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Strategic Plan for Oil Spill Research in Canadian Arctic Waters

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Strategic Plan for Oil Spill Research in Canadian Arctic Waters

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Prepared for:
Environmental Studies Research Fund (ESRF)

Revision 3.1
July, 2013

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Prepared for:

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Prepared by:

C-CORE

C-CORE Report Number:

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Smart Solutions for Challenging Environments

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EXECUTIVE SUMMARY

The Environmental Studies Research Fund (ESRF) finances research to support the decision-making process related to oil and gas exploration and development on Canada's Northern frontier lands. Accordingly, this document comprises a five-year strategic plan designed to guide ESRF in designing and implementing a research program dedicated to the management and mitigation of oil spills in Canadian Arctic waters, with emphasis on the southern Beaufort Sea. To this end, the strategic plan summarizes the state of knowledge in the key technical areas of cleanup and mitigation, detection and monitoring and impact and assessment. It provides a model for evaluating the importance of each research theme, highlights potential linkages with relevant external initiatives and provides a prioritization of research themes within each technical area to guide ESRF funding investments for oil spill research for 2013 to 2017.

The primary means of gathering information on knowledge gaps and research priorities was a workshop held with key stakeholders concerned with Arctic resource development and environmental protection. The participants were selected to ensure a balanced representation from relevant interest groups, including industry, science, government regulators and northern communities. All participants hold senior positions in their respective organizations and are internationally recognized experts in their field or leaders of their communities.

Prior to the workshop, preparatory input was solicited from all participants to gather information on critical information needs and key research questions. Post-workshop analysis involved consolidating all information gathered before and during the workshop, reviewing the highlighted research themes, identifying major relevant research initiatives and formulating evaluation criteria to rank research themes with respect to their importance and impact.

The thematic clusters encompass research themes, which will give rise to one or more dedicated research projects. Within each technical area described in the following sections, the individual research themes are discussed in order of priority. In some cases, the research themes identified might be better characterized as operational issues. However, they are included in this plan as they indicate critical gaps in capabilities or knowledge with respect to effective Arctic oil spill response. The cross-cutting elements apply to all thematic areas and can be incorporated as dedicated work packages within each research project, or they may be implemented as overarching projects with emphasis on coordination and collaboration across the thematic clusters and with relevant external activities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Environmental Studies Research Fund (ESRF) finances research to support the decision-making process related to oil and gas exploration and development on Canada's Northern frontier lands. Accordingly, this document comprises a five-year strategic plan designed to guide ESRF in designing and implementing a research program dedicated to the management and mitigation of oil spills in Canadian Arctic waters, with emphasis on the southern Beaufort Sea (see Figure 1). In light of a globally observed trend towards decreasing sea ice extent and increasing resource exploration activities and vessel traffic, the plan aims to support a sound, science-based approach to the responsible development of natural resources throughout the Canadian Arctic.

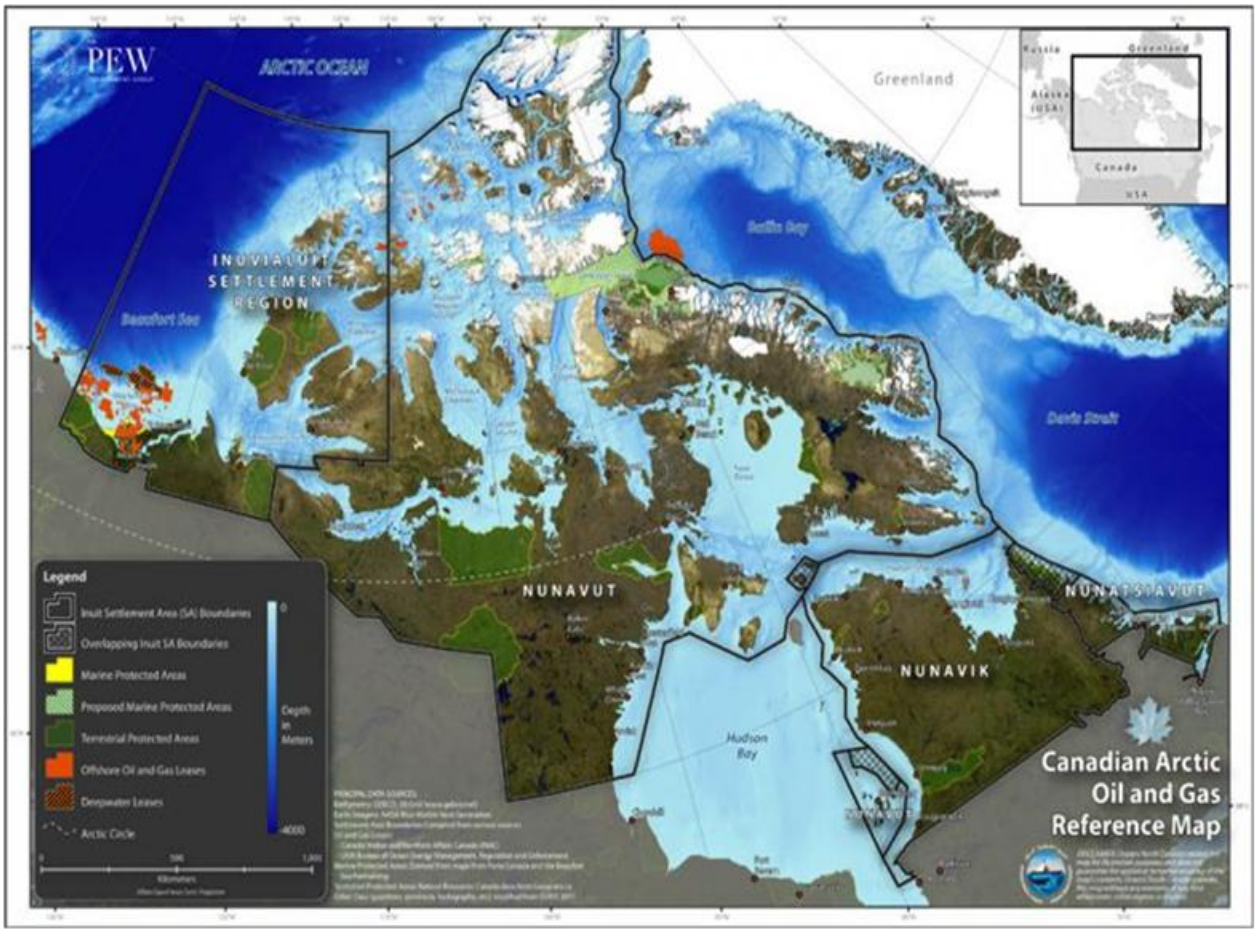

Figure 1. Oil and Gas Leases in the Canadian Arctic[1]

[1]Copyright Oceans North Canada

Resource development in the Arctic faces unique challenges in terms of a harsh, inhospitable environment, remoteness, difficulty of access, presence of sea ice and persistent conditions of low visibility due to weather and the polar night. In addition, the public frequently lacks an informed understanding of current efforts and capabilities related to spill prevention, cleanup and environmental protection. However, the continued and express support from communities and the public at large is a critical element for the sustainable development of northern resources.

In order to overcome Arctic challenges, industry and government are showing a strong interest in collaboration in Canada and internationally, and there exists a significant opportunity to pool limited financial resources and approach research collaboratively. Leveraging against existing initiatives and broadly sharing observations and results is an efficient way to generate complementary research output. The strong public interest in northern development and new communication technologies also offer new possibilities to engage the public and build trust and understanding regarding the exploitation of Arctic oil and gas resources.

1.1 GOALS AND OBJECTIVES

This document provides a framework for Canadian Arctic oil spill research that will enable stakeholders to maximize the protection and recovery from oil spills in the Arctic marine environment; this will in turn build confidence among communities, government organizations and the public at large that industry can operate safely and can be prepared for and respond effectively to oil spills.

To this end, the strategic plan summarizes the state of knowledge in the key technical areas of cleanup and mitigation, detection and monitoring and impact and assessment. It provides a model for evaluating the importance of each research theme, highlights potential linkages with relevant external initiatives and provides a prioritization of research themes within each technical area to guide ESRF funding investments for oil spill research for 2013 to 2017.

2 APPROACH

This section summarizes the approach taken to collect and analyze relevant information to formulate Arctic oil spill research priorities for the next five years.

2.1 MULTI-STAKEHOLDER WORKSHOP

The primary means of gathering information on knowledge gaps and research priorities was a workshop held with key stakeholders implicated in knowledge generation around Arctic resource development and environmental protection. The participants were selected by the research team in consultation with the client to ensure a balanced representation from relevant interest groups, including industry, science, government regulators and northern communities. All participants hold senior positions in their respective organizations and are internationally recognized experts in their field or leaders of their communities. A list of workshop participants is presented in Appendix A.

The workshop comprised a series of presentations on key issues related to Arctic oil spill research, plenary sessions with synoptic discussions attended by all participants, as well as breakout groups for the in-depth treatment of each technical area under consideration. The following major technical areas were discussed:

- Cleanup and mitigation:
  - In-situ burning;
  - Dispersants;
  - Mechanical recovery; and
  - Shorelines.
- Modelling, Detection and monitoring:
  - Trajectory and fate modelling; and
  - Remote sensing.
- Impact and assessment:
  - Environmental sensitivity and risk;
  - Social and economic sensitivity; and
  - Impact of mitigation measures.

Prior to the workshop, preparatory input was solicited from all participants to gather information on critical information needs and key research questions. Post-workshop analysis involved consolidating all information gathered before and during the workshop, reviewing the highlighted research themes, identifying major relevant research initiatives and formulating evaluation criteria to rank research themes with respect to their respective importance and impact.

2.2 RESEARCH PRIORITIZATION AND RANKING

The criteria presented in Table 1 were used to prioritize the research themes identified during the workshop. To this end, participants were asked to assign a score from one to three to each research theme, with three indicating the highest rank. The priority within each technical area was subsequently established by computing an average score from all responses and ranking the themes accordingly.

Table 1. Ranking Criteria

Criterion	Description	Score
Ability to Respond Effectively to Major Arctic Spills	The research is expected to result in incremental benefit with respect to improved spill response in Arctic waters	1
	The research is expected to improve key elements of effective response in Arctic marine environments	2
	The research is expected to result in a major step change with respect to the ability to respond effectively to oil spills in Arctic waters	3
Improvement of the Regulatory Framework	The research does not immediately link to an improved regulatory framework	1
	The research is expected to improve key elements of the existing regulatory framework	2
	The research will contribute significantly to an optimized, transparent and efficient regulatory framework	3
Understanding the Impacts on the Arctic Marine Environment	The research will result in a better understanding of some elements of oil spill impacts on the Arctic marine environment	1
	The research is expected to increase the understanding of key components of the impact of oil spills on the Arctic marine environment	2
	The research will contribute significantly to an understanding of the vulnerability and recovery of Arctic marine environments with respect to oil spills	3
Risk and Likelihood of Success	The research involves significant risk, which may affect the likelihood of success	1
	The potential risks associated with the research are well understood and likely to be addressed effectively	2
	The risks associated with the research are considered minor and are easily mitigated	3

2.3 RELEVANT EXTERNAL INITIATIVES

The widespread interest in Arctic resource development has led to a significant research and development effort by industry as well as Canadian and international government agencies. Table 2 presents major research programs of relevance to future oil spill research in the Canadian Arctic. Moving forward with mobilizing new research activities, it will be important to consider collaborating with ongoing and planned initiatives to avoid duplication, to encourage the leveraging of limited financial resources and to foster the generation of complementary research outcomes.

Table 2. Major Relevant Research Initiatives

Initiative	Link
Beaufort Regional Environmental Assessment (BREA)	http://www.beaufortrea.ca/
Bureau of Safety and Environmental Enforcement (BSEE) Oil Spill Response Research Program	http://www.bsee.gov/Research-and-Training/Oil-Spill-Response-Research-(OSRR).aspx
Bureau of Ocean Energy Management (BOEM) Alaska Environmental Studies	http://www.boem.gov/akstudies/
International Oil and Gas Producers Association (OGP)- International Petroleum Industry Environmental Conservation Association (IPIECA) Oil Spill Response (OSR) Joint Industry Project (JIP)	http://oilspillresponseproject.org/about-us
American Petroleum Institute (API) Oil Spill Prevention and Response (OSPR) Joint Industry Task Force (JITF)	http://www.oilspillinfo.org/jitf-overview.html
Program of Energy Research and Development (PERD)	http://www.nrcan.gc.ca/energy/science/programs-funding/1603
ArcticNet	http://www.arcticnet.ulaval.ca/
Marine Environmental Observation Prediction and Response Network (MEOPAR)	http://meopar.ca/
OGP Arctic OSR Technology JIP	http://www.arcticresponsetechnology.org/research-projects
Arctic Council Emergency Prevention, Preparedness and Response (EPPR) Working Group	http://www.arctic-council.org/eppr/

3 RESEARCH THEMES

This section describes the research themes identified during the multi-stakeholder workshop in each of the technical areas of in-situ burning, dispersants, mechanical recovery, shorelines, modelling, detection and monitoring, as well as impact and assessment. In some cases, the themes identified address operational rather than research issues. However, they point to critical gaps with respect to effective Arctic OSR and are consequently included in this discussion. For each technical area, the current state of capabilities is briefly summarized, together with research required to close knowledge gaps. An overview of potentially relevant external initiatives is provided for each research theme. In addition, a number of common issues applicable across all technical areas are presented.

3.1 CROSS-CUTTING ELEMENTS

In the following, the cross-cutting elements applicable to all research themes are described. These elements are also pertinent to many of the ongoing external programs presented in Section 2.3, and collaboration with these activities should be considered where appropriate.

3.1.1 Net Environmental Benefit Analysis (NEBA)

A NEBA framework is required for the Beaufort Sea to enable an operational, effective spill response decision-making process for the Beaufort Sea and minimize environmental and socio-economic impact of a spill. The framework will be based on rigorous science to support informed decisions by regulators, promote acceptance by communities and facilitate the pre-approval of permits. It will comprise an assessment of impacts on all available treatment options (e.g., dispersants, burn residues) with respect to the impact on Beaufort Sea species, consider the option of natural recovery and place lessons learned from the Deepwater Horizon Spill in a Beaufort context.

3.1.2 Field Trials

Much of the current state of knowledge of the interactions of oil with Arctic environments is based on past research that involved controlled spills to study the fate and impact of oil as well as the efficacy of counter measures. **There is broad agreement among scientists from industry and government that the critical gaps in the current knowledge base cannot be filled without significant field trials, as large-scale operational guidelines and best practices cannot be developed from studies conducted in laboratories and test facilities.** Obtaining permits from regulatory authorities to conduct large-scale controlled spills remains the principal challenge. A successful field trial will require a collaborative, multi-stakeholder and multi-disciplinary effort.

3.1.3 Effective Communications with Stakeholders

In order to build public trust, acceptance and support for oil and gas development in the Arctic, a comprehensive strategy is required to communicate current response capabilities, preventive measures and ongoing research efforts to a wide range of stakeholders (i.e., local, territorial and federal governments, regulatory agencies, northern communities and associations, and the public at large). Tailored approaches will be required to reach different target audiences (e.g., peer-reviewed publications, public seminars, workshops, video, web casts, etc.).

3.1.4 Involvement of Northern Communities and Traditional Knowledge

The successful development of oil and gas resources in the Canadian Arctic will require acceptance, support and buy-in from Arctic communities and associations. Traditional knowledge constitutes a valued element for several of the disciplinary research themes, and community-based environmental monitoring efforts currently underway can potentially provide critical in-situ observations. A number of countermeasures rely heavily on local solutions, to which end the active participation of local populations is required.

3.1.5 Understand the Regulatory Environment, Processes and Requirements

There is uncertainty in the regulatory process and responsibilities (e.g., Federal and territorial mandates) to get approval for the application of oil spill countermeasures during response actions and field tests. A clear understanding is required in terms of Federal/Territorial regulatory mandates, permitting processes and regulatory requirements.

3.2 In-Situ Burning

In-situ burning is fully operational with a long history of application to marine spills outside the Arctic. It should be considered a response option for Arctic spills. With respect to future developments, it is expected that improvements will be largely incremental, focusing on elements such as herders, booms, improved ignition, etc. Other ongoing work includes the inclusion of in-situ burning in NEBA.

3.2.1 Physical and Chemical Properties of Oil

In the Beaufort Sea, a wide range of oil types have been discovered to date. An understanding of the fundamental physical and chemical properties of these oil categories is required with respect to their interaction with environmental factors and impacts on the environment. Although initially discussed within the context of in-situ burning, the understanding of oil properties applies to all spill response options as well as to the modelling of oil spill fate and behaviour. It should therefore be evaluated at the earliest possible point in time. Potential links exist between this theme and the following initiatives:

- BOEM Alaska Environmental Studies Program: Physical and Chemical Analyses of Crude and Refined Oils - Laboratory and Mesoscale Oil Weathering;
- PERD: Environmental Persistence of Petroleum Hydrocarbons in Arctic Waters;
- Environment Canada’s Oil Properties Database; and
- Ongoing collaboration between Environment Canada and National Oceanic and Atmospheric Administration (NOAA).

3.2.2 Develop Toxicity Testing for Herders

Chemical herding agents are used to thicken oil slicks in preparation for in-situ burning. As current studies regarding herder toxicity are not comprehensive, it is proposed to investigate the toxicity of herders on key indicator species in the Beaufort Sea. With respect to the Canadian context, this research will address regulatory requirements and facilitate regulatory approval. Initial work will involve laboratory testing to be followed by large-scale field testing and demonstration. Possible linkages exist with the following initiatives:

- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

3.2.3 Field Operations Manual for Arctic In-Situ Burning

Although an increasing number of guidelines and other related documents have emerged in recent years, there is a continuing requirement for operational manuals to assist in the planning and execution of successful burns, as well as support training activities. In this context, linkages with the following programs and initiatives should be considered:

- API OSPR JITF 3.5: In-Situ Burning;
- ESRF: Strategic Plan for Beaufort Spill Prevention and Management;
- OGP-IPIECA OSR JIP 5: In-Situ Burning;
- OGP Arctic Response Technology JIP: In-Situ Burning Working Group;
- Alaska Clean Seas spill response manual;
- EPPR field guide for oils spill response in Arctic waters; and
- Decision-making guideline by Alaska Department of Environment and Conservation, United States (US) Environmental Protection Agency and US Coast Guard.

3.2.4 Examine Capabilities of Herders as a Function of Oil Type

Given the wide range of oil types present in the Beaufort Sea, the capabilities and effectiveness of Arctic-specific herders should be examined to identify the parameters of their efficacy with different types of oil. This will require field trials with significant spill sizes. Potential links with the following activities should be explored:

- OGP-IPIECA OSR JIP 5: In-Situ Burning;
- API OSPR JITF 3.5: In-Situ Burning; and
- OGP Arctic Response Technology JIP: In-Situ Burning Working Group.

3.3 DISPERSANTS

Dispersants have been widely applied as a spill treatment agent, a solid body of knowledge exists regarding their application in non-Arctic environments, and they should be considered as a treatment option for major Arctic spills. However, the knowledge of their application under Arctic conditions remains limited, especially with respect to large-scale injection at the source of a spill. Therefore, a more complete understanding of large-scale injection in Arctic environments is required, including surface spills and spill sources at depth. In addition, the mechanism for gaining approvals must be clarified.

3.3.1 Develop Capacity for Direct Source Injection for Subsea and Surface Spills

It is required to evaluate the potential for direct source injection to provide a step change in industry's ability to respond effectively to Tier 3 spills under Arctic conditions, both at the surface and at depth. In the case of a deep sea blowout, the capacity for direct injection at the source should be considered in conjunction with a pre-installed blowout preventer and capping stack to stop the discharge in the shortest possible time. This is of particular relevance in the Arctic, where logistical challenges and environmental factors restrict windows of opportunities for effective response. This effort would also identify regulatory requirements to be satisfied in order to make direct source injection a primary response technique. Linkages with the following activities should be evaluated:

- BREA: Deep Water Seabed Geohazards;
- ESRF: Strategic Plan for Beaufort Spill Prevention and Management;
- OGP-IPIECA OSR JIP 1: Inform Decision Makers on the Value of Dispersants - Subsea Dispersant Injection (SSDI) Manual;
- API OSPR JITF 3.2: Dispersants; and
- OGP Arctic Response Technology JIP Dispersants Working Group.

3.3.2 Effective Application of Dispersants in Arctic Conditions

Dispersants are an effective means of responding to marine spills. The efficacy of dispersants in non-Arctic waters is well understood and it is generally accepted that dispersants work in cold waters. Challenges specific to Arctic environments include the effective application of dispersants in the presence of sea ice and the artificial generation of wave energy for optimized dispersion. Oil-mineral aggregates (OMAs) are naturally produced in marine environments rich in suspended sediment and may be attractive for offshore applications. Of particular interest could be the application of readily available material, such as drilling mud constituents carried by supply vessels. Meso-scale tank testing should be followed by field trials to evaluate the efficacy of OMA formation under different ice conditions. The examination of effective dispersant application requires field testing. Impacts of Dispersant and OMA application should be captured by a comprehensive NEBA. Potential links exist with the following initiatives:

- BOEM Alaska Environmental Studies Program: Applications for Mapping Spilled Oil in Arctic Waters (AK-12-03b);
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in OSR;
- PERD: Oil Spill Impacts Assessment and Oil Spill Remediation Technologies (Dispersants, Oil-Mineral Aggregates);

- OGP-IPIECA OSR JIP 4: Dispersant Effectiveness and Monitoring;
- API OSPR JITF 3.2: Dispersants;
- OGP Arctic Response Technology JIP: Dispersants Working Group;
- BSEE: Operational Chemical Dispersant Research at Ohmsett;
- BSEE: Laboratory-Scale Investigation of a Method for Enhancing the Effectiveness of Oil Dispersants in Destabilizing Water-in-Oil Emulsions; and
- BSEE: Assessment of Dispersant Effectiveness using Ultrasound to Measure Oil Droplet Size Distributions.

3.4 Mechanical Recovery

Mechanical recovery is routinely used in open water, but its application in the presence of sea ice is currently extremely limited due to the interference of ice with recovery equipment. It is therefore not considered a viable response option to treat major spills in the Arctic. This contrasts with a common public perception that considers mechanical recovery as a total solution and generally the preferred response option. It is therefore necessary to build a better understanding of the limitations inherent in mechanical recovery among the public and the advantages of other techniques. In order for mechanical recovery to become a viable response option in the Arctic, large-capacity equipment capable of separating oil, water and ice would be required. A second issue regarding recovery in the Arctic is the limited capability for the storage and disposal of recovered oil and residue.

3.4.1 Examine Solutions for Mechanical Recovery in the Presence of Sea Ice

Current mechanical recovery equipment works well in open water but its application in ice is currently limited to small spills in trace ice conditions. Therefore, a requirement exists for large-scale equipment capable of separating ice, oil and water. To this end, the adaptation of existing technology used in other contexts, such as ice deflection barges or dredging equipment, should be considered. For smaller spills, novel concepts for containment devices should be pursued (e.g., air-deployed auto-unfold equipment, boom with open apex and ice screen). The following external activities may be relevant in this context:

- Shell: Feasibility studies for novel recovery concepts;
- BSEE: Looking at recovery at low light;
- API OSPR JITF 3.6: Mechanical Recovery; and
- OGP Arctic Response Technology JIP: Mechanical Recovery Working Group.

3.4.2 Storage and Disposal of Recovered Oil

There is currently no comprehensive infrastructure in place to store and dispose of recovered oil and residue in the Arctic. Accordingly, the capacity for temporary storage and ultimate disposal needs to be developed. Given the logistical limitations prevalent throughout the Arctic, effective approaches will need to be based on local solutions. In addition to technical issues, this will require an understanding of regulatory requirements and acceptance by local communities. Current external activities of possible relevance include the following:

- Shell: Feasibility studies for novel recovery concepts; and
- OGP Arctic Response Technology JIP: Mechanical Recovery Working Group.

3.5 SHORELINES

Although best practices for shoreline cleanup have been established (i.e., application of the Shoreline Cleanup and Assessment Technique (SCAT), development of treatment endpoints, constraints, proper selection of tactics and expedited generation of clear treatment plans etc.), the logical process is frequently not followed or key issues are not addressed early enough. Therefore, principles and guidelines on best practices need to better documented and communicated to all relevant stakeholders. A significant body of knowledge has resulted from the worldwide application of shoreline cleanups. However, the Arctic context imposes limitations regarding logistics, weather, safety and waste. Existing techniques may need adaptation for the Arctic environment, with special emphasis on in-situ solutions. Due to the challenges inherent in Arctic response, natural removal must be considered as a serious option for shoreline treatment. To this end, natural removal and degradation processes must be properly understood.

3.5.1 Improved Cleanup and Mitigation Tactics for Arctic Shorelines

The decision-making for shoreline cleanup is based on substrate composition, geomorphological processes and biological parameters, and the efficacy of shoreline cleanup has been demonstrated at several non-Arctic major spills. In the Arctic, however, persistent logistical challenges and unique shoreline environments (i.e., tundra cliffs, peat shorelines and inundated low-lying tundra) will affect the approach to cleanup and mitigation. It is therefore required to adapt existing best practices for shoreline cleanup and restoration to Arctic conditions. Emphasis should be placed on the use of in-situ methods and understanding the natural recovery processes. Potential linkages may exist with the following ongoing activities:

- OGP-IPIECA OSR JIP 12: Good Practice Guide;
- API OSPR JITF 3.3: Shoreline Protection; and
- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

3.5.2 Pre-Spill Characterization of Arctic Shorelines

In order to facilitate effective response to oiled shorelines in the Arctic using the SCAT approach, a comprehensive pre-spill characterization of Arctic shorelines should be carried out. This will allow the appropriate assessment of sensitivity and vulnerability of different shorelines. The pre-spill characterization will be essential in defining cleanup endpoints. Links with the following activities should be explored in this context:

- BREA: Beaufort Sea Environmental Database;
- Environment Canada: Work on emergency spatial pre-SCAT for Arctic coastal ecosystems (eSPAC); and
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping.

3.5.3 Detect Buried Oil on Arctic Shorelines

Depending on shoreline type, substrate and prevalent coastal processes, oil may penetrate the shoreline substrate and/or may be covered by oil-free sediment deposited onto the oiled substrate. In this case, oil present in the substrate is difficult to detect, posing an ongoing hazard. To this end, it is required to build a capacity to detect buried oil with considerable accuracy and reliability. Significant potential in this context may be offered by the use of trained dogs. Links with the following activity should be explored:

- API OSPR JITF 3.3: Shoreline Protection (3.3.2 Assess Shoreline Protection Technologies).

3.6 MODELLING

The current ability to model oil fate under Arctic conditions is inadequate as currently operational oil fate and trajectory models have not been designed for ice-affected waters, and present ocean-ice models have not been implemented with sufficient resolution to capture sea ice characteristics and dynamics suitable for oil spill trajectory modeling. In addition, the characterization of oil-in-ice weathering processes in current models relies on simplified assumptions based on limited laboratory work from the 1980s and 1990s and has not been supported by more recent work and understanding of the behavior of oil in ice. Future research should deliver quantitative results from laboratory and full-scale field experiments under different ice conditions to better understand oil spreading, emulsification, entrainment and oil-ice interactions. An integrated system is required to determine fate, trajectory and impact and help guide response efforts.

3.6.1 Model Improvement

In order to improve current oil spill fate, behaviour and trajectory models, the accuracy of the coupled systems currently in use at Department of Fisheries and Oceans (DFO) and Environment Canada should be determined and opportunities for improvement should be assessed. Oil-ice interaction models should be evaluated with a view to developing an oil spill model for the marginal ice zone. Algorithms for oil transport and fate in marginal and ice covered zones should be improved. Physical and chemical properties of Arctic oil should continue to be incorporated into models to improve the understanding of oil behavior in ice. The ability to estimate uncertainty should be incorporated into all models. The following current activities may be of relevance to this theme:

- BREA: RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea;
- BREA: Understanding Extreme Ice Features in the Beaufort Sea;
- BREA: Forecasting Extreme Weather and Ocean Conditions in the Beaufort Sea;
- BREA: Seasonal Forecasting of Ocean and Ice Conditions in the Beaufort Sea;
- BREA: Southern and Northeastern Beaufort Sea Marine Observatories;
- Marine Environmental Observation Prediction and Response Network (MEOPAR);
- ESRF: Improving the accuracy of short-term ice and ocean forecasts in the Beaufort Sea;
- OGP-IPIECA OSR JIP 10: Oil Spill Trajectory and Subsea Plume Modelling; and
- OGP Arctic Response Technology JIP: Modelling Working Group.

3.6.2 Assimilation System to Use Satellite Data for Ice Tracking

Given that oil is likely to move with ice at high concentrations of sea ice, it is required to predict the movement of the sea ice cover. The first step would be to determine the required input information under different scenarios as well as the tracking accuracy. Therefore, models are needed for both remote sensing and on-going observations. This work would build on existing systems and capabilities. Special attention will need to be devoted to obtain suitable ice thickness measurements. The estimated duration of such an activity would be three to five years. Potential linkages exist with the following ongoing activities:

- BREA: RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea;
- BREA: Understanding Extreme Ice Features in the Beaufort Sea;
- BREA: Forecasting Extreme Weather and Ocean Conditions in the Beaufort Sea;
- BREA: Seasonal Forecasting of Ocean and Ice Conditions in the Beaufort Sea;
- BREA: Southern and Northeastern Beaufort Sea Marine Observatories;
- MEOPAR;
- ESRF: Improving the accuracy of short-term ice and ocean forecasts in the Beaufort Sea; and
- OGP Arctic Response Technology JIP: Modelling Working Group.

3.6.3 Fate and Behaviour of Oil in Different Ice Conditions

In order to apply in-situ burning effectively, it is important to understand when conditions for successful burning exist in a wide range of ice conditions. Of particular interest is the understanding of when and how brine channels form in multi-year ice, as well as when and where oil trapped in ice will resurface. Also relevant in this context is the study of sea ice roughness and adhesion of oil to pockets on the lower surface of the ice. Potential links with the following initiatives should be considered:

- BOEM Alaska Environmental Studies Program: Enhanced Interpretation of Arctic Ice Formation, Distribution, and Density (proposed);

- BREA: Measuring the Thickness and Strength Deformed Multi-Year Ice in the Beaufort Sea;
- BREA: RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea;
- BREA: Understanding Extreme Ice Features in the Beaufort Sea; and
- OGP Arctic Response Technology JIP: Modelling Working Group.

3.6.4 Evaluate and Establish the Performance of Existing Models for Oil Spill Drift in the Presence of Ice

Current models predicting oil drift largely consider ice-free water only. For Arctic applications, however, it is required to estimate the drift of oil in the presence of sea ice. This work would build on existing ice forecasting concepts, models and research capacity. Although it would not be possible to evaluate all scenarios, the expected output includes a baseline evaluation of existing system performance as well as a methodology to assess incremental improvements with respect to other relevant projects. The duration of the activity would be two to three years. The following activities may be relevant for this theme:

- BOEM Alaska Environmental Studies Program: Enhanced Interpretation of Arctic Ice Formation, Distribution, and Density (proposed);
- BREA: Forecasting Extreme Weather and Ocean Conditions in the Beaufort Sea;
- BREA: Seasonal Forecasting of Ocean and Ice Conditions in the Beaufort Sea;
- BREA: Southern and Northeastern Beaufort Sea Marine Observatories;
- MEOPAR;
- ESRF: Improving the accuracy of short-term ice and ocean forecasts in the Beaufort Sea;
- OGP-IPIECA OSR JIP 10: Oil Spill Trajectory and Subsea Plume Modelling; and
- OGP Arctic Response Technology JIP: Modelling Working Group.

3.6.5 Develop Long-Term (3-4 month) Drift Scenarios and Likely Fate of Oil and Ice

Developing long-term drift scenarios would build on past and ongoing work, including ecological investigations related to impact and assessment, risk assessment and traditional knowledge. Natural variability would also have to be considered (e.g., as a result of climate change). The expected duration would be two to three years. Links with the following activities should be explored:

- BOEM Alaska Environmental Studies Program: Application of High Frequency Radar to Potential Hydrocarbon Development Areas in the Northeast Chukchi Sea (AK-09-06);
- BOEM Alaska Environmental Studies Program: Characterization of the Circulation on the Continental Shelf Areas of the Northeast Chukchi and Western Beaufort Seas (AK-12-03a);
- BREA: RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea;
- BREA: Understanding Extreme Ice Features in the Beaufort Sea;
- BREA: Forecasting Extreme Weather and Ocean Conditions in the Beaufort Sea;

- BREA: Seasonal Forecasting of Ocean and Ice Conditions in the Beaufort Sea;
- BREA: Southern and Northeastern Beaufort Sea Marine Observatories;
- MEOPAR;
- ESRF: Improving the accuracy of short-term ice and ocean forecasts in the Beaufort Sea;
- OGP-IPIECA OSR JIP 10: Oil Spill Trajectory and Subsea Plume Modelling; and
- OGP Arctic Response Technology JIP: Modelling Working Group.

3.6.6 Fate and Impact of Plumes Resulting from In-Situ Burning

In-situ burning has been demonstrated as an effective means of responding to oil spills. However, it is recognized that burning results in a transfer of harmful substances to the atmosphere. A better understanding is therefore required of the fate of atmospheric plumes resulting from in-situ burning and possible impacts on the environment and communities in the north. Previous investigations have yielded a significant amount of knowledge concerning the behaviour and impact of smoke plumes in areas outside the Arctic. Potential impacts resulting from smoke should be captured in a comprehensive NEBA. The following activities may be relevant:

- AIRMAP air transport model: http://www.asascience.com/software/airmap/index.shtml;
- OGP-IPIECA OSR JIP 5: In-Situ Burning; and
- API OSPR JITF 3.5: In-Situ Burning.

3.7 Detection and Monitoring

The ability to detect and monitor oil is of critical importance when responding to major oil spills. However, the current capacity to provide reliable detection and monitoring is poor in most ice scenarios. There are not enough satellites to get sufficient Near Real Time (NRT) data, and communications bandwidth limitations persist in the Arctic. A capacity for reliable detection and monitoring over wide areas in low visibility and different ice conditions is required, and better assimilation of satellite imagery into models is desired. This must be paired with the ability to transfer oil and ice surveillance data as well as processed map information effectively between command centers and field personnel. Opportunities for detecting oil under ice using autonomous underwater vehicles (AUVs) should be explored.

3.7.1 Improve Methods to Detect Oil in the Presence of Ice Using a Variety of Remote Sensing and Other Data

The successful detection of oil in a variety of ice conditions and the prevalence of false alarms present the major issues of oil spill surveillance in the Arctic. Accordingly, this project would lead to a better understanding of different sensors and their capabilities in different scenarios. This is a longer-term activity that would draw on new sensors and capabilities as they are developed or indicated by other work. The project would build on existing results and some new data at low or no cost, specialized sensor hardware development expertise resident in

Canada, expertise in developing applications in Canada, and a growing number of new satellite systems, including the potential for higher resolution hyperspectral sensors. Challenges include the collection of suitable training and validation data in the field (i.e., without controlled spills), data turnaround suitable to meet operational needs, existing sensor characteristics, and logistics. Expected outputs include improved accuracy and reliability for detecting oil on, in, among and under ice, as well as the processing and information delivery in near real-time. Potential linkages exist with the following activities; although special emphasis should be placed on related work carried out under the OGP Arctic Response Technology JIP:

- OGP Arctic Response Technology JIP: Oil Spill Detection and Monitoring in Low Visibility and Ice;
- OGP-IPIECA OSR JIP 8: Surveillance of Oil Spills; and
- API OSPR JITF 3.4: Oil sensing and Tracking.

3.8 Impact and Assessment

To date, knowledge of the fate and effects of oil spills on Arctic organisms is limited. Discrepancies exist between laboratory research and ecosystem-based approaches. Emphasis has been placed on acute effects, but there is movement towards a focus on chronic effects. The understanding of oil spill impacts on ecosystem services is limited, and there is limited science available to support a comprehensive NEBA. The natural variability is not well understood, and an accurate biological baseline is required to evaluate the potential for natural recovery and biodegradation.

3.8.1 Revisit Baffin Island Oil Spill (BIOS) Field Experiment

The BIOS transects should be re-sampled. Building on the substantial amount background data collected during BIOS, there is an opportunity to use the BIOS data, and learn what has happened since the experiments completed in the 1980s and the most recent revisit in 2000. This activity would be applicable to the Beaufort Sea due to biological and environmental similarities with Baffin Island. Concerns to be addressed include dispersion projections and control plot contamination, as well as relevance of the dispersants used in the experiment compared to today. The cost for this effort is estimated at $500K and the duration would be one year.

3.8.2 Habitat Mapping and Sensitivity Analysis Off-shore

Carrying out offshore habitat mapping and sensitivity analysis would complement work on in-shore environments as well as shorelines currently carried out under ESRF, BREA and ArcticNet. The expected cost would be moderate and the duration would be two to three years. The following external activities may be relevant:

- BOEM Alaska Environmental Studies Program: Applications for Mapping Spilled Oil in Arctic Waters (AK-12-03b);
- BREA: Active Acoustic Mapping of Fish in the Beaufort Sea;
- BREA: Coastal and Marine Bird Usage of the Beaufort Sea Region;
- BREA: Database and Atlas of the Birds of the Canadian Beaufort Sea;
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in Oil Spill Response;
- BREA: Impacts of Development in the Beaufort Sea on Fish, their Habitats and Ecosystems; and
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping.

3.8.3 Identify Endpoints for Habitat Recovery

In order to balance effort and resources with effectiveness of cleanup and mitigation, it is required to identify end points of cleanup and response efforts. This is applicable both to offshore and onshore environments. Accordingly, this project would develop a framework for setting endpoint in the Arctic context. The expected duration is two to three years; potential links exist with the following external activities:

- BREA: Active Acoustic Mapping of Fish in the Beaufort Sea;
- BREA: Coastal and Marine Bird Usage of the Beaufort Sea Region;
- BREA: Database and Atlas of the Birds of the Canadian Beaufort Sea;
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in Oil Spill Response;
- BREA: Impacts of Development in the Beaufort Sea on Fish, their Habitats and Ecosystems;
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping; and
- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

3.8.4 Understand the Long-Term Natural Variability

Understanding the natural variability, including trend modifications due to climate change, constitutes critical baseline knowledge against which potential impacts can be evaluated. This research needs to cover both near-shore and offshore environments, and the duration will be more than five years. It will be complementary to the work being carried out by ArcticNet and Canadian Water Network and will include traditional knowledge. The expected project duration will exceed five years, and high costs are anticipated. Potential linkages with the following activities should be considered:

- BOEM Alaska Environmental Studies Program: Population Assessment of Snow Crab, Chionoecetes opilio, in the Chukchi and Beaufort Seas Including Oil and Gas Lease Areas (AK-08-12-09);
- BREA: Active Acoustic Mapping of Fish in the Beaufort Sea;

- BREA: Coastal and Marine Bird Usage of the Beaufort Sea Region;
- BREA: Database and Atlas of the Birds of the Canadian Beaufort Sea;
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in Oil Spill Response;
- BREA: Impacts of Development in the Beaufort Sea on Fish, their Habitats and Ecosystems;
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping; and
- ArcticNet.

3.8.5 Effects of Oil Spills and Counter-Measures on Ecosystem Services and Valued Ecosystem Components (VECs)

To date, there is no complete picture of the impacts of oil and countermeasures on ecosystem services and valued ecosystem components. Initial work will involve the execution of a comprehensive literature survey followed by subsequent analyses requiring field trials. The issue of spill treatment agent toxicity will be evaluated. The duration is two to three years. Links with the following activities should be evaluated:

- BREA: Active Acoustic Mapping of Fish in the Beaufort Sea;
- BREA: Coastal and Marine Bird Usage of the Beaufort Sea Region;
- BREA: Database and Atlas of the Birds of the Canadian Beaufort Sea;
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in Oil Spill Response;
- BREA: Impacts of Development in the Beaufort Sea on Fish, their Habitats and Ecosystems;
- PERD: Oil Spill Impacts Assessment and Remediation Technologies (Dispersants, MAs);
- PERD: Environmental Persistence of Petroleum Hydrocarbons in Arctic Waters;
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping;
- API OSPR JITF 3.2: Dispersants;
- API OSPR JITF 3.5: In-Situ Burning; and
- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

3.8.6 Biodegradation and Environmental Persistence of Residual Oil

A better understanding is required of biodegradation and the persistence of oil in Arctic marine environments. This work would build on previous (e.g. BIOS experiment) and ongoing efforts and would require simulations in a laboratory environment as well as field trials. The duration would likely exceed three years and the expected cost is moderate. The following external activities may be relevant in this context:

- PERD: Environmental Persistence of Petroleum Hydrocarbons in Arctic Waters;
- API OSPR JITF 3.2: Dispersants; and

- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

3.8.7 Integrative Risk Assessment Model, including a Region-Specific Environmental Data Server

This project includes requirements analysis, design and implementation based on Environment Canada's Environmental Emergencies Management System (E2MS). It would include a NEBA management interface and a link to NOAA's Environmental Response Management Application (ERMA). The projected duration is five years and linkages with the following initiatives should be considered:

- SIMAP model by ASA: http://www.asascience.com/software/simap/index.shtml;
- Arctic ERMA: http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-response-management-application-erma/arctic-erma.html;
- E2MS: http://geoconnections.nrcan.gc.ca/45;
- BREA: Beaufort Sea Environmental Database;
- BREA: Forecasting Extreme Weather and Ocean Conditions in the Beaufort Sea;
- BREA: Seasonal Forecasting of Ocean and Ice Conditions in the Beaufort Sea;
- BREA: Southern and Northeastern Beaufort Sea Marine Observatories;
- ESRF: Arctic Coastal Ecosystems – Beaufort Sea/Mackenzie Delta Mapping;
- ArcticNet; and
- OGP-IPIECA OSR JIP 6: Upstream Risk Assessment and Response Resource Planning.

3.8.8 Secondary Effects of Countermeasures

Secondary effects of countermeasures will take into account the ecological relevance, such as exposure time and dosage in open water. This work would be integrated with field trials and the duration is two to three years. Potential linkages may exist with the following activities:

- BREA: Active Acoustic Mapping of Fish in the Beaufort Sea;
- BREA: Coastal and Marine Bird Usage of the Beaufort Sea Region;
- BREA: Database and Atlas of the Birds of the Canadian Beaufort Sea;
- BREA: Biological Data to Assess the Net Environmental Benefits and Costs of Dispersants and In-Situ Burning in Oil Spill Response;
- BREA: Impacts of Development in the Beaufort Sea on Fish, their Habitats and Ecosystems;
- PERD: Oil Spill Impacts Assessment and Remediation Technologies (Dispersants, MAs);
- PERD: Environmental Persistence of Petroleum Hydrocarbons in Arctic Waters;
- API OSPR JITF 3.2: Dispersants;
- API OSPR JITF 3.5: In-Situ Burning; and
- OGP Arctic Response Technology JIP: Environment/Effects Working Group.

4 RECOMMENDED RESEARCH PROGRAM 2013-2017

Based on the research themes and common issues described in Section 3, it is recommended that a five-year research program comprise both vertical thematic clusters as well as horizontal cross-cutting elements as illustrated in Figure 2.

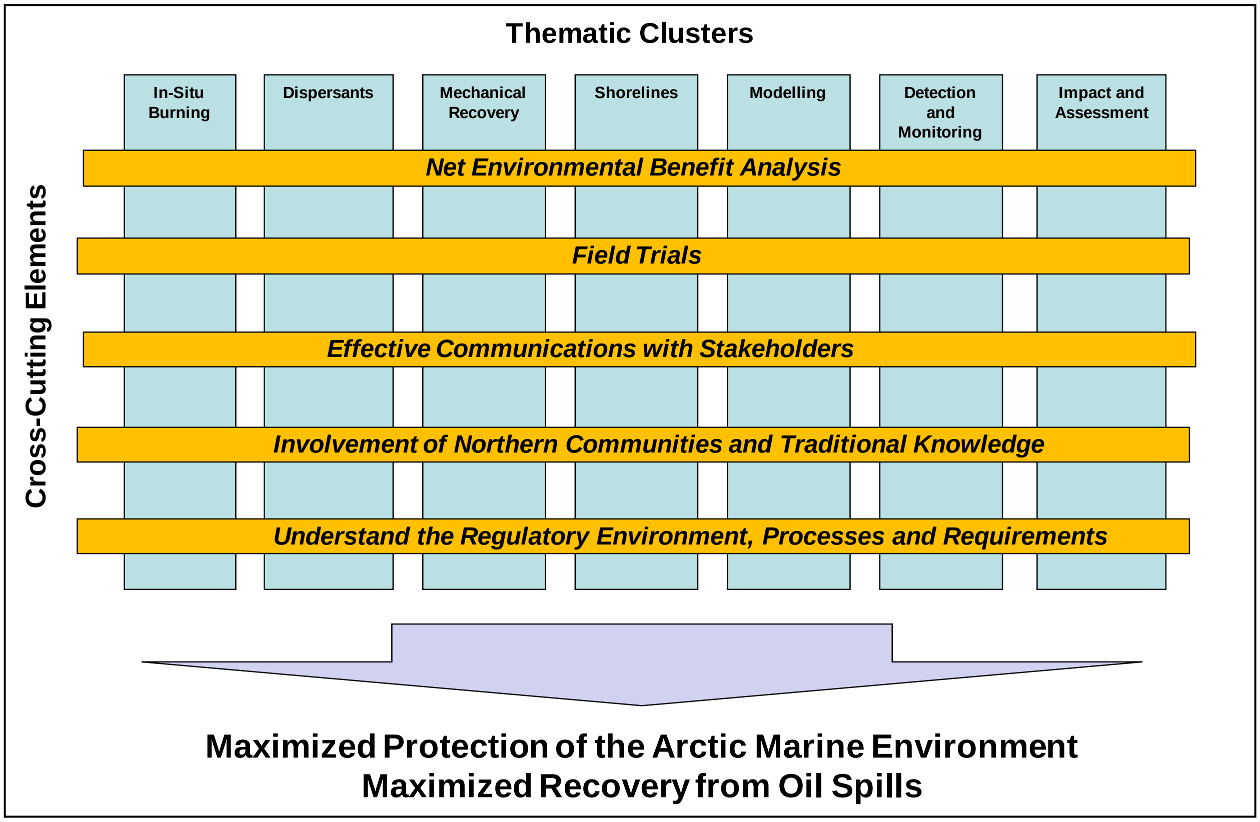

Figure 2. Recommended Architecture of 2013-2017 Oil Spill Research Program

The cross-cutting elements apply to all thematic areas and can be incorporated as dedicated work packages within each research project. Alternatively, they could be implemented as overarching projects with emphasis on coordination and collaboration across the thematic clusters and with relevant external activities. The thematic clusters encompass the research themes for each technical area and will give rise to one or more dedicated research projects. In this context, linkages between themes should be considered where appropriate, as well as the interaction with external programs and initiatives relevant to the objectives of this plan.

Table 3 provides a guide for prioritizing individual research themes within each of the technical area described in the previous sections. The priority scores presented were derived from a total of five responding participants during the post-workshop analysis. While this limits a full quantitative interpretation of the ranking, it should be noted that the prioritization reflects the opinion of key experts encompassing all technical areas under consideration.

Table 3. Research Themes and Priority Scores

Technical Area	Research Theme	Priority Score
In-Situ Burning	Physical and Chemical Properties of Oil	2.4
	Develop Toxicity Testing for Herders	1.8
	Field Operations Manual for Arctic In-Situ Burning	1.8
	Examine Capabilities of Herders as a Function of Oil Type	1.4
Dispersants	Develop Capacity for Direct Source Injection for Subsea and Surface Spills	2.1
	Effective Application of Dispersants in Arctic Conditions	1.7
Mechanical Recovery	Examine Solutions for Mechanical Recovery in the Presence of Sea Ice	1.7
	Storage and Disposal of Recovered Oil	1.7
Shorelines	Improved Cleanup and Mitigation Tactics for Arctic Shorelines	2.2
	Pre-Spill Characterization of Arctic Shorelines	2.2
	Detect Buried Oil on Arctic Shorelines	1.7
Modelling	Model Improvement	1.9
	Assimilation System to Use Satellite Data for Ice Tracking	1.9
	Fate and Behaviour of Oil in Different Ice Conditions	1.9
	Evaluate and Establish the Performance of Existing Models for Oil Spill Drift in the Presence of Ice	1.9
	Develop Long-Term (3-4 month) Drift Scenarios and Likely Fate of Oil and Ice	1.8
	Fate and Impact of Plumes Resulting from In-Situ Burning	1.7
Detection and Monitoring	Improve Methods to Detect Oil in the Presence of Ice Using a Variety of Remote Sensing and Other Data	2.3
Impact and Assessment	Revisit Baffin Island Oil Spill (BIOS) Field Experiment	2.4
	Habitat Mapping and Sensitivity Analysis Off-shore	2.2
	Identify Endpoints for Habitat Recovery	2.1
	Understand the Long-Term Natural Variability	2.1
	Effects of Oil Spills and Counter-Measures on Ecosystem Services and Valued Ecosystem Components (VECs)	2.0
	Biodegradation and Environmental Persistence of Residual Oil	1.9
	Integrative Risk Assessment Model, including a Region-Specific Environmental Data Serve	1.9
	Secondary Effects of Countermeasures	1.6

An initial focus for further consideration may be provided by the highest-ranked themes in each technical area. Accordingly, an improved understanding of the physical and chemical properties of oil would constitute important baseline knowledge for response actions as well as model predictions. Developing a capacity for direct source injection of dispersants has been identified as important in the Arctic context, although it may be considered an engineering challenge rather than a target for scientific enquiry and environmental research.

By contrast, based on the workshop discussions as well as the subsequent ranking, mechanical recovery is unlikely to be a viable tool for responding to major oil spills in the Arctic. Regarding shorelines, improved cleanup and mitigation tactics ranked equally with the pre-spill characterization of Arctic shorelines. Existing fate, spill behaviour and trajectory models need to be adapted to work under Arctic conditions, and the ability to detect and monitor of oil in a variety of ice and low-visibility conditions is required. Revisiting data from the BIOS field experiment may provide useful lessons for current and future Arctic developments.

In most instances, the workshop discussions did not extend to a detailed capture of the duration and budgets applicable to each research theme. Therefore, the subsequent confirmation of research targets and the design and implementation of research activities should build on the initial ranking described in this document and consider the additional elements of timelines and cost, together with expected benefits and attainability.

APPENDIX A: WORKSHOP PARTICIPANTS

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[1]Expert did not attend workshop but provided input to post-workshop analysis

APPENDIX B: WORKSHOP AGENDA

Development of a 5-Year Strategic Plan for Oil Spill Research in Canadian Arctic Waters

January 28 and 29, 2013, Calgary

MONDAY, JANUARY 28		
08:00	**Registration and Networking**	
08:30	**Welcome and Opening**	R. Steedman
08:45	**Tour de Table** Name and organization Interest in workshop Expected results	Plenary
09:45	**Workshop Outline** Objectives Guidelines Organization	T. Puestow
10:00	**Keynote: Oil Spill Cleanup and Mitigation** Current state of knowledge and capabilities Arctic challenges Closing the gaps	I. Buist
10:30		
10:45	**Keynote: Oil Spill Detection and Monitoring** Current state of knowledge and capabilities Arctic challenges Closing the gaps	D. Dickins
11:15	**Keynote: Oil Spill Modelling** Current state of knowledge and capabilities Arctic challenges Closing the gaps	M. Spaulding
11:45	**Keynote: Oil Spill Impact and Assessment** Current state of knowledge and capabilities Arctic challenges Closing the gaps	K. Lee
12:15	**Lunch (non-host)**	
13:15	**Strengths, Weaknesses, Opportunities, Threats** Summary of material received from participants SWOT analysis within the context of Arctic oil spill research	B. Ryerson
14:00	**Guiding Principles** Building common ground for discussion	Plenary
14:30	**Moving Towards a Strategy** Vision for effective research	Plenary
15:00	**Break**	
15:15	**Vision of Arctic Oil Spill Research** Vision and strategy Vision Drivers	Plenary
16:00	**Vision Drivers** Current status of the vision drivers (e.g. current capabilities, knowledge and information gaps, etc.)	Plenary
17:00	**Day 1 Wrap-Up**	B. Ryerson
19:00	**Non-Host Dinner: Chicago Chophouse, 604 - 8th Avenue S.W.**	

TUESDAY, JANUARY 29		
08:30	**Synopsis of Day 1**	B. Ryerson
08:45	**Vision Drivers** Future desired state	Plenary
09:30	**Articulating a Vision** Develop vision statement for Arctic oil spill research	Plenary, breakout groups
10:15	**Present Visions from Breakout Groups** Discussion	Plenary
10:30	**Break**	
10:45	**Common Vision Statement** Develop combined vision statement based on results from breakout groups	Plenary
11:15	**Building a Strategy** Introduction to breakout sessions	Plenary
11:30	**Research Strategies, Obstacles, Performance Measures** Cleanup and mitigation Detection and monitoring Impact and assessment	Breakout groups
12:30	**Lunch (non-host)**	
13:30	**Research Strategies, Obstacles, Performance Measures (continued)** Cleanup and mitigation Detection and monitoring Impact and assessment	Breakout groups
14:30	**Summary of Breakout Discussions** Cleanup and mitigation Detection and monitoring Impact and assessment	Plenary
15:00	**Break**	
15:30	**Priority Areas of Research** Short term (< 2 years) Medium term (2 to 5 years) Long term (> 5 years)	Plenary
16:30	**Next Steps** Development of strategic plan Timelines	Plenary
17:00	**Wrap-Up and Adjourn**	

APPENDIX C: KEYNOTE PRESENTATIONS

LAST PAGE OF DOCUMENT