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Proceedings of the national peer review workshop on identifying research requirements for the biological effects of oil and gas-related contaminants on aquatic ecosystems

March 26-27, 2014
Ottawa, Ontario

Chairperson: Gilles Olivier
Editor: Bradley Park

Fisheries and Oceans Canada
200 Kent Street
Ottawa, ON K1A 0E6

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A national peer review workshop was held March 26-27, 2014 at the Minto Suite Hotel in Ottawa, Ontario. The purpose of the workshop was to identify research requirements for the biological effects of oil and gas industry-related contaminants on aquatic biota. Workshop participants critically reviewed a research document entitled “Literature Review on the Aquatic Toxicology of Crude Oil: An Overview of Toxic Components and the Acute and Chronic Toxicity to Aquatic Organisms”, and helped formulate biological effects research priorities. A total of 17 participants attended the workshop, including experts from DFO Science, Environment Canada, Academia, a non-Governmental organization, and US Federal Science organizations. This Proceedings report summarizes the material presented, key discussion items, and decisions reached at the workshop. A supporting Research Document resulting from the workshop is published on the CSAS website.

SOMMAIRE

Les 26 et 27 mars 2014, un atelier national d'examen par les pairs a été tenu à l'hôtel Westin, à Ottawa, en Ontario. L'objectif de l'atelier était de déterminer les besoins en matière de recherche dans le domaine des effets biologiques des contaminants liés à l'industrie pétrolière et gazière sur le biote aquatique. Les participants à l'atelier ont procédé à un examen critique d'un document de recherche intitulé « Literature Review on the Aquatic Toxicology of Crude Oil: An Overview of Toxic Components and the Acute and Chronic Toxicity to Aquatic Organisms » [Analyse documentaire de la toxicologie aquatique du pétrole brut : un aperçu des composants toxiques et de la toxicité aiguë et chronique pour les organismes aquatiques] et ont contribué à la formulation de priorités en matière de recherche sur les effets biologiques. Au total, 17 participants ont assisté à l'atelier, dont des experts du Secteur des sciences du MPO, d'Environnement Canada, du milieu de la recherche universitaire, d'une organisation non gouvernementale et d'organismes scientifiques fédéraux des États-Unis. Le présent compte rendu résume le matériel présenté, les points de discussion clés et présente les conclusions importantes tirées de la réunion. Un document de recherche à l'appui, découlant de la présente réunion, a été publié sur le site Web du SCCS.

INTRODUCTION

The workshop Chair (Gilles Olivier) welcomed participants to the workshop, and conducted a roundtable of introductions to provide the name, affiliation, and area of expertise for each participant in the field of oil and gas contaminant research (Appendix 1). Participants were asked to review the workshop Terms of Reference (Appendix 2), as these would highlight the objectives, provide context for the discussions, and define the expected publications. The Chair then provided an overview of the two-day workshop agenda (Appendix 3), consisting of a series of presentations and discussions on subsections of the working document; a draft literature review on the biological effects of oil and gas contaminants relevant to Canadian aquatic ecosystems.

The Chair presented an overview of the DFO science advisory process, emphasizing that the process requires active engagement from all participants, and that the principle of consensus would be essential to achieve the workshop objectives. It was noted that the main goal of the workshop was to peer-review the working document, with emphasis on generating a list of research priorities based on the information therein; this list of priorities would inform future research initiatives of DFOs National Contaminants Advisory Group.

PRESENTATIONS AND DISCUSSION

PRESENTATION 1: OVERVIEW OF THE NATIONAL CONTAMINANTS ADVISORY GROUP

Presented by Judith Leblanc

In 2012, following Strategic and Operating Review, DFO ceased all in-house research on the biological effects of contaminants. In 2013, DFO created the National Contaminants Advisory Group (NCAG) to coordinate effects-based research through external experts and to use the research output to provide advice on priority contaminant issues in support of the departmental mandate. The group is part of DFO's Ecosystem Science Directorate, and is comprised of five biologists based at the Freshwater Institute (Winnipeg), Institute of Ocean Sciences (Sydney B.C.), and Institut Maurice-Lamontagne (Mont-Joli, Que). The group's activities are focused on assessing biological effects relating to fisheries, whereas spatial-temporal monitoring and human health effects of contaminants are beyond the NCAG mandate. The group uses various financial and administrative mechanisms to facilitate external research with other government departments, academia, and the private sector.

Current priority research topics are pesticides, aquaculture-related substances, emerging contaminants, and oil and gas-related contaminants. Based on industry forecasting, it is anticipated that the Canadian oil and gas sector will continue to evolve. It was noted that this will create in an increased need to prioritize research gaps on oil and gas contaminants effects.

Discussion

- It was noted that information generated by NCAG would be disseminated to the public through primary publications in peer-reviewed journals, DFO technical reports and CSAS publications, and that NCAG may develop an internal peer review system in the future.

PRESENTATION 2: DEPARTMENTAL DRIVERS - DFO COMMITMENTS AND PRIORITIES ON OIL AND GAS CONTAMINANTS: NATIONAL PERSPECTIVE

Presented by Mike Stoneman

In recent years, there has been increased interest in oil and gas contaminant issues due in part to the magnitude of the Deep Water Horizon spill impacts in the U.S., as well as the proposal to increase the production and transportation of diluted bitumen in Western Canada via the Northern Gateway Pipeline. The World-Class Tanker Safety Expert Panel was formed to review and assess Canada's ship-source oil spill preparedness and response regime in two phases; the review for Phase I (south of 60^{o}N) is complete, whereas the review for Phase II (north of 60^{o}N) is ongoing. The Phase I review highlights the need for risk-based area response plans. Going forward, DFO will be expected to provide science advice pertaining to potential ecosystem sensitivities and toxicity of end products resulting from spills, which will have implications for future work supported by NCAG. It was noted that the World-Class Tanker Safety System doesn't capture potential inland impacts from pipeline, rail, and truck transport, but that DFO will be expected to provide advice on these issues.

Discussion

- The use of chemical dispersants as a mitigation measure was discussed.
    - Currently, in Canada there is a blanket prohibition on the use of dispersants. There is an ongoing examination of legal mechanisms regarding the application of dispersants in Canada. Studies are underway to examine the conditions for use (types, timing etc). If a spill were to occur, Environment Canada scientists would advise on the use of dispersants.
    - In the U.S., various chemical mitigation measures are used in spill response; new regulations under the Environmental Protection Agency (EPA) National Contingency Plan will be released in the near future; these mitigation measures may inform future work in Canada.
- It was acknowledged that the effects associated with wastewater from hydraulic fracturing ("fracking") are an issue of concern for DFO, and will likely warrant further research.
- Historically, DFO's Centre for Offshore Oil and Gas Environmental Research (COOGER) has provided advice to the Department on effects of oil and gas contaminants on fisheries, but due to changes within the Department, future effects-based research will be coordinated with external providers through NCAG.

PRESENTATION 3: OVERVIEW OF LITERATURE REVIEW ON THE AQUATIC TOXICOLOGY OF CRUDE OIL

Presented by Alain Dupuis

The primary author of the working document presented an overview highlighting the purpose, scope, and structure of the document. The purpose of the literature review was to summarise the current state of knowledge on crude oil products currently used in Canada and their effects on aquatic species, and to identify knowledge gaps on biological effects. The majority of the review was based on crude oil production and transportation; however it also covered condensate, drilling fluids, chemical dispersants, and oil sands-derived bitumen. While the emphasis was on fish, the scope of the review also included other aquatic ecosystem components. Effects-based information was derived from laboratory and field-based studies, including accidental and controlled spill scenarios. The main body of the report was comprised

of four sections: (1) the oil industry in Canada (production and transport), (2) physical and chemical properties of oil products, (3) toxicity to aquatic biota, and (4) research gaps on biological effects. It was re-iterated that the ultimate objective of the workshop was to peer review the working document to develop research priorities for future work. There were no major discussion items following this presentation.

PRESENTATION 4: OVERVIEW - LITERATURE REVIEW SECTIONS 1 AND 2: IDENTIFICATION OF AQUATIC CONTAMINANTS FROM OIL AND GAS ACTIVITIES

Presented by Alain Dupuis

The primary author provided an overview of sections 1 and 2 of the working document.

Section 1: Oil industry in Canada

Currently, the vast majority of Canadian oil production occurs in the west, with oil sands production projected to increase in the coming years, and conventional production projected to remain relatively steady. The three main oil sands deposits are the Athabasca, Peace River, and Cold Lake deposits. Extraction techniques are site-dependant, and include both surface mining and in situ techniques. While in situ production is roughly equal to surface mining in current operations, it is anticipated that in situ production will increase in the future.

Oil sands bitumen is typically upgraded on site to reduce viscosity, thereby facilitating pipeline transportation. Diluted bitumen ('dilbit') is roughly 70% bitumen and 30% condensate, whereas 'synbit' is a roughly equal mix of bitumen and synthetic crude oil. The composition of diluted oil products varies by season and method of transportation. Because western Canadian oil supplies are landlocked, the vast majority of transportation is by pipeline, with rail transport becoming increasingly important in recent years. There are extensive networks of rail and pipeline transportation that cross through various aquatic habitats throughout Canada, with linkages to transport hubs in the Pacific, Atlantic, and northern coasts, thus diverse freshwater and marine ecosystems could be affected by accidental releases.

Section 2: Properties and toxic components

There is great diversity in the physical and chemical properties of oil products extracted, processed, and transported within Canada. Information of physical and chemical properties of numerous oil products can be found in an Environment Canada database (http://www.etc-cte.ec.gc.ca/databases/OilProperties/), and the composition of some specific products is also reported in the primary literature. Density is a critical physical variable that determines fate and behaviour during an accidental release in aquatic environments; condensates, light to heavy crude oil, and some diluted bitumens tend to float on water, whereas undiluted bitumen would tend to sink. The generalized chemical composition of various oil products were summarised in tables in the working document, and it was noted that low molecular weight components tend to be associated with acute toxicity, whereas high molecular weight components tend to be more environmentally persistent, and are associated with chronic toxicity.

Discussion

- Participants noted that while bitumen is a major product transported in Canada, biological effects research priorities should also account for the significant volumes of condensate required to dilute bitumen for pipeline transport, as well as other products such as fuel oil, synbit, liquefied natural gas, etc. The impact of fracking was also noted as a research gap.

- It was recommended to incorporate volumes of product shipped in Canada, the types of product and any spill probability data into the working document, with commentary on potential limitations of these data.
- It was recommended to incorporate recent spill data into the working document, with commentary on potential limitations of these data.
- Participants noted that while the NCAG mandate is focused on biological effects research, it is critical to identify broader research gaps, including physical habitat issues, such as removal of snags from rivers during spill response, and environmental fate and behaviour issues, such as heating of oil products during rail transport and the resulting effects on environmental behaviour in the event of a spill.
- It was recommended that the API gravity value be used to classify and distinguish between major classes of conventional oil to facilitate comparisons among studies.
- It was suggested to include discussion on weathering, persistence, bioavailability, biodegradability, miscibility as it relates to different environmental conditions and that a conceptual model might be helpful. Weathering discussion was suggested to consider thermodynamics as it relates to behaviour and partitioning.
- It was suggested to include definitions for key terms and to consider using “miscibility” instead of “solubility”, to use “conventional” for crude oil and “unconventional” for diluted bitumen, to refer to “diluents” instead of “condensate”.

PRESENTATION 5: OVERVIEW – LITERATURE REVIEW SECTION 3: BIOLOGICAL EFFECTS OF CONTAMINANTS FROM OIL AND GAS ACTIVITIES ON (A) FISH (B) INVERTEBRATES (C) MARINE ANIMALS, AND (D) ECOSYSTEM-SCALE IMPACTS.

Presented by Alain Dupuis

The primary author provided an overview of section 3 of the working document.

Oil and gas toxicity can occur at multiple levels of biological organisation, and both acute and chronic effects warrant investigation. Main exposure pathways in fish and invertebrates include uptake of dissolved contaminants across biological membranes and direct ingestion of dissolved or particulate matter, whereas marine mammals can be exposed via direct inhalation of volatiles. Biological effects research can be based on laboratory exposures, mesocosm studies, controlled spills, or monitoring of accidental spills. Ecological relevance and degree of experimental control are important elements to consider in the experimental approach. The main mechanism of acute toxicity in aquatic organisms is narcosis, whereas chronic exposure has been primarily related to effects associated with metabolism of PAHs by cytochrome P450. Toxic effects include endocrine disruption (i.e. changes in circulating sex steroid hormone concentrations), genotoxicity, immunotoxicity, and behavioural effects. For marine and freshwater fish and invertebrate species, early life stages tend to be more sensitive to acute and chronic effects than adults. Many invertebrate species have pelagic early life stages and benthic adult stages, thus life history characteristics will affect potential exposure to contaminants. Embryotoxicity in fish is comprised of deformities, cardiac abnormalities, and impaired growth. Given that early life stages tend to be more sensitive, there may be potential population-level impacts due to reduced recruitment. For marine mammals, controlled experimental data is highly limited; however results from accidental exposure indicate that both mortality and sublethal effects can occur.

Discussion

- It was noted that it is important to consider multiple modes of action in oil and gas toxicity; it was emphasized that the aryl hydrocarbon receptor pathway can induce genotoxic effects in embryos, whereas cytochrome P450 induction can result in toxic metabolites.
- Participants noted that recently published research on fish cardiotoxicity should be incorporated, and also suggested expanding the working paper to include potential epigenetic effects, developmental toxicity, neurobehavioural effects, and photoxicity as a mechanism of action.
- It was noted that more context is required to discuss the advantages and disadvantages of field vs lab-based studies in oil and gas ecotoxicology research, and that the two approaches are complementary.
- It was suggested to use the terms ‘lethal’ and ‘sublethal’ for clarity when discussing toxic effects, rather than ‘acute’ and ‘chronic’.
- It was noted that the formulation of end products is important to consider in toxicity research, i.e. diluted bitumen would be more bioavailable than bitumen;
- It was suggested to examine and acknowledge the potential limitations of the CROSERF methodology for standardised toxicity testing.
- Participants noted that approaches to measurement of chemical properties have been inconsistent for chronic/sublethal exposures; standardised methods in this area of research would improve inter-laboratory comparisons.
- A major research gap is the development of effective analytical techniques to support toxicology research. In exposure studies, it is critical to know the exposure concentration in water, as well as the actual amount taken up into the test organism. When determining exposure routes and biological effects, it is critical to consider the distinction between uptake of particulate or suspended oil droplets (i.e. ingestion) and uptake of dissolved oil components across membranes.
- Participants suggested some additional references, and recommended structural and formatting changes to tables and figures.

PRESENTATION 6: OVERVIEW OF ATHABASCA OIL SANDS JOINT MONITORING PLAN

Presented by Joanne Parrott

This presentation was added to the agenda to inform participants on environmental monitoring currently underway in the Athabasca region.

Environment Canada researchers are currently monitoring potential impacts from oil sands mining activities in the Athabasca River region. The main potential source of contamination is open pit mines. Waste water from mining operations is collected in settling ponds, resulting in potential seepage of contaminated groundwater into the Athabasca watershed. Atmospheric deposition is a secondary source of contamination. A major challenge in the monitoring impacts is to discern anthropogenic sources from naturally occurring bitumen exposure in the region. To this end, studies are underway to compare fish health in tributaries with and without mining activity in their watersheds. Fish health monitoring is being conducted at numerous sites to assess growth, recruitment, reproduction, external abnormalities, liver neoplasia, and parasite load. Standardized fathead minnow (*Pimephales promelas*) toxicity tests are being conducted to

assess potential impacts on the embryo-larval stage, as well as on adults. Growth and survival of caged bivalves and *Hyallela sp*. are also being monitored. There were no major discussion items following this presentation.

PRESENTATION 7: OVERVIEW OF OIL AND GAS CONTAMINANTS EFFECTS ON FISH

Presented by Peter Hodson

Based on extensive research experience in the field of Canadian oil and gas ecotoxicology research, the presenter summarised major research needs on the biological effects of oil and gas products in four areas, to help inform the group discussions:

Receptors –

- Identify life history traits that make species susceptible to oil;
- Assess ecological impacts of oil effects on fish;
- Collect data for test species from eco-regions where oil is likely to be spilled (Arctic; marine; freshwater);

Hazards –

- Produce toxicity data for diluted bitumen, synthetic crude oil and oil-gas condensates;
- Develop standardized methods for comparing toxicity among species and among oils;
- Identify the toxic components of crude oil beyond broad scale ‘families’ of alkyl PAH
- Establish cause-and-effect;

Exposures –

- Relate the properties, fate, and distribution of different types of oil to habitat and life history requirements of indigenous fish species;
- Determine the role of droplets in estimating toxicity to aquatic species
- Establish chemical and biological markers of exposure

Environment –

- Identify ecosystems (eco-regions) in which oil spills will be particularly damaging by virtue of
    - Habitat for ‘important’ species (fisheries, culture, endangered status)
    - Oil persistence (low rates of dilution, volatility, biodegradation, photodegradation)
    - Physical characteristics (e.g., freshwater vs marine)
    - Challenges for remediation (remoteness, terrain)
    - Sensitivity to damage by clean-up
- Develop clean-up methods appropriate to unique ecosystem characteristics

CONCLUSIONS: KNOWLEDGE GAPS PERTAINING TO (A) BITUMEN (B) CONVENTIONAL CRUDE OIL (C) CONDENSATE AND (D) CHEMICAL DISPERSANTS

The final section of the working paper comprised a series of knowledge gaps on the biological effects of oil and gas industry-related contaminants on aquatic organisms, based on the review of the primary literature and published reports. The primary author of the working paper provided a brief overview of the list of knowledge gaps, and the participants critiqued the list, and made revisions via an on-screen live editing exercise. Through guided discussions, taking into account the information presented and debated throughout the workshop, the group reached consensus on the following list of research recommendations, listed in order of decreasing priority:

Oil and Gas Research Recommendations

1. *Toxicological studies on oil sands-related products such as natural bitumen, diluted bitumen, synthetic crude oil and bitumen blended with synthetic crude oil.*
    a. Determine appropriate study species for standardised testing
    b. Conduct acute and sublethal toxicity tests, early life stages tests
    c. Compare the toxicity of dilbit, synbit, and syncrude relative to other products; if they are uniquely toxic, determine mechanisms of effect
    d. Establish a reference dilbit product for standardised toxicity testing using a standard suite of chemical analyses and effects endpoints
2. *Assessment of fate and behaviour of diluted bitumen following a spill in aquatic environments*
    a. Identify areas and habitats of greater risk of oil spill, and fate of oil within these systems
    b. Improve modeling capacity
    c. Developing clean-up methods appropriate to unique ecosystem characteristics
    d. Ecotoxicology of conventional and unconventional crude oil products in ice-covered Canadian waters
3. *Assessment of potential consequences of a condensate spill to aquatic organisms*
    a. Validation of existing acute toxicity models and/or development of new models as required
    b. Determine exposure potential - fate and behaviour in the aquatic environment
4. *Improved ecological relevance of oil and gas toxicity studies*
    a. Establish cause and effect in field-based studies
    b. Validate laboratory studies using field-based approaches
    c. Identify susceptible life-history traits and relate to oil fate characteristics
    d. Extend research beyond individual-effects to population, community, ecosystems
    e. Develop the capacity to assess biological effects during and after spill events, especially recovery times
5. *Demonstrate mechanisms of chronic toxicity in support of improved predictive models*

a. Identify characteristic exposure responses
b. Identify unique biomarkers of exposure to bitumen
c. Conduct pharmacokinetic studies
d. Identify unique chemistry profiles of oil products, including geochemical markers
e. Determine the role of oil droplets (residual oil) in estimating toxicity
f. Establish the relative importance of photo-toxicity after an actual oil spill.

6. *Assessment of biological effects of chemically dispersed bitumen*
7. *Potential effects of metals in bitumen to benthic organisms if sinking occurs*

Upon achieving consensus on the list of research recommendations, the workshop chair also indicated that the working document was considered acceptable pending the satisfactory completion of major revisions, as outlined in the two days of discussions. Finally, the workshop chair provided two major recommendations to NCAG:

Major Recommendations to NCAG

1. The National Contaminants Advisory Group was advised to seek out international partnerships in this field of research.
2. The National Contaminants Advisory Group was advised to revisit the oil and gas contaminants research priorities within three years, to reassess the state of knowledge and research needs in this field.

The chair concluded the workshop by thanking the participants for their input.

APPENDIX 1: WORKSHOP PARTICIPANTS

Name	Affiliation
Gilles Olivier (Chair)	DFO
Judith Leblanc	DFO – National Contaminants Advisory Group
Bradley Park	DFO – National Contaminants Advisory Group
Alain Dupuis	DFO – National Contaminants Advisory Group
Cory Dubetz	DFO – National Contaminants Advisory Group
Mike Stoneman	DFO – Ecosystem and Biodiversity Science
Francisco Ucan-Marin	DFO – Ecosystem and Biodiversity Science
Jim Kristmanson	DFO – Canadian Science Advisory Secretariat
Darlene Smith	DFO – Canadian Science Advisory Secretariat
Thomas King	DFO – Centre for Offshore Oil, Gas, and Energy Research
Joanne Parrott	Environment Canada
Valérie Langlois	Royal Military College of Canada / Queen's University
Peter Hodson	Queen's University
Paul Paquet	Raincoast Conservation Foundation
David Pinsent	Husky Energy
Mace Barron	U.S. Environmental Protection Agency
Mark Carls	National Oceanic and Atmospheric Administration – National Marine Fisheries Service

APPENDIX 2: TERMS OF REFERENCE

IDENTIFYING RESEARCH REQUIREMENTS FOR THE BIOLOGICAL EFFECTS OF OIL AND GAS INDUSTRY-RELATED CONTAMINANTS ON AQUATIC ECOSYSTEMS

National Peer Review - National Capital Region

March 26-27, 2014
Ottawa, Ontario

Chairperson: Gilles Olivier

Context

In light of increasing oil and gas resource development in Canada, there is increased potential for aquatic contamination resulting from both routine operations and accidental releases. Given that oil and gas contaminants can have deleterious effects on aquatic biota, and that the industry is currently growing and evolving, it is necessary to determine the gaps in the current knowledge base on the biological effects of these contaminants on aquatic ecosystems. Ultimately, this information will guide future research efforts in support of ecologically sound decision-making.

Aquatic contamination may occur at multiple phases in oil and gas production:

Extraction - While some research has been conducted to assess the potential biological effects of offshore oil platforms (e.g. drilling muds, core cuttings, and produced water), other extraction methods such as oil sands mining and hydraulic fracturing ("fracking") warrant further investigation for biological effects.

Processing and Transportation - Transportation of diluted bitumen is expected to increase in the near future, thus potential biological effects of accidental releases of condensate and diluted bitumen need to be characterized. Research pertaining to the biological effects of tanker crude oil spills on marine ecosystems is a high priority for the Department and the Government of Canada. In addition, there is an increasing need to assess potential impacts of accidental releases from overland transportation (i.e. rail and pipeline) in various environments.

Spill response – Chemical dispersants (e.g. Corexit) may be used in the event of accidental releases, thus it is necessary to understand potential biological effects.

Fisheries and Oceans Canada (DFO) – National Contaminants Advisory Group (NCAG) administers funds to facilitate external research on priority issues pertaining to the biological effects of contaminants on aquatic ecosystems, and provides evidence-based advice to departmental and external clients. It is anticipated that NCAG will devote significant departmental resources to research on biological effects of oil and gas contaminants on aquatic ecosystems during the next 5 years, and therefore requires science expertise to identify knowledge gaps.

Objectives

The objective of the meeting is to identify research requirements relating to the biological effects of oil and gas industry contaminants on aquatic biota relevant to the DFO mandate (invertebrates, fish, marine mammals, and sea turtles, but not birds), based on current and anticipated resource development activities, and on the current state of scientific knowledge.

Participants will critically review the working paper:

"Literature Review on the Aquatic Toxicology of Crude Oil: An Overview of Toxic Components and the Acute and Chronic Toxicity to Aquatic Organisms".

Specifically, participants will collectively validate three main sections from the literature review based on their respective expertise and regional knowledge:

1. Identification of contaminants from oil and gas activities;
2. Biological effects on fish, invertebrates, marine animals, and ecosystem-scale impacts;
3. Knowledge gaps pertaining to bitumen, crude oil, condensate, and chemical dispersants.

The resulting peer review proceedings and research document will guide future research facilitated by NCAG, which will in turn inform sound decision-making relating to ecological impacts.

Expected Publications

- Workshop Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO, Ecosystems and Oceans Science Sector, FPP, CCG, Oceans)
- Environment Canada
- Academia or Academics
- Industry Representatives
- Environmental Consultants
- International Experts

APPENDIX 3: WORKSHOP AGENDA

Day 1: Wednesday March 26, 2014	
8:30 – 9:10	Opening Remarks and Overview of CSAS Process (Policies and Guidelines) *Gilles Olivier – Chair*
9:10 – 9:40	Overview of National Contaminants Advisory Group (NCAG) *Judith Leblanc (DFO) – NCAG Senior Science Advisor (Acting)*
9:40 – 9:50	Departmental Drivers - DFO Commitments and Priorities on Oil and Gas Contaminants (National Perspective) *Mike Stoneman (DFO) – Science Advisor, Ecosystem and Biodiversity Science Branch*
9:50 – 10:10	*Health Break*
10:10 – 10:30	Overview of Literature Review on the Aquatic Toxicology of Crude Oil *Alain Dupuis (DFO) – Primary Author, NCAG Science Advisor*
10:30 – 10:50	Overview - Literature Review Sections 1 and 2: Identification of Aquatic Contaminants from Oil and Gas Activities *Alain Dupuis (DFO) – Primary Author, NCAG Science Advisor*
10:50– 12:00	Guided Discussion and Expert Review – Literature Review Sections 1 and 2: Identification of Contaminants from Oil and Gas Activities *Gilles Olivier – Chair*
12:00 – 1:00	*Lunch – not provided*
1:00 – 1:20	Overview – Literature Review Section 3: Biological Effects of Contaminants from Oil and Gas Activities on (A) Fish (B) Invertebrates (C) Marine Animals*, and (D) Ecosystem-Scale Impacts. (*marine mammals and sea turtles, not birds) *Alain Dupuis (DFO) – Primary Author, NCAG Science Advisor*
1:20 – 3:00	Guided Discussion and Expert Review – Literature Review Section 3: Biological Effects of Contaminants from Oil and Gas Activities on (A) Fish (B) Invertebrates (C) Marine Animals*, and (D) Ecosystem-Scale Impacts. (*marine mammals and sea turtles, not birds) *Gilles Olivier – Chair*
3:00 – 3:20	*Health Break*
3:20 – 4:30	Continued - Guided Discussion and Expert Review – Literature Review Section 3 *Gilles Olivier – Chair*

Day 2: Thursday March 27, 2014	
8:30 – 8:40	Opening Remarks and Review of Day 1 *Gilles Olivier – Chair*
8:40 – 9:00	Overview – Literature Review Section 4: Knowledge Gaps Pertaining to (A) Bitumen (B) Conventional Crude Oil (C) Condensate and (D) Chemical Dispersants *Alain Dupuis (DFO) – Primary Author, NCAG Science Advisor*
9:00 – 9:30	Critique – Literature Review Section 4: Knowledge Gaps Pertaining to (A) Bitumen (B) Conventional Crude Oil (C) Condensate and (D) Chemical Dispersants *Peter Hodson – Research Scientist, Queen's University*
9:30 – 10:00	Guided Discussion and Expert Review – Literature Review Section 4: Knowledge Gaps *Gilles Olivier – Chair*
10:00 - 10:20	*Health Break*
10:20 – 12:00	Continued - Guided Discussion and Expert Review – Literature Review Section 4: Knowledge Gaps *Gilles Olivier – Chair*
12:00 – 1:00	*Lunch – not provided*
1:00 – 3:00	Continued - Guided Discussion and Expert Review – Literature Review Section 4: Knowledge Gaps *Gilles Olivier – Chair*
3:00 – 3:20	*Health Break*
3:20 – 4:30	Continued - Guided Discussion and Expert Review – Literature Review Section 4: Knowledge Gaps *Gilles Olivier – Chair*