BRITISH COLUMBIA OFFSHORE HYDROCARBON DEVELOPMENT

REPORT OF THE SCIENTIFIC REVIEW PANEL

January 15, 2002

BRITISH COLUMBIA OFFSHORE HYDROCARBON DEVELOPMENT:
REPORT OF THE SCIENTIFIC REVIEW PANEL

A report in two volumes

(Volume II: BRITISH COLUMBIA OFFSHORE HYDROCARBON DEVELOPMENT: VOLUME II – APPENDICES TO THE REPORT OF THE SCIENTIFIC REVIEW PANEL)

Submitted to the BC Minister of Energy and Mines, Hon. Richard Neufeld

January 15, 2002

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BRITISH COLUMBIA OFFSHORE HYDROCARBON DEVELOPMENT

Executive Summary

On October 19, 2001 the British Columbia Minister of Energy and Mines appointed this panel to advise on four particular matters:

i) *"the scientific and technological considerations relevant to offshore oil and gas exploration, development and production;*
ii) *"further research or studies that should be undertaken to advance the "state of knowledge" on these considerations;*
iii) *"any specific government actions that should be taken prior to a decision on whether or not to remove the current provincial moratorium; and*
iv) *"any specific conditions or parameters that should be established as part of a government decision to remove the moratorium."*

Our response to the first two items forms the core of this report, based upon extensive reviews of previous reports and scientific literature, as well as a number of specially commissioned reports.

We identify a number of important knowledge gaps on which "further research or studies should be undertaken to advance the state of knowledge on these considerations", to allow for responsible "scientific and technological considerations relevant to offshore oil and gas exploration, development and production". In response to items (iii) and (iv) of our mandate, we provide some observations on the science and technology-based, but not inherently science and technology, issues of public policy related to matters such as capacity-building, regulation and monitoring.

The basic messages from this review are:

A. The prospective areas for oil and gas offshore British Columbia have many similarities with other jurisdictions around the world, and there is much to be learned from their experience. While BC is unique in the particular combination of components of its marine ecosystem, resources and coastal heritage, most of these can be found individually or in other combinations in other areas of offshore production. For example, eastern Canada and Alaska have a more severe climate; the Cook Inlet of Alaska is more confined; Alaska and California generally experience more severe earthquakes. Nevertheless, any offshore activities in British Columbia, at least in the inland waters between the Queen Charlotte and Vancouver Islands, would be near-shore activities, and any adverse environmental impacts would be quickly felt in coastal communities and habitats, and so would require rapid response and remediation.

B. Although the region is seismically active (Chapter 2), that is not considered to constitute any overwhelming risks for offshore exploration, development or production (Chapter 4).

C. Although risks of direct impacts on marine ecosystems may be small, there is poor understanding of potential long-term cumulative impacts on marine ecosystems of oil or gas spills or discharges from production activities, or of the impact of seismic exploration on marine mammals in particular and the ecosystem in general. These potential impacts may be of very low probability but may be catastrophic in the short term and carry serious and possibly irreversible consequences in the long term (Chapter 3).

D. Although the region is subject to intense storms as well as seismic activity (Chapter 2), present engineering knowledge, technology, industry practice and regulatory regimes can ensure that structures necessary for drilling and production activities are constructed to survive any foreseeable natural threats and to operate within acceptable standards (Chapters 4).

The panel is aware that in dealing with such matters as the cumulative impacts of human activities on marine ecosystems, the BC and Canadian governments have committed themselves to adopt a precautionary, ecosystem-based approach to integrated adaptive management. This panel endorses the Wingspread formulation of the precautionary principle, but also underlines the observation in the December 17, 2001 Lowell Statement on Science and the Precautionary Principle that emphasizes, "*The goal of precaution is to prevent harm, not to prevent progress*." (See Appendix 20 in Volume II of the Report)

The remaining issues identified above can best be addressed in a concrete setting in assessment of proposals for specific activities to be undertaken, not in abstract or general terms. The panel concludes on the basis of its review that the existing blanket moratorium has served its purpose, but has also set back our understanding of the coasts and oceans of British Columbia. It is time now to return marine scientific research to levels appropriate for a modern advanced society in general terms, and particularly as a basis for comprehensive, balanced and inclusive deliberation and assessment of specific proposals for BC offshore activity.

In short, the panel endorses the concerns expressed in the JWEL and preceding reports about the possible impacts of exploration or drilling activities on marine ecosystems and associated human communities, but sees this concern not as an argument for a general prohibition on all offshore activity—that is, for maintenance of a blanket moratorium—but rather as a need to examine specific proposals for any human activities, including offshore hydrocarbon-related activities, carefully with respect to their location, timing and impacts on particular species or components of marine ecosystems over the long term, and against broadly conceived alternative strategies (Chapter 5).

In order to consider the science and technology dimensions of any decision on whether to remove the moratorium, the Panel was obliged to ask what the moratorium actually is, how it could be removed, and what would be the situation subsequently. These questions are not straightforward, but we believe the short answer to be, as the dictionary says, that the present moratorium is a temporary prohibition or suspension of an activity, in this case of activities related to exploration for hydrocarbon resources offshore British Columbia. It appears that the current moratorium could be ended simply with a provincial decision to that effect, and a federal announcement agreeing that bids for licenses or applications for permits to undertake exploratory work in specific parcels of offshore areas would be considered.

Thus, in the panel's understanding of the situation, it seems there actually is today no legislated moratorium formally in place, either federally or provincially. For the panel, the central point seems to be that the concerns with this 'current moratorium' are all procedural and perceptual, not scientific or technical. The sooner the Province can move on to careful consideration of concrete proposals from identifiable proponents, the sooner we will get into constructive assessment of the issues based on the scientific, social and ethical realities of the sea in its actual setting.

Were the present moratorium ended, any further action would presumably await concrete expressions of interest in the development potential of specific sites. There would be several important things that would need to be done before there could be any expectation of investor interest, public or private, in proposals for exploration or development work in the BC offshore. While they are not strictly scientific or technical issues, they are germane to points (iii) and (iv) of our mandate, and we endorse the following preconditions that have been spelled out already by industry, First Nations, and others. These include:

- Development of an integrated federal-provincial regulatory framework. (The panel is aware that the Canadian Environmental Assessment Act and the British Columbia Environmental Assessment Act are undergoing review and amendment, and that the existing Canada-British Columbia bilateral accord on harmonized assessment expires in April 2002 and must be renegotiated.)

- Negotiation of a Pacific Accord that provides for agreed federal-provincial revenue sharing and other fiscal and management arrangements.

- Clear delineation of sensitive or vulnerable areas essential to preserve biodiversity and ensure ecosystem integrity, so that industry and others will be able to develop proposals for offshore activity with a clear initial understanding of any boundary conditions or restrictions.

- Strengthening and development of scientific and technical capacity to build baseline data and assess the state of the ecosystem, including natural and human components, and capacity also to undertake quantitative risk analysis, valuation and assessment spanning the full range of strategic options.

Thus, in the above context, the decision as to whether or not to remove the present blanket moratorium seems to be again one of procedure, more than science and technology.

To the general question posed to it, therefore, this panel concludes overall that, while there are certainly gaps in knowledge and needs for intensification of research as well as for a commitment to building comprehensive baseline information systems and to long-term monitoring, these do not preclude responsible deliberations on the questions related to offshore oil and gas exploration and development. There is no inherent or fundamental inadequacy of science or technology, properly applied in an appropriate regulatory framework, to justify a blanket moratorium on such activities. With a firm commitment to comprehensive assessment of any proposals for specific offshore activities as provided in the existing legislative framework, and continuing commitment to ongoing principles of adaptive management and sustainable development, the existing policies maintaining an ongoing moratorium on hydrocarbon exploration and development offshore British Columbia can responsibly be ended.

ACKNOWLEDGEMENTS

The logistic and editorial, as well as the 'non-scientific' aspect of this review have been supremely managed by The Maritime Awards Society of Canada. This is a registered charitable organization established to provide scholarships for Canadian university graduate students in marine and coastal affairs. At present MASC donations support scholarships at four universities: Victoria, Memorial, Dalhousie and Calgary. In addition, MASC has undertaken to provide a public service through annual workshops, public conferences, and other educational activities that are designed to raise awareness and enhance understanding of public policy issues related to the ocean in general and to Canada's coastal waters. The panelists are pleased to acknowledge the MASC contribution, and more specifically those of Mr. Justin Longo, Executive Director and Professor Douglas Johnston, Program Coordinator.

We are grateful to the many people who have generously provided us with reports, advice, information and opinions, and hope that they are all identified in the following list.

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- Dr. Richard Haedrich, Memorial University, Newfoundland
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- Dr. Michael Whiticar, School of Earth and Ocean Sciences, University of Victoria
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CHAPTER ONE INTRODUCTION

1.1 Background

On October 19th, 2001, the British Columbia Minister of Energy and Mines appointed this Panel to provide advice on four related matters (see Appendix 1 in Volume II of this Report):

- the scientific and technological considerations relevant to offshore oil and gas exploration, development and production;
- further research or studies that should be undertaken to advance the "state of knowledge" on these considerations;
- any specific government actions that should be taken prior to a decision on whether to remove the current provincial moratorium; and
- any specific conditions or parameters that should be established as part of a government decision to remove the moratorium.

At the same time this Panel was requested to take into account the findings of the report on the status of offshore development technologies that was produced, under contract with the BC Ministry of Energy and Mines, by the consultancy firm Jacques Whitford Environment Limited (JWEL), and made public in October 2001. In reviewing the JWEL report, this Panel has also undertaken to examine and comment upon several earlier reports that seem equally germane to its mandate:

- the **1986 "Offshore Hydrocarbon Exploration**" federal/provincial review of conditions that should attach to proposed programs of exploratory drilling off the coast of BC, and the extraneous events that led to the placing of moratoria on such development for the balance of the 1980s;
- the **1992/93 SPARK** review for the Science Council of British Columbia outlining the potential for technological and economic opportunities from ocean-related activities;
- the **1996 COFRI** report reviewing the 1986 recommendations in the new context of another decade;
- the **1998 AGRA** report re-examining the continuing moratorium, on which was based the **2001 JWEL** report, again reviewing the question of the continuing provincial moratorium;
- reports of the BC Northern Development Commission;
- a compendium of papers, reports, notes and abstracts compiled as the "**Briefing Book**" for the Workshop "Exploring the Future of Offshore Oil and Gas Development in BC: Lessons from the Atlantic", Simon Fraser University, May 17-18, 2000;
- a report from the Maritime Awards Society of Canada, "**B.C. Offshore Hydrocarbon Development: Issues and Prospects**", released in early 2001.
- numerous reports and documents on the **web-sites** of organizations identified in Appendix 2.
- and not least, a number of **interviews and special reports** commissioned especially for this review, as identified and/or provided in the Acknowledgements and Appendices.

It is clear from the first two terms of reference that this Panel should concentrate chiefly on the offshore-related research literature of the science-and-technology community. However, the Panel interprets the third and fourth terms of reference as somewhat broader in scope, permitting technical or cognate considerations and recommendations that seem relevant to a government decision whether or not to remove the current provincial moratorium. Some of these considerations are incorporated into the main text of this Report, and others are included in Volume II of this Report (the Appendices). The Panel's recommendations are brought together in Chapter Five.

1.2 The General Context

Despite the vastness of its interior across the breadth of North America, Canada is a coastal nation. As possessor of the longest coastline, Canada has an enormous, virtually unequalled, stake in ocean affairs. During the seminal, law-making negotiations beginning in 1967, and continuing throughout the Third UN Conference on the Law of the Sea (1973-82), Canadian diplomats achieved impressive gains through global consensus on a massive extension of coastal state jurisdiction. As a result, Canada is the beneficiary of the second largest continental shelf, as defined under the new international law of the sea.

British Columbians have always looked to the sea for sustenance and transport. Prior to contact with Europeans, the original coastal communities of these territories nurtured a special cultural relationship with the spirits and resources of the Pacific offshore. In more recent times the people of BC have developed one of the largest ports in North America, and, taking advantage of their commercially strategic location, have created important modern industries based on vessel and underwater technologies.

Table 1-1. Estimated Reserves in Sedimentary Basins in British Columbia (Source - Preliminary Report of the Energy Policy Task Force)

Basin Name	Gas (TCF)	Oil (million barrels)	Coalbed Methane(TCF)
Western Canada Sedimentary Basin	50.0	265	60.0
Whitehorse/Bowser	8.3	2500	8.0
Quesnel/Nechako	9.5	5100	1.0
Fernie	0.4	88	19.0
Georgia/Vancouver Island	1.0	0	6.5
Total	70.3*	7953	94.5

* The total for this column differs from the arithmetic sum of the above numbers due to modelling discrepancies.

Proposals for an offshore oil and gas industry off the coast of British Columbia have been raised for half a century. It may be worth noting that BC already produces more than twice the volume of natural gas than it consumes, with significant reserves estimated for a number of on-land sedimentary basins (Table 1-1, Figure 1-1). In the past year the total volume of provincial oil and gas revenues exceeded $1.8 billion, with approximately $1.3 billion derived from natural gas royalties. In 1999 approximately 14,500 people were directly employed by the oil and gas industry in the province. So it is logical to consider BC's offshore hydrocarbon resources as a possible extension of one of its most valuable, job-creating industries.

The Geological Survey of Canada has estimated that in the offshore sedimentary basins (Figure 1-1) there may be as much undiscovered hydrocarbon reserves as 9.8 billion barrels of oil (BBL) and 25.9 trillion cubic feet

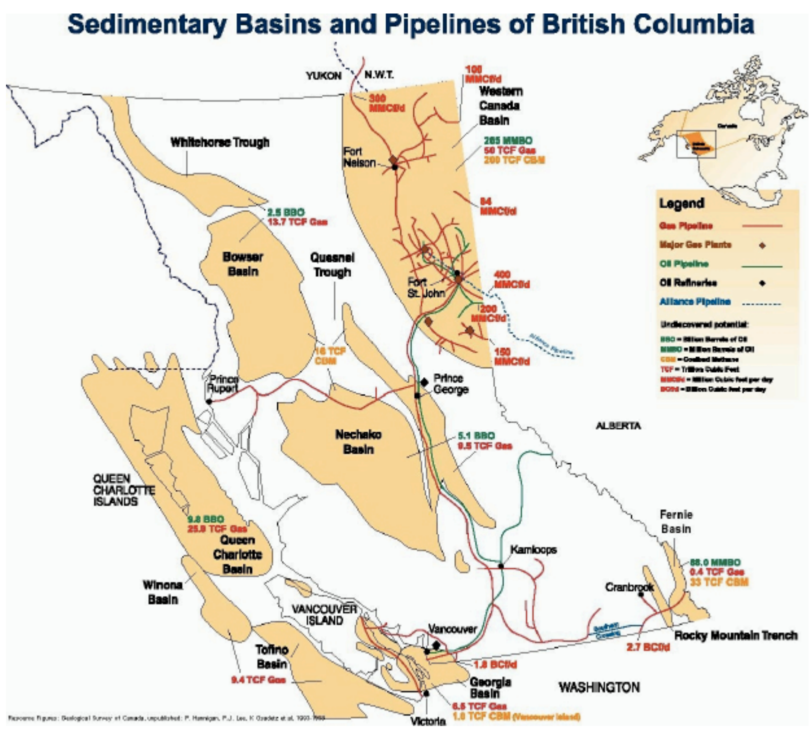

Figure 1-1. Map showing on-land and offshore sedimen-tary basins and pipelines of British Columbia (Source: Preliminary Report of the Energy Policy Task Force)

(TCF) of gas in the Queen Charlotte Basin, 9.4 TCF in the Tofino and Winona Basins, and 6.5 TCF of gas in the Georgia Basin. Such estimates can only be confirmed by drilling, which must be preceded by and based upon sophisticated scientific and technical surveys, which in turn will only be carried out if permitted by the governments of British Columbia and Canada. The first step in such a process would be for the British Columbia government to decide whether or not to remove the moratorium, which has restricted such surveys and subsequent exploration activity since 1959.

Given the science-and-technology focus of its mandate, the Panel has avoided excursions into matters of policy, but since the line between technical and non-technical is sometimes thin and wavering, observations on public policy issues referred to in the terms of reference are offered from a science-and-technology perspective, mostly in Chapters Five.

Nevertheless, we must note that oil pollution of the oceans derives not from offshore oil and gas exploration and development activities, but from shipping and land-based activities (see Figure 1-2). The Province of British Columbia's November 1989 *Report to the Premier on Oil Transportation and Oil Spills* (commonly referred to as the "David Anderson Report"), and many others world-wide, correctly recognized the importance of shipping as the main agent of marine oil pollution and recommended that only double-hulled tankers should be used for transport of oil and gas. This report also led to a renewal of the moratorium. This Panel feels that attention would more appropriately be directed to sub-standard shipping, rather than to the much more intensely regulated offshore oil and gas regime.

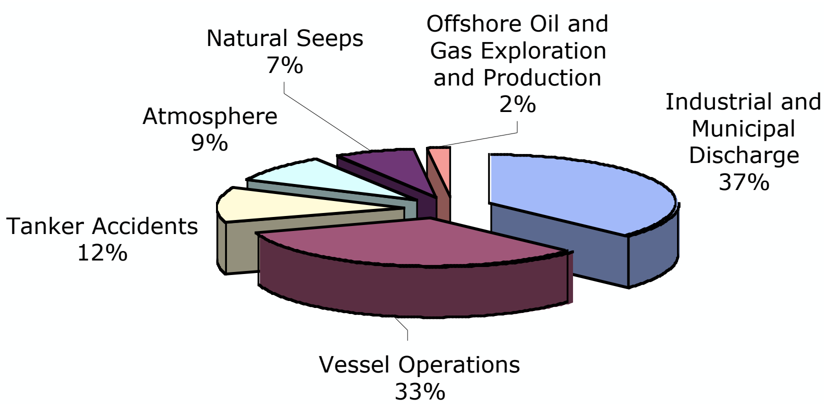

Figure 1-2. Sources of oil pollution in the oceans (from JWEL, 2001)

1.3 The Relevance of Offshore Development Experience in Other Districts

A conscientious re-examination of the offshore moratorium issue in British Columbia should take stock of experience elsewhere. Since the late 1930's, when the era of offshore oil production began, thousands of wells have been drilled in relatively shallow and not-so-shallow waters, covering oil-bearing areas of the continental shelf in virtually all regions of the world. For over 60 years the oil and gas industry has been active in the offshore, and is now producing in all climate zones, in many kinds of geological, oceanographic and climatic conditions, and in a wide variety of coastal ecosystems. There is no doubt that such activities have had negative impacts, environmental and otherwise, particularly in the earlier years, due to accidents, carelessness, and a plain lack of knowledge. It is also true that new knowledge, new designs, sophisticated regulation and greater public awareness and concern have continued to result in dramatic advances and improvements in offshore exploration and production, particularly over the last decade. These have, however, been either of a generic nature and general applicability to any region including BC, or of a site-specific nature, essential and useful only to the particular site of exploration or production.

The immediate areas of interest for offshore oil and gas exploration in BC are the Queen Charlotte Basin (QCB), and those to the south (see Figure 1-1). Coastal conditions in these waters are variable, ranging from dynamic beaches with extensive sand flats to steep cliffs and deep fjords. Similar conditions are found in other regions, and we note in particular four coastal regions which seem to have particular relevance to the offshore development issues in British Columbia.

First, the Canadian oil industry, the federal government of Canada, and the provincial governments of Newfoundland and Labrador and of Nova Scotia have, for more than thirty years, been acquiring first-hand experience in the offshore waters of Atlantic Canada in:

- scientific, environmental and technical research;
- monitoring and assessment;
- technological applications;
- local community planning and development;
- the design and implementation of strict regulatory regimes governed by joint federal-provincial agencies established for that purpose; and
- day-to-day operational arrangements worked out between these agencies and the private sector.

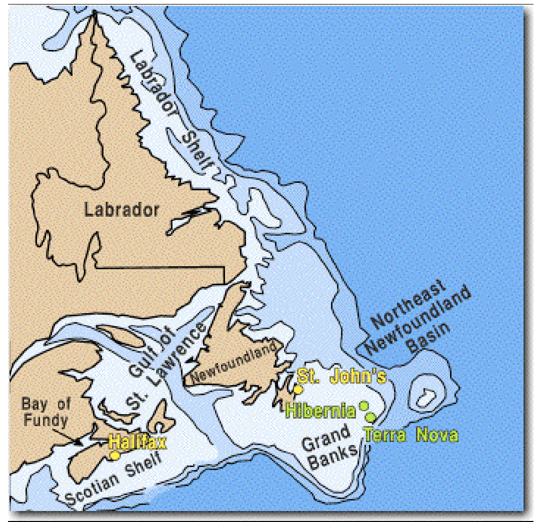

Figure 1-3. Setting of offshore oil and gas plays in eastern Canada (Source CNOPB)

The modern era of oil and gas development in Atlantic Canada began in the early 1960s. Since then more than 300 exploratory and development wells have been drilled in Atlantic Canadian waters. Cumulatively, this drilling and seismic activity alone has generated nearly $8 billion in investment expenditures and has resulted in the creation of more than 100,000 jobs throughout the region. More than $14 billion has been committed to the development of upstream and downstream oil and gas projects since 1990.

Offshore Atlantic Canada is now firmly established in Canada's petroleum sector, and some of the world's major oil and gas companies have embarked upon aggressive and ambitious exploration and development programs in these waters. Since 1995 more than $700 million in exploration commitments have been announced for four regions within the Atlantic Canadian offshore: the Jeanne d'Arc Basin, Scotian Shelf, Sub-Laurentian Basin and the St. Pierre Bank (Figures 1-3 and 1-4). While there are differences in geological and other environmental aspects of the Atlantic offshore, it is of critical importance in providing a well-established regulatory framework on which to build for any BC offshore oil and gas exploration and development.

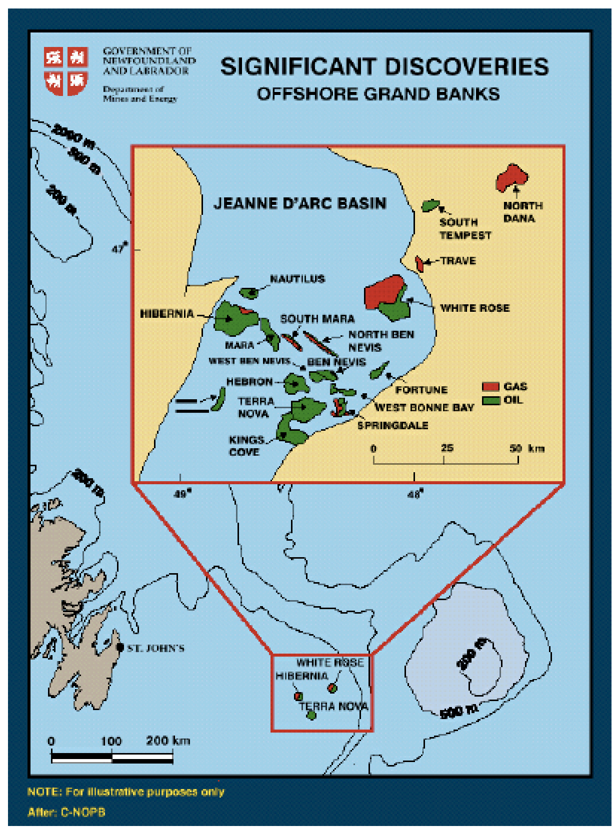

Figure 1-4. Detail of significant discoveries for Newfoundland and Labrador. (source CNOPB)

Second, and more directly relevant, it is important also to learn from the experience off the coast of Alaska, particularly the Cook Inlet, which is so close and, despite some significant and more severe conditions such as ice, snow, and glacial outwash, has so many direct geological and environmental similarities. Production began in Cook Inlet in 1957, mostly involving offshore platforms with pipelines to terminals on both sides of the Inlet. Total petroleum resources of the Cook Inlet Basin have been estimated about 2.2 BBL of oil and 10TCF of gas, with individual fields comparable in size to those projected for the QCB. Other production in Alaska was subsequently extended to the North Slope, where 13 BBL have been produced since 1973. More recently exploration and development activities have been expanded to the offshore waters of the Beaufort Sea, with first production at

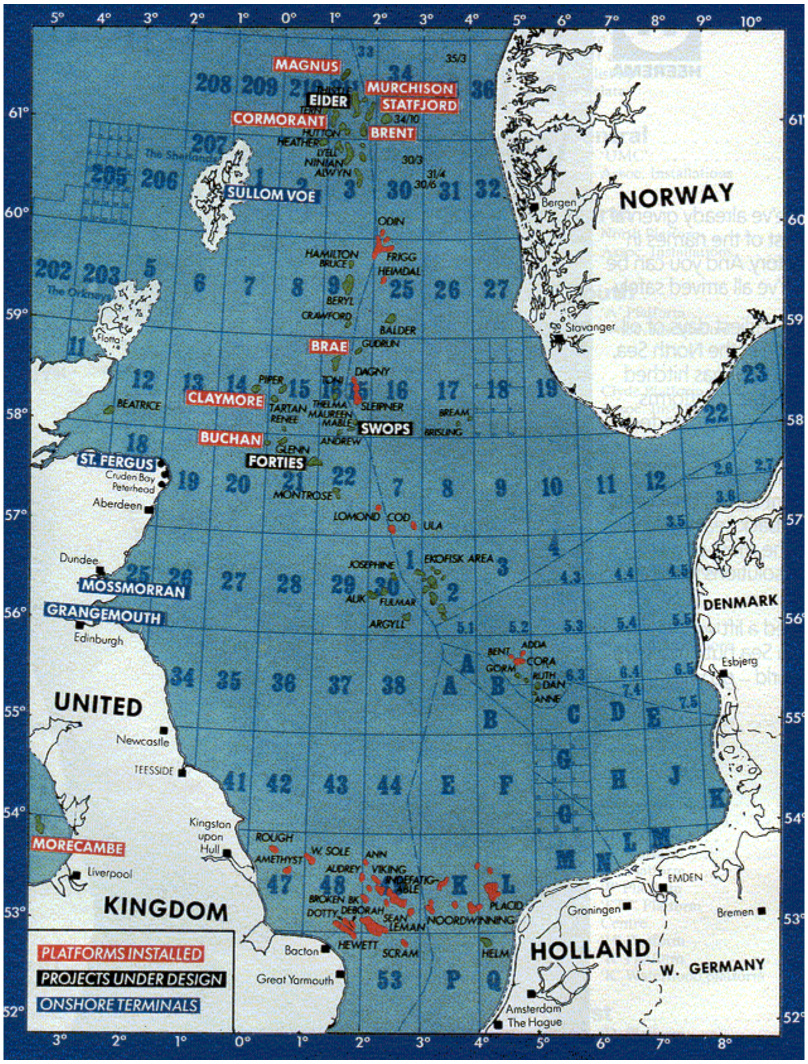

Figure 1-5. Oil and gas activities in the North Sea (from Mathew Hall Engineering, in "The North Sea Platform Guide" Oilfield Publications Ltd.)

the BP Northstar Project on November 1 of 2001.

Third, oil and gas production in the state of California occurs in an earthquake-prone regime that has substantial geological similarities to that of BC, and the Queen Charlotte Basin in particular. These characteristics are reviewed in Chapter Two.

Fourth, the most comprehensive regional offshore operating experience of relevance to BC is almost certainly that which has accumulated since the 1960's in the North Sea (Figure 1-5). As this experience has been incorporated into the Atlantic Canada regulatory regime, we do not give it further attention in this review, other than to point out that the waters of the Queen Charlotte Basin between Dixon Entrance and Hecate Strait experience weather and hydrographic conditions comparable with those of the North Sea.

1.4 Roles of Ocean Science and Technology

Some idea of the complexity of the science and technology that is required at each stage from exploration to production of offshore oil and gas is given in Figure 1-6, and Appendix 4, where some of these terms are defined.

Because the field is so vast and our time was limited, we have necessarily been selective in conducting a review of this kind. Nevertheless, we note that decision-making is based on a sound understanding of science and technology at all phases in any current offshore production area (see Appendix 5), from the preliminary phase prior to the first decision, whether or not to permit seismic studies and exploratory drilling, right through all the subsequent stages of planning, project design, assessment, installation, production, and post-production decommissioning of platforms and other facilities.

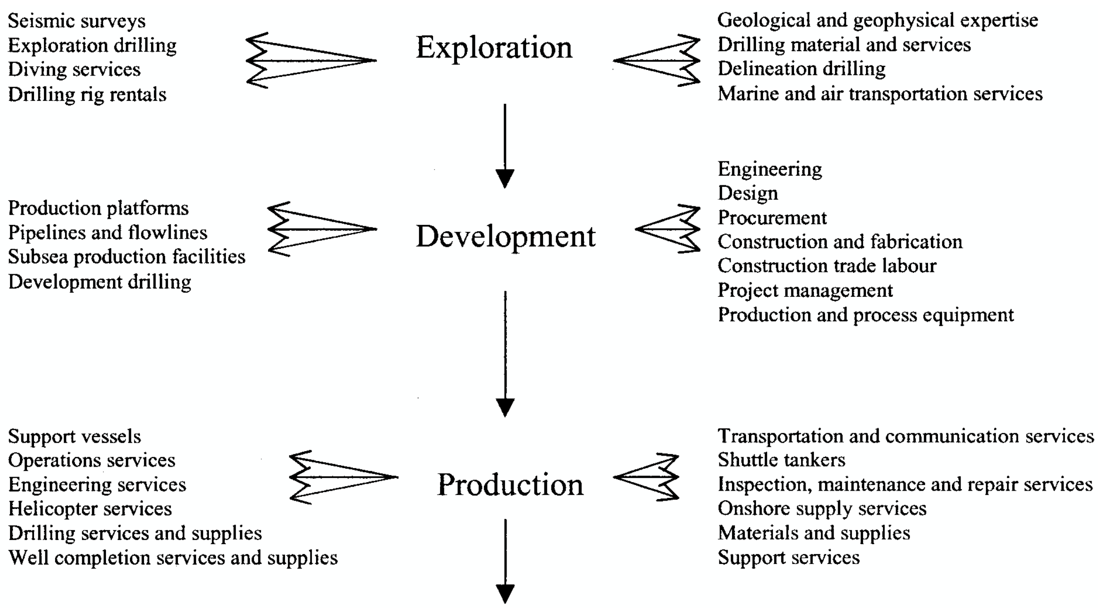

Figure 1-6. "Oil and Gas Value Chain" and technical expertise required at the up-stream stages of exploration, development and production of offshore oil and gas. (Source: NOIA, 1998)

The review by this Panel belongs to the preliminary phase, prior even to any start of exploration. At later stages of the process, it will become necessary to integrate and interpret more closely the results of regional and site-specific research that would need to be done in order to provide specific scientific foundations for risk assessment and appropriate design. Regimes of regulatory requirements will have to be framed around what is known about the local resource, the scale of production proposed, the types of technologies to be deployed, and the nature and vulnerability of the affected ecosystem. If there is a decision to lift the moratorium and proceed further, a long and continuous series of more focussed scientific and technical evaluations will become an integral part of the entire process, which, judging by the experience in other regions, would involve at least the stages of approval as set out for the Newfoundland offshore (Appendix 5).

However, at this preliminary stage, when the extent and locations of the offshore resources are still uncertain, and the Panel has been asked to address the blanket moratorium, it is necessary to conduct a review primarily within a generic frame of reference to describe the state of knowledge in offshore-related science and technology. Reference to regional and site-specific research is made only with a view to identifying knowledge gaps, setting research priorities, and determining measures that should be taken to ensure that technically appropriate standards will be achieved and maintained in the event of a government decision to proceed with the lifting of the BC moratorium.

CHAPTER TWO PHYSICAL SCIENCES

The successful exploration for oil and gas and the subsequent development and production stages depend upon a solid understanding of the geological environment, particularly the formation and development of hydrocarbon-bearing sedimentary basins and the geotechnical characteristics of the production site. Much of our understanding of the offshore sedimentary basins shown in Figure 1-1 has come from on-land geological mapping, which was extrapolated into the basins to aid in the interpretation of information obtained by more remote means. Within offshore basins, where most geological information is of necessity obtained by remote or proxy measurements, virtually all branches of the physical sciences - physics, chemistry and mathematics - are brought to bear, particularly through their specific applications in geophysics, geochemistry and information processing. These requirements in BC have to date depended upon the cooperation of many scientists in federal, provincial and university laboratories, particularly in the absence of any industrial involvement. Definitions of some of the more important terms are provided in Appendix 4, although we recognize that a report of this nature necessitates specialized language to some degree.

As can be seen in Figure 1-1, there are several offshore sedimentary basins in BC. While the others are briefly reviewed below, the main focus of early attention, and therefore of this Report, is on the Queen Charlotte Basin.

2.1 Geological Environment

2.1.1 The Georgia Basin

Limited drilling has been conducted, without commercial success, within the onshore regions of the Georgia Basin, both on eastern Vancouver Island and in the Fraser Valley (Figure 1-1). Of the 122 wells drilled since the turn of the century, most were water wells and only 16 reached depths in excess of 1,000 metres. Therefore, most of the basin's potential remains unevaluated. Recent resource assessment by the Geological Survey of Canada has estimated that as much as 6.5 TCF of in-place natural gas exists in three conceptual play types within the confines of the Georgia Basin, about two-thirds (3.55 TCF) being in Canada and one-third in Washington state. Of this, the median estimate of gas potential for Canada would be about 1.39 TCF. Available geochemical information indicates there is little potential for oil. One should be aware that there is some disagreement about these estimates, others suggesting that they could be substantially lower.

2.1.2 The Winona-Tofino Basin

The Tofino assessment region of the Geological Survey of Canada combines both the Winona and Tofino Basins (Figure 1-1). The main potential is indicated for the Tofino Basin from on-shore gas shows on the Olympic Peninsula, and is estimated at a median value to be 9.4 TCF of gas in-place in a single defined play type.

2.1.3 The Queen Charlotte Basin (QCB)

The QCB (Figure 2-1) is the largest Tertiary basin on Canada's West Coast, representing an area of approximately 80,000 km^2 (500 km long, 150 - 200 km wide). It includes (i) Queen Charlotte Islands; (ii) offshore areas of Hecate Strait; (iii) Queen Charlotte Sound; and (iv) Dixon Entrance.

The QCB is bounded to the south and north by Vancouver Island and Alaska. It is terminated to the east by the Coast Plutonic Complex and to the west by the large Queen Charlotte Fault that separates the North American Plate from the Pacific Plate. To date, 18 exploration wells have been drilled in the QCB, with 8 offshore in the Hecate Strait and 10 on Graham Island. These wells, combined with the regional geophysical seismic studies and land-based geology, are the basis of the prospectivity projections. Estimates are based on abundant reservoir strata, presence of potential source rocks, numerous structural traps, and common occurrence of oil and gas shows.

The QCB and the Queen Charlotte Islands are thought to have substantial petroleum accumulations. Estimates of the oil in place average around 400 million cubic metres or 2.5 billion barrels (BBL), and natural gas is estimated to be around 565 billion cubic metres or 20 trillion cubic feet (TCF) (Table 2-1). Based on National Energy Board figures, these potential oil and gas resources are significant on a national scale (Table 2-1), although the accuracy of these estimates would be known with certainty only after drilling.

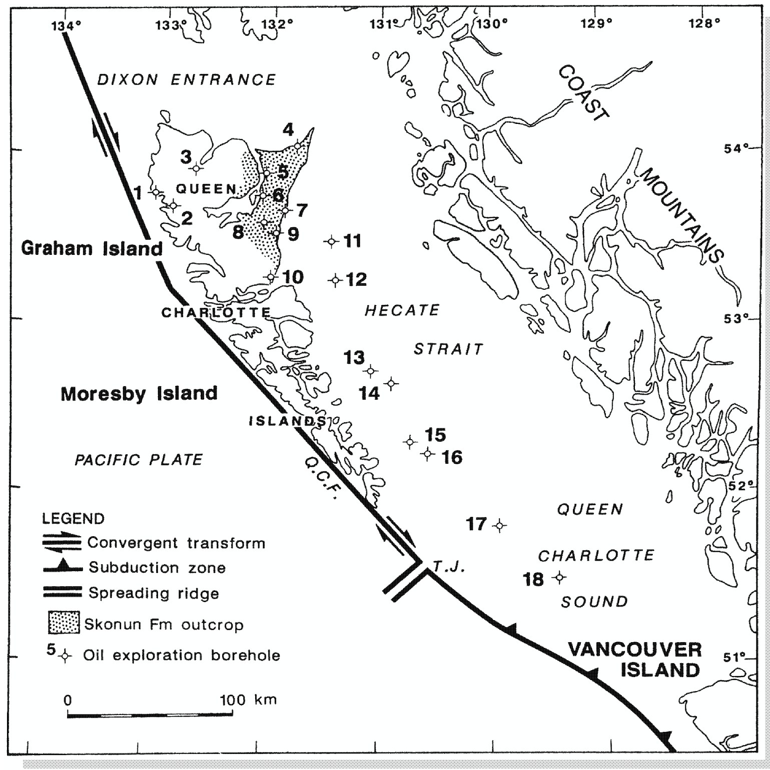

Figure 2-1. Location map of Queen Charlotte Basin (Hecate Strait) showing the major tectonic features and 18 previous drillhole locations (Appendix 6).

Table 2-1. Comparison of Discovered Marketable (D/M) and Ultimate Potential Resource (UR) hydrocarbon resources of different Canadian regions (Appendix 6)

Location	D/M Oil (10^6 m^3)	UR Oil (10^6 m^3)	D/M Natural Gas (TCF)	UR Natural Gas (TCF)
Queen Charlotte Basin	400*?	730*?	20*?	26*?
A. Canada	4,555	9,177	198	733
B. WCSB	2957	3,623	159	335
C. Frontier	528	4,255	33	303
D. BC conventional	129	184	20	50

**? = Speculative estimation; WCSB = Western Canada Sedimentary Basin.*

Geological Features of the Queen Charlotte Basin

The Queen Charlotte Basin is expected to contain 80% of the region's total petroleum resource volume and nine of the ten largest fields. Geographically speaking, the most prospective areas are southern Hecate Strait and Queen Charlotte Sound, followed by eastern Graham Island, northern Hecate Strait and Dixon Entrance (Figure 2-1). High potential for southern Hecate Strait is based on abundant Neogene reservoir strata, numerous large structural features, and the presence of Neogene and Jurassic source rocks. Outside the basin margins, western Graham Island and adjacent shelf areas have some potential targets, but very little petroleum potential is expected overall in the onshore/inter-island areas of the southern Queen Charlotte Islands and adjacent Pacific continental shelf.

Over 50 oil, tar, or natural **gas seeps** have been identified onshore in the Queen Charlotte Islands. These seeps are widespread and exposed in road-cuts, quarries and beach outcrops, with bitumen and tar as the main products. Lawn Hill on the southeast coast of Graham Island contains one of the most areally extensive surface **oil seeps**, and strata in the surrounding or basin-ward areas is considered highly prospective for conventional oil accumulations. Shows at King Creek include oil staining, lighter oils, natural gas seeps and volatile petroleum hydrocarbons. Hydrocarbons occur from Otard Point to the head of Otard Bay, where oil films are common on streams and pools that drain this area. Subsurface shows were encountered in several wells, most notably oil staining in Neogene sandstones of the Tow Hill (onshore) and Sockeye B-10 (offshore) wells.

Shallow **gas deposits and seeps** in the Queen Charlotte Basin are distributed over most of Hecate Strait and occur in most types of surficial sediments except where glacial till is at the surface. Thick Holocene age (<10,000 years) silt deposits contain extensive amounts of biogenic gas. Gaseous sediments are also found along the base of underwater terraces, including the northern portion of the main trough and within the northern trough into Dixon Entrance. Sediments containing gas are generally near the contact of glacial till with a sand and gravel unit, and gas appears to migrate along the boundary. Gas-charged sediments are also present on the western side of Hecate Strait, and along the axis of Hecate Strait. Deep gas accumulations in Neogene strata have been identified on conventional seismic profiles in several offshore locations, several at a stratigraphic level similar to the Sockeye B-10 well show.

Faulting and Seismicity in Queen Charlotte Basin

Earthquakes from the western boundary of the Basin, the Queen Charlotte Fault, are generally of low intensity, but one as large as magnitude 8.1 has been recorded (Figure 2-2), with considerable shaking in the adjacent plate margin. A detailed analysis of the seismic pattern, at current levels of understanding, is given in Appendix 8.

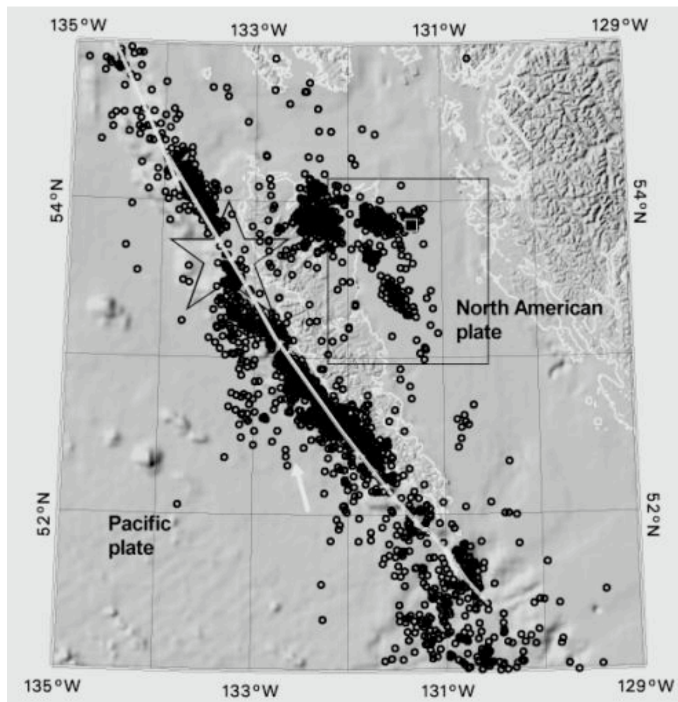

Figure 2-2. Microseismicity from Bird (1997) plotted on bathymetry; each event is shown as a single uniform-sized circle. Queen Charlotte Fault (white line) is the plate boundary between the Pacific and North American plates; the arrow indicates relative plate motion. Magnitude 8.1 event is shown as a star. (Appendix 8)

Detailed information for micro-earthquakes is best for the period of 1982 to 1996 when extra stations were placed in the region. Whether that 14-year time slice is representative of the last 100 years and can be reliably used to predict the next 10 to 50 years of earthquake activity is unknown. Geological, morphological and paleomagnetic data of the Queen Charlotte Islands have been interpreted as indicating that deformation has proceeded from south to north in the last few million years, suggesting that one could reasonably expect seismic activity to remain concentrated in the north. Much more detailed information would be required in order to assess the possibility of earthquakes occurring elsewhere in the weak and regionally stressed crust underlying the Queen Charlotte Basin.

Within the regime of any “normal” earthquake risk, the Canadian Standards Association has design standards for offshore structures, but these are currently undergoing review to be consistent with the format of the-next generation seismic hazard maps. Regulators may require more detailed seismological or geotechnical investigations to define final engineering design criteria for structures associated with offshore production (See Appendix 4).

2.1.4 Comparison of the Queen Charlotte Basin with Other Offshore Basins

Cook Inlet, Alaska

Cook Inlet, on Alaska's southern coast (Figure 2-3), has been an area of active hydrocarbon exploration and production since1957, when the first field was discovered at Swanson River. Production is from six oil fields (Trading Bay, McArthur River, Middle Ground, Granite Point, Beaver Creek, Swanson River) and three gas fields in upper Cook Inlet. Oil fields occur near the basin margin, both on-shore and offshore. Total petroleum resources (produced and remaining) in Cook Inlet are 2.2 BBBL of oil and 10 TCF of gas, the largest being the McArthur River oil field (570 MBBL) and the Kenai gas field (2.3. TCF), both of comparable magnitude to the largest fields predicted for Queen Charlotte Basin.

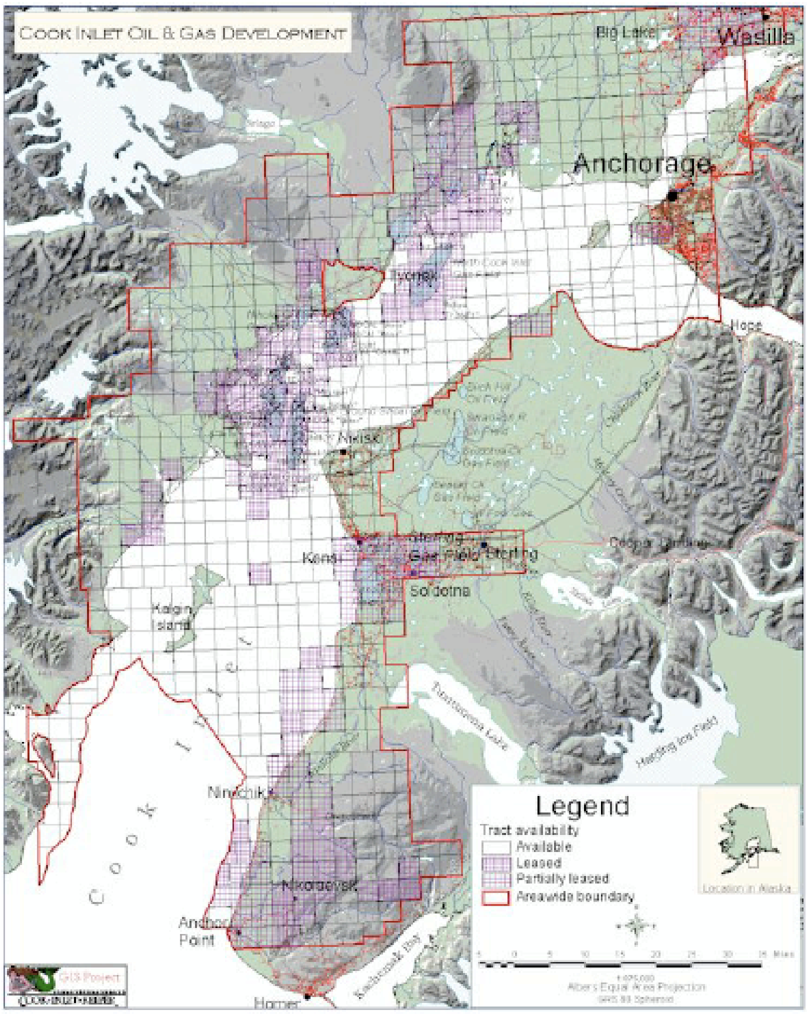

Figure 2-3. Cook Inlet, Alaska, showing the oil and gas tracts available for new leases, fully leased, or partly leased, all within the boundary outlined in red (from Cook Inlet Keeper http://www.inletkeeper.org/).

"Forty years of scientific studies, as well as continuous monitoring by government agencies and by the Cook Inlet Regional Citizens Advisory Council, show no adverse effects on Cook Inlet, whose waters support healthy sport and commercial fisheries. Even Greenpeace, which conducted a study near the Trading Bay Production Facility, found no evidence of industry-related contamination." … "In short, there has been no documented evidence of any long-term degradation to the environment from more than 40 years of industry activity in Cook Inlet." – Alaska Oil and Gas Association, Current Issues, 1998 (http://www.aoga.org/)

Despite some significant differences, (e.g. more severe winter climate, and glacial sedimentation at the head of the Inlet). Cook Inlet has more geological and environmental similarities to the QCB than any other offshore oil and gas basin. It is a large estuary running northeast from the Gulf of Alaska for about 360 km, and ranges from about 80 km wide at its mouth to an average of 25 km. Some of the most extreme tides in the world, approaching 14 metres, can generate currents exceeding seven knots. In winter, thick slabs of sea ice move with the tides and currents. It is subject to the most extreme of winter storms. Oil and gas production occurs both on and close to shore. Alongside the oil and gas exploration and production are major commercial fisheries, including five species of Pacific salmon, numerous species of bottom fish, crab, clams and shrimp. The area is known for its abundance of seabirds and sea mammals, and wilderness recreation and sports fishing abound.

The comprehensive and detailed geological / geophysical / geochemical understanding of the Cook Inlet provides a good basis for comparison with the much less studied QCB, which shares many geological similarities.

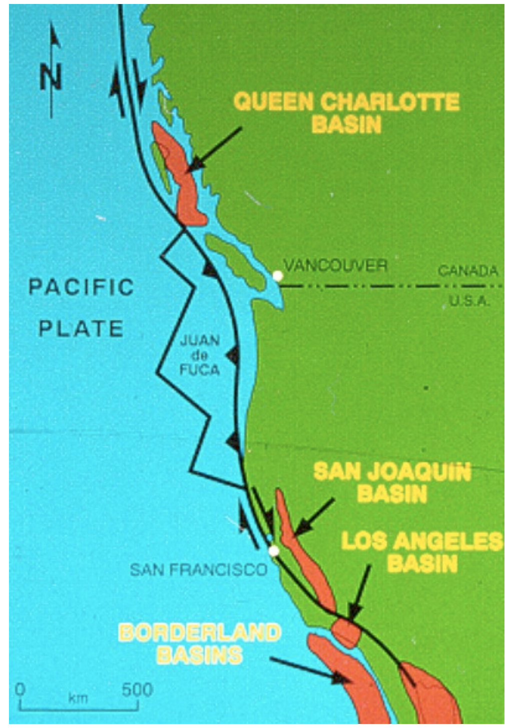

Figure 2-4. Outline of Pacific and North American plate boundaries (See Appendix 8 and 9)

California

The Southern California basins are of particular interest to this review, because their similar tectonic history and structural characteristics result in comparable seismic (earthquake) activity (see Figure 2-4).

Tectonically, both the Queen Charlotte region and California are dominated by a transform plate boundary between the Pacific and North American plates. In California the plates are moving at a relative rate of 40 km/Ma (million years), that mainly carried by the San Andreas Fault, but also by a number of secondary faults. Off British Columbia the rate is 48 km/ per million years, almost entirely carried by the Queen Charlotte Fault west of the QC Islands. In California slight compression across the plate boundary has folded and faulted the adjacent basins into structures that trap hydrocarbons. The same kinds of structures are observed in Hecate Strait.

Hundreds of scientists have been detailing California's geology and tectonics since the 1800's. Over 700 seismometers monitor every temblor; and in some areas events can be mapped with an accuracy of metres, resulting in new insights into how faults behave. In contrast the Queen Charlotte region has only six permanent seismograph stations; and the depth distribution of earthquakes on the Queen Charlotte Fault is entirely unknown. Stations lie east of the Fault and do not provide a good geometry to determine focal depths.

California has a long and rich history of utilizing and producing oil and gas (Figure 2-6). The first commercial well began production in 1876. Since then production has varied, reaching a peak in 1985 at 423.9 million barrels of oil. Oil wells tend to be in southern California and purely gas wells in northern California. In 2000 there were 46,799 oil wells and 1,169 gas wells producing hydrocarbons from 288 fields; and total production was 307.4 million barrels of oil and 379.1 billion cubic feet of gas. Altogether 1,412 offshore wells accounted for 17.6% of the total oil production and are largely found off southern California in a seismically active region.

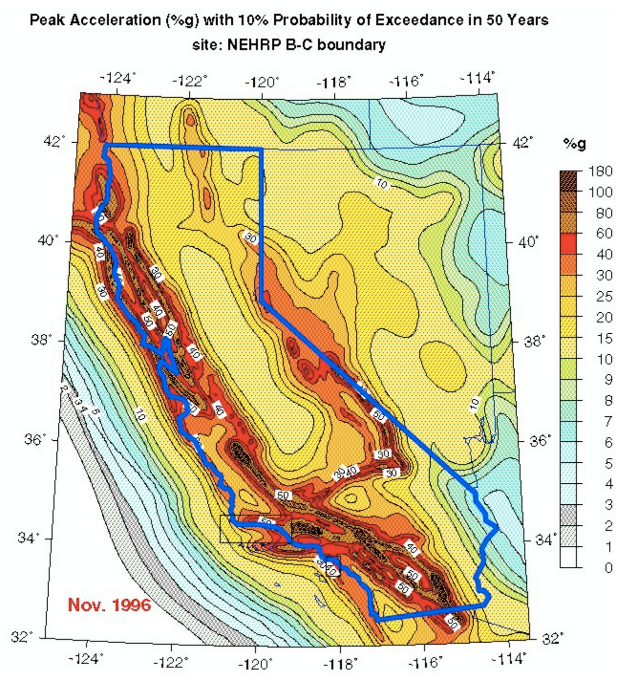

Figure 2-5. Hazard map for California and Nevada. Most of California's offshore oil production occurs in high-risk areas (Appendix 9).

Damaging earthquakes have also been a part of California's history, killing hundreds of people and causing hundreds of millions of dollars of damage. In available accounts of damage caused by major earthquakes, damage to wells and ensuing oil spills is not mentioned, and an official from California's Division of Oil, Gas and Geothermal Resources, which regulates drilling and production of wells, could recall no instance of damage done to offshore production facilities by an earthquake. An earthquake near Coalinga (Figure 2-6) (M=6.7, 1983) caused minor damage to storage tanks, which were stressed by sloshing fluids. In any event these tanks are surrounded by berms to protect against the more imminent danger of leakage from corrosion. However, nearby houses and commercial buildings of unreinforced adobe and concrete were heavily damaged, leaving 1,000 people homeless.

Spills from blow-outs were not unusual in the early days of drilling, but the last major blow-out offshore occurred in 1969 off Santa Barbara in federally regulated land. The state placed a temporary moratorium on drilling offshore until stricter regulations were in place to prevent another such occurrence. Since that time exploration and production have been highly regulated but active at a modest level.

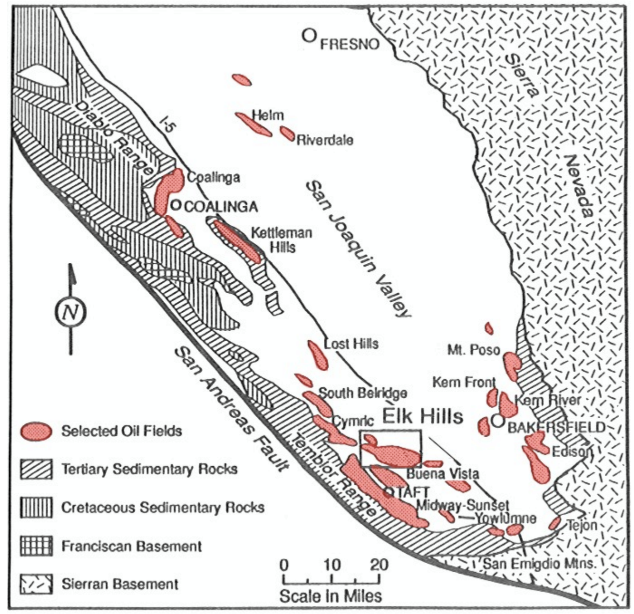

Figure 2-6. Outline of San Joaquin sedimentary basin highlighting selected oil fields (from Reid and Wilson, 1990). Note that many are within 20 miles of the San Andreas Fault. 38,733 wells within this entire region produced 217.3 million barrels of oil or 71% of California's oil in 2000. (Appendix 9)

Other Canadian Offshore Basins

No direct geological analogies can be drawn between the Queen Charlotte Basin and other Canadian oil provinces. In ranking median recoverable resource estimates, the Queen Charlotte Basin with 2.6 BBBL of oil and 20 TCF of gas has a gas endowment comparable to the Scotian Shelf (18 TCF) and oil reserves of about half those in the Jeanne D'Arc Basin (4.7 BBBL). The Jeanne D'Arc Basin also contains an estimated 13 TCF of gas. All these basins are overshadowed by a potential 7 BBBL of oil and 68 TCF of gas projected for Beaufort-MacKenzie Basin in the Canadian Arctic.

2.1.5 Natural Gas Hydrates

Natural gases such as methane, ethane, and propane typically occur as a gas phase. However under special conditions these gases can combine with water to form a solid "gas hydrate", (or "clathrate"). These gas hydrates represent a tremendous reserve of natural gas, especially methane, globally estimated to be 6×10^5 TCF, twice that contained in conventional reservoirs.

Deep-sea gas hydrates off the west coast of Vancouver Island have been studied by seismic techniques and by the International Ocean Drilling Program (ODP) boreholes. They occur in a 30 km-wide band beneath much of the continental slope, and are thought generally to represent mixtures of pure methane and seawater.

If the estimated hydrate concentration at the ODP site is taken as representative of the areas of the Vancouver Island continental slope, where there is a strong bottom seismic reflector over an area of 30 km by 200 km, the total gas is about 350 TCF. This would be a 200-year supply for Canada at the present rate of natural gas consumption, although it is unlikely that the economic or technical parameters will be right for exploitation of these resources in the immediate future.

Nevertheless, it is important to understand the occurrence and characteristics of such deposits because, as explained in Appendix 10, they:

- can pose geotechnical concerns, such as large-scale submarine slumping;
- can cause difficulties during drilling operation due the possibility of over-pressured gases beneath the gas hydrate stability zone; and
- can be a major factor in greenhouse gas storage and climate change.

2.1.6 Overview of Geologic Hazards to Offshore Petroleum Development[1]

In the current context, geologic hazards are those conditions or active processes that pose a potential threat to petroleum exploration or development activities, or to the longer term security of sea-floor production installations (e.g., wellheads, pipelines). In many instances these hazards are interrelated (e.g., earthquakes and slope stability) and in others can be related to oceanographic conditions (waves and currents, and sediment mobility). Appendix 11 presents a detailed review of the important geologic hazards that exist in various areas on the exposed continental shelf off British Columbia. These include: bedrock outcrops; Holocene faults and associated seismicity; boulder beds; sediment mobility (large bedforms in high wave and current regions); mass wasting (underwater landslides); steep slopes; shallow gas; and dynamic coastal processes. This is provided within a scenario of offshore development and production with associated pipelines, which traverse the shelf to an unspecified coastal site.

2.2 Initiatives in Coastal Oceanography

Understanding the oceanographic environment is critical at all stages of offshore operations, from exploration to production, both for the safety of operations and for the protection of the natural environment. The field of oceanography is broad and deep, and is marked today by a number of excellent international, national and BC initiatives, which will serve to strengthen our ability to monitor and manage offshore and coastal zone activities. A brief review of just a few will serve to illustrate the point.

2.2.1 International – GESAMP

The Joint **Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP)** was established in 1967 by a number of United Nations Agencies. Its purpose was to provide advice to the agencies and, through them, to their member governments on a problem that was just beginning to be recognized as a major threat.

In a synopsis of current problems facing the world's oceans and the progress made in addressing them, the report of the 28th GESAMP session notes that, despite some localized successes, degradation of the oceans continues on a global scale. Persistent problems include pollution by sewage (especially pathogens), chemicals and nutrients, as well as unrestrained coastal development and over-exploitation of marine resources. On the other hand, concerted action at national and international levels has reduced the quantities of oil discharged from ships and there is convincing evidence that in certain areas better management of land-based activities has led to cleaner beaches and bathing water and seafood that is safer to eat. The report further concludes that: "Although oil is a highly visible pollutant and when spilled in large quantities can cause severe local effects, it is not regarded as a significant pollutant on global scales." Nevertheless, accurate information on trends with respect to specific qualities and conditions in different sea areas is difficult to obtain, and a Global Ocean Observing System (GOOS) has been proposed to redress this lack of data and its implementation is being planned by UNESCO-IOC, UNEP and WMO. There are component modules on the Health of the Oceans (HOTO) and on the coasts.

[1] See appendix 11.

2.2.2 Bilateral – NEPTUNE (North-East Pacific Time-series Undersea Networked Experiments) and VENUS (Victoria Experimental Network Under the Sea)

NEPTUNE is a US/Canada initiative to create the world's first large-scale, long-term deep-water observatory. It will deploy a network of instruments linked by optical fibers and a power grid on the Juan de Fuca tectonic plate off the coasts of British Columbia, Washington and Oregon (Figure 2-7).

NEPTUNE will consist of a network of around 30 unmanned sea-floor observatories (Figure 2-10) linked to shore by submarine fibre optic cables and electrical power (50-150 kw). The network will be an invaluable tool for scientific research and education, as well as fertile ground for industrial innovation. It will provide:

- 30 years of multidisciplinary observations of a scientifically significant ocean area, including the sea-floor, with the time and space resolution needed to describe major processes;
- "community" data in near-real-time for science and education; and
- an ability to add new sensors or experiments.

NEPTUNE observations will contribute significantly to the understanding of practical issues such as earthquake hazards and the impacts of climate change on fisheries and on gas hydrates along the continental margins.

Part of the proposed Canadian side of the initiative (NEPTUNE Canada) will be a small observatory network in the Strait of Georgia and the Juan de Fuca Strait, installed before the main NEPTUNE system. This will be called "VENUS", (Victoria Experimental Network Under the Sea). These protected and accessible coastal areas will be used as testing grounds for NEPTUNE systems and equipment. Also, observations collected in the process will contribute to the understanding of exchanges between coastal basins and the open ocean, and the acquisition of real-time information on fluxes of pollutants and nutrients.

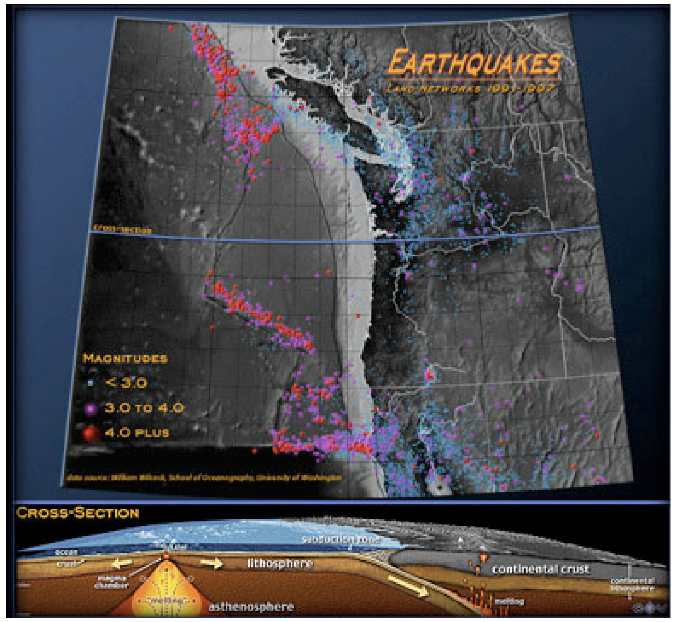

Figure 2-7. Earthquake activity offshore BC and Washington State based on observations from land-based seismic networks. The cross section at bottom shows the geological features of the Juan de Fuca plate (from US NEPTUNE site http://www.neptune.washington.edu).

Figure 2-8. Disposition of cables for the proposed NEPTUNE real-time observatory (from NEPTUNE Canada http://www.neptunecanada.com).

2.2.3 National - Canadian Geospatial Data Infrastructure Project

A "geospatial data infrastructure" can be said to encompass all of the data sources, systems, network linkages, standards and institutional policies required to deliver geospatial data and information from many different sources to the widest possible group of potential users

Agencies around the world cooperate in the implementation of an internationally designed technological and policy framework to facilitate access to geospatial data and information. In Canada, government and industry are collaborating in the development of a Canadian Geospatial Data Infrastructure through a national program called GeoConnections. As partners in this initiative, key agencies with an interest in the marine and fresh water areas are leading the development and implementation of a Marine Geospatial Data Infrastructure (MGDI), funded as a $60 million initiative in 1999 by the federal government under the leadership of Natural Resources Canada. The purpose of the MGDI Initiative is to acquire, manage and disseminate marine data and information to all users in a timely and cost-effective manner. It will provide an information infrastructure, encourage common data and information protocols, and facilitate third party access under controlled conditions.

2.2.4 Provincial - British Columbia Marine Ecological Classification (BCMEC) and Coastal Resources Information Management System (CRIMS) (Appendix 12)

The Province of British Columbia is responsible for the management of about 30,000 km. of shoreline and sea-bed in the inshore and near-shore waters, and works with other levels of government on the management of resources under federal and local jurisdiction. BC has developed a number of coastal resource programs in support of initiatives to address economic development and diversification problems, coastal threats, land and resource conflicts, and First Nations issues, so as to support informed decision-making. Many of those programs are managed by Decision Support Services (DSS) of the Ministry of Sustainable Resource Management.

BC has been collecting some coastal resource data in a systematic and synoptic manner since 1979, using peer-reviewed provincial Resource Inventory Committee Standards, which include standards for data management and analysis. Types of environmental resource information collected include oceanographic, physiographic, and biological data, as well as anthropogenic data on fisheries, traditional knowledge, coastal tenures and land uses, and recreation and tourism use and capability. Coastal resource information is stored in the Coastal Resource Information Management System (CRIMS), which currently consists of several integrated technologies, including GIS and image-processing software, digital video, an attribute-data-management system and a trajectory model for oil spills. These different technologies have been integrated into a single system that is accessed through a custom-designed user interface.

2.2.5 Coasts Under Stress Project (CUS)

Coasts Under Stress is a five-year project that started in April 2000. Funding of $6.2 million has been provided by the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Natural Science and Engineering Research Council of Canada (NSERC), with additional funding from participating universities and partners in government, business, non-governmental organizations and First Nation groups.

The natural sciences relevant to BC coastal regions will be investigated along with the human dimensions in this project, involving three universities and more than 70 researchers in natural sciences, health, social sciences and humanities. The CUS goal is to identify important ways in which changes in society and the environment in coastal British Columbia and coastal Newfoundland and Labrador have affected, or will affect, the health of people, their communities and the environment over the long run.

This program is likely to be of valuable assistance at all stages of offshore activities, and will be exceedingly important with regard to the downstream issues should a decision be made to lift the moratorium.

2.3 Comparison of Physical Conditions around Hecate Strait with those of Eastern Canada Offshore Basins

Although somewhat protected from the Pacific Ocean by the Queen Charlotte Islands, Hecate Strait is susceptible to severe weather conditions, due to its size (less than 100 km across), its morphology, and its oceanographic characteristics. The Dixon Entrance to the north and Queen Charlotte Sound to the south have oceanographic and weather conditions somewhat different from the Hecate Strait, but all bear comparison to those of eastern Canada offshore operations (Appendix 14).

Most of the waters of Hecate Strait, Queen Charlotte Sound, and the Dixon Entrance are between 400m to 200m deep, with the exception of the 35 m Learmonth Bank at the mouth of the Dixon Entrance. These depths are common for offshore petroleum exploration and development, and thus do not present any technological or seasonal restrictions. For comparison with the east coast Jeanne d'Arc Basin (Figure 1-4), the discovery well Chevron *et al*., Hibernia P-15 was drilled from May 27,1979 to January 2, 1980 to a total depth of 4407m in 80m water depth. In the same Jeanne d'Arc Basin, the discovery well Husky/Bow Valley *et al*. Whiterose N-was drilled between 22 June 27, 1984 to January 4, 1985) to 4628m in 122m water depth.

The climate of the Hecate Strait can be characterized as temperate, with a strong westerly onflow of moist marine air. It is one of the areas of Canada with the strongest winds, reaching 200 km/hr, driven by seasonally changing surface ocean temperatures and barometric pressure systems. Temperatures are mild, with only about 20 frost days annually in the region. Although the freezing and icing associated with this is recognized as a particular hazard of operations, it does not pose any unusual conditions in comparison to those encountered in similar higher latitude onshore and offshore exploration and production operations elsewhere in BC, Canada and internationally. For example in the Jeanne d'Arc Basin temperature variations are larger and more severe over more than half of the year. There the air temperature ranges from –17.3°C to 26.5°C, the surface water temperature ranges from –1.7°C to 15.4°C, and the thickness of icing (glaze and rime) can be 72 mm (10 year maximum) to 169 mm (100 year maximum), with spray icing thickness in the region of 316 mm (10 year maximum) and 514 mm (100 year maximum). Furthermore, there are considerable iceberg sightings in the Jeanne d'Arc Basin area of operations (annual mean: 72, maximum: 169 on a one-degree grid).

The two barometric pressure systems are the North Pacific High and the Aleutian Low. The former dominates in the summer and generates northerly winds (ca. 30 km/h). The Aleutian Low is dominant in the winter months and creates southerly winds (ca. 50 km/h). Winds are strongest from October to February and are usually out of the south or southeast. In comparison, the winds in the Jeanne d'Arc Basin have one-hour maxima of 120 to 157 km/h and one-minute maxima of 139 to 167 km/h.

Wave heights in the Jeanne d'Arc Basin, which has experienced substantial exploration and production activities, are very similar to the Hecate Strait. In the Jeanne d'Arc Basin the significant wave height is 11 to 14 m (1 to 10 year report), and a 100-year value of 17.5m. The corresponding maximum wave heights are 20.9 to 30.4m (1 to 10 year) and 30.4m (100-year).

Tidal range of the QCB is much higher than in the Jeanne d'Arc Basin, and typical surface current speeds of 25 to 50 cm/s (equivalent to 0.5 to 1 knot) are faster than those of the Jeanne d'Arc Basin (7.5 to 8.0 cm/s).

A series of current moorings are deployed by the federal government in the region, and together with IOS drifter studies, the surface currents are well studied in the prospective petroleum exploration regions of Hecate Strait and the Queen Charlotte Sound. However, more site-specific bottom current studies would be required to support any specific decisions on offshore exploration.

Regionally, the QCB water temperatures can vary from 8 to 16°C in the summer to 4 to 9°C in the winter, with most of the range in the surface waters that vary from 6 to 16°C. These relatively mild and constant water temperatures strongly moderate the regional climate. In contrast, in the Jeanne d'Arc Basin the temperature variations are larger and much more severe, with air temperatures ranging from –17.3°C to 26.5°C, the surface water temperature from –1.7°C to 15.4°C, and the sea bottom temperature from –1.7°C to 3.0°C.

CHAPTER THREE MARINE ECOLOGY

3.1 The State of the Oceans

It is well-established that our oceans have been deteriorating for many decades and continue to do so despite the numerous actions focused on reversing the negative trends. Throughout most of the 20th century the proliferation of human activities at sea, and especially in coastal waters, have had adverse effects on the marine environment. The services that the ocean provides to the biosphere, such as regulating atmospheric gas and nutrient cycling, are being compromised. At the same time, increasing demands are being placed on the world's oceans to provide food, resources and services for an expanding human population.

Although the crisis of the ocean is well-established, it is not yet widely understood on the part of the general public, nor sufficiently accepted as a priority concern on the part of many governments despite numerous efforts to meet the challenge at global and regional levels. At a recent UNESCO-sponsored conference in Paris, held in December 2001, it was noted that "we are in a critical situation of declining trends … worldwide", and that unless oceans and coasts are given a higher priority by the world community, the outlook leaves little room for optimism.

In order to appreciate the ecological features of British Columbia's coastal and offshore resources, and the possible impacts of offshore hydrocarbon-related activity on them, it is necessary to understand the complex interconnected marine ecosystem and its food webs, and to grasp the goals of conservation, maintenance of biodiversity and ecosystem integrity in complex systems involving the dynamics of other resource networks and human communities.

3.2 Government Responsibilities

3.2.1 International obligations and responsibilities

As a signatory to the international Convention on Biological Diversity, Canada recognizes "the importance of biological diversity for evolution and for maintaining life sustaining systems of the biosphere". Further, Canada recognizes "that the fundamental requirement for the conservation of biological diversity is the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings", and "the close and traditional dependence of many indigenous and local communities embodying traditional lifestyles on biological resources, and the desirability of sharing equitably benefits arising from the use of traditional knowledge, innovations and practices relevant to the conservation of biological diversity and the sustainable use of its components".

This instrument provides an international framework for an ecosystem-based approach that calls for protection of marine habitats and resources at regional and national levels. All signatories to this Convention have agreed to a significant shift from a sectoral to an ecosystem-based approach of management that recognizes precaution and linkages among physical and biological characteristics of marine ecosystems and human activities.

3.2.2 Federal government responsibilities

Oceans Act (Appendix 17)

The Oceans Management Strategy section (II) of Canada's Oceans Act, which came into force in January 1997, outlines a new approach to managing oceans and their resources. This section of the Act contains provisions for the Minister of Fisheries and Oceans to lead the development and implementation of a national strategy for oceans based on the principles of:

- sustainable development (development that meets the needs of the present without compromising the ability of future generations to meet their own needs);
- integrated management of activities in estuaries, coastal and marine waters; and
- the precautionary approach (a commitment to err on the side of caution)

This section of the Act also provides the Minister with some basic authorities and management tools to be used within the context of "integrated management plans". They include among others:
- the establishment of Marine Protected Areas (MPAs); and
- the establishment and enforcement of Marine Environmental Quality guidelines, criteria and standards designed to conserve and protect ecosystem health

Further, it states that, on the recommendation of the Minister, the Governor-in-Council may make regulations
(a) designating Marine Protected Areas; and
(b) prescribing measures that may include, but not be limited to,:
    (i) the zoning of Marine Protected Areas; and
    (ii) the prohibition of classes of activities within MPAs

Fisheries Act
Through this Act, Fisheries and Oceans Canada has a legislative mandate for the conservation and protection of fish and fish habitat supporting Canadian fisheries (commercial, recreational and Aboriginal), where "fish habitat" refers to:

> *spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes*

This Act prohibits the harmful alteration, disruption or destruction of fish habitat (HADD) unless authorized by the Minister.

Environment Canada has the responsibility of administering the pollution prevention sections of the Fisheries Act (sections 34 - 42), which prohibit the deposition of deleterious substances into water frequented by fish, unless authorized by the Minister.

3.2.3 Provincial government responsibilities

The provincial government responsibilities for oceans and coasts include management of the shoreline and the seabed in the inshore and nearshore waters.

3.3 Knowledge about Marine Ecosystems

3.3.1 Limits to knowledge of the oceans and capacity to monitor changes

Overall, we know relatively little about our oceans, the largest and most biologically diverse environment on our planet, particularly with respect to the role and vulnerability of the resources and habitats. So that the human population can pursue opportunities for economic development in the coasts and oceans, and at the same time protect their ecological integrity and biodiversity, there is an urgent need to
- obtain detailed scientific information about the physical and biological aspects of marine ecosystems;
- build greater capacity to manage and regulate access to resources; and
- strengthen science-based monitoring and assessment to identify marine ecosystem changes and the impacts of human use of ocean services and resources.

To address concerns about the importance of using an integrated approach in the management of ocean resources globally, there has been a switch in recent years from sectoral-based, single-species management systems to systems that take a more holistic, ecosystem approach. It is also now recognized globally that a system of marine protected areas is an essential component for ocean management and for the overall understanding of marine ecosystems and protection of their biodiversity.

3.3.2 Knowledge gaps about marine ecosystems

There are extensive gaps in our knowledge about marine ecosystems, especially when compared with terrestrial ecosystems. With many unanswered questions with respect to their structure and function, we need more complete knowledge in order to understand their complexity and how the removal of resources and disturbance of habitat will affect them. Examples of areas where more information is needed for effective management using an ecosystem approach include:

- the relationship between the physical environment (for example, mixing attributes and flushing rates, sediment properties, and other aspects of the habitat) and the dependent biological environment;
- marine microorganisms, plankton, the benthos and the algae that are the foundation of the ecosystem, feeding those higher up on the food chain (see Appendix 15);
- the relationship between the overall ecosystem productivity and biological diversity, especially in determining the impact of removal or altering the productivity of single species;
- the precise spawning times and areas for all species and the seasonal and vertical distribution of eggs and larvae;
- the amount of habitat required to support a viable population of a certain species and the feeding and reproduction requirements of a population or species;
- the effects of habitat disruption on species interactions and survivorship;
- the role of deep-sea animals in global cycles of nutrients, carbon and contaminants; and
- the role of nearshore areas as migration corridors, rearing, feeding and staging areas for many species.

With this background in mind, a cautious approach must be employed when considering any future development of the resources of the ocean.

3.3.3 Assessment and monitoring of marine ecosystems

As marine ecosystems are considered for resource development, there is a need for rigorous, meaningful and long-term environmental monitoring. As part of the responsibilities of the federal and provincial governments described above, it is critical to obtain, assemble and analyze baseline information that is already available about the structure and function of the ecosystem and to monitor natural or human-induced changes in these values over time, in order to identify areas for which data are insufficient or non-existent. What is needed is a complete set of detailed physical oceanographic and biological information for each marine ecosystem. There are a number of initiatives addressing this need already in place, or under development, at the international, national, regional and local levels. Some of these are described below.

International

The Global Ocean Observing System (GOOS) is a unified, permanent, global public service for data and information exchange about the oceans and seas designed to meet the needs of the world community of users of the oceanic environment. It is a coordinated system for gathering data about the oceans and seas and it promotes integration of the coastal environmental research community and its linkage to the community at large. It will develop and implement an international strategy for the acquisition, gathering, and exchange of these data, and will provide descriptions of the present state of the oceans, including living resources.

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is discussed in Chapter 2. Its role is to cover all scientific aspects of the prevention, reduction, and control of marine environment degradation, and within that framework it provides evidence that the best way to conserve marine diversity is to conserve habitat in the coastal area.

Federal

The new federal initiative, the Seabed Resource Mapping Program (SeaMap; http://seamap.bio.ns.ca) is led by the federal departments of Natural Resources, National Defence, and Fisheries and Oceans. The focus of SeaMap, which is still in its early planning stages, is sea and lake-bed mapping of Canada's offshore, coastal and aquatic lands. This information will assist in decision-making with respect to ocean resource use. The applications cover a broad range, from telecommunications to offshore exploration; national security to environmental assessment; and fish habitat assessment to sustainable development.

Regional

A newly proposed initiative for monitoring regions of the Pacific Ocean, the North East Pacific Time-series Undersea Networked Experiments (NEPTUNE) is described in Chapter 2. This project will result in a large-scale ocean observatory system interconnected by fibre-optic cable which will, for the first time, provide intensive and comprehensive observations of the deep-sea ecosystem at a number of sites, over a long period of time. This information will allow us to assess long-term and cumulative changes in marine, particularly deep-sea, ecosystems brought about by natural occurrences and human activities and will be in place long enough to monitor the potential recovery of any damaged systems.

Provincial

Through the Decision Support Services Division, the British Columbia Ministry of Sustainable Resource Management manages and coordinates the B.C. coastal inventory and analysis programmes. The various programmes, which are focused on obtaining information about marine ecosystems and marine conservation and protection, are briefly described below.

The CRIS (Coastal Resource Information System) is a comprehensive GIS-based inventory system. It was originally designed for oil-spill response and countermeasures, but also provides data and analyses for coastal and marine planning, conservation, protection and management applications (see Chapters 2 and 4)

The BC Marine Ecological Classification is a hierarchial marine classification consisting of four nested divisions based on physical properties, and a fifth division based on current, depth, relief, substrate, salinity, slope, temperature, stratification, and wave exposure. This fifth division, termed “ecounits”, is the first example of a large-scale (1:250,000) classification applied over a large area. The ecounits were developed for the application to coastal management and marine protected areas planning. Currently, there are no data available for the offshore out to Canada’s 200nm EEZ boundary of BC or for the north coast fjords.

A preliminary list of Valued Marine Environmental Features (VMEFs), which are key features of the marine environment valued for their conservation, recreational and cultural-heritage characteristics, has been compiled, including, for example, kelp beds.

An initiative is also in place to develop a methodology to identify Marine Sensitive Areas (MSAs), where an MSA is defined as

> *an area containing habitats, biotic communities or species important to the ecological function of the local, regional or global environment that is also vulnerable to human disturbance*

and habitats are defined as

> *areas occupied by species that are particularly susceptible to human disturbances or areas occupied by species which would experience difficulty recovering to viable or manageable levels if disturbed. ... For example, habitats such as marshes, estuaries, wetlands, and eelgrass beds are formed by the interaction of complex physical processes and have very slow recovery rates if these physical processes are disrupted or disturbed.*

The goal of this programme is to use systematic intertidal, subtidal and offshore inventories to delineate sensitive and vulnerable habitats.

3.3.4 Difficulties associated with monitoring change in marine ecosystems

The difficulty with any set of information on marine ecosystems lies in determining whether or not it is representative of the "natural" state of the ecosystem, and assessing whether or not observed changes are the result of human activities or natural occurrences. Because of the natural spatial and temporal variability of both physical and biological characteristics in marine ecosystems, it is essential that information be collected over the long term.

3.3.5 Monitoring cumulative effects

Similarly, it is difficult to assess the potential effects of one type of human activity on a marine ecosystem, because the data are frequently confounded by the effects of other human activities. It is generally agreed that we do not currently have the capacity or all of the knowledge to undertake meaningful environmental effects monitoring at the ecosystem level over the long term, especially with respect to cumulative effects of a variety of stresses.

It is important that the cumulative effects of all activities be evaluated, as much as is possible, on an ecosystem scale; that is, encompassing the effects of multiple activities on multiple species at multiple ecological levels. Clearly, this is far more complex than measuring the effects of just one single variable on an ecosystem: for example, the measurements of temporary seismic noise relative to background noise from frequent vessel traffic in a marine area.

With the commitments and initiatives described above, we are gaining a better understanding of what is required to undertake this type of monitoring. Without adequate information available, prudence, caution and conservatism must continue to be the watchwords for any management of marine resources and habitats.

3.4 Protected Areas

3.4.1 Marine Protected Areas

For several years, Fisheries and Oceans Canada, Environment Canada and Parks Canada have been working together with the government of British Columbia on a Pacific Marine Protected Areas Strategy. The goal is to take a coordinated, collaborative approach towards the development of Marine Protected Areas (MPAs) on the Pacific coast. This Strategy was released for public distribution in August 1998, but the province has not yet officially signed.

Fisheries and Oceans Canada takes an ecosystem approach to the establishment of MPAs, whereby the entire ecosystem will benefit. At the time of the Oceans Act, four areas of the Pacific were identified for MPAs, two nearshore and two offshore. The locations for the nearshore MPAs have been identified; and one of these, Race Rocks, is nearing completion as an official MPA. The offshore locations have not yet been identified. Subsection 35 (3) of the Oceans Act allows the federal Minister of Fisheries and Oceans to prescribe measures or prohibit activities that may interfere with marine ecosystem integrity.

The British Columbia government has also identified a number of MPAs for BC. A provincial MPA is any area of tidal water together with associated natural and cultural features in the water column, within, or on top of the seabed which has been designated by the Protected Areas of British Columbia Act or under the Park Act, Ecological Reserve Act or the Environmental and Land Use Act. The primary tools used to evaluate provincial MPAs include CRIS, VMEFs, and the BCMEC (see above). A list of the more than 100 provincial MPAs identified to date is available at: http://srm.www.gov.bc.ca/dss

3.4.2 Marine Conservation Areas

Bill C10, which is now in the Senate and very likely to pass this year, will allow for the development of Marine Conservation Areas. Parks Canada has identified a number of eco-regions for Canada, each of which has a unique collection of physical and biological characteristics. Five eco-regions have been identified on the west coast of Canada. The proposed Gwaii Haanas Marine Conservation Area covers two of these eco-regions. This will be the only Marine Conservation Area in northern BC. One other Marine Conservation Area will be established in coastal BC. Exploration and development of hydrocarbons will be prohibited in Marine Conservation Areas.

3.5 Queen Charlotte Basin

3.5.1 An overview

For any marine ecosystem, the structural and functional elements are defined by a diverse array of organisms, together with the physical characteristics of the water and the coastal and seabed areas. In comparison to most of the earth's marine ecosystems, the Queen Charlotte Basin, which has not been subjected to urbanization or significant industrialization, would be expected to be in good condition. A description of the boundaries for the Queen Charlotte Basin, and of the physical factors which determine the types of organisms that will reside there and 'make a living' or pass through it, are included in Chapter 2.

Each marine ecosystem is unique and very complex, with numerous interactions between and within a diverse group of living organisms and the physical environment. The 1986 Report of the West Coast Offshore Assessment Panel describes this complexity and diversity in Queen Charlotte Sound:

> *Nearshore ecosystems occur near rocky shores, on mud flats, in estuaries and in shallow bays. Sunlight penetrates throughout nearshore ecosytems and nutrients flowing through them from the sea are supplemented by those from the land. In shallow bays, estuaries and mudflats, nutrients regenerated from decaying organic matter are important to productivity. Water movement distributes some of the nearshore production into deeper water in the form of drifting detritus and rafts of seaweed, which contributes to pelagic and benthic foodwebs. In turn, the larvae and juveniles of fish such as salmon and herring depend on this production for survival.*
>
> *Continental shelf ecosystems exist where deeper water prevents sufficient light from penetrating far enough for plants to grow on the seabottom but where the water is shallow enough so that production in the surface waters is directly accessible to the benthic community. The animals in benthic and pelagic communities interact directly. For example, sandlance migrate to shallow waters diurnally to feed on plankton, thereby transferring organic matter to the benthic community. Such shelf seas are also shallow enough so that currents and winds can mix the waters to make nutrients available to all parts of the foodweb.*
>
> *In contrast to the nearshore ecosystems where seaweeds and seagrasses are primary producers, phytoplankton are the primary producers in continental shelf ecosystems. The growing season for phytoplankton in Queen Charlotte Sound and Hecate Strait is from April or May through to October.*
>
> *Both nearshore and continental shelf ecosystems have grazers and scavengers. Grazers such as zooplankton, snails, clams, chitons, and urchins consume phytoplankton and seaweeds. Grazers, in turn, are eaten by starfish, predacious snails, salmon, herring, seabirds and gray whales. Some of these are eaten by halibut, ling cod, cormorants, eagles, falcons, seals, dolphins and killer whales.*

> *Scavengers exist on the remains and excretions of other organisms. Typical of these are bacteria, sea cucumbers, anemones, and shore crabs.*

The wetlands that are also part of the Queen Charlotte Basin are most important for their function as nursery and rearing areas, and for stabilizing coastlines and providing protection against storm surges. They filter out nutrients from land run-off and are areas where fine sediments rich in organic matter accumulate, making them a highly productive component of the ecosystem that is critical to its biodiversity and fisheries.

On the western limits of the Queen Charlotte Basin, there are regions deeper than 1000 metres, the deep-sea, and the physical and biological characteristics of this part of the ocean are the least understood. In fact, it is only in the past year that we have known about the existence of unique sponge reefs in the deeper regions of Hecate Strait. Most deep-sea communities depend for their food on events at the surface. Very little is known about how deep-sea communities respond to natural events and human disturbances or resource extraction.

3.5.2 What do we know about the structure and function of the Queen Charlotte Basin marine ecosystem?

The Queen Charlotte Basin is a dynamic and diverse ecosystem that is highly productive, with resident and transient species. It also supports numerous aboriginal, commercial and recreational fisheries and tourism. It is currently in very good condition relative to many of the globe's marine ecosystems.

A description of our current knowledge with respect to the location and physical attributes of the Queen Charlotte Basin is provided in Chapter 2. With respect to the biological components of the ecosystem, there is considerable information about the number of species and types of habitat, but our knowledge of the biology and life cycles of most of these species, and of the role of each in the ecosystem overall, is very limited.

To provide a snapshot of the diversity of species (overall species numbers estimated to be between 500 and 1,000) that exists in this marine ecosystem, examples of numbers for just a few of the species of fauna are described in the Table 3-1 below:

Table 3-1. Queen Charlotte Basin Ecosystem Diversity

Organism	Number of species and (or) stocks
Salmon	6 (many stocks and more than 5,000 populations)
Herring	1 (five stocks in QCB)
Groundfish	more than 70
Shrimp	7
Crab	5
Sea Urchins	5
Seabirds	15 species which breed on the coast
Marine Mammals	29
Octopus	9

There may also be species as yet undiscovered (such as, until recently, the deep-water sponges in Hecate Strait, or the species of giant squid discovered in the Gulf of Mexico) in 2001, or not normally abundant in the area.

A comprehensive description of the biological components of the Queen Charlotte Basin is presented in Appendix 15 and additional information is found in the JWEL report. Some key points are described below.

Salmon

The 1986 Offshore Exploration Environmental Assessment Panel Report states:

> " About 650 rivers and streams in the region are used for spawning by juveniles. Large runs of salmon occur in the Bella Coola River, Skeena River, Nass River, Smith Inlet, Rivers Inlet and elsewhere. Also, salmon stocks from Alaska, Washington, Oregon, and California migrate through the region's waters to and from the Gulf of Alaska and the north Pacific. Immature salmon may spend several months feeding in estuaries while gradually becoming adjusted to salt water before moving offshore. More than 1 billion fry are believed to migrate up the coast. "

Salmon subsequently become a key species contributing to the fertility of forest ecosystems through their use as food for bears, eagles and other species.

In the JWEL Report's sections on salmon (3.1.2) and salmon fisheries (3.2.1, 3.4.2) there are several incorrect or misleading statements. The productivity for salmon stocks tends to cycle over long periods (e.g., ten years or more) in relation to "ocean regime shifts". These decadal scale shifts have only recently been recognized. During the past five years on the Pacific coast, we have been experiencing a downward trend in marine survival associated with an ocean regime shift. However, this is now turning around and we expect that salmon stocks will be much more productive in the next few years as a result of the increased marine survival produced by the regime shift. New information provides new perspectives on environmental change that will affect the salmon stocks and overall ecosystem structure and function in the Queen Charlotte Basin.

The statement "However, the 1999 wild salmon harvest was the lowest in 50 years, and has resulted in concerns over conservation", although true, is misleading. In fact, a major contributor to reductions in the harvest were the significant conservation measures that were put in place by the Department of Fisheries and Oceans in 1998, specifically to protect certain coho salmon stocks. The statement, *"*decline in the salmon industry is being mitigated largely through aquaculture in BC*"* is again misleading. Aquaculture might temporarily make up in commercial terms for a decreased wild salmon catch, but it cannot mitigate the decline in the wild salmon industry. Salmon aquaculture and the wild salmon fishery are separate industries. In fact, a network of scientists, First Nations people, non-governmental organizations, and others, currently working with DFO in the development of a wild salmon policy, are concerned that the effects of aquaculture of primarily an "exotic" species (Atlantic salmon, *Salmo salar*) will endanger the future of the six wild Pacific salmon (*Oncorhynchus*) species.

Marine Mammals

The JWEL report reviews the species of marine mammals found on the coast of British Columbia. The species that reside in, or migrate through, the Queen Charlotte Basin include gray, sei, humpback, minke, finn, sperm and killer whales, dolphins, and seals, including the Northern elephant seal, which breeds in California and resides in the north in the summer. Overall, we understand very little about the biology, habitat and ecological roles of these species. Most of our information is on killer whales, harbour seals, and Steller sea lions, and yet it is by no means complete.

Almost all individual killer whales (*Orcinus orca*) on the British Columbia and Alaska coasts have been identified and catalogued on the basis of natural markings and fin shape. Records of their seasonal movements, diet, social structure and life-history are available. Very recent studies have expanded our understanding of killer whale populations. There are now thought to be two non-associating populations of whales, known as residents and transients. Transients differ in travel patterns, dive intervals and group sizes; and they feed on different prey (residents, fish; transients, marine mammals). There are five populations of killer whales on the coast: two residents (north and south), two transients (north and south), and one offshore population.

In November 2001 the southern resident population, which has declined by 20% in the past six years, was listed as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). An endangered species is one that is facing imminent extirpation or extinction. The northern resident and southern and northern transient populations were designated by COSEWIC as “threatened”. Threatened species are likely to become endangered, if limiting factors are not reversed. Both northern resident and transient killer whales are found in Queen Charlotte Basin. The offshore population was listed as ”of special concern”.

Seabirds

Appendix 16 reviews what is currently known about seabirds of the waters of Western Canada, identifies knowledge gaps, and offers suggestions about how to complete the current picture on seabirds in this unique and diverse habitat to form a solid, updated and internationally compatible baseline of information.

3.5.4 Ecological niche

Each species in the marine ecosystem has its own ecological ”niche” or way of life. Each niche is unique, and each species is a member of a community, sharing the resources and contributing to overall ecosystem function. Something that apparently affects only one species may, therefore, ultimately affect the whole ecosystem. Examples of ecological niche are described in Table 3-2 and 3-3 below.

Table 3-2. The Ecological Niche of the Spot Prawn, *Pandalus platyceros*

Habitat	**Rocky or hard substrate in depths from the intertidal to 487m**
Spawns	Late fall or early winter
Larvae	Planktonic stage of up to three months. Diurnal, moving from depths during day and towards surface at night
Feeding pattern	Bottom foragers
Moult	Spring and early summer
Predators	Larval stage: many larger species including fish, marine mammals and seabirds Adult stage: many species including pelagic and benthic fish, marine mammals, and birds

Table 3-3. The Ecological Niche of the Pacific Herring, *Clupea pallasii*

Habitat	Juveniles Inshore, Nearshore Adults Pelagic
Spawns	March to April
Spawning location	Inshore protected waters; eggs are deposited on kelp, red algae, eelgrass and rockweed
Hatching	Eggs hatch after 10 to 20 days. After hatching, larvae found in large masses near the spawning grounds.
Feeding pattern	Larvae small planktonic organisms Juveniles larger planktonic organisms Adults large plankton, larval fishes
Predators	At least 40 other species including seabirds, seals, sea lions, whales and salmon and groundfish

3.5.5 Issues related to the Queen Charlotte Basin marine ecosystem

Importance of understanding life cycles and species interactions

The complexity of the life history of a variety of both invertebrate and vertebrate species demonstrates the importance of the life cycle and the changes that occur in the cycle of each species, together with associated different uses of the ecosystem. It is because of this great diversity of organisms, and life cycle stages, that much of the Queen Charlotte Basin marine ecosystem is used almost year-round, as spawning and rearing habitat.

The interactions between species are very important to the overall function of the ecosystem with some species (the keystone species) playing a more critical role. Any factor that has a negative impact on the keystone species would be expected to have profound impacts on the entire ecosystem.

For example, sea mussels form densely aggregated beds from the upper intertidal to subtidal depths. They provide a protective matrix for a very complex community of more than 300 different species. They are long-lived, and species richness increases with increasing mussel bed age and thickness. However, as filter feeders, mussels are very sensitive to oil contamination and are known to readily accumulate Polycyclic Aromatic Hydrocarbons (PAHs) in areas of urban run-off and oil spills.

Consequently, the exposure of sea mussels to oil as the result of frequent small or catastrophic large spills would have serious implications for the entire food web, including fish, sea-birds and marine mammals.

3.5.6 Economic value of the current fisheries

In addition to providing traditional food for the First Nations peoples that reside in this area, this rich and diverse ecosystem provides significant economic benefit through commercial fisheries, which can be sustainable if managed appropriately. For example, the estimated annual landed value of one species of prawn, the spot prawn, from north coast waters ranges from $1.2 - $4.3 million and for the Queen Charlotte Islands, approximately $1 million. For red urchins, the largest of the five sea urchin species, the estimated value of the total annual catch from 1995 to 1999 for northern waters ranged from approximately $6 - $10 million. The estimated annual landed value for groundfish is very high: for example, the total landed value of groundfish for British Columbia (a significant portion of which was caught in the north) in 2000 was $133.7 million, with a wholesale value of $186.5 million. In the past six years the annual value of sablefish and halibut, most of which was landed on the north coast, ranged from $24 - $32 million and $30 - $40 million, respectively. It is important to note that prices quoted here reflect a period where there has been a downturn in the market and a decrease in the currency of the major buyers. So these values could be substantially higher in the future.

3.5.7 Current stresses on the Queen Charlotte Basin ecosystem

There are a number of human activities that currently affect the Queen Charlotte Basin ecosystem, including: commercial fisheries for numerous invertebrate and vertebrate species; recreational fisheries (primarily salmon); shipping; and tourism. In addition, it is anticipated that in the future this region will be the location for significant shellfish foreshore harvesting, and shellfish and finfish aquaculture activity. Further, there are natural stresses such as the decreased productivity related to the recent ocean regime shift as well as anticipated stresses associated with climate change. A possible new stress would be caused by exploration and development of other resource industries such as oil and gas.

In summary, it is very difficult to measure the cumulative effects of natural occurrences and human activities on marine ecosystems. However, it is critical to understand that these stresses, many of which are insidious, can threaten the health and even the viability of the marine ecosystem over the long term.

3.6 Oil and Gas Industry - Potential Stresses

Generally, any effects attributed to the oil and gas industry will depend on the unique factors of the ecosystem and must be viewed over the long term.

There are two categories of impacts that the oil and gas industry would have on the Queen Charlotte Basin marine ecosystem:

- impacts associated with exploration, development and production; and
- impacts associated with catastrophic spills from blowouts or product transport.

3.6.1 Impacts associated with oil and gas exploration, development and production

Produced Water and Drilling Muds

Theoretically, it is possible to use technology whereby produced water and drill cuttings are re-injected and drilling muds are recycled, resulting in near zero emissions (Chapter 4). However, to our knowledge there is no site where this is currently the standard practice. The JWEL report discusses evidence for impacts of produced water and drilling muds on surrounding habitat and biota, and acute effects are thought to be generally minimal, particularly with the use of the less toxic synthetic-based fluids. However, recent reports of heavy metal contamination indicate that discharged drilling muds can have significantly adverse impact on the biota in areas in the immediate vicinity of drill rigs, and may even be incorporated into the food chain. On the other hand, a body of knowledge obtained in recent years from field studies conducted in Atlantic Canada, the North Sea, Gulf of Mexico, and California using indicator species as well as larval and juvenile fish and some zooplankton species, suggests that discharges pose little risk to the biota and habitat. These uncertainties still need to be addressed, especially with respect to site-specific and localized effects on larval and planktonic communities and to long-term chronic effects on all species and the ecosystem in general.

Small Oil Spills

Frequent small oil spills are known to be associated with all phases of offshore oil and gas operations. Many of these spills originate from the transfer of diesel fuel from supply vessels to the rig. The spills would be expected to have direct effects on the biota, especially on the larval and juvenile fishes that frequent the water column, which are known to be particularly vulnerable to oil. For example, the larvae of many fish species must ascend to the surface to swallow the seed bubble of air that initiates the development of the swim bladder. Even a very thin film of oil on the surface could interfere with this process at the ‘swim up’ stage and thus result in undeveloped swim bladders, arrested development and greater mortality of larval fishes.

The cumulative effects of these small spills over time, particularly when coupled with effects of other stresses, could seriously damage components of the marine ecosystem. For example, there is some evidence that chronic, low-level pollution from shipping operations may have negative effects on seabird populations. We need to determine what levels of risk are acceptable for the small oil releases associated with offshore development, and to understand that in the broader context of such spills from regular shipping, tourism, commercial fishing, and other activities.

Flares and Lights

A brief review is provided in Appendix 16.

Noise and Seismic Activity

There is a general consensus that hearing is probably the primary sense of whales, dolphins, and a number of other marine species. Most marine mammals depend on sound as they hunt for food, detect predators, find mates and keep their herds together. There are already concerns with regard to ”noise pollution” in the oceans, originating especially from the propellers of super tankers and cargo ships, and the effects it may be having on global marine ecosystems over the long term. The velocity of sound in water is four times greater than in air, and the transmission loss in water is much lower due to lower attenuation. Therefore, depending on local conditions, sound waves may travel long distances under water, and detection ranges can exceed 100km. Underwater noise can potentially mask marine mammal underwater communication and perception of natural sounds.

A variety of constant noises is associated with the operation of drill rigs during all phases: for example, depending on the rig, there will be continual noise from equipment such as compressors, pumps, generators, and gas turbines in addition to the noise from aircraft and supply vessels. Noise in the air could have effects on birds and pinniped haulout areas. Recent reports from Russia show that the operational noise associated with rigs during production is affecting the migratory behaviour of gray whales.

The greatest impact from the exploration and development phases, however, is associated with seismic activity. A review of the effects of seismic activity on marine ecosystems is provided in Appendix 15 and the JWEL report.

Seismic Noise and Marine Mammals

Hecate Strait and Queen Charlotte Sound are sufficiently confined by land on both sides that there is a concentration of migratory and non-migratory fish, mammals, birds and other biota in the nearshore zone. Although very little information exists about the role of hearing and listening in the overall ”way of life” for many of these organisms, it is thought that a number of species that travel in the nearshore area are ‘listening’ as they migrate. Transient killer whales, in particular, travel or forage in this area, without echolocating, suggesting that passive listening provides cues for prey detection and orientation. Additional noise could possibly mask these auditory cues, increasing the likelihood of stranding or collision with the bottom, or reduced effectiveness in feeding, communication or migration.

Whales have been observed to swim away from seismic noise. However, their normal activity may be disrupted for long periods and functions such as surfacing and respiration or feeding can be affected, thus inducing stress. Of greatest concern is evidence of physical and physiological damage to hearing, and the consequent hearing loss, of mammals from intense sound sources such as sonar and airguns used for seismic surveys. This effect can have serious consequences: for example, in March 2000, shortly after the US Navy conducted exercises in the Bahamas, 17 whales from four different species beached themselves over a four-day period. Seven of the whales died; and a number of them were found to have haemorrhages of varying degree in their hearing organs.

Seismic Noise and Fish

Adult fish respond by swimming away to avoid the seismic zone. A fish may react to a seismic array more than 30 km away, and intense avoidance behaviour can be expected within 1 – 5 km. This type of noise may affect the role of the swim bladder and lead to haemorrhaging and even mortality of adult fish. There is evidence of short-term disruption of fish density in areas of seismic testing and this may affect fisheries in those areas. However, it should be noted that fisheries and the oil and gas industry have been co-existing in the North Sea and in Cook Inlet, Alaska over a long period of time.

Seismic Noise and Early Life Stages of Fish and Invertebrates

Seismic activity would be expected to affect organisms that are unable to move away from the vicinity, such as plankton, eggs, and larval and juvenile life stages of fish and invertebrates. Probably of most concern with respect to impacts is the potential effect on the vulnerable larval or juvenile stages of fish, and future recruitment, although information is lacking on this subject. For example, in particular it would be expected to interfere with swim bladder development. Any adverse effects on these early life cycle stages could be crucial for the Queen Charlotte Basin region, as much of it is used as nursery grounds or rearing areas throughout the year.

The serious threat that seismic activity poses for some species of the marine ecosystem makes it critical to obtain as much information as possible about:

- the acoustic sensitivities of whales and other marine mammals;
- the effects of seismic activity on adult, juvenile and larval fishes and invertebrates and plankton; and
- the cumulative, chronic and population-level impacts of noise on marine life

Ballast water

Deballasting of oil rigs and associated vessels could theoretically add to the spread of invasive species such as the predacious European green crab, a species introduced to San Francisco Bay by way of ship’s ballast water several years ago. This organism has now migrated to the south coast waters of British Columbia, where it threatens the future of indigenous crab species.

3.6.2 Impacts of major oil spills

Each oil spill event and its environmental impacts are unique. Many conditions affect oil impacts, often in complex, cumulative or synergistic ways that are still not well understood. A thorough description of oil impacts on individual species typically associated with the Queen Charlotte Basin ecosystem has recently been published by Parks Canada (www.dsp-psd.pwgsc.gc.ca/Collection/R61-2-8-11E.pdf). There are also specific references to oil impacts on organisms in the JWEL report and Appendix15.

The numerous studies following the *Exxon Valdez* oil spill in 1989 have made a major contribution to our knowledge regarding the impacts of oil on marine ecosystems. We now, for the first time, have extensive information with respect to the long-term effects of oil spills on several species.

One of the key factors determining the extent of the impact of an oil spill is the type of habitat. Effects on pelagic (open water) and deeper subtidal benthos species are relatively small, whereas effects at interfaces can be significant, for species such as seabirds and marine mammals that contact the sea surface. Similar large effects are seen in intertidal ecosystems at the land-sea interface. Pelagic species, which complete part of their life cycle at interfaces by having floating eggs at the sea surface or by spawning intertidally, are also particularly vulnerable.

Fish readily accumulate oil into their tissues, through ingestion as well as by absorption through the body surfaces. Depending on the species, they can detoxify some oil through metabolism, but the process of detoxification can be stressful and interfere with other functions. A typical response to stress in many vertebrates is increased susceptibility to disease, as well as interference with reproduction and growth.

Our understanding of the oil impacts on eggs and larval and juvenile fishes is incomplete, but it is thought that these stages are particularly vulnerable to oil. Encounters with oil could lead to arrested development and poor recruitment or even mortality. However, the natural fluctuations in fish recruitment are so great that even in well-studied fisheries, oil-induced mortalities of juvenile and pre-recruitment fish of less than an order of magnitude would be unlikely to be detectable.

Contamination by oil, leading to loss of fish habitat and food sources, and the persistence of oil residues in fine sediment and sheltered habitats such as estuaries and streams, could have long-term effects on nursery and rearing habitat.

Marine mammals

Marine mammals show no avoidance of areas contaminated by oil spills and therefore would be expected to be at risk. Most of the mortalities observed with oil spills have been for fur-bearing mammals, such as harbour seals, sea otters and seal pups. Because they depend on their fur for insulation, these animals are thought to have the most difficulty with oil.

The presence of oil has not been proven to cause mortality in whales. Unlike furred animals, they do not have a thermal problem when oiled, because they rely on blubber for insulation. There is evidence that the presence of oil reduces the filtration efficiency of baleen whales, but these effects are reversed in the short term. However, any mammals that are dependent for food on bottom-dwelling species (such as invertebrates that are known to accumulate hydrocarbons) may exhibit sub-lethal or long-term effects in response to oil spills.

Our understanding of the linkage between tissue hydrocarbon levels and oil-related tissue damage and health status in marine mammals is incomplete. Also, because of our incomplete understanding of the natural cycles of many species, it is difficult to separate out effects of natural cycles from effects of oil spills. For example, the decline of the sea otter populations of Alaska's Aleutian Islands, which was observed prior to the EVOS event, is known to be the result of reductions in available prey; whereas the decline of the Prince William Sound sea otter populations has been attributed directly to the EVOS event.

Seabirds

The effects of oil, both short-term and long-term, on seabirds are discussed in Appendix16. Similarly to other species, specific effects, vulnerability, and ability to recover will vary, based on life history and natural history characteristics. These would include, for example, differences in habitat use, energetics or life history strategy. Nearshore species would be the most vulnerable. Large variability in seabird numbers and breeding success due to natural factors is a common natural event, making detection of the degree of oil effects difficult (Appendix 16).

However, with the long-term studies following the *Exxon Valdez* oil spill event, there is new information demonstrating that a number of bird populations, including loons, harlequin ducks and pigeon guillemots, have not fully recovered from the effects of the oil nine years after the spill. As is the case with other species, the long-term effects of chronic low-level pollution are now being recognized as a significant threat to bird populations, and they may possibly be more damaging from a population-level perspective than the one-time mortality associated with a major spill.

Invertebrates

Generally, oil contamination affects invertebrates more than finfish species. The effects range from mortality to flesh tainting, reproductive disruption and compromised immunity, which may last for months. Bioaccumulation of oil compounds has been demonstrated in rapidly growing organisms. Most important are the indirect effects where the mortality of important species at the bottom of the food chain, or the consumption of contaminated invertebrate species, may disrupt the food web and possibly disrupt overall ecosystem function. For example, sea urchins and sea mussels, which are food for numerous invertebrate and vertebrate species, are known to be highly sensitive to oil. Severe impacts on these species could have significant consequences for the ecosystem's diverse community, and recovery could take many years to happen.

Long-term effects

The visible effects of an oil spill permit a quick assessment of damage to the immediate physical environment, but the long-term effects on flora, fauna and the affected area (including contiguous habitat) are more subtle, and difficult to measure and evaluate. The most recent publications on the effects of the *Exxon Valdez* spill by the scientists at the Alaska Fisheries Science Centre Auke Bay Laboratory demonstrated long-term impacts that have altered our perception of the impacts of oil spills. Their results show that oil persists in certain habitats for extended periods of time, such as in the intertidal reaches of salmon streams, in soft sediments underlying mussel beds, and on cobble beaches with large boulders. Thus, a major point-source pollution problem has evolved over time to a non-point-source event with long-term persistence and impacts. The highest concentrations of oil in beach sediments in the early years following the *Exxon Valdez* spill were found in soft sediments underlying mussel beds. The resulting contamination of the mussels by PAHs indicated that the underlying oil was biologically available and thus posed a risk to the other species of the food web, such as fish, birds and marine mammals.

These Alaskan scientists have also demonstrated that the same event resulted in significant damage to pink salmon abundance in the early years following the spill, caused both by reduced survival of embryos in oiled stream deltas and reduced growth of fry in contaminated marine waters in the year of the spill. Recent experiments have provided evidence that leaching of PAHs into the water still continues in some streams, indicating continued exposure of salmon eggs, more than 10 years after the spill. Similar experiments with herring embryos in saltwater noted increased mortality at low concentrations of weathered oil, suggesting that the results are not unique to pink salmon or fresh water.

3.6.3 Knowledge gaps about effects of oil spills

Some lessons from the Exxon Valdez oil spill

One lesson is that pre-perturbation baseline data are absolutely critical for understanding what resources are at risk from oil and gas development, as well as for evaluating the population and community-level consequences that may result following development. Furthermore, there is a problem with relying on data from short-duration studies conducted under laboratory conditions, as the field conditions for each spill are different, and the unnatural spatial and temporal scales in laboratory studies cannot account for natural variations. Also, most studies involve single species and do not address the integrated or ecosystem nature of the impacts. Our ability to differentiate between natural ecosystem changes and oil pollution effects is not well-developed. We need to know much more about natural ecosystem changes. Moreover, our understanding of long-term chronic sub-lethal impacts of oil pollution, which may show up generations later, is incomplete. Finally, obtaining accurate measurements of recovery in oil-damaged ecosystems is proving to be just as difficult as obtaining meaningful data on the effects of the original damage.

3.7 Conclusions

A rich and diverse ecosystem such as the Queen Charlotte Basin presents a number of options for sustainable economic benefit, including fisheries, tourism and possibly oil and gas development. The nature of ecosystem structure and function means that serious disturbance to habitat, or any of the biological features, by any of these options, could possibly cause damage to the overall ecosystem, and there is also the possibility that this damage would be irreversible. If this should happen as the result of oil and gas development, then the options with regard to other benefits, such as from fisheries and tourism, will be reduced.

Before any new industry is initiated in a specific marine ecosystem such as the Queen Charlotte Basin, it is critical to establish a complete set of pre-perturbation baseline data on the biota, including life-cycle history, and their habitats, so that we can understand and assess which aspects of the marine ecosystem are at risk from the proposed development and evaluate the population and community-level consequences that may result following development.

CHAPTER FOUR ENGINEERING AND TECHNOLOGY

The JWEL report constitutes a good general review of the significant engineering literature related to the economic, safety and environmental concerns of exploration and development activities for the offshore oil and gas industry. Recent technological advances and operational procedures relevant to British Columbia offshore areas were described, as were the qualitative risks associated with all phases of exploration and development. The five sequential phases in typical offshore oil and gas developments were characterized as follows: seismic and geophysical surveys; exploration; development; production; and decommissioning. Some observations will be made about most of these phases, many of which have been discussed by the Environmental Assessment Panel in 1986 and the authors of the COFRI and JWEL reports.

4.1 Seismic and Geophysical Surveys

The 1986 Panel proposed that airgun seismic surveying be limited in time, space and intensity, and that the initial surveys on the West Coast serve as experimental opportunities to develop the knowledge to assess the likely impacts of further work. The need to use explosives to shoot "tie-ins" has been eliminated by the development of airguns capable of working in shallow water. Recent geophysical exploration routinely uses 3-D seismic surveying undertaken by vessels that carry out multiple lines at a time, using multiple airguns. It should be noted that recent advances in the acquisition, processing, and interpretation of airborne gravity and magnetics surveys now enable the use of these data for solving a wide range of seismic problems. A review of the gravity data demonstrates an accuracy approaching that of 2D marine surveys. Incorporation of high resolution gravity and magnetics into 3D seismic surveys and interpretations yield a positive impact on the final interpreted results.

The issue to be assessed is whether the greater rate of airgun firing over an intensive survey area for 3D seismic surveying results in greater impacts. Little information exists, as mentioned in Chapter 3, on the impacts on fish eggs and larvae or on salmon migration and behaviour from seismic surveying. Recently the Joint Nature Conservation Committee (JNCC) in the UK has established guidelines for reducing the impacts of seismic exploration on marine mammals. Member companies of the UK Offshore Operators Association and the International Association of Geophysical Contractors have indicated they will comply with these guidelines in all areas of the UK Continental Shelf and in some areas elsewhere. Certainly this Panel would urge application of similar guidelines to be required under license conditions to all blocks licensed off the BC coast.

4.2 Exploration

The JWEL report reviewed a number of significant advances in drilling technology that have enabled the industry to conduct offshore exploration and production in much deeper waters. It is now technically feasible to contemplate the extension of offshore operations beyond the narrow continental shelf off the coast of BC. Among the most important technological advances are the advent of horizontal multilateral drilling, the development of dynamic positioning systems, and improvements in blowout preventer (BOP) design. Exploration drilling would most likely be undertaken by a semi-submersible unit or by a drillship.

In 1986 concerns were expressed about the use of high-toxicity oil-based drilling muds and about the use of bright artificial lighting on rigs and platforms. Today, Canadian offshore regulations require the use of much less toxic synthetic-based drilling fluids. It should certainly be possible for a joint Canada-British Columbia Offshore Petroleum Board or equivalent to require the re-injection of drill cuttings and produced water. Although it is generally accepted that fish and squid are attracted to sources of bright light, the effects of light on their populations appear to be negligible. Birds can become disoriented by lights, particularly in foggy or overcast weather, but incidents of bird mortalities caused by operating lights or gas flares appear to be low. (See Appendix 16)

4.3 Development and Production

Production options include a moored semi-submersible, a tension leg platform, a Floating Production Storage and Offloading unit (an FMSO is being used to produce the Terra Nova oilfield off the coast of Newfoundland in about 90 m of water) or possibly a gravity base structure similar to some of those in the UK and Norwegian sectors of the North Sea. A typical field development concept is shown in Figure 4-1.

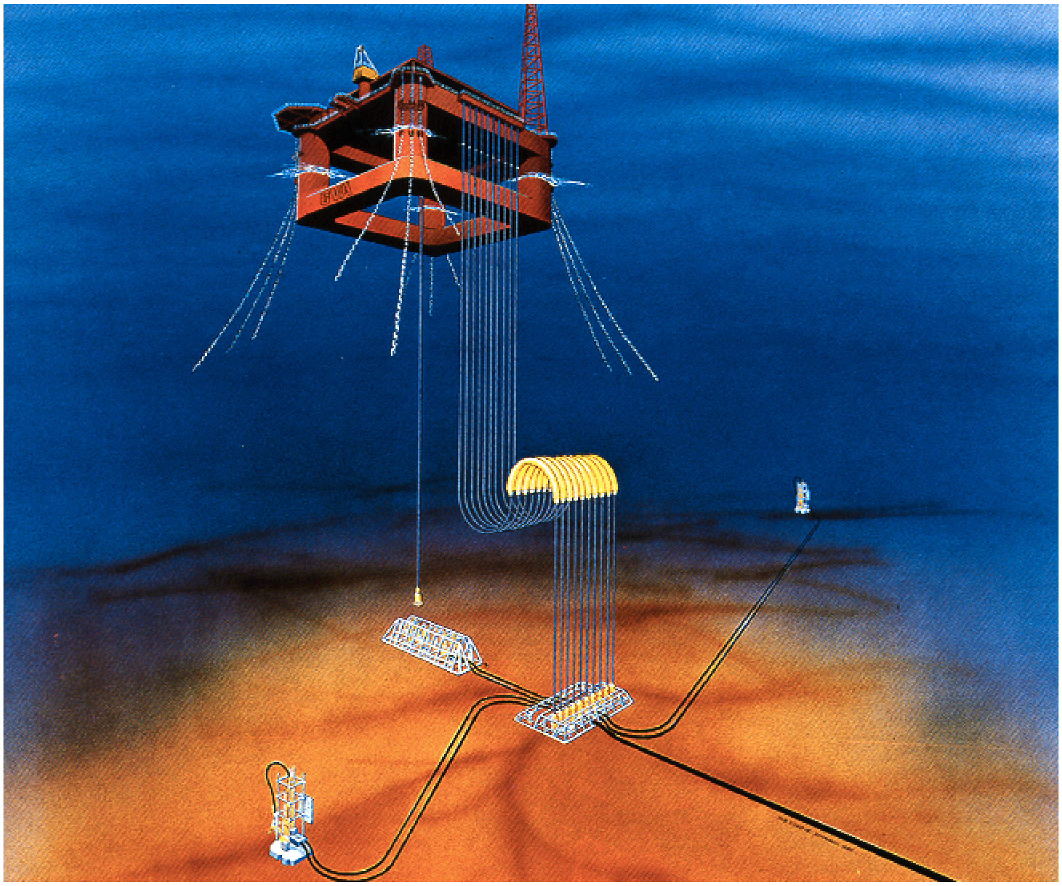

Figure 4-1. Conceptual field development scheme using a floating production system. (KME a.s promotional material).

It should be possible to require that export lines from the production platforms be tied into pipelines as opposed to offloading the oil into shuttle tankers by way of buoys. Pipeline monitoring and shut-down systems should be employed that would maintain maximum pipeline integrity and the least possible environmental risk. Suitable surveying would be required to establish the most secure pipeline route.

One way to manage carbon is to use energy more efficiently to reduce our need for a major energy and carbon source-fossil fuel combustion. Another way is to increase our use of low-carbon and carbon-free fuels and technologies. The third and newest way to manage carbon, capturing and securely storing carbon (carbon sequestration), is truly radical in a technology context. Many oil fields worldwide use injected CO_2 for enhanced oil recovery, and CO_2 sequestration is being practised in a reservoir in the Norwegian sector of the North Sea. The ocean itself represents a large potential sink for sequestration of anthropogenic CO_2. A recent report sponsored by the US Department of Energy notes that carbon sequestration holds great potential to reduce greenhouse gas accumulations to levels of acceptable impact at affordable costs.

A catastrophic explosion and fire occurred in 1998 on the Piper Alpha steel jacket production platform in the UK sector of the North Sea. A total of 167 people lost their lives and immense financial losses were suffered by the industry and the by the UK government. The central recommendation of the public enquiry under Lord Cullen was that a safety case regime be developed for offshore installations. The Health and Safety Executive set up the Offshore Safety Division to take over offshore health and safety matters from the Department of Energy. The separation of the regulatory authority for these matters from the organization that issues the exploration and production licensees is something that the government of British Columbia should investigate, as is now being recommended for the Canada-Nova Scotia Offshore Petroleum Board.

The JWEL report concluded that uncertainties in the physical environment (highly variable bathymetry, strong waves and currents, high waves, high seismic activity with the associated risks of slope failure and tsunami generation) could be dealt with through increased factors of safety in engineering designs and operational procedures. One omission in the engineering section of the JWEL report is reference to the Canadian Standards Association (CSA) Code for Offshore Structures, currently being updated. The standard was formulated so as to achieve target safety levels of (1×10^{-5}) per annum. The loads specified for earthquakes, for example, are set at annual probability exceedance of 10^{-4} per annum. The Canadian environment was very much the focus of this reliability-based standard and some background information is given in Appendix 18.

4.4 Risk of Oil Spill and Blowout

According to the JWEL report, "spills larger than 50 barrels have decreased considerably due to improved technology and higher operational standards. The risk of a blowout is highest during exploration drilling, considerably lower in the development phase, and lowest during the period of production. The only recorded blowout in Atlantic Canada occurred in 1984 and involved only 1500 barrels of condensate". However, a blowout is always a possibility with exploratory and production well drilling, and could have significant consequences for the North Coast. It should also be pointed out that existing tanker traffic within our 200 nautical mile exclusive economic zone continues to threaten the same coast. Some progress in governance has been made through the Canada Shipping Act since the Public Review Panel on Tanker Safety and Marine Spills Response Capability, chaired by David Brander-Smith, tabled their report. However, gaps in marine oil-spill response capacity exist for the Pacific coast, and Canada still allows single-hulled tankers and tank barges in its ports.

The consequences of a large oil spill are uppermost in the minds of the First Nations, and the communities bordering northern Vancouver Island, the Queen Charlotte Islands and Hecate Strait. It is now realized that oil-spill response decisions based on minimizing the cumulative damage over a ten-year period are more likely to yield the best long-term outcome for the resources and the habitat. If the potentially affected areas contain habitat capable of retaining oil for long periods of time, the best long-term outcome might be achieved by preventing the oil from coming ashore by the use of dispersants or otherwise. Although a particular dispersant may have toxic properties, dispersants also minimize the amount of oil coming ashore, causing less habitat contamination and lowering the potential for long-term damage. In such circumstances, the use of dispersants might be appropriate, despite the potential for short-term damage. Conversely, if there is little critical fish habitat within the spill trajectory, it might be prudent to leave the spill untreated.

Exploratory drilling and production create the risk of an uncontrolled release of oil from a blowout. This risk was recognized by the 1986 Panel, which described three documented incidents resulting in significant losses of oil to the marine environment. Drilling operators recognize the risk and take steps to mitigate it. It is recognized that the risk of a large loss of oil has a low, although finite, probability of occurring. However, since such incidents can occur, it seems prudent that the BC government should understand its potential liabilities in such a contingency before a decision is taken to remove the moratorium.

4.4.1 Approach

The technical approach to providing this information involves making a quantitative risk evaluation of exploratory drilling and/or production. A risk assessment of this nature has two components: (i) estimating the probability of the spill actually occurring; and (ii) determining the consequences of such an event.

The first component can be approached from two directions: one, based on the statistics of spills from similar operations under similar environmental and geological conditions in other jurisdictions; or two, using reliability analysis.

The prerequisite information and mathematical tools for the second component include:

- data on the natural resources that can be damaged by oil;
- data on the cultural and economic resources that can be damaged by oil;
- data on the marine climate (winds, ocean currents and ocean chemistry) of the area;
- an oil spill trajectory and weathering model; and
- a mathematical model for evaluating natural, cultural and economic resource damages.

A number of outcomes are possible depending on the formulation of the model for evaluating damage, but a useful form was found to be the "conditional risk curve" expressing probability of damage in monetary units for a particular spill. This approach was used, for example, by Chevron in 1980-81 during a preliminary evaluation of exploratory drilling risks in Queen Charlotte Sound. Of course, in addition to the quantified risk curves, one gains valuable insight into the social and cultural consequences of an oil spill (how it affects people's everyday lives), and what components of the ecosystem are at most risk (e.g. the commercial and native food fishery).

4.4.2 Sufficiency of Knowledge

The following comments pertain to the current status of data and knowledge applied to determining the consequences of a large spill.

Natural resources

Baseline data for the North Coast have increased somewhat in the past decade, through scientific studies undertaken through federal and BC agencies. However, the reduction in the scientific capacity of these departments is alarming in view of the numerous scientific knowledge gaps identified in Chapter Three. The work undertaken by the BC government is of particular importance in this regard, specifically the creation of the Coastal Resource Information Management System (CRIMS), which makes important baseline data available in GIS format. This system is managed by Decision Support Services (DSS) of the Ministry of Sustainable Resource Management, and is used to provide data and analyses for coastal resource management, conservation, protection and planning applications. An important component of CRIMS in the oil spill context is the Biophysical Shore-zone Mapping System, which obtains and stores spatial information on physical and biological characteristics of the shoreline. Basic data collection has been completed for the North Coast. This information is currently being analyzed and entered into the database (available in mid- to late 2002). It is also understood that other spatial data sets on biological resources have been assembled for the offshore areas in CRIMS, and that recent efforts have been made to coordinate and share such data with the federal departments, as mentioned in the JWEL report. It is hoped that sufficient data, in terms of spatial coverage, relevance and quantity, will be available for a risk study as early as mid-2002.

Data on cultural and economic resources

As part of the coastal inventory and information management system developed by the BC government, data have also been collected on human uses (e.g., fisheries, traditional knowledge, coastal tenures and land uses, and recreation and tourism use and capability). Within this framework, a preliminary list of *Valued Marine Environmental Features* (VMEFs) has been drawn up, based on a multi-disciplinary literature review complemented by discussions with experts in marine sciences, recreation and cultural-heritage resources. The completeness of these data for the North Coast has not been assessed at the time of writing, but the data structures and definitions are in place that would allow for filling gaps as part of a risk evaluation. As is the case for natural resources, these data are accessible in GIS format, greatly facilitating the spatial analysis required in a risk evaluation.

Marine climate

Understanding and predicting marine climate variables have advanced greatly since 1986. These developments are reviewed in the COFRI and JWEL reports. While the new data are not necessarily in forms immediately useable for oil spill simulation, they can be converted relatively easily, and there is no impediment to a quantitative risk evaluation.

Oil spill trajectory and weathering model

Advances in oil-spill modelling in British Columbia were reviewed by COFRI in 1996. Essentially, the principles for modelling, with suitable algorithms for weathering (evaporation, emulsification and changes in density and viscosity), are understood and programmed in useful computer models. Both the BC government and Fisheries and Oceans Canada currently use the SPILLSIM model developed in Vancouver by Seaconsult Marine Research Ltd. When applying these models to the North Coast, the spatial scale of possible effects must be carefully considered. Natural, economic and cultural resources occur at relatively small scales; and an accurate risk evaluation, the spill model must provide data at suitably equivalent scales. One can gain an appreciation for the behaviour for floating oil from Figure 4-2, which shows the slick from the *Exxon Valdez* in Prince William Sound. The slick is comprised of long streamers and patches of oil, not large "pools" moving coherently across the sea. It is desirable to attempt to simulate this real behaviour of oil as far as possible. The Prince William Sound setting is appropriate for British Columbia. The highly indented shoreline of the North Coast leads to complex currents, at small scales, that will require careful derivation. Similarly, available oil spill models will probably require improvement to handle these data and deal properly with small-scale effects around islands and inlets, and the application of weathering algorithms at these fine scales.

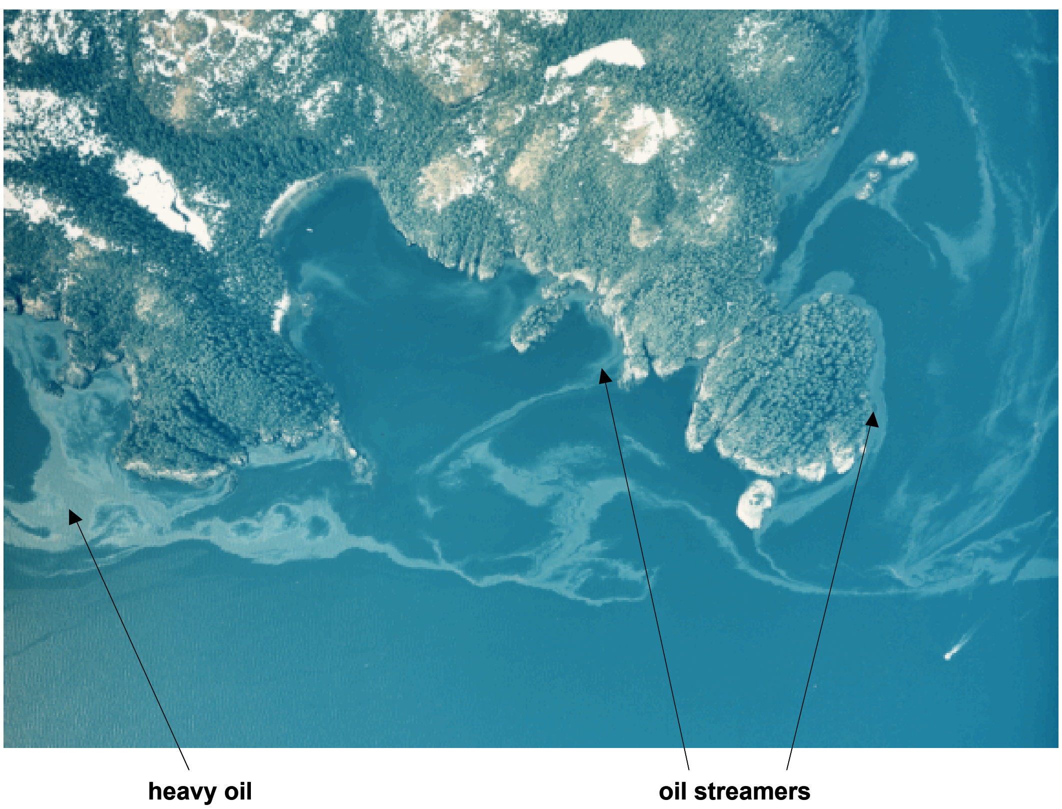

Figure 4-2 Aerial photograph of the Exxon Valdez spill in Prince William Sound, illustrating how oil spreads in streamers close to shore.

Resource damage model

In general terms the resource damage model makes an interaction of the oil with the valued resources — biological, physical, economic and cultural — to compute damage. The analysis is essentially spatial, but it accounts for variations in time as the oil moves through a particular area. Damage may result from toxicological effects on biota (e.g. loss of fish at sensitive life stages), destruction of habitat, direct and indirect costs, loss of use and enjoyment, loss of real property value, and loss of culturally important marine areas or artifacts, amongst others. Definition of the damage function is an important step in risk evaluation. It is obvious that definitions of damage contain uncertainty: uncertainty in direct cause and effect, like mortality of fish and mammals; uncertainty of long-term cumulative effects; and uncertainty in more subjective definitions such as those dealing with loss of cultural value. Uncertainty in all of these components is dealt with in a statistical manner in the resource damage model. The procedure then yields a *conditional*[2] *risk curve*, showing the probability of exceeding a particular damage level. If damage is expressed in dollars, the risk curve shows the likelihood of exceeding certain costs associated with a spill, and can include clean-up costs as well as direct damage to the environment. Simulation of different spills provides a family of risk curves for the scenarios included in the suite of runs, from those with the lowest damage to that with the greatest potential for damage. When the family of curves is related to the location of the spill, the information provides a method of ranking areas where drilling might or might not be permitted. Similarly, when applied to spills at different times of the year, the results can be used to restrict drilling in particular seasons, if there is a significantly greater risk of damage at one time of the year compared with other seasons.

4.5 Conclusion

Offshore hydrocarbon exploration and development cannot be undertaken without impacts on the environment. The subject area is a sensitive one and care is needed in any development. The objective should be to maintain risks at an acceptable level and to mitigate them. Safety has been improving in the industry and techniques and methodology are available for dealing with risks. Decisions with regard to lifting the moratorium and proceeding with development can be taken on this basis. As actual exploration and other activities take place, there is a need for quantitative risk analysis. This will provide an appropriate vehicle for decision-making in which the various stakeholders can assess the situation. Risk analysis will also assist in defining some measures to be employed in the regulatory regime. Decisions can be made, for example, on procedures for mitigation of oil spills, effluent discharges, and type of drilling fluid to be used. Existing practice and the regulatory environment in Canada are such that risks would be on the low end of the scale.

[2] Conditional means that only the probability of damage is considered, independently of the probability of the spill occurring.

CHAPTER FIVE CONCLUSIONS AND RECOMMENDATIONS

5.1 General

It may be useful to remind British Columbians that the principal reasons for the current provincial moratorium are two-fold: jurisdictional and environmental. The question of whether the sea-bed and subsoil under the Queen Charlotte Basin and adjacent waters belong to provincial or federal jurisdiction remains unresolved. There is still a variance of opinion on the degree of environmental risk associated with ocean and coastal activities in general, and with offshore hydrocarbon activities in particular.

Other reasons have been given for keeping the moratorium in place. It has been argued that the benefits of offshore production for the local economy would be short-lived: that the introduction of an offshore industry would bring in outsiders who might cause social disruption and challenge local cultural patterns; that British Columbia, lacking the necessary infrastructure of industrial knowledge and skills, would become dependent on other economies and jurisdictions; and that, in any event, the benefits and costs for BC are uncertain, depending on the outcome of complicated and protracted negotiations with the federal government, the oil industry, and possibly other extra-provincial interests.

On the other hand, it appears that the resource may be very substantial, perhaps comparable with reserves under the continental shelf in the areas of the Northwest Atlantic. If these estimates are accurate – and this can only be determined through exploratory drilling – then an offshore industry of Northern BC could become a major revenue generator for the provincial economy. Most of the above objections, it can be argued, could be met through careful planning, through the development of a rigorous regulatory regime governing all phases before, during and after production activities, and through the negotiation of fair federal-provincial fiscal arrangements, and of revenue-sharing arrangements with the First Nations and other coastal communities.

Given the complex and sometimes controversial nature of offshore development policy, and the relative open-endedness of the third and fourth of our terms of reference, this Panel offers a number of comments on the implications that seem to flow from the stock of scientific and technical knowledge summarized in the preceding chapters. Comments are offered also on some of the concerns that should be addressed, as the BC government considers whether to revise its present moratorium policy; and on various challenges that might have to be met if offshore development were to proceed with maximum benefit to the people of British Columbia.

We structure our conclusions and recommendations below in the order of the Panel's terms of reference.

(i) the scientific and technological considerations relevant to offshore oil and gas exploration, development and production;

5.2 Energy Context

From the perspective of the offshore science and technology community there is a great deal of technical knowledge that needs to be considered in order to assess the potential role of offshore hydrocarbon production. In short, the case for or against removal of the moratorium should be evaluated in the broader context of energy policy options among various alternative sources of energy.

5.2.1 Alternative Energy Systems

In the summer of 2001 the BC Government appointed a five-member Energy Policy Task Force to develop a "comprehensive, long-term energy policy" for the province. The report and recommendations of that Task Force are to be submitted to the BC Minister of Energy and Mines by January 31, 2002. Although that will follow the date for completion of this Panel's own report on offshore science and technology, our terms of reference seem sufficiently broad to permit comment on the relationship between long-term energy priorities and the current offshore hydrocarbon moratorium, from the science-and-technology perspective.

Offshore oil and gas production – like onshore oil and gas production – belongs to the mainstream of conventional non-renewable energy production. World demand for oil and natural gas is high and rising steadily, especially on the part of the more rapidly developing countries. A great deal of technical knowledge has accumulated in the various sectors of petroleum science and technology, and operational standards, onshore and offshore, have risen impressively.

As no doubt being reviewed by the BC Energy Policy Task Force, a number of alternative sources of energy, both conventional and non-conventional, can be considered as candidates for inclusion in a sophisticated, economically feasible and environmentally sound energy strategy for the province over the next 30-40 years, a period that would coincide with the period that any offshore hydrocarbon production would be expected to last. From the science-and-technology perspective, each of these options has to be examined with a view to the research-and-development time and cost requirements that must be met before they can claim the status of solutions to the difficult problems of sustainable energy. In this Panel's view, ending of the present offshore moratorium policy would be compatible with, and could be used to reinforce, a provincial energy policy that encouraged more substantial future investments in research and development of sustainable energy systems.

The candidate sectors might include existing sources such as hydropower and nuclear power, but a longer-term global strategy should be developed so as to give a high priority to the least environmentally harmful of options, such as hydrogen and fuel cell technology, wind-wave-and-tidal power, solar energy, and ocean thermal energy conversion (OTEC). Initiatives could be designed to build upon particular BC strengths or advantages, such as hydrogen and fuel cell development, wind-wave-and tidal power projects, gas hydrates and coal-bed methane production.

Such a long-term, multi-source, energy strategy developed along these lines would be compatible with a number of research and development programs being conducted in Canada and in British Columbia specifically.

The National Research Council's Innovation Centre located on the UBC campus is engaged in efforts to develop core competencies relevant to the long-term strategic technology needs of Canadian manufacturers, with a focus in the field of hydrogen-based fuel cell technology. At present Canada has a large share of this secondary power market, but it faces severe competition from other countries, especially the United States and some European countries. In the Canadian context, BC universities are leaders in hydrogen and fuel cell research, providing a particular opportunity for British Columbia to make a major contribution to sustainable energy production at the global level by using its oil and gas reserves as a means of transition to a hydrogen-based future.

It is also believed that BC has numerous coastal locations appropriate for tidal energy extraction, using new "non-barrier" technology, apparently with small risk of environmental disturbance, for the generation of ultra-high-density electricity. At present BC Hydro is conducting a province-wide assessment of tidal current potential. It seems that the North Coast region (especially around Prince Rupert, Kitimat and Stewart), Vancouver Island (Discovery Passage, Quatsino Narrows, and Dodge Narrows), and the Vancouver region have sufficient tidal and wave volume, depth and flow characteristics to generate thousands of megawatts. Investment in tidal/wave power, which has long been operational in France for example, would help BC to meet rising energy demands, provide export revenues, and create new jobs in manufacturing, engineering and sales, and also help Canada to meet its Kyoto Protocol commitments for long-term control of greenhouse gas emissions.

Recommendation 1. **We recommend that a decision by the BC government on the immediate question of whether or not to lift the offshore moratorium should be taken with a view to its priorities in the larger context of a provincial energy policy.**

(ii) further research or studies that should be undertaken to advance the "state of knowledge" on these considerations

5.3 Deficiencies in Knowledge and Capacity

This Panel has interviewed a number of specialists and, with the assistance of earlier reports and new ones prepared by highly qualified consultants, has reviewed the literature on offshore-related science and technology. The growth of generic knowledge in these areas over the past 15 years is impressive, and the technologies available to the petroleum and related sectors of industry have improved considerably.

However, significant gaps remain in a number of scientific and technical areas that would be of special relevance to British Columbia if the government should decide to revise the current blanket moratorium policy and signal its willingness to consider programs of offshore exploration and development. It is of similar concern that the public sector capacities to regulate the range of activities that might ensue from such a policy appear to be deficient.

The offshore and coastal regions of BC present an array of potential hazards and engineering challenges, including earthquakes, tsunamis, severe storms, high tidal ranges and currents, and other natural phenomena. However, in the year 2002 we look back on a half-century of offshore experience on the part of the petroleum industry in many countries, and here in Canada on three decades of oil and gas operations off the coasts of eastern Canada. The international and Canadian oil and gas industries are now immersed in the challenges of offshore development and production, and in the application of technology far superior to that of just a decade ago. Nevertheless, risks need to be assessed.

5.3.1 Sea-bed Conditions and Sub-surface Geology

Multi-beam swath bathymetry is the current state-of-the-art technology for determining sea-floor morphology and characterization. It provides an indication of materials present on the ocean bottom, including bedrock, sediment distribution, and, by extension and interpretation, areas of more or less risk from submarine slumping, liquefaction, turbidity currents, and related phenomena. Other techniques, such as side-scan sonar, sub-bottom profiling and sampling are routinely incorporated into the final interpretations. Surveys have been done for selected areas of the BC offshore, most locations being close to population centres that might be most at risk from related hazards such as disruption of communications or pipelines. The only currently available interpretation of possible sea-floor hazards in Queen Charlotte Basin is the Geological Survey of Canada Open File No. 2195, at a scale of 1:250,00. Some side-scan, high-resolution seismic reflection and multi-channel seismic reflection data are available in the regions of earthquake activity in the Queen Charlotte Basin. Much more reliable data and interpretations at a larger scale are needed.

Recommendation 2. **We recommend that the governments of both Canada and BC take steps to gain significantly higher levels of understanding of the sea-bottom and sub-surface conditions of the BC offshore in general, with an early and specific focus on the Queen Charlotte Basin and Hecate Strait areas.**

5.3.2 Marine Ecosystems

While we note below a number of the key physical parameters that must be considered in relation to most offshore activities, including oil and gas, and which like sea-bottom conditions influence habitat variability, it is essential to keep in mind that there is need for a more comprehensive data-base and information system for all aspects of the marine ecosystem.

There are large gaps in our understanding of the impacts on marine biota of acoustic phenomena such as seismic surveys, production rig and drilling noises, or passing ships, but studies of this kind are difficult to conduct on a comprehensive scale, and there is little interest in doing them as long as a moratorium on these activities is maintained. In the meantime, major changes in technology have been introduced, such as air guns in place of explosives for seismic surveys, and in some offshore regions, including those of eastern Canada, the use of air guns and other acoustic devices is subject to strict regulatory controls.

A rich and diverse ecosystem such as the Queen Charlotte Basin presents a number of options for sustainable economic benefit, including fisheries and tourism. But under any of these options, as well as under oil and gas production, serious disturbance to habitat or any biological features could ensue and possibly cause damage to the overall ecosystem; and there is the possibility that this damage might be irreversible. If this should happen as the result of any one activity, then the potential benefits available from the other options would be reduced.

There is concern among biologists and other scientists that the marine biota of BC is threatened by a proliferation of uses. The Panel emphasizes the need to address the deficiencies of knowledge in these areas of scientific knowledge. Reference to research in other offshore areas provides valuable guidance to researchers in BC, but this kind of knowledge is not a substitute for the regional and site-specific research needed in the event of offshore exploration and development.

Recommendation 3. **We recommend that, before any new industry is introduced into a specific marine ecosystem such as the Queen Charlotte Basin, action be taken to establish a comprehensive set of pre-perturbation baseline data on the biota, including life-cycle histories of different species and their habitats, so that we can understand and assess which aspects of the marine ecosystem might be most at risk from the proposed development, and evaluate the population- and community-level consequences that may result.**

5.3.3 Oil-Spill Response and Countermeasures

In the early years of oil and gas operations, especially on land in the period before the 1950's, legally sanctioned controls were often weak, at least in practice. Now the oil and gas industry is highly regulated world-wide, and in a technically advanced country such as Canada the regulatory regime is extremely strict, not least as it affects offshore operations. Indeed today it may be among the strictest in the world. Moreover, it appears that the Canadian oil and gas industry, compared with any other extractive industry, has a good record in compliance. The fact is that less than 2% of the oil spilled into the sea comes from offshore oil rigs and production platforms, while a combined total of 45% comes from maritime transportation, (shipping 33% and tankers 12%).

As Appendix 18 indicates, spills larger than 50 barrels have decreased dramatically over the last two decades, due to both improved technology and higher standards in offshore operations. Likewise, the risk of a blowout has been reduced to very low probability: the only recorded one in Atlantic Canada occurred in 1984 and involved only 1500 barrels of condensate. The same is not true for the shipping and tanker industries, which provide cause for concern about oil-spill response and countermeasures.

Atlases for oil-spill response and countermeasures have been developed for the west coast of Vancouver Island, the southern Strait of Georgia, and Burrard Inlet (underway), which provide information on coastal biophysical and human use, resources, and the sensitivity and vulnerability to both oiling and clean-up of these regions. We note that such reports as these have not yet been prepared for other areas such as the QCB.

Recommendation 4. **We recommend that the governments of both Canada and BC set a high priority on completion of critical data-bases, as well as the enhancement of capabilities for oil-spill responses and countermeasures, both for the coast in general, and particularly for areas likely to be designated for offshore exploration.**

5.3.4 Capacity Building

Oil and gas exploration would bring with it the need for the development of expertise and capacity to manage and sustain it in the best interests of all stakeholders. We identify four approaches that we consider to be essential.

The building or re-building or strengthening of **scientific and regulatory capacity** in the agencies of the provincial government and the BC-based agencies of the federal government is crucial. Since 1986 when the moratorium was last reviewed, there has been stagnation or decline, albeit interspersed with sporadic enhancement, of scientific expertise among the related ministries and laboratories of both the British Columbian and Canadian governments. Recent examples include the loss of six of the twelve seismic monitoring stations in the Queen Charlotte Islands, and there have been large, indeed excessive, cuts in funding of federal agencies in BC that have seriously crippled functions like fishery stock and habitat assessment, monitoring and enforcement. Over this period the Coast Guard was integrated with DFO and much of the DFO fleet eliminated, resulting in higher ship costs and lower levels of service to both science and enforcement. Comparable cuts have been made to provincial agencies, perhaps the most disturbing being the proposed dramatic down-sizing of the BC Geological Survey. The evidence suggests that at present there is insufficient capacity for the research, assessment, monitoring and management needed to provide an adequate baseline knowledge framework for ocean and coastal policy-making.

Recommendation 5. **We recommend strengthening and re-building of federal and provincial expertise in BC to ensure adequate scientific and regulatory/administrative capacity in agencies that would be given responsibilities in the event of a decision to initiate the process of offshore hydrocarbon development.**

(iii) any specific government actions that should be taken prior to a decision on whether to remove the current provincial moratorium

5.4 Procedural Considerations

In the present context, the decision whether or not to end the present blanket moratorium policy is fundamentally one of procedure. While the Panel sees no scientific or technical rationale for its retention, it does recognize the importance of addressing knowledge gaps and other problems, should the moratorium be ended.

In order to consider the science and technology dimensions of any decision on whether to end the moratorium, the Panel has had to ask what the moratorium actually is, how it could be removed, and what would be the situation subsequently. According to the dictionary, a moratorium is a temporary prohibition or suspension of an activity. The original legal authority for a prohibition of offshore exploration in BC is cloudy, but includes a federal announcement in 1972, a provincial Order-in-Council in 1982, and further provincial announcements in 1989. However, the Note associated with the 1982 Order in Council that carried the prohibition on drilling in the Inland Marine Zone was removed by a BC Regulation in 1994. Moreover, it is the Panel's understanding that the current federal moratorium does not rest upon any legislative foundation. So it seems there is no moratorium formally in place, either federally or provincially.

The Panel is, therefore, inclined to take the view that concerns with the "current moratorium" are conceptual and procedural in nature, and that no legislative action is necessary to revise the existing moratorium "policy" before inviting concrete proposals to initiate exploratory drilling and related activities by interested proponents. Any such proposals would then be subject to the existing legislative and regulatory apparatus, including specifically the Canadian Environmental Assessment Act, the British Columbia Environmental Assessment Act, and the Canadian Council of Ministers of Environment Policy on Canada-Wide Environmental Harmonization, under which a bilateral Canada-British Columbia Environmental Accord provides for an integrated joint environmental assessment and review process.

However, there are several important things that would need to be done before there could be any expectation of investor interest, public or private, in initiatives in the BC offshore. The Panel notes that the key preconditions have been spelled out already by industry, First Nations, civil society organizations and community leaders. These include:

- Development of an integrated federal-provincial regulatory framework. (The Canadian Environmental Assessment Act and the British Columbia Environmental Assessment Act are undergoing review and amendment, and the existing Canada-British Columbia bilateral accord on harmonized assessment expires April 2002 and must be renegotiated.);
- Negotiation of a Pacific Accord that provides for agreed federal-provincial and First Nations revenue-sharing and fiscal and management arrangements;
- Clear delineation of sensitive or vulnerable areas and definition of marine reserves, protected areas and conservation areas essential to preserve biodiversity and ensure ecosystem integrity, so that industry and others will be able to develop proposals for offshore activity with a clear initial understanding of any areas that must be off-limits; and
- Development of capacity to build baseline data and assess the state of the ecosystem, including natural and human components, and the impact of continuing activities, and capacity also to undertake quantitative risk analysis, valuation and assessment spanning the full range of strategic options.

Thus, in the present situation, the decision on whether or not to remove the present blanket moratorium seems to be fundamentally one of procedure, not science and technology. While the Panel sees no scientific or technical rationale for retention of the moratorium, it does recognize the importance of knowledge gaps and of steps that must be taken should the moratorium be ended. The balance of this text is oriented to this purpose.

(iv) any specific conditions or parameters that should be established as part of a government decision to remove the moratorium.

5.5 Regulatory Regime

5.5.1 Design of the Regulatory Structure

In Chapter Three of this report, the Panel identifies potential threats to the marine ecosystems of British Columbia, including the potential effects of oil pollution. But, as noted before, very little of the oil in the sea comes from offshore production. Most of the threats to marine ecosystems arise from other uses of offshore waters, and more specifically from a wide range of land-based (coastal and upriver) activities. For example, many in the BC biological research community, noting the accumulation of wastes discharged into BC waters from a growing volume of vessel traffic, now augmented by a growing cruise ship industry, point to the need for stricter controls over vessel-source pollution in general, and routine discharges in particular. The Panel favours a strengthening of efforts to protect marine ecosystems through more effective controls, but it does not find convincing evidence that the introduction of offshore installations and the commencement of drilling operations off the coast of BC should continue to be banned for general ecological reasons. Obviously, however, comprehensive data are required with respect to critical components of the ecosystem in advance of any exploration activity, along with a commitment to monitor and assess changes over the long term and take appropriate action in the light of any changes.

Marine ecosystems reflect a high degree of physical, chemical and biological variability. Accordingly, federal and provincial governments today have responsibilities for environmental policy related to coastal waters, including the establishment of conservation or protected areas. We note a particular need to focus on sensitive areas (e.g. sponge reefs, spawning and nursery grounds) or vulnerable species (e.g. killer whales, abalone).

Because of the recent history of offshore oil and gas exploration and development in eastern Canada, there is a sophisticated regulatory and management regime shared jointly by the federal and provincial governments. These systems are in place and are not significantly dependent on the need for new scientific or technical research.

Recommendation 6. **Should the moratorium be removed, the government should ensure, through appropriate consultation, that it has an up-to-date and properly resourced regulatory and management regime in place.**

5.5.2 Risk and the Role of the Regulatory Regime

At international and national levels, several sectors of natural resource development and management have been marked in recent years by divisions among specialists on the weight that should be given to precautionary considerations in situations where there is a credible risk of substantial environmental damage arising from any project under consideration. Environmental lawyers, in particular, have argued over the question of whether the need for reasonable precaution should be treated as a universally binding legal rule, a generally applicable legal principle, a standard applicable in special situations, or merely a guideline to prudent use.

From a scientific point of view offshore hydrocarbon exploration and development cannot be undertaken without some impacts on the environment, and the objective should be to maintain risks at an acceptable level and to mitigate them immediately and effectively. Safety has been improving in the industry, and improved techniques and methodology are available for assessing and dealing with risks and providing a basis for decisions related to offshore exploration and development. This will be helpful not only in supporting technical decisions, such as procedures for mitigation of oil spills, effluent discharges and type of drilling fluid to be used, but also in designing regulatory measures.

Recommendation 7. **We recommend that, before actual exploration and related activities take place, a quantitative risk analysis be undertaken as a vehicle for decision-making by the various stakeholders. A thorough cost-benefit analysis should also be undertaken to assess alternative strategies for uses of the marine ecosystem.**

5.5.3 Seismic Surveys

Recently the Joint Nature Conservation Committee (JNCC) in the UK has established specific seismic survey guidelines with regard to marine mammals, and member companies of the UK Offshore Operators Association and the International Association of Geophysical Contractors have indicated they will comply with these guidelines. We note that such acoustic disturbances could have effects beyond marine mammals and on other components of the marine ecosystem.

Recommendation 8. **This Panel urges application of guidelines for reducing the impacts of seismic exploration on the ecosystem, as license conditions for any oil and gas exploration off the BC coast.**

5.5.4 Rig and Pipeline Regulation

The Queen Charlotte Basin is subject to occasional severe storms, and the Northeast Pacific experiences fairly frequent earth movements under the ocean, which can trigger tsunamis. However, platforms can be designed to withstand the forces caused by these events and Canadian regulations require the highest possible standards of engineering design and construction ever applied to this sector of technology.

As noted above, pipeline delivery systems would be preferable to shuttle tankers, given that tankers and other vessels contribute far more to oil pollution of the oceans than oil and gas production platforms. However, should pipelines be used to export oil from production platforms, it would become more critical to have careful site-specific surveys and understanding of the local earthquake regime, as well as mechanisms to ensure that pipelines are designed, emplaced and monitored for the maintenance of maximum integrity.

Recommendation 9. **We recommend that regulations require, were production to take place in the BC offshore, that export lines from the production platforms be tied into pipelines, as opposed to offloading the oil into shuttle tankers by way of buoys. We further recommend that pipeline monitoring and shut-down systems be employed that would maintain maximum pipeline integrity and the least possible environmental risk. Site-specific surveys and assessments should be required to establish the most appropriate pipeline route.**

5.5.5 Conflicting Regulatory Priorities

We note that a bill has been introduced recently in the Nova Scotia Legislature (Bill 97, November 2001) to address perceived problems of conflicting priorities in the regulation of offshore health and safety matters. This and other issues of institutional design will demand close attention in any new offshore regulatory framework to be established in British Columbia, and the lessons to be drawn from experience elsewhere to date should be carefully assessed.

Recommendation 10. **We recommend that the separation of the regulatory authority for health and safety matters from the organi-**

zation that issues the exploration and production licenses is something which should be addressed in any new BC regulatory regime.

5.6 Supportive Strategies

5.6.1 Human Resource Development Strategy

One of the lessons learned from the eastern Canada offshore experience is that new opportunities for provincial and local employment can be lost in the absence of a concerted, multi-agency planning effort. The job market does not adjust quickly or automatically when a decision is made to begin or resume exploratory offshore drilling. It is essential to alleviate the already difficult challenges in recruitment of skilled and highly qualified people.

An appropriate technical training program would be designed to encompass a wide variety of technical skills covering the entire range of the ocean technology industry. BC educational institutions that specialize in vocational training should be helped to develop offshore-related courses in consultation with the appropriate sectors of the petroleum industry and others in BC, and perhaps with specialized institutions elsewhere. Such courses should be made available throughout BC

Recommendation 11. **If the BC government should decide to begin preparations for offshore exploration, one of its first steps should be to design a strategy for the training of British Columbians for the wide range of job requirements and opportunities associated with these activities.**

5.6.2 Coastal Community Development Strategy

As soon as possible following any decision to proceed with offshore development, the first steps should be taken to prepare the affected coastal communities for their potential relationship with the industry. A strategy should be developed before the industry has begun to move in. One of the industry's obligations should be to clarify the nature of the economic opportunities that may be created, and the pattern of social impacts and benefits that might be experienced. Such a strategy should also be designed so that the incoming industry has an opportunity to learn about the social history of the coastal communities, the richness of their traditions, and the nature of their expectations.

Recommendation 12. **The Panel recommends that, at the earliest stage of any offshore oil and gas activity, a strategy be developed to ensure effective participation of First Nations and Northern BC coastal communities in this new industry.**

5.6.3 Ocean Technology Industry Development Strategy

The private sector invariably leads in the creation and deployment of new activities, new business development, and ultimately the creation of new wealth. Yet entrepreneurial success often depends on a supportive government strategy. In British Columbia an ocean technology sector already forms an important part of the province's high-tech business community, which consists largely of small and medium sized enterprises (SMEs) that produce equipment and electronics for both domestic and export markets. These SME products include ships outfitting, engines, pipes, electronic navigational charts, navigation systems, remote and autonomous underwater vehicles, marine communications technology, advanced marine acoustics, underwater sensors, and advanced radar technology, among others.

An offshore oil and gas industry off the coast of BC would open up new opportunities for local SMEs in other sectors such as sub-sea equipment related to resource exploration, and the construction and maintenance of production platforms, and would increase the demand for highly specialized services such as ocean charting, sea-floor mapping, the acquisition and interpretation of seismic data, and environmental monitoring and assessment of marine ecosystems affected by offshore activities, to mention only a few. If an oil and gas industry were to develop off the coast of BC, it would likely create a snowball effect within the BC business community and enable it to become a more effective and significant exporter of specialized ocean-related skills and technology, as is happening in eastern Canada.

Such an initiative will rest largely with the private sector, including the academic community, but it is unlikely to happen as long as the moratorium is in place, and if it occurs at all, it will do so more efficiently through closer collaboration with the public sector in the form of joint planning and a clear provincial strategy.

Recommendation 13. **We recommend that, should the moratorium be removed, the BC government consider what steps it can take in partnership with the private sector to build upon any oil and gas development as the main driver of renewed marine engineering and construction sectors, as well as a broader-based ocean technology industry.**

5.6.4 Consultation Strategy

In an open, democratic society such as ours it is normal for governments to accept responsibility for cultivating appropriate consultative relationships with stakeholders and others with special knowledge, especially in situations that are complex and controversial to some degree. There are at least four constituencies.

The General Public: The present and previous governments of BC have maintained, at least intermittently, a kind of dialogue with the electorate on moratorium issues, which today is reflected in the work of the Northern Caucus of the governing party. In recent years the process of consultation was institutionalized by the establishment of the BC Northern Development Commission, which undertook extensive consultations in the North. The Panel presumes that a policy of public consultation, through the Northern Caucus or some other means, would be maintained if a decision were made to lift the provincial moratorium.

Northern Coastal Communities and First Nations: Experience elsewhere proves that the smoothest transition to an offshore development economy tends to occur when the local community and other directly affected parts of the population have been consulted throughout the entire process of development In British Columbia there is a special need for the players, from the beginning, to work with the First Nations coastal communities of Northern BC and their representatives on basic issues of entitlement, revenue-sharing, capacity-building, and governance within a framework of constructive collaboration.

The Research Community: The history of offshore development around the world shows that national governments do not always display much interest in benefiting from the past experience of other countries in technically complex sectors like offshore development, despite the availability of information in various forms such as model statutes and training manuals. However, at an early stage of its offshore planning, Newfoundland chose to consult with the public and private sector institutions carrying out oil and gas operations in the North Sea. Valuable lessons were learned, especially through intense consultation and interaction with the responsible British, Scottish and local agencies in Northern Scotland, Norway, and other countries around the North Sea. Nova Scotia followed suit, albeit within a shorter time-frame.

Other Jurisdictions: The Panel believes it will be useful for the BC government to establish a continuing consultative process with the governments of Newfoundland and Nova Scotia, in order to avoid unnecessary mistakes in the implementation of any decision to begin preparations for oil and gas development off the coast of BC Inter-regional technical consultations outside Canada would also be useful, especially, it seems, in Alaska and California, and perhaps also in Scotland and Norway. Moreover, these consultations should extend to the research and business communities in these jurisdictions.

Recommendation 14. **The Panel recommends that the BC government enter into consultations, at an early stage of any post-moratorium planning, with at least the above four constituencies: the general public, the northern coastal communities and First Nations, the research community, and other jurisdictions.**

5.6.5 Information Strategy

Public Access to Information: If the BC government decides to lift the moratorium, it will be important, in the Panel's view, to have a public information strategy as a corollary to its consultation policy. Ideally, a designated agency of the provincial government should be made responsible for maintaining a Web Site with information on current or recent developments related to exploration and subsequent phases of offshore oil and gas operations. Selected information, including certain scientific and technical data, should also be made available in non-electronic form.

Science and Local Knowledge: By definition, scientific and technological knowledge about the offshore is usually highly technical in nature. Both the acquisition and interpretation of such information is very largely the domain of the research community, and most of it tends to be confined to scientific and technical journals and reports. Despite the dominant role of the research community in this technical sector, the Panel believes that in certain contexts there is much to be learned from the observations and experience of seafarers in coastal and offshore areas, and of coastal communities. Most local knowledge tends to be anecdotal in form, or derived from logs and personal records, and some exists entirely as oral knowledge. Yet the Panel believes that valuable insights might become available to policy-makers from current BC research on local knowledge inputs.

Recommendation 15. **The Panel recommends that, if the provincial moratorium is ended and relevant technical research begins on an expanded scale, the BC government might wish to consider setting up an arms-length mechanism (e.g. through the province's educational institutions) that would both provide the general public with periodic summaries or abstracts of the technical literature, written in non-technical language, and also receive, interpret and communicate data from local and independent observers.**

5.7 Conclusion

There are a number of regional and site-specific gaps or inadequacies of data, knowledge, understanding, and indeed infrastructure and capacity, which must be addressed in the early stages following any removal of the moratorium. Nevertheless, oil and gas are being produced offshore under the full range of conditions found in virtually every variety of natural environment in the world, and clearly there have been steady improvements in the science, the technology and the regulations enabling and governing such activities. We conclude overall that, while there are certainly gaps in knowledge and needs for intensification of research and a continuing commitment to baseline and long-term monitoring, these do not preclude a decision on the moratorium. There is no inherent or fundamental inadequacy of the science or technology, properly applied in an appropriate regulatory framework, to justify retention of the BC moratorium.