Sponsored by:**
- Centre for Offshore Oil and Gas Environmental Research (COOGER) Fisheries and Oceans Canada
- Environmental Studies Research Funds (ESRF)
- One Ocean

# COOGER Hosts NATO/CCMS Oil Spill Response Workshop

~ Dr. Kenneth Lee is the Executive Dirctor of COOGER at the Bedford Institute of Oceanography in Darmouth, Nova Scotia and Dr, Wakter Davidson is the Director of National Facilities at the National Research Council of Canada and CCMS National Representative.


Kenneth Lee


Walter Davidson

**From October 11th to 13th**, 2006, 28 delegates from 17 member countries of the North Atlantic Treaty Organization (NATO) (Austria, Belgium, Canada, Denmark, France, Kyrgyz Republic, Latvia, the former Yugoslav Republic of Macedonia, Norway, Poland, Russian Federation, Slovenia, Spain, Sweden, Turkey, United Kingdom, and the United States) and an additional 81 experts in marine oil spill response from government, industry and academia arrived at BIO to participate in the NATO/Committee on the Challenges of Modern Society (CCMS) Third Annual workshop on Oil Spill Response. The 3 day workshop was hosted by DFO's Centre for Offshore Oil and Gas Environmental Research (COOGER) and was sponsored by NATO's Public Diplomacy Division, primarily under the aegis of the NATO-Russia Council; and in Canada, by the Department of Fisheries and Oceans, the National Research Council of Canada, and the Department of Foreign Affairs and International Trade. The Workshop was organized jointly by Dr. Kenneth Lee, Executive Director of the Centre for Offshore Oil and Gas Environmental Research (COOGER) at BIO; and Dr. Walter Davidson, Director of National Facilities at the National Research Council of Canada, and CCMS National Representative.

**This Workshop was the third in a series,** preceded by two NRC-CCMS workshops on Oil Spill Response held in Horten, Norway in July 2004 and Moscow, Russian Federation in October 2005. The NATO-CCMS addresses problems affecting the environment of the nations and the quality of life of their peoples. CCMS goals include emerging risks to the environment and society that could cause economic and political instability; and addressing non-traditional threats to security.

**The Workshop maintained** a pragmatic focus on issues of current relevance including Artic research. With both the International Polar Year quickly approaching and the threat of increasingly heavy shipping traffic through previously

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# Memorial University's Ocean Research Reaches New Depths

Ms.Michelle Osmond is the Communications Coordinator with the Faculty of Engineering and Applied Sciences at Memorial University, St. John's, Newfoundland. Haibo Niu, is a PhD candidate with the Faculty of Engineering and Applied Sciences at Memorial University.


Haibo Niu

**The Underwater** Vehicles Laboratory in Memorial University of Newfoundland's Faculty of Engineering is home to a new and very unique piece of equipment. The MUN Explorer is an autonomous underwater vehicle (AUV). Weighing 700 kilograms, it is the only AUV of its size and capability available to the university research community in Canada. In fact, there are only a handful of groups worldwide involved in AUV research and even fewer focused on what engineering researchers at Memorial are undertaking.

**The MUN Explorer** is a 4.5 metre ocean-going AUV with a 100 km range built by International Submarine Engineering Ltd. (ISE) in Port Coquitlam, British Columbia. It is based on a design that ISE has been fine-tuning for more than 20 years. Funded by the Atlantic Canada Opportunities Agency through an Atlantic Innovation Fund award to the Pan-Atlantic Petroleum Systems Consortium, it is the second in a line of three. The first vehicle of its kind is operated out of France. The Explorer is also a survey class AUV which means it


The MUN AUV goes for a trial run.

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impassable Arctic waters, developing existing and novel techniques for oil spill response in this region is of critical importance. The Arctic constitutes a large part of Canada, it is linked to sovereignty, it is being changed by global warming so that the North-West passage is becoming increasingly navigable, and it will witness increased activity in offshore oil and gas exploitation and transportation which will likely lead to increased risk of deleterious oil spills. The one day Arctic session resulted in ideas which are evolving into several international collaborative initiatives to address this emerging issue. The presentations touched on the predicted retreat of the Arctic ice cap in this century, behaviour of oil in pack ice, remote sensing and detection of oil in and under ice, in situ burning of oil spills, state-of-the-art industrial oil clean up technology and products including booms and herders, the need to understand bulk oil weathering of ice, the use of dispersants to mitigate the toxicity and concentration of residual oil, and the use of large-scale test facilities such as the OHMSETT installation in the US and the Bedford Institute wave tank.

**The session topics** on the second and third days of the Workshop focused on oil spill countermeasures, biological effects, modeling fate and transport, risk assessment, contingency planning, operational response, and related policy issues. Among the key topics discussed in oil spill countermeasures were the operation of boom systems, the use of flow-enhancing techniques to pump heavy oil via viscosity reduction, oil weathering models, the use of chemical oil dispersants, the outcomes of various field trials, the critical role of breaking waves for effective and lasting dispersion of oil slicks, and the role of particle size. The session on biological effects emphasized the strategy of preventing oil from beaching, the effects of oil on bottom feeding (benthic) biota in Sakhalin peninsula, the toxic effects of oil on fish, and microbial and abiotic hydrocarbon removal in oil tanker ballast water, and related clean up strategies. The third day of the Workshop addressed management control of environmental terrorist attacks including the identification of areas of critical vulnerability, the integration of GPS and GIS data into identification and monitoring of oil spills, the overviews of national oil spill response capabilities from various participants and related science policy inputs, Norwegian contingency and preparedness plans for vessel spills in an environment where the petroleum industry is heading north into increased challenges of ice, icebergs, and weather; the Alaskan experience of Regional Citizen's Advisory Council at Valdez, the issues of using aerial application of dispersants, contingency planning and operational activities in the UK, the necessity of applying SAR imaging to oil spill modeling, and legislation and policy issues in case of oil spills in the Russian Federation.

**Proceedings from this workshop** will produced in the next few months as a thorough review of the 3 day workshop. In summary, the Workshop generated a well rounded and global perspective of the most pivotal issues of importance surrounding the topic of Oil Spill Response.

Workshop updates are avaiable on the NATO/CCMS website (http://www.nato.int/ccms).

Continued from Pg. 7, Memorial University's Ocean Research Reaches New Depths

can handle up to 150 kilograms of different sensors allowing it to do large scale surveys of the water column or seafloor. In addition, it can go to depths of 3000 metres – something very few underwater vehicles can do. Researchers at Memorial will be pushing its capabilities in offshore environmental engineering, iceberg exploration and characterization, and seabed surveys.

**Dr. Neil Bose** is Memorial's Canada Research Chair in Offshore Underwater Vehicles Design. He says he would also like to use the vehicle for seabed mapping and eventually take it underneath the ice to do research that icebreakers and remotely operated vehicles normally do. Dr. Bose says the Explorer is a major asset for Memorial. "It puts MUN on the map for AUV based research and adds to the ocean monitoring capabilities and tools at the university. For example, from the results of missions using the AUTOSUB vehicle from the National Oceanography Centre Southampton, under Antarctic ice, they discovered krill habitat found under the ice sheet edge. This is new and exciting knowledge to biological oceanographers. This type of discovery is possible with a tool like the Explorer."

**The Explorer is initially being operated** in coastal areas of Newfoundland for environmental monitoring and vehicle dynamics testing. Work is on-going to develop AUV sensors to measure conductivity, temperature and depth, and sonar and camera devices to give increased versatility and capabilities.

For more information concerning MUN Engineering vist http://www.engr.mun.ca. Please contact Haibo Niu via e-mail at haibo@engr.mun.ca.

# Monitoring and Mitigating Aquatic Environmental Impacts: Integration of R&D Programs Between the National Research Council and Fisheries and Oceans Canada

~ Dr. Kenneth Lee is a Research Scientist with Fisheries and Oceans Canada and Executive Director of COOGER and Dr. Charles Greer is the Group Leader of the Environmental Microbiology Group, Biotechnology Research Institute – NRC, Montreal, Quebec.

**The Biotechnology Research Institute** (BRI) of the National Research Council of Canada (NRC) and Fisheries and Oceans Canada (FOC) have been working together for 7 years to integrate research programs to develop and evaluate new technologies for the assessment of environmental health and contaminated site remediation. These horizontal research programs addressing the clean-up of contaminated sites have a direct impact on human and environmental health, and hence the quality of life in Canada and elsewhere. Joint expertise in monitoring microbial processes and environmental genomics has been used to characterize the role of microorganisms in the removal of contaminants, develop oil spill bioremediation strategies, and methodologies to monitor marine environmental health.

Aerial view of oil spill study conducted along the St. Lawrence River.

**To protect the health of our oceans** and the sustainability of its resources, scientists within COOGER, Fisheries and Oceans Canada with a responsibility to both monitor and mitigate environmental impacts, bring to the program expertise and infrastructural resources (laboratories and ships) required to access contaminated sites. The Biotechnology Research Institute of the National Reseach Council has expertise in pollutant biodegradation, bioremediation, and biomonitoring, and contributes its environmental laboratories and analytical equipment to the program. Together they are developing and exploiting a variety of new environmental genomics approaches for environmental effects monitoring to support the development of appropriate guidelines for environmental conservation, protection and regulatory enforcement. The development and validation of remediation technologies will ultimately be transferred to industry generating direct economic and social benefits.

Aerial view of oil spill study conducted near Conrod's Beach, Nova Scotia.

## The Development of Oil Spill Countermeasures

**A number of collaborative research programs** have been developed between FOC and NRC to develop and validate new oil spill mitigation strategies and techniques to monitor habitat recovery. It has been estimated that up to $10^7$ tons of crude oil impact marine and estuarine environments annually. With increases in marine transport and the development of offshore oil and gas reserves off the coast of Canada, including the Arctic, accidental oil spills have become an environmental issue of priority concern.

**In recognition of their importance** as fish nurseries, wildlife habitats, protection against shoreline erosion, flood mitigation and water quality improvement, an experimental oil spill study was conducted

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The Eureka high Arcitic weather station on Ellesmere Island (1990).

in a freshwater wetland environment along the St. Lawrence River near Quebec City. In this project, designated plots sprayed with crude oil were subjected to a variety of treatments including the application of two different fertilizers to stimulate indigenous bacterial and plant growth and petroleum degradation activity. Over time, various physical, chemical, biological and toxicological parameters were monitored to develop a better understanding of the ecosystem response to the oil insult, and to develop data on the impacts of biostimulation on the activity of sediment microorganisms, and the recovery and growth of the wetland plants and other organisms that thrive on or within the sediments. The success of this initial study led to an experimental spill on a salt marsh located near Conrod's Beach, Nova Scotia, to examine bioremediation as an oil spill response strategy. These wetland studies emphasized the importance of a multi-disciplinary approach to ecosystem monitoring, which included chemical, physical and biological characteristics. The results have provided scientific data that has altered the methodologies to be used by oil spill responders for the clean-up of wetlands impacted by oil spills. Rather than physically removing oiled sediments or burning the oil in-situ, which may be detrimental to habitat recovery (e.g., loss of the wetland habitat from erosion due to loss of the plants), natural attenuation (natural recovery) and/or nutrient enrichment stimulates plant growth and microbial activity. This has now been demonstrated to be an effective and environmentally sound treatment option.

DFO staff use a Lehigh Gravity Core to collect sediment in Sydney Harbour.

**NRC and DFO are also evaluating** the feasibility of biotreatment strategies in the Arctic. A fuel leak at the Eureka high Arctic weather station in 1990 along the shoreline of Ellesmere Island resulted in the release of 37,000 litres of diesel, which contaminated 3,200m$^2$ of soil. A simple bioremediation protocol based on the application of fertilizer and soil tilling, has been monitored over several years by examination of chemical and microbiological parameters, to develop baseline data on the impact of a contamination event and its subsequent cleanup on the biodiversity of the indigenous soil microbial community in this fragile ecosystem.

**Monitoring the Condition and Recovery of Contaminated Sites**

**As the result of industrial activities**, Sydney Harbour, Nova Scotia, has been described as one of the most hazardous toxic waste sites in Canada. The environmental significance of microbial degradation of organic contaminants (PAHs) within sediments was assessed by radiotracer and gene probe analysis in a joint study between DFO and NRC scientists. Indigenous sediment microorganisms were shown to have the capacity to degrade and/or transform many of the contaminants of concern. Mass balance models formulated with the chemical, biological and hydrodynamic data from this program have provided us with a means to predict the natural rates of contaminant transport and habitat recovery, with and without remedial action. These tools may now be used to monitor the impact of proposed remediation activities for the Sydney Tar Ponds Remediation Program that may result in an episodic release of contaminants into Sydney Harbour from the construction of planned containment barriers and the excavation of sediments.

REAL PEOPLE

# Lin Zhao

~ COOGER would not be possible without the dedication of our highly skilled collaborators.

Leading Seaman Derrick Rideout works with Lin on the winch to collect water samples.

**Growing up** in the industrial automotive city of Changchun, the capital city of Jilin Province in China, Lin Zhao never expected to live in Canada. Nonetheless, after completing her Bachelors Degree in Engineering at Hohai University, Nanjing, China, she did just that.

**In October 2004**, in an effort to improve her English, Lin moved to Canada. After only a year of studying English Lin applyed for a Masters position with Dr. Zhi Chen, an Associate Professor of Civil and Environmental Engineering at Concordia University. Dr. Chen has a diverse background, working extensively with acadamia, government and the oil and gas industry. His research focuses primarily on the development of models to predict the fate and transport of pollutants.

**Through a cooperative effort** between Dr. Chen and the Centre for Offshore Oil and Gas, funding was provided for Lin to pursue a Masters in Engineering focusing on assessing the long term ecological risks associated with relatively high heavy metal concentrations from produced water discharges from offshore oil and gas production.

**The complexity of heavy metal dispersal** and the potential detrimental ecological impact of long term exposure in the environment make modelling and the associated assessment of risk a challenge.

**In June of 2006**, Lin joined DFO staff and the crew of the Hudson on their mission to Hibernia. After a brief Search and Rescue mission in winds reportedly in excess of 70 kts and waves as high as 40 ft, Lin got to work assisting primarily with the retrieval of water samples for various types of analysis. This mission to monitor the environmental effects of produced water acted as a real world classroom that provided concrete examples of difficulties of working at sea and the interdisciplinary interactions necessary to provide useful data for modelling.

**COOGER relies** on the knowledge provided though interactions that involve talented young scientists. It is these interactions that are essential for the generation of fresh perspectives necessary for gaining a new understanding of the oceans and the marine environment.

# Simon Courtenay

**Dr. Simon Courtenay** - Is a DFO Research Scientist currently working as a Research Professor, and Fellow with the Canadian Rivers Institute, Department of Biology, University of New Brunswick, courtens@unb.ca.

**Simon grew up** along the shores of Victoria BC where he first imprinted on the ocean and the abundant marine life of it's bays and estuaries. Paired with a tropical aquarium hobby, fish biology became his passion.

**Simon pursued his interest** in fish biology at the University of Western Ontario where he completed a B.Sc. and M.Sc. working on fish behaviour. From there, Simon went to the University of British Columbia to complete a PhD with Peter Larkin and Kees Groot, a scientist with DFO's Pacific Biological Station. He wanted to confirm when salmon learn the smell of their home stream.

**By the time Simon finished his PhD**, he was engaged to Hélène Dupuis. When she was offered a job working on herring at the Gulf Fisheries Centre in 1988, they both moved to Moncton. Once in New Brunswick, Simon started a post-doc on juvenile herring ecology and later was offered employment with DFO as a salmon assessment scientist.

**Over the years**, Simon's research evolved into directing research projects focussing on environmental monitoring in the Environmental Sciences Section. In 2006, as part of a memorandum of understanding between the University of New Brunswick and Fisheries and Oceans Canada (DFO), Dr. Courtenay agreed to work out of the UNB Fredericton, Canadian Rivers Institute for five years. This MOU will

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Continued from Pg. 11, Simon Courtenay.

act to consolidate UNB and DFO resources focussing on issues associated with the estuaries and coastal zones of the Gulf of St. Lawrence. Simon maintains a lab and aquatic facility at the Gulf Fisheries Centre in Moncton and is more than ably assisted by technician Monica Boudreau and biologist Matthew Hardy.

**The majority of Simon's time** is still spent researching his own projects, all of which involve collaborators and students and relate to the central theme of developing tools and approaches for measuring marine environmental quality.

**Simon is also involved** in the scientific aspects of oil and gas development, in particular the impact of seismic activity - the use of sound in exploring for oil and gas deposits - in the southern Gulf of St. Lawrence. "We began working with COOGER on the snow crab seismic issue back in 2004. My lab looked at whether snow crab embryos, being carried by mothers that were exposed to seismic energy, were affected. This involved a collaboration with Margaret Beaton at Mount Allison University to look at morphology of the newly hatched larvae and a collaboration with Edwin Demont from St. Francis Xavier University to look at their swimming behaviour. Since then, we have become more involved in oil and gas issues including doing bioassays to look at early life development of mummichog (an estuarine fish species) and Atlantic herring (marine fish species) exposed to orimulsion, oil and produced water. With the construction and recent expansion of the wave tank at BIO, we are very excited about opportunities to work with Ken Lee, Kats Haya, Les Burridge, university collaborators like Peter Hodson from the Queen's University School for Environmental Studies and the whole COOGER team on how hydrocarbon products may really affect animals in the ocean." ♦

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For more information on the Canadian Rivers Institute visit http://www.unb.ca/cri. Please contact Simon via e-mail at courtens@unb.ca.

# DFO Science Renewal and Centres Of Expertise

~ Leah Braithwaite is a Senior Science Advisor for Ocean Sciences - Canadian Hydrographic Service, Fisheries and Oceans Canada, BraithwaiteL@DFO-MPO.GC.CA

**DFO has prepared** a new framework for its Science Sector that will result in a vibrant and sustainable aquatic research program. The DFO Science Renewal initiative is under the leadership of Serge Labonte, Senior Director General, Science Renewal. Its overriding premise is to foster science excellence and is designed to meet DFO and government-wide needs by enhancing research strengths through a wide range of collaborations. A variety of initiatives are being undertaken as part of the Science Renewal framework, including:

1. Aligning DFO Science with the Departmental strategic outcomes of Safe and Accessible Waterways, Healthy and Productive Aquatic Ecosystems and Sustainable Fisheries and Aquaculture,

2. Ensuring Departmental research is responsive to priorities,

3. Creating an integrated research program that supports an Ecosystem-Based approach to resource management,

4. Developing strategies to encourage an affordable program, and

5. Delivering a modern science program that makes effective use of partnering and collaboration with academia, industry and other government departments both domestically and internationally.

**A key part of the DFO Science Renewal** Partnering and Collaboration Strategy is the development of Centres of Expertise (COEs). The COEs will provide the capacity to address long-term research challenges that cannot be met by a single DFO Region or Institute. Two types of COEs are envisioned: Virtual Centres of Expertise (VCEs) which network dispersed expertise and have a central office located at the Institute where the Director resides; and Geographic Centres of Expertise (GCEs) which will concentrate the human, financial and infrastructure resources in specific locations to deliver specialized programs/services such as laboratory analysis.

Four COEs are fully operational:

1. **COOGER** - Centre for Offshore Oil and Gas Environmental Research -. Kenneth Lee, Bedford Institute of Oceanography, Halifax (VCE)

2. **CEMAM** - Centre of Expertise on Marine Mammalogy -Michael Hammill, Maurice-Lamontagne Institute, Mont-Joli (VCE)

3. **N-CAARE** - National Centre for Arctic Aquatic Research Excellence -Martin Bergmann, Freshwater Institute, Winnipeg (VCE)

Six COEs are in the implementation phase:

1. **CHIF** - Centre for research on Hydropower Impact on Fish and their habitat -Jean-Denis Dutil, Maurice-

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Lamontagne Institute, Mont-Joli (VCE)

2. **COMDA** - Centre for Ocean Model Development and Application - John Loder, Bedford Institute of Oceanography, Halifax (VCE)

3. **CAAHRD** - Centre for Aquatic Animal Health Research and Diagnostics - Gilles Olivier, Gulf Fisheries Centre, Moncton (VCE)

4. **CEARA** - Centre for Expertise for Aquatic Risk Assessment - Nick Mandrak, Canada Centre for Inland Waters, Burlington (VCE)

5. **Aquaculture Centre of Expertise** - Robert Stephenson, St. Andrew's Biological Research Station, St. Andrew's (VCE)

6. **Toxic Chemical Analyses** - Serge Gosselin, Maurice-Lamontagne Institute, Mont-Joli (GCE)

**COEs will foster collaboration** both within DFO and with partners in academia, industry and other government departments. Additional COEs will be considered over the coming months to respond to specific needs. ♦

If you have questions please contact Kim Darling (DarlingK@dfo-mpo.gc.ca, (613) 998-4361) for further information.

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.* ♦