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Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia

An Expert Panel Report
prepared by

The Royal Society of Canada

at the request of

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Ottawa, Ontario
Telephone / Téléphone: (613) 991-6990
Facsimile / Télécopieur: (613) 991-6996
E-mail / Adresse électronique: adminrsc@rsc.ca

www.rsc.ca

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Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia

Expert Panel:

Richard Addison, BSc, PhD, Salt Spring Island, British Columbia

John Dower, BSc, PhD, Assistant Professor, Department of Biology and the School of Earth & Ocean Sciences, University of Victoria, British Columbia

Jeremy Hall, PhD., Professor, Department of Earth Sciences, Memorial University of Newfoundland
Panel Chair

Ian Jordaan, PhD, Research Professor, Memorial University of Newfoundland

Panel Support:
Kevin Barr, The Royal Society of Canada
Sandy Jackson, The Royal Society of Canada

Louise Green
Pauline Honarvar
Mary Kennedy
Janet Lockyer

Workshop Assistance:
Sarah Dudas,
Julie Henderson
Robert Wilson

Ce document est disponible en français
Traducteur : Pierre Turmell
Réviseur technique : David Marchand

Gilles Paquet, President
The Royal Society of Canada

This report provides a framework for public discussion on science issues related to potential oil and gas activities offshore of British Columbia (BC). There has been a series of moratoria on such activities for over 30 years and now the question is being asked, "should the moratoria --federal and provincial -- be lifted?" Decisions on this question will be taken by governments after debate involving public consultations. The purpose of this report is two-fold. Firstly, it is the response to a request made in mid-2003 by the Minister of Natural Resources Canada that an independent Expert Panel advise him regarding science issues around oil and gas development off the BC coast. Secondly, the report is intended to be one input to the public consultations that will be conducted later in 2004 by a separate review panel, appointed by the Minister.

The report is intended to be accessible to those people who have a stake in the future of the Queen Charlotte Basin, the area offshore BC to which this report is limited by the Minister's mandate. The majority of the stakeholders are not experts in the areas of science discussed. The report references much technical literature, but provides syntheses for the lay person, and is intended to be read alongside several other recent reports, which deal at greater length with particular issues.

The report must also be physically or electronically accessible to the stakeholders. It will be available on the internet, as are the complementary reports. Hard copies of the report will be available to local communities around the Queen Charlotte Basin, so that residents can participate fully in the public consultations that follow.

The Expert Panel has taken advice from a large number of people, and many organizations. All views presented to the Panel have been considered carefully, during the Panel's deliberations. The Panel has been guided by the precautionary principle in reaching its conclusion and recommendations. These provide a framework for ensuring that the appropriate knowledge is acquired and are intended to facilitate the consultations and decision making that will follow.

Jeremy Hall (Chair)
Richard F. Addison
John F. Dower
Ian J. Jordaan

10 February 2004

Prefatory Note

In May 2003, the Earth Sciences Branch of the Department of Natural Resources approached the Royal Society of Canada with a request to commission an Expert Panel to conduct a review of science issues arising from possible oil and gas activity, offshore British Columbia, and to identify science gaps that may need to be filled prior to, or following, any decision on lifting of the current moratorium on such activities. The Society agreed to do so, and the Committee on Expert Panels undertook the task of screening and selecting the individuals whose names now appear as the authors of this report for panel service.

The report entitled *Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia* represents a consensus of the views of all of the Panelists whose names appear on the title page. The Committee wishes to thank the Panel Members and Panel Chair, the Peer Reviewers, and the Panel staff for completing this very important report given the urgency that decision-makers placed upon delivery..

The Society has a formal and published set of procedures, adopted in October 1996, which sets out how Expert Panel processes are conducted, including the process of selecting Panelists. Interested persons may obtain a copy of those procedures from the Society. The Committee on Expert Panels will also respond to specific questions about its procedures and how they were implemented in any particular case.

The Terms of Reference for this Expert Panel are reproduced elsewhere in this report. As set out in our procedures, the terms are first proposed by the study sponsor, in this case Natural Resources Canada, and accepted provisionally by the Committee. After the Panel is appointed, the terms of reference are reviewed jointly by the Panelists and the sponsor; the Panelists must formally indicate their acceptance of a final Terms of Reference before their work can proceed. These are the terms reproduced in this report.

The Panel first submits a draft of its final report in confidence to the Committee, which arranges for another set of experts to do a peer review of the draft. The Peer Reviewer comments are sent to the Panel, and the Committee takes responsibility for ensuring that the Panelists have addressed satisfactorily the Peer Reviewer comments.

The Panel's report is released to the public without any prior review and comment by the study sponsor. This arm's-length relationship with the study sponsor is one of the most important aspects of the Society's Expert Panel process.

Inquiries about the Expert Panel process may be addressed to the Chair, Committee on Expert Panels, The Royal Society of Canada.

Jeremy McNeil, FRSC
Chair, Committee on Expert Panels

on behalf of the Committee Members for this Panel:

Christopher Garrett, FRS, FRSC, University of Victoria
David Layzell, FRSC, Queen's University
William Leiss, FRSC, Queen's University

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Background

The Government of British Columbia (BC) has asked the Government of Canada to consider lifting the federal moratorium on oil and gas activities offshore of British Columbia. In response, the Government of Canada is proceeding with a review to:

(a) identify science gaps related to possible oil and gas activity offshore BC;
(b) hear the views of the public regarding whether or not the federal moratorium should be lifted for selected areas; and
(c) consult with First Nations to ensure that issues of unique interest to First Nations are fully explored.

Part (a) of this three-stage process is this science review being conducted at the invitation of the Minister of Natural Resources Canada. Only the Queen Charlotte Basin (QCB) is under consideration by the Minister and the Expert Panel has therefore restricted its focus to the Dixon Entrance, Hecate Strait and Queen Charlotte Sound. The review included three open science workshops, in Vancouver and Prince Rupert, during which experts informed the Panel about the area, the nature of oil and gas activities and their impacts, followed by open discussion. The Panel also received and considered many written briefs before drawing its conclusions.

Responding to the terms of reference for the review

The key requirements spelled out in the terms of reference for the review are as follows:

(a) to identify science gaps which may need to be filled before a decision is made in respect to the moratorium;
(b) to provide a path forward on the science requirements which would precede, or be concurrent with, any exploration or development activity;
(c) to identify who should be responsible for filling the identified gaps;
(d) to evaluate risks associated with not filling an identified gap;
(e) to evaluate sensitive environments and previously recommended exclusion zones within the proposed review area; and
(f) to identify additional areas requiring special management measures in the event of a decision to lift the moratorium.

The Panel recognizes that oil and gas development takes place in discrete phases of activity separated by analysis and decision points. It has determined what science gaps need to be filled to ensure safe practice (safe for both human life and the environment) for each successive activity. These phases include exploration mapping (in the offshore, this is achieved mainly by seismic surveys which image the subsurface); exploration drilling, to test structures found for oil and gas; delineation drilling, to determine the extent of potentially commercial reservoirs of oil and gas; production; and decommissioning. It is likely to take about 15 years to move through the stages of activity prior to first production. There are periods of years before some activities occur and therefore adequate time to fill the science gaps for them.

Safe practice depends on knowledge, risk assessment and regulation. Because the three are closely linked, the requirement for science knowledge cannot be divorced from the needs for both risk assessment and regulation. We have described the need for quantitative risk assessment, and have made assumptions that the regulatory regime, put in place for oil and gas activity offshore British Columbia, would use current best practices from other areas of the world.

We have enumerated the science gaps that would need to be filled before each phase of activity commences. We have stated the consequences of not filling those gaps—potentially safety built into the design of facilities, which could lead to the activity being non-economic, or prohibition of activity until

risks are better defined by acquisition of new knowledge. A third possibility—of activity being pursued and then being found harmful—is unlikley if the regulatory regime is sufficiently stringent.

We discuss the development of protected areas, and special restrictions that should be applied to oil and gas activities, as well as noting the need for other activities to be restricted around some oil and gas facilities.

The Panel completes its response to the terms of reference by making a series of recommendations and coming to conclusions with respect to moratoria. We note that the terms of reference refer to the moratorium (federal, presumably), but other moratoria cover this activity, including a provincial moratorium, and because most of those with whom we have consulted are aware of these, we use the plural herein.

In this summary, we outline our response to the terms of reference as described above, but first provide some background on the area of concern and the nature of oil and gas activities.

Physical setting of the Queen Charlotte Basin

The QCB is a semi-enclosed basin between mainland BC and the Queen Charlotte Islands. The basin is connected to the NE Pacific via Dixon Entrance (in the north) and Queen Charlotte Sound (in the south), and to the Strait of Georgia via Queen Charlotte Strait (in the southeast). Water depths in most of the basin are greater than 100 m, with maximum depths of more than 400 m. Several submarine canyons penetrate the basin.

Much of the seabed is covered by silty sediment, but there are rock outcrops, boulder beds, sands, and several unique sponge reefs. The rugged nature of the seabed poses several potential hazards to oil and gas activities: slope instability, moving sediment, shallow gas, and active faulting.

The QCB is an area of current earthquake activity. A fault movement would endanger the integrity of seabed structures cutting across the fault surface (e.g., a well bore), and could destabilize sediments. Earthquake waves (tsunamis) have been recorded in the QCB, but they are smaller than those of storm waves.

Tides and currents in the QCB are vigorous (1-5 knots). Drifter studies show evidence of eddies that retain water (and by extension, oil spills) in the basin. Wind and sea conditions in the QCB are among the most severe in Canada. Winter wind speeds average 35 km/h, with gusts of up to 200 km/h. Typical wave heights in the basin range from 1.5-2.5 m, but “monster waves” of more than 25 m may occur during extreme storms which can develop in less than 8 hours.

Ecological setting of the Queen Charlotte Basin

The QCB is a typical highly seasonal, mid-latitude, coastal marine ecosystem, like those elsewhere in British Columbia and in southern Alaska. Production is high in the spring, when plankton blooms fuel growth of higher trophic levels. Commercially valuable species include six species of salmon, a suite of demersal fish, and several invertebrate species. The QCB plays host to a number of ecologically sensitive species, including more than 20 species of whales and pinnipeds, sea otters, plus many species of colonial seabirds (including some for which much of the global population occurs in the QCB). The basin also contains a series of sponge reefs, unique in the world.

Except for commercially valuable species, the distributions of most marine species (and therefore the areas of critical habitat) in the QCB remain poorly known. Beach surveys have been conducted throughout the basin, but subtidal communities (especially deep water communities) have received little attention. To determine the best locations in which to establish representative marine protected areas (as well as site

selection for monitoring sites), research must be undertaken to better describe the distribution of species in the QCB, with special attention paid to species sensitive to oil and gas activities. Collection of baseline and monitoring data should begin as soon as possible.

As of November 2003, sixteen marine species in the QCB were listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as "endangered", "threatened" or "species of special concern". Under the Species at Risk Act (SARA), it is an offence to "…*kill, harm, harass, capture or take*…" an individual of any species listed as endangered or threatened. SARA also requires that Recovery Plans be developed for these species, including the identification and protection of critical habitat. Where such data do not exist (as is the case for most of the species at risk in the QCB) new studies must be undertaken to collect the necessary data. The Panel assumes that Recovery Plans will be implemented in a timely fashion, resulting in critical habitat being identified and protected. This will reinforce the requirements of regulation prior to commencement of oil and gas activities.

Oil and gas activities

Initial offshore exploration will involve seismic surveys conducted from ships. These surveys involve sophisticated echo sounding to create 2D images of sub-seafloor geological structure below the ship's tracks. The acoustic sources used can be harmful to nearby animals. 2D images provide a regional picture of geological structure and may lead to a phase of more intensive 3D imaging over favourable structures. Testing to find out if such structures contain oil or gas is then done by drilling. Rotary rigs, mounted on the seabed or free floating, would be used. Mud is circulated through the drill string to remove drilled out rock cuttings. Disposal of mud and rock cuttings is a contaminant issue. If discoveries prove commercial, production of oil and gas may be developed, using a more permanent operating platform. Transport of oil and gas from producing fields is either via pipeline or tanker. Discharge of large amounts of water produced from the reservoir with the oil, and oil spills from accidental leaks or blow-outs are additional contaminant issues. At termination of production, decommissioning involves plugging the well and cutting it off just below the seabed. Production platforms are then abandoned or removed.

The QCB has significant potential for oil and gas. Oil seeps occur on the Queen Charlotte Islands and gas seeps are known offshore, but despite pre-moratorium seismic exploration and eight wells drilled offshore, there has been no commercial discovery. It is thus difficult to estimate the oil and gas resource, but current estimates suggest there may be 6 fields of over 100 million barrels of oil, which together could produce 1.3 billion barrels, worth about C$50 billion. There may be 9 fields with more than 500 billion cubic feet of recoverable gas, totalling 9.8 trillion cubic feet, worth around C$60 billion. The hydrocarbon potential of the Basin is thus of similar order to the mature Cook Inlet oil and gas fields in Alaska, and to the currently developed or developing fields in the Jeanne d'Arc Basin offshore Newfoundland.

Environmental impacts and safety

Oil and gas activities can have negative impacts on marine and shoreline systems. Oil is unlikely to be produced from the QCB for at least 15 years and, as the technology will change during that interval, production processes and their impacts should be assessed closer to that time. The Panel has focussed on the activities occurring at the earlier stages of oil and gas development (i.e., seismic surveys and exploratory drilling). Oil and gas development in the QCB would lead to increased activity on shore, at service bases. Their impact will be merely incremental to other port activities.

Seismic surveys use air gun acoustic sources. These have localised lethal effects (i.e., within a few metres) on plankton, drifting eggs and larvae, but these will be small compared to natural mortality. Other physical effects on eggs are not of concern since it is unlikely they could be detected against background levels of mortality. Any fish or marine mammal within a couple of metres of an air gun detonation would be killed or suffer permanent hearing damage. Farther away, effects are more variable, but some marine mammals and fish change behaviour, with largely unassessed consequences for survival of individuals or populations,

in the presence of air gun detonations. It is therefore prudent to prohibit seismic surveys at places during times when sensitive life-stages of commercially important or ecologically-significant species are known to be present (e.g., during juvenile or adult salmon migrations, or areas when herring are spawning). In such cases, basic patterns of distribution and habitat usage should be established before any seismic surveys are undertaken. The Species at Risk Act legislates that such studies be carried out for QCB species currently listed by COSEWIC as being endangered or threatened.

Exploratory and production drilling produce waste: cuttings, usually associated with residues of drilling fluids, and produced (i.e., formation) water. Discharges of cuttings leads to smothering of organisms on the seabed within the cuttings "plume"; if toxic residues from drilling muds are also present, these will exacerbate deleterious effects. Proponents should be required to address feasibility of "zero discharge" of cuttings (either by re-injection or transport to shore) as part of the permitting process for drilling. Some cuttings from water-based drilling muds (WBM) may have to be discharged at the initial seabed entry of exploratory drilling. The acute and sub-lethal toxicity of cuttings and mud should be dealt with during the permitting process, when their nature will be better defined. Produced water may present problems of sub-lethal effects, which should be assessed during the permitting of production operations.

The probability of major spills or blow-outs has been declining over the last two decades of oil extraction and transport. Such an event could still occur in the QCB. Spill trajectory models can be made, with assumptions about the nature of oil produced and the weather and sea-state conditions at the time. The impact of any spill would depend on the relative vulnerability of the local ecosystems, especially at the landfall. The QCB is largely an enclosed coastal basin, so any spill originating within it is likely to be caught up in the internal circulation eddies, until it reaches the shore, probably within a few days. Negative impacts can be expected on mammal, bird, fish and invertebrate populations. These effects may range from subtle sub-lethal effects to large-scale kills, depending on the size and timing of the spill, and the nature and biotic populations of the landfall. Negative economic impacts might include those on the fishing economy, both commercial and sport-fishing, due to loss of accessibility to fishing grounds and reduced marketability of fish, and impacts on tourism through loss of eco-tourism opportunities as a result of real or perceived environmental damage. Persistence of impacts due to slow degradation of spilled oils in gravel beaches or to slow recovery of affected species is a factor in risk assessment.

Assumptions

The identification of science gaps, itemised below, the consequences of not filling them, and the recommendations that follow are premised on the following principles and assumptions.

The precautionary principle. In engineering design and in risk assessments that are carried out as part of the development process, it is assumed that a precautionary approach would be used. The Panel's terms of reference interprets the precautionary principle so: "in the face of scientific uncertainty, it is preferable to err on the side of caution." The degree of caution to be applied would be determined on a case by case basis by quantitative risk assessment, in which the amplitude of the negative impact would be a function of both its immediate effect and its persistence. Our terms of reference also add, "the absence of full scientific certainty shall not be used as a reason to postpone decision-making."

Best practices. Best practices would be employed in all aspects of oil and gas development. These are continually improving and will be advanced further from the present state of the art by the time activities such as oil or gas production are likely to commence in the QCB.

Target safety levels. Oil and gas activities in the QCB must be safe for the people involved and for the wider environment. Safe practice must be regulated. We assume that assessments for the safety of oil and gas activities in the QCB would be carried out using the principles of risk analysis, guided by targets. The targets apply to consequences which entail a great risk to human life or a high potential for environmental damage, as in Canadian Standards Association S471, part of the Code for Offshore Structures. The targets

for specific process causes are assumed at a level of 1 in 100,000 per year, and for all causes 1 in 10,000 per year. The ALARP ('as low as reasonably practicable') principle would be used to assist in judging specific processes within the range from 1 in 10,000 (10^{-4}) to 1 in 100,000 (10^{-5}) per year. In assessing safety with regard to human life and the environment, objective-based or goal-setting regulation would be preferable, with prescription where needed. To implement this, the requirements for regulators would be demanding and the expertise of regulator and staff critically important to the standards achieved.

Prime beneficiary pays. Any scientific knowledge required, that would benefit the community significantly by its relevance to issues beyond oil and gas activities alone, should be the responsibility of government. Scientific knowledge required only to benefit the assessment and development of specific oil and gas activities should be the responsibility of the developer. In cases where both benefits accrue, public-private partnership would be appropriate. In all cases, public access to the information collected and deliberations thereon is to be encouraged.

Regulation. It is assumed that a regulatory board would be set up at arm's length from government and industry to ensure safe and environmentally-responsible development, using current best practice.

Activity specific requirements. We assume that approvals for specific activities involved in oil and gas development would require specific conditions, as follows.

Seismic surveys. These would not be permitted in defined protected areas or close to sensitive areas at critical times for valued ecological and economic components (VEECs). Surveys would be carried out subject to common protocols practiced elsewhere (biological observers on survey ships, ramping up of air guns, termination of shooting on encountering VEECs in potentially harmful situations). In addition acoustic propagation modelling would be required for prior assessment of impact on sensitive areas and survey areas would be overflown by biological observers before commencement of surveys and at least once per day thereafter.

Drilling. Drilling would only be permitted after assessment of the impact of contaminants released into the ocean. The Panel notes that 'zero discharge' policies are being practised increasingly for disposal of drilling mud and cuttings in biologically sensitive areas, close to shore, with exceptions made for initial 'spudding' of drill holes in the seabed. We assume that regulation of discharges of mud and cuttings in the QCB would be at least as stringent as those in place for offshore oil and gas activities elsewhere in the world.

Production and transport. We assume that a zero discharge policy would apply with limited exceptions to initial 'spudding in' of drills into the seabed, incidental gas production, and produced water: reinjection, or disposal on land would be standard practice. For both permanent installations (platforms, pipelines) and mobile transporters (tankers), oil spill trajectory modelling would be required and a spill response plan (including all the associated infrastructure) would be put in place, with a requirement of no more than 24 hours delay between spill and on-site remedial action.

Decommissioning. We assume that all production infrastructure would be removed from the sea on cessation of production, and the well plugged, cut off a small distance below the seafloor, and abandoned.

Science gaps identified and consequences of not filling them

In considering the QCB and the oil and gas activities that might be pursued in it, the Panel suggests filling science gaps as follows.

Valued Ecological and Economic Components (VEECs). Species at risk, ecologically important species and harvested species constitute the VEECs of the QCB. These need to be defined as the foci for baseline

and monitoring studies. Failure to determine these, could result in critical species not being studied, with risk of unassessed (and therefore unanticipated) impacts from oil and gas development.

High-resolution swath bathymetry is needed, especially for areas of the QCB with high hydrocarbon prospectivity. These data will allow areas of seafloor instability associated with gas seeps, steep slopes and rapid sediment transport to be identified. They are essential in characterizing benthic environments for selection of monitoring sites, and delineation of critical habitat. Without these data, there is potential for unstable foundations for seabed structures, and lack of understanding of the location of particular seabed habitats.

Measurements of currents, winds and waves should be accelerated. In particular, topographic modelling of winds is needed to allow for measurements at wind stations on variable topography on land to be reliably extrapolated to sea; bottom currents and trajectories in summer and winter flow at all depths is needed, for assessments of physical impact on structures; updated wind and wave hindcast models should be run for the same reason; variability of climate change on long time series for winds and currents should be established. These metocean data are needed for structural design, for oil spill trajectory modelling and for modelling dispersion of discharged mus and cuttings. Without these data, consequences of spills and releases would be inadequately resolved, and structures would be built to compensate for greater uncertainty in maximum and sustained loads, with consequences for economic viability of projects. Data collected should be focused on determination of impacts and loads for locations in areas of high hydrocarbon prospectivity.

Earthquake monitoring is needed to determine the temporal variability of stress release, and to establish how the stress release is partitioned among specific fault structures that may be close to oil and gas activities in the QCB. This should be done through installation of an enhanced network of seismographs in the QCB, including strong-motion seismographs, which give much improved data on events of >5.5 or so. The recurrence periods for such magnitudes are decadal or greater, so this is a long-term public-good need that might bring useful results within the time scale of oil and gas activities. All these data will be used to refine earthquake hazard estimates for the QCB, and to identify active faults. Without such data, structures may be designed to compensate, and there would be a greater possibility of drilling through an active fault.

Acoustic propagation of seismic survey sources should be modelled for assessment of potential impacts on the behaviour of mammals (especially whales). Behavioural disturbance is itself uncertain because of the wide range of observed responses, but proposals for individual seismic surveys should be required to provide estimates of received sound levels at critical sites and times in the QCB. Without this, there might be behavioural disturbance during calving, migration through restricted channels, and similar events that might impair the viability of some of the smaller vulnerable whale populations.

The space-time distributions of fish that are VEECs is needed to define periods and areas when seismic surveys can be safely carried out, without endangering spawning, migration and populations. Of particular importance might be the inshore distribution of herring, and salmon migration routes.

The major confined spawning areas for critical fish species must be defined, together with the spawning times, so that seismic surveys can be excluded from those areas. While in general it appears that seismic sources kill fewer eggs and larvae than die because of harsh conditions or are preyed upon by other species, spawning areas for critical species should be avoided as a measure to assist in their recovery.

The space-time distributions of those mammals that are VEECs, together with their behaviour patterns should be determined so that critical concentrations at critical times can be avoided by seismic surveys. Recovery of vulnerable populations might be hampered by seismic surveying through nursery areas.

Observers on seismic vessels should log the occurrence and behaviour of diving birds close to active sources. It is unlikely that significant numbers of diving birds are harmed by seismic surveys, but there is little data on this: collecting some would be of value.

Baseline studies of benthic fauna and habitat, including seabed sediment hydrocarbon and other chemical distributions, benthic community structure, and other appropriate indices of environmental stress which have proved useful elsewhere, should be collected to provide a datum to allow the impacts of oil and gas activities to be assessed. Without such data, the attribution of cause of an unwanted event to a specific activity might not be possible.

Oil spill trajectory modelling should be carried out for a wide range of oil types, spill locations within the QCB, and weather and sea conditions. Seasonal variations in weather should be included. This will reveal general patterns for the dispersal of oil that will be of great value in setting up an optimal oil spill response system. Without such modelling, oil spill response will be less effective.

Defining the impact of oil spills on their landfalls should be derived from knowledge of shoreline types, from sources such as the BC Government Coastal Resource Inventory program and products derived from those data. Without this information, oil spill response might be less optimally designed.

Seasonal variations in species populations along shorelines is needed for assessment of the vulnerability of biota to an oil spill. Without these data, the priority assigned to, and nature of, oil spill response for different parts of an impacted coastline could not be made.

In meeting the requirements of the terms of reference regarding exclusion zones, the Panel suggests the following actions be pursued.

Marine Protected Areas in the QCB. There is a collective responsibility to identify the most suitable candidate areas and legislate their protection. This should be a high priority for the appropriate stakeholders. The Panel recommends that the natural resource potential—both of renewable and non-renewable resources—be considered as a factor in the choice of such areas. If this is not done, the uncertainties of when and how it might be done will mean continuing threats to species at risk and prove frustrating for those contributing to economic activity.

Critical species close to shore. For specific seismic surveys that are intended to approach close to the shoreline (within 1 km of the 20 m isobath), it should be required that the proponent establish the nature and distribution of biota (especially VEECs) within 1 km of the intended ship's track, in order to provide information for regulators to assess the safety of such surveys for those biota. This would allow for lifting of the suggested restriction made by the Panel (to exclude seismic within 1 km of the 20 m isobath) for areas that pass the test. Not allowing this might prevent discovery of potential prospects , near-shore that could be drilled from land.

Areas of critical habitat should be defined clearly by those stakeholders mandated to carry out the demands of the Species at Risk Act, so that seismic surveys can be excluded from them. Not to do so would further endanger the species for which those habitats are critical.

20 km coastal zone buffer for drilling Oil spill trajectory modelling for various possible scenarios has been proposed. The results should be used, with modelling carried out for specific oil and gas activities, to establish coastal zone buffers of such size that oil spill response would be activated before oil from a spill makes landfall. These buffers might be greater or smaller than 20 km, depending on location and specifics of plans for response. Until these analyses are available, the present 20 km buffer zone should be maintained.

The regional data needed cannot necessarily be collected quickly. In some instances, long time series are required to assess temporal variations of the natural system prior to commencement of oil and gas activities. Given the 15 years required to reach oil or gas production, and the knowledge that some parts of the natural systems are subject to decadal variability (the climate system especially), it is urgent to start

measurement as soon as is practicable. This means that there should be overlap in time in the acquisition of science knowledge required for different oil and gas activities.

All the science gaps above need to be filled, but early priority should be given to the following baseline studies, which establish an observational datum now, before oil and gas activities start, and monitoring studies (in which long time series are needed).

Recommendations and conclusion

Based on the science gaps noted above and consideration of how to approach the science requirements in a coordinated way, where possible, the Panel offers the following recommendations and conclusions.

Recommendation 1: Advisory body

It is recommended that, at the earliest possible opportunity, an advisory body be formed of stakeholders from government (including those of First Nations), the oil and gas industry, other industries active or potentially active in the QCB, community leaders, environmental NGOs, and other relevant groups. *The Panel notes that such bodies in mature oil basins like Cook Inlet, Alaska, similar in many respects to the Queen Charlotte Basin, have been very effective in channelling concerns, organising monitoring programs, and in liaising with industry. The body would advise government, industry and regulators on matters and concerns related to oil and gas projects and requirements for safe practice.*

Recommendation 2: Baseline studies

The Panel recommends that collection of the following baseline data begin as soon as possible. These data are deemed necessary either to characterize baseline conditions (i.e., prior to any oil and gas development), or are considered vital to enabling the implementation of best practice at subsequent stages of development. Where appropriate, the value of these data in a context of change should be enhanced by incorporation of historical data, including traditional ecological knowledge.

- ***Characterization of the spatial and temporal distribution of ecologically important, sensitive and harvested species in the QCB:*** *The logical place to start would be with those species already listed by COSEWIC as endangered, threatened, or of special concern (in keeping with legislation under the Species at Risk Act), as well as species that are of ecological importance, but about which little is known (e.g., sand lance), and important harvested species.*
- ***Swath bathymetric mapping:*** *Necessary to identify areas of seafloor instability associated with gas seeps, steep slopes and rapid sediment transport. Also essential in characterizing benthic environments for selection of representative monitoring sites, delineation of critical habitat and the establishment of representative MPAs.*
- ***Measurement of near bottom currents:*** *These data are required to model environmental forces, sediment movement and the transport of water based drilling muds and cuttings during exploratory drilling.*
- ***Baseline studies of benthic fauna and habitat, including seabed sediment hydrocarbon and other chemical distributions, benthic community structure, and other appropriate indices of environmental stress which have proved useful elsewhere:*** *These data allow the impacts of oil and gas activities to be assessed.*
- ***Drifter studies of winter surface currents, and spill trajectory modelling:*** *These data are essential for extreme and operational modelling and for estimating oil spill trajectories.*
- ***Topographic modelling of winds:*** *These are needed so that site-specific estimates can be obtained of wind conditions at sea based on long-term observations of shore-based winds.*
- ***Strong motion seismograph measurements:*** *These data are needed to better characterize the ground motions associated with large earthquakes.*

- ***Reintroduce a network of seismographs around the basin:*** *These are needed to resolve better earthquake foci and determine the location and motion of active faults.*

Recommendation 3: Monitoring studies

The Panel recommends that chemical and biological monitoring studies (based on accepted best practices in other jurisdictions) should commence (or continue) as soon as possible at each of the following groups of sites:

- ***Potential and past drill sites:*** *Sites representative of locations where drilling has taken place in the past or is likely to take place in the future (to allow detection of changes caused by drilling activities).*
- ***Control (or reference) sites:*** *Chosen to be representative of locations where drilling is unlikely to occur (to allow detection of trends caused by natural factors or factors unrelated to oil and gas activities), and should include revisiting sites that have been sampled in the past to extend the time frame of analysis.*

Recommendation 4: Protected areas

The Panel recommends the following actions with respect to protected areas:

- ***In light of their unique nature, the sponge reefs in the QCB be officially designated as Marine Protected Areas (MPAs) as soon as possible.*** *These MPAs should be protected from all fishing and drilling activity, and be surrounded by an appropriate buffer zone. Because of the depth of water above the reefs, it is unlikely that there will be any impact on the sponges from the kinds of seismic survey described in this report.*
- ***Concerted action be taken by government (with assistance from other stakeholders) to determine the areas that should be protected in the QCB, the level of protection to be enforced, and to pass the enabling legislation.*** *In determining the areas to be protected, it would be appropriate to consider the potential for development of all the natural resources of the basin, renewable (fish, shellfish, etc.) and non-renewable (oil, gas, minerals).*

Recommendation 5: Other exclusion zones

The Panel recommends that

- ***The coastal exclusion zone for drilling be maintained at 20 km, until such time as more site-specific restrictions can be justified, for which improved knowledge of oil spill trajectories and shoreline vulnerability will be required; and***
- ***Seismic surveys should be prohibited from waters less than 20 m in depth, from any area within 1 km of the 20 m isobath, and from all areas deemed as critical habitat for species listed by COSEWIC as endangered, threatened or of special concern, and during periods when these species are most vulnerable (e.g., during migrations, spawning, etc).*** *As improved knowledge is acquired on the space-time distribution and activities of critical species in the QCB, and on the impacts of seismic survey on biota, the general restrictions should be replaced by more site- and time-specific restrictions.*

Conclusions regarding the moratoria on oil and gas activities

The moratoria were put in place because of concerns that oil and gas activities, including tanker traffic transiting through the area, would unduly endanger the environmental health of the region. The Panel has reviewed all the oil and gas activities that might ensue in the QCB, were development to proceed. It has also considered the effects of evolving practices by industry and of the increasingly stringent technical demands of regulation, in jurisdictions covering offshore U.S, the North Sea, and eastern Canada.

With implementation of the recommendations made above, and the assumptions on which they are based, all the safeguards will be in place, when they are needed, to ensure that assessments of risk of oil and gas activities to human life and the environment in the QCB are adequate. Such assessments would be undertaken by those most knowledgeable of the particular activities, of their impacts and of the consequences for those impacted. The assessments would involve public participation. Given all this, the significance of the moratoria to this discussion of science issues is reduced to their inhibiting the generation of relevant new knowledge. Our principal conclusions follow.

Conclusion 1

Provided an adequate regulatory regime is put in place, there are no science gaps that need to be filled before lifting the moratoria on oil and gas development.

It is extremely important to recognize that this does not mean that science gaps do not exist (we have outlined many). Nor should it be taken to mean that the Panel is recommending that development be allowed to begin immediately. What it does mean is that, if the moratoria were lifted, regulation would be in place to ensure that these critical science gaps would be filled before development of an oil and gas industry in the QCB. We also note that lifting the moratoria would enhance the opportunities for filling many of the science gaps, through shared-cost partnerships involving industry participation.

Conclusion 2

The present restriction on tanker traffic in transit along the West Coast of North America from entering the coastal zone should be maintained for the time being.

The current moratoria are intended to restrict tankers in transit along the West coast of North America from entering the coastal zone. Even with the improved record of spills in territorial waters off North America over the last 10 years, there is no imperative to relax this restriction. Detailed risk analysis in future may indicate sufficiently low risk of spillage that the restriction might then be relaxed.

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Short Biographies of Panel Member:

Richard F. Addison

Born and educated in Belfast, UK; B.Sc.(Hons.) in chemistry and Ph.D. in agricultural chemistry (animal nutrition). From late 1960's to 1992 worked as a research scientist in labs. of the Department of Fisheries and Oceans (and its predecessors) on issues relating to marine pollution in eastern Canada and the Arctic. As head of the Marine Environmental Quality division at Bedford Institute of Oceanography (Dartmouth, NS) co-ordinated DFO's responses to Environmental Impact Statements supporting proposals for offshore hydrocarbon developments in the Scotian Shelf/Sable Island area and in the eastern Arctic; co-ordinated DFO's scientific response of offshore emergencies including the Sable Island (Venture) gas blow-out (1984). From 1993-2001 was head, Ocean Chemistry division at Institute of Ocean Sciences, Sidney, BC. Since 2002 has been President of a successful environmental consulting company in BC.

Author of over 100 primary publications and another 60 invited reviews, book chapters and conference proceedings dealing with various aspects of pollutant distribution and environmental toxicology. Past Chairman or member of various inter-governmental working groups of the International Council for the Exploration of the Sea, the North Pacific Marine Science Organisation, and the Intergovernmental Oceanographic Commission which dealt with marine pollution. Fellow, Royal Society of Chemistry (UK) and Fellow, Chemical Institute of Canada; past Chairman, CIC Environment Division.

John F. Dower

Born and raised in St. John's Newfoundland, Dr. Dower received his BSc in Biology from Memorial University of Newfoundland and his PhD in Biology (biological oceanography) from the University of Victoria. He was a Research Associate at Queen's University (Kingston, ON) from 1996-1998, Assistant Professor at UBC (Earth and Ocean Sciences) from 1998-2000 and currently holds a joint appointment in the Biology Department and the School of Earth & Ocean Sciences at the University of Victoria. He has published on various aspects of marine ecology and biological oceanography and served on the DFO Advisory Team for the establishment of a Marine Protected Area at Bowie Seamount. He is a member of an international panel that conducted an ecosystem review of the Eastern Tropical Pacific (ETP) for the US National Marine Fisheries Service and of the City of Victoria's CRD Marine Monitoring Advisory Group. He participated in the GLOBEC Canada research program and is currently a co-PI on an NSERC Strategic Project examining the coupling of physical and biological processes in the Strait of Georgia.

Jeremy Hall, Chair

Dr. Hall is highly respected among the scientific community for his contributions to earth sciences research. He has chaired several important science committees, including the Canadian Geoscience Council and its Standing Committee for the International Continental Drilling Program, and has acted in a science advisory role to government for several years. Dr. Hall was a member, from 2000–2002, of the Minister's National Advisory Board for Earth Sciences, that reports to the Minister of Natural Resources.

Dr. Hall is a professor in the Department of Earth Sciences at Memorial University of Newfoundland. He holds a doctorate degree in seismic studies from the University of Glasgow and is a member of the Association of Professional Engineers and Geoscientists of Newfoundland.

Ian J Jordaan

Dr. Jordaan is presently University Research Professor, and for the period 1986 - 1996 was NSERC-MOBIL Industrial Research Professor of Ocean Engineering, at Memorial University of Newfoundland. He is also President, Ian Jordaan and Associates Inc., St John's. Previously he served as Professor, Department of Civil Engineering, at the University of Calgary, and worked for several years at Det norske Veritas (Canada) Ltd., ending as Vice-President (Research and Development) in 1986. He has been involved extensively in developing methodology for engineering design criteria, and in the use of probability theory, risk analysis and extremal analysis applied to engineering problems. He has also worked on problems in mechanics, including viscoelasticity, fracture and failure applied to various materials including ice. He was chair of the CSA Committee S. 471, General Requirements, Design Criteria, Environment and Loads, forming part of the Code for the design, Construction, and Installation of Fixed Offshore Structures, and continues to contribute to this effort by serving on several committees. He also served on a working group charged with reviewing the Proposals for the Revision of the Arctic Shipping Pollution Prevention Regulations. He has acted as a consultant in many studies, including the design loads for the Confederation Bridge, and studies for the Terra Nova design, the West Bonne Bay prospect, the Hebron development, and the White Rose development. He has published extensively in the areas of risk analysis, probabilistic design criteria and the mechanics of solids. He has received the Horst Leipholz Medal for contributions to mechanics, and the P.L. Pratley Award for the best paper on bridge engineering, both from the Canadian Society for Civil Engineering.

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283 Sparks Street
Ottawa Ontario K1R 7X9

Tel: 613-991-6990
Fax 613-991-6996
Email adminrsc@rsc.ca

www.rsc.ca

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