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Les enjeux liés aux levés sismiques dans
l'estuaire et le golfe du Saint-Laurent

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**SUMMARY OF THE REPORT OF THE COMMITTEE OF EXPERTS
ON THE ENVIRONMENTAL ISSUES
ASSOCIATED WITH SEISMIC SURVEYS
IN THE ESTUARY AND GULF OF ST. LAWRENCE**

March 2004

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TABLE OF CONTENTS

1.	INTRODUCTION.....	1
2.	DESCRIPTION OF THE STUDY AREA.....	5
	Limits of the area	5
	Biophysical sectors	5
	Protection areas.....	5
	Commercial fisheries	6
	Harvesting of fishery resources by the Amerindians.....	7
	Recreational tourism.....	7
3.	HYDROCARBON POTENTIAL OF THE STUDY AREA.....	8
	Exploration techniques.....	9
	The notion of decibel	9
	The notion of attenuation.....	10
4.	ISSUES.....	11
	Development of hydrocarbons.....	12
	Preservation of the commercial, traditional and sport fisheries.....	13
	The vitality of the recreational tourism industry.....	13
	Protection of marine mammals	13
	Conservation of resources and biodiversity	16
	Legal protection tools	16
	Precaution in the face of scientific uncertainties	16
5.	POSSIBLE SOLUTIONS.....	17
	Mitigation measures.....	17
	Better adapted laws and regulations	18
	Precaution principle	19
6.	CONCLUSION	19

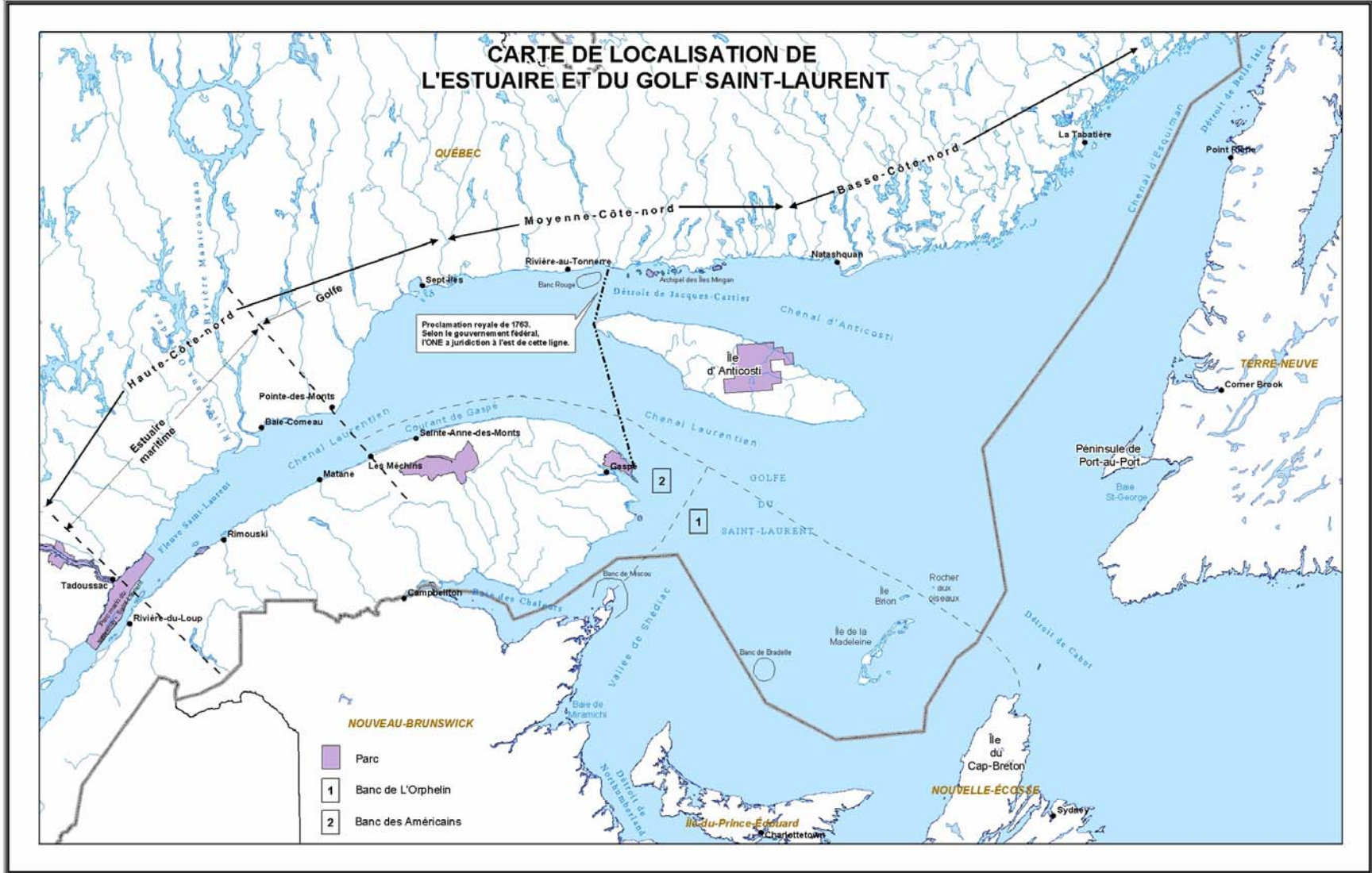
1. INTRODUCTION

Since the announcement of a seismic survey project in the estuary and Gulf of St. Lawrence in November 2002, many questions and concerns have been raised regarding the potential impacts of these activities on aquatic wildlife, the fishing industry and the tourism industry. Environmental groups, tourism associations and citizens' groups have reacted in the face of the absence in Québec of a specific environmental assessment and authorization procedure for carrying out seismic surveys in a marine environment.

The carrying out of seismic surveys is the first stage of oil and gas exploration. The techniques employed for this purpose make it possible to represent the structure of the sea floor over several kilometres in depth and to detect the areas where the possibility of the presence of oil and natural gas is most promising.

In light of the foregoing, Mr. Thomas J. Mulcair, Minister of the Environment, and Mr. Sam Hamad, Minister of Natural Resources, Wildlife and Parks, announced on December 3, 2003 the creation of a Committee of experts on the seismic survey projects in the estuary and Gulf of St. Lawrence. This committee was mandated to identify the environmental issues associated with the seismic survey projects, to take stock of scientific knowledge, and to propose possible solutions. Mr. Mulcair also announced his intention, once the committee's work has been completed, of mandating the Bureau d'audiences publiques sur l'environnement to hold consultations with the public, interest groups and experts to allow them to voice their concerns about the impacts of the seismic surveys on the environment.

This document summarizes the report of the Committee of experts on the seismic survey projects in the estuary and Gulf of St. Lawrence. This work took place between December 15, 2003 and February, 15, 2004.



Source: Ministère des Ressources naturelles, de la Faune et des Parcs

Figure 1: Study area

2. DESCRIPTION OF THE STUDY AREA

Limits of the area

The study area comprises the marine portion of the estuary and Gulf of St. Lawrence. It is bounded to the west by the Saguenay Marine Park and to the east by the drawing of 1964 which establishes the interprovincial limits of the Gulf of St. Lawrence (Figure 1).

Biophysical sectors

The lower estuary extends over a length of about 230 kilometres and a width varying between 24 kilometres at Tadoussac and 50 kilometres downstream from the Pointe-des-Monts and Les Méchins sector.

The Gulf of St. Lawrence, for its part, is a semi-enclosed sea, whose freshwater inflows produce an estuarine circulation. The Gulf extends from west to east over more than 1000 kilometres between the brackish waters of the lower estuary of the St. Lawrence and its two main openings on the Atlantic Ocean, i.e. the Strait of Belle-Isle to the northeast and Cabot Strait to the southeast.

The cold water and certain physical processes, i.e. deep water upflows, freshwater inflows, the currents from Labrador and Gaspé, help to make the Gulf of St. Lawrence a region that is just as productive as the other coastal sectors of eastern Canada. The Gulf's plant life and wildlife are highly diversified.

Protection areas

Three national parks of Québec, two national parks of Canada and the Saguenay-St. Lawrence Marine Park (Canada-Québec) are located inside the area covered by this report (Figure 1). The objective of these parks is to ensure the conservation and permanent protection of territories that

are representative of the natural regions and of natural sites that are exceptional, due in particular to their biological diversity.

The parks are protected areas having marine habitats and ecosystems. Several marine species are found here during certain periods of the year and at various stages of their life cycle. For the Saguenay-St. Lawrence Marine Park and the national parks contiguous to the estuary and gulf, the resident or migratory species are essential and constituent components of the ecological processes of the coastal or marine ecosystems. Several species are the focus of conservation or protection plans or adapted management methods when they frequent these protected areas.

The enhancement and development of several parks are based, among other things, on the observation, at sea or from land, of several marine species, mainly mammals and certain birds. Seismic surveys are not authorized in these parks.

Commercial fisheries

Commercial fishing in the estuary and Gulf of St. Lawrence is the main social and economic activity in the coastal regions. In 2000, the global value of landings represented close to \$166 million.

In 1997, fishing provided income for 4,844 registered fishers distributed fairly equally among the Gaspé Peninsula, the North Shore and Îles-de-la-Madeleine. In 2000, 4,400 workers were employed by processing plants. As a result, fishing provides income for some 9,000 people. It is basically a coastal fishery since two-thirds of the registered boats are less than 35 feet in length.

The entire Gulf of St. Lawrence is concerned by fishing activities. The main activity is located near the coasts. However, the zones that are located further off-shore are visited for crab, black turbot, Atlantic halibut and shrimp.

The official fishing seasons can cover the entire year. Fishing activities are carried out in the gulf from April to October. They vary according to the zones and the species, and are subject to local

adjustments. Generally, most of the activity takes place from the time when the ice recedes in the spring until the fall, towards October and November.

Québec's fisheries are moving from an economy that is basically geared to groundfish to a more diversified economy, supported by high value invertebrates, snow crab and lobster in particular.

Harvesting of fishery resources by the Amerindians

The Amerindian populations inhabiting the area of the estuary and gulf are spread out over twelve communities totaling close to 15,000 people. The general level of activities has intensified in most of the communities since the early 1980s. The most frequently used species are seals, salmon, ducks and "migratory birds" in general.

The commercial sea fishery carried out by the Innu has witnessed phenomenal growth over the last three years in the wake of the Marshall Ruling which recognized aboriginal rights to harvest marine resources commercially. Several species are harvested or may soon be harvested: snow crab, rock crab, shrimp, lobster, turbot, mackerel, herring, whelk or periwinkle, softshell clam, scallop and Stimpson's clam. This fishery represents revenues of a few million dollars and several dozen seasonal jobs.

Recreational tourism

The estuary and Gulf of St. Lawrence comprise five tourism regions, i.e. Bas-Saint-Laurent, the Gaspé Peninsula and Îles-de-la-Madeleine on the south shore and Manicouagan and Duplessis on the north shore. Each year, these regions play host to 2.5 million tourists. To this number must be added the 1.1 million excursionists who crisscross this large region over the course of the year. During this period, these visitors spend some \$375 million here, which results in major economic activity: 7,617 jobs are associated with the tourism activity of these regions. In terms of activities, cruise excursions are the most important. The proposed cruise excursions mainly deal with the observation of marine mammals and, to a lesser extent, the observation of islands, lighthouses and birds, all attractions of the marine environment.

3. HYDROCARBON POTENTIAL OF THE STUDY AREA

Québec has a total surface area of 1.7 million square kilometres. The part of the territory that is favourable to the presence of oil and natural gas occupies about 200,000 square kilometres, i.e. 13 % of Québec's territory. This area, where geological formations composed of sedimentary rocks are found, is located in the southern part of the province in the St. Lawrence axis. It comprises three basins. Approximately 60% of the territory that is favourable for prospecting is situated in the marine environment.

The sedimentary basins of the estuary and Gulf of St. Lawrence are made up of a large variety of geological formations. These rock formations were deformed during the major geological episodes, thus creating vast structures that are conducive to hydrocarbon accumulations. The seismic surveys carried out in this sector led to the discovery of the Old Harry geological megastructure. It is estimated that the reserves of Old Harry can supply Québec with natural gas for about 20 years.

Elsewhere in the estuary and Gulf of St. Lawrence, the presence of geological formations and structures that are conducive to the accumulation of hydrocarbons and exploration drilling targets now need to be confirmed with the help of regional or local seismic surveys. The first seismic surveys in the estuary and Gulf of St. Lawrence began in the late 1960s. To date, approximately 33,000 kilometres of surveys have been acquired in the Québec portion of the Gulf of St. Lawrence and more than 1.4 million kilometres have been acquired off the Atlantic coasts since the early 1980s. With the exception of the seismic surveys conducted above the Old Harry structure, no survey has been done in the marine environment in the Québec portion of the Gulf of St. Lawrence since 1983. Despite a large number of seismic lines done in this region, a new coverage is essential to better represent the geological structures below the surface.

Exploration techniques

Different types of geophysical surveys can be used in oil and gas exploration to better characterize the physical properties of the rocks of a sedimentary basin identified as being favourable to hydrocarbon accumulations. Surveys of the magnetic, gravimetric and seismic types are most often used.

Seismic surveys provide a two or three-dimensional picture of the various layers of the Earth's crust and associated structures, such as faults, unconformities, foldings, thrusts, etc. The physical principle is based on the variation in the speed at which waves propagate in the layers being crossed, much like ultrasound examinations performed in the medical field.

To carry out a seismic survey campaign in a marine environment, a ship travels at speeds varying between 4 and 6 knots. The ship tows a sound source composed of an array of airguns that emit a sound (compression wave) in a range of frequencies varying between 10 and 300 Hz. The wave penetrates the floor and a part of the wave is reflected towards the surface when new geological layers are encountered. The reception of the signal (the return wave) is recorded on magnetic tapes using an array of sensors (hydrophones) also towed by the ship. The source and the array of sensors are submerged at a depth that is generally situated between 3 and 10 metres.

The notion of decibel

By definition, a decibel is a relative measurement unit used to compare two power intensities on a logarithmic scale. The audibility threshold of a sound propagated in the air has been set at a pressure of 0.00002 Pascals. This is the lowest pressure at which the human eardrum can vibrate. It corresponds to the reference pressure having been defined for measurements made in the air (0 dB). The tolerance threshold corresponds to a pressure of 20 Pascals. The ratio between an audible sound and a sound that damages the human ear is 1/1 000 000, and the measurement in dB of a sound that is loud and unpleasant for the human ear is 120 dB.

This 120 dB threshold corresponds to the sound of a jackhammer whose power is one million times greater than a sound that is barely audible. When comparing a sound intensity value in dB in water and in air, it is important to make corrections. Indeed, 120 dB in the air do not correspond to 120 dB in water, because one has to take into account the difference between the reference pressure in the air which is 0.00002 Pascals and that in water which is 20 Pascals.

The expression in dB for air and for water will differ by 26 dB due to the reference pressures. Moreover, the characteristics of acoustic impedance (speed of the seismic wave multiplied by the density of the medium) also vary between air and water. The acoustic impedance is 3,600 times greater in water than in air. This implies that the conversion factor for a given sound intensity at equal pressure between air and water is 36 dB.

By considering the reference difference between air and water and the acoustic impedance difference, the intensity difference between air and water will be: **26 dB + 36 dB = 62 dB**. In order for an intensity of 120 dB of sound emitted in the air to correspond to an equivalent intensity in water, the latter would have to reach 182 dB (**$\text{dB}_{\text{air}} + 62 \text{ dB} = \text{dB}_{\text{water}}$**).

The notion of attenuation

The power of seismic waves diminishes according to the distance from the source and the emission frequency. This attenuation phenomenon varies according to the logarithm of distance. Sound disperses in a sphere-like pattern to the sea floor. The loss of wave intensity is 6 dB each time the distance doubles.

The following table presents different wave intensity attenuation values according to the distance for a source that has a spectral intensity of 214 dB. This transmitted power is typical of that currently used to carry out seismic surveys in a marine environment. In this example, the intensity of the wave at a distance of one kilometre from the source will be less than that of a merchant ship and will be slightly greater than that of a fishing boat or a pleasure boat powered by a 90 hp engine.

Attenuation of the spectral intensity

Distance from source (metres)	Attenuation (dB)	Intensity (dB)
1	0	214
10	20	194
50 Ex: Magdalen plateau	34	180
100	40	174
200	46	168
400 Ex: Laurentian channel	52	162
1000	60	154
2000	66	148
10000	80	134

Finally, as a reference, the background noise in the open sea varies according to the state of the sea. Waves and wind are the main sources of sound waves of natural origin in the sea. A background noise of 100 dB may be considered a usual sound intensity in which marine mammals live.

4. ISSUES

The major issue of the seismic waves consists of permitting a sustainable use of resources in the estuary and Gulf of St. Lawrence. The aim here is to ensure the protection of the Gulf's ecosystems while improving the quality of life of coastal communities. The environmental and socioeconomic issues ensue from the impacts that could potentially arise from the seismic survey activities and that could affect the resources and components of the environment, as well as the activities related to the development and exploitation of natural resources in a marine environment.

Development of hydrocarbons

The perspective of a hydrocarbon supply obtained from reserves situated in Québec is a first socioeconomic issue of importance. This issue is at the very heart of the initiative to develop Québec's oil and gas potential and the very reason for the seismic survey projects in the estuary and Gulf of St. Lawrence.

The economic benefits associated with the development of hydrocarbons on Québec's territory are numerous: strengthening of the security of hydrocarbon supplies, increase in investments, job creation, generation of additional revenue for governments, increase in regional development and stimulation of industrial development.

Oil and natural gas meet about 50% of Québec's energy needs. One hundred percent (100%) of our hydrocarbon supplies come from outside Québec, which explains the importance of developing our own oil and gas resources. The economic spin-offs anticipated for the exploration period could reach \$1.5 billion. These spin-offs will profit the Gaspé and Îles-de-la-Madeleine regions in particular. The discovery of exploitable natural gas resources would generate \$4 billion in additional investments. In comparison, the Hibernia deposit, located off New Brunswick and Labrador, generated \$14.6 billion in economic spin-offs and created some 1,800 jobs. The development of the gas potential of Sable Island, near Nova Scotia, generated \$7.35 billion in economic spin-offs and led to the creation of about 1,100 jobs. The net revenue for the Government of Québec could reach \$150 million per year during the first ten years of production.

The economic spin-offs of exploration activities and, eventually, those ensuing from the exploitation of deposits, would stimulate the economy of Québec and of its resource regions. It must however be possible to carry out these activities in harmony with the other activity sectors on which the regional economy is currently based.

Preservation of commercial, traditional and sport fisheries

The economic and social activities related to the fisheries industry are very important for the coastal communities of the Bas-Saint-Laurent, Gaspésie, Îles-de-la-Madeleine and North Shore regions. The issue is major in a context where fishing represents the basic economic activity of many coastal communities. Groundfish species are in an extremely precarious state. The fishing economy is based on a few species of invertebrates. It is therefore necessary to make sure that the seismic surveys are done in such a way as to preserve the stocks of these species and that these surveys have no potential effect on the harvested organisms, the eggs, larvae as well as the behaviours that influence reproduction mechanisms and fishing yields. The eggs and the larvae of the harvested species are part of the plankton. Based on the available information, mortality should be negligible in relative terms. However, given the precarious state of the stocks, this mortality must be minimized as much as possible.

The vitality of the recreational tourism industry

The preservation of recreational tourism activities is crucial for the economy of the Bas-Saint-Laurent, Gaspésie, Îles-de-la-Madeleine and North Shore regions. There is a direct link between the presence of marine mammals in the estuary and Gulf of St. Lawrence and the number of tourists visiting the regions in question. Knowing that the recreational tourism industry is a major product for the regions' economic vitality, any intervention that would modify over the short or medium terms the behaviour of marine mammals could have an impact on the number of tourists and consequently the ensuing economic spin-offs.

Protection of marine mammals

The impacts on marine mammals represent the first and principal environmental issue. The disturbance of, physiological damages to and interference with the populations that are present are the main manifestations of such impacts.

Marine mammals, i.e. whales and seals, live in a universe where sounds play a major role. Indeed, these animals use, in varying degrees, sounds to communicate, look for food, detect predators and obstacles, move about, establish contacts, ensure the cohesion of the group and collaboration in obtaining food, warn of the presence of danger, etc. These vocalizations must be emitted, disseminated and perceived despite the presence of a series of natural background noises generated by nature or human activities (man-made).

The degree of adaptation and adaptability of the various marine mammal species to some of these man-made background noises is unknown. However, it is known that certain animals tolerate disturbances and pursue their activities to meet their physiological needs. This habituation does not exclude the possibility of a medium- or long-term effect on the animals' hearing system. The scientific knowledge concerning this aspect needs to be increased.

When detected by marine mammals, the sound waves produced by seismic surveys can induce two behavioural changes, either a disturbance that leads to avoidance or flight reactions or an interference with mammal behaviour involving vocalizations such as communication, the search for and location of prey, and navigation.

In the first case, the animal reacts to a noise that bothers, worries or scares it. The animal may then alter its trajectory, if it is moving, to avoid the noise or flee the sector it was frequenting for a precise activity. These avoidance and flight reactions are generally observed in whales, whereas seals are not bothered much by seismic pulses. The degree of disturbance varies according to the sensitivity and the level of tolerance of each species and depends on the distance between the sound source and the animals, the power of the source, the phenomenon of wave attenuation in the water, and the biophysical conditions of the environment. Depending on the intensity and the duration of the reaction, these disturbances could have an influence on the energy balance of each individual animal due to feeding interruptions, nursing interruptions or efforts to move about. The importance of the impacts will also depend on the season.

In the second case, the sound waves interfere directly with the behaviour in progress associated with the vocalization. This may lead to an energy deficit caused by the disturbance of a feeding

activity, an inability to manage a group activity including ties between the mother and her young, an inability to communicate over large distances with other animals of the same species and a disorientation phenomenon. The effect on the individual animal or population will vary according to the species involved, the duration, the intensity and the proximity of the source of disturbance, the behavioural activity under way, and the condition of the animals involved.

The physical damages caused to organisms may be temporary or permanent. The hearing mechanism of marine mammals is unquestionably well developed, able to capture sounds from different origins in a range of frequencies that includes the frequencies used for seismic surveys. However, the degree of hearing sensitivity of marine mammals under water is not well known.

For whales and seals, the sounds generated by seismic surveys can have detrimental effects on the hearing system over the long term. The tolerance threshold that has become the standard around the globe is 180 decibels. Above that threshold, marine mammals are thought to be affected. However, at the present time, there is no unanimity among scientists on this standard, and this shortcoming in our knowledge warrants caution. It is possible that the danger threshold is different from one species to the next, depending on the physiological characteristics specific to each species.

Before undertaking activities that generate sound waves, precautions are in order to take into account the habitats and biological cycles of sensitive species, in particular endangered species (blue whale, St. Lawrence beluga and right whale), and species whose situation is of concern (fin whale, humpback whale and harbor porpoise). These measures must also take into account elements such as the species' conservation status, intensive feeding grounds, concerns about the reproduction rate, vocalizations masked by sound waves, the species' presence and distribution in winter, as well as shortcomings in the knowledge concerning the life cycle and noise tolerance threshold.

Conservation of resources and biodiversity

A second environmental issue concerns the protection of the resources and the environment as a whole for several species, as well as of habitats other than those of marine mammals. For example, nesting success, in particular for colony nesters such as the northern gannet, Atlantic puffin, the common murre and razorbills depends on the presence of banks of fish and crustaceans near the colonies in order to feed and nourish their brood.

The estuary and Gulf of St. Lawrence have several wildlife habitats and parks located near the shores or nearby. The purpose of these protected territories is to ensure the conservation of the biological and natural resources present and to guarantee their sustainability. Although these protected areas do not risk being directly affected by the seismic surveys, the integrity of their resources could be affected, thereby compromising the fulfillment of their missions.

Legal protection tools

The zone of the estuary and Gulf of St. Lawrence is currently a region where the possibilities for government environmental control over seismic surveys are limited. The question of the appropriateness of adopting a legislative and regulatory framework in the environmental field for this activity must be envisaged.

For Québec, it is important to determine if Québec's right to authorize seismic surveys in a marine environment under the Mining Act includes an obligation to protect local resources and the environment from the potential impacts of these activities.

Precaution in the face of scientific uncertainties

The context that surrounds the decision-making process concerning the environmental feasibility and acceptability of seismic surveys in the estuary and Gulf of St. Lawrence is marked by uncertainties. These uncertainties are due to the limits on scientific knowledge, which may relativize the effectiveness of mitigation measures.

5. POSSIBLE SOLUTIONS

Following its analysis, the Committee of experts recognizes that the potential impacts of seismic surveys in a marine environment and the environmental issues associated with such impacts warrant caution since the environment is already highly solicited and biological resources have been fairly weakened by human activities as a whole. The Committee is of the opinion that for the time being, a preventive approach requires that we resort to effective and tangible mitigation measures to minimize the impacts of seismic survey campaigns. Moreover, environmental security rules must be applied on the basis of the applicable risk thresholds or the protection perimeters for safeguarding marine species.

Mitigation measures

The disturbances of the marine environment caused by seismic survey campaigns must be limited as much as possible. To delimit the disturbance zones, it will be necessary to evaluate what the attenuation of the seismic signal will be in order to determine the risk corridors based on avoidance behaviours and physical damages.

Several mitigation procedures have already been adopted in the world to reduce the impact of seismic waves on biological components, marine mammals in particular. A code of mitigation measures has been developed in Northern Europe, in the Beaufort Sea and on the west coast of the United States for various marine mammal species.

The measures generally applied in eastern Canada and elsewhere in the world include in particular:

- a delimitation of the work corridor for marine mammals, the width of which will be established taking into account the applicable critical threshold according to avoidance behaviours and risks of physical damages, the power of the sound source, the wave

attenuation phenomenon and a safety coefficient corresponding to twice the calculated value of the risk corridor;

- the progressive start-up of seismic surveys at all times;
- a program for visually detecting marine mammals and diving birds;
- an acoustic program for detecting marine mammals;
- a protocol for progressively reducing the power of the source when marine mammals are inside the safety corridor corresponding to avoidance behaviour;
- a protocol to stop seismic surveys when marine mammals are inside the safety corridor corresponding to physical damages;
- the progressive start-up of specific seismic surveys in sensitive areas;
- a restriction to certain times of the day in sensitive areas;
- the optimization of the sound power according to the objectives;
- the choice of the period for carrying out the seismic surveys with the fewest potential impacts;
- acoustical measurements of signal attenuation;
- the avoidance of the critical habitats of fishing resources; and
- the avoidance of marine parks having a high biological value.

Moreover, certain shortcomings identified in the field of scientific knowledge make it difficult to establish direct ties between seismic techniques and environmental impacts. The acquisition of new knowledge on the estuary and Gulf of St. Lawrence, in particular during seismic surveys, is therefore necessary. This new knowledge will permit, where applicable, the development over the medium term of adapted environmental management tools to provide a framework for these activities.

Better adapted laws and regulations

Resorting to appropriate management tools would ensure that the seismic survey work is carried out with mitigation measures that are equivalent or superior to those in use in Canada and elsewhere in the world. The development of technical protocols or the introduction of new procedural rules within the context of the Regulation respecting petroleum, natural gas, brine and

underground reservoirs governed by the Mining Act would be desirable. The seismic surveys could also be subject to environmental assessments and authorizations.

Precaution principle

The management of the uncertainties should guide the authorities in charge when deciding between uncertain and unproven damages to the environment and the means available to reduce risks and minimize the damages possibly caused by seismic surveys. On the one hand, the opinions of experts can help determine the risks and examine plausible hypotheses for reducing them. Moreover, the consultations will allow the public and the stakeholders concerned to voice their concerns and their expectations regarding the socioeconomic and environmental questions that must be taken into account.

When there is great uncertainty associated with the impact of an activity such as seismic surveys, the approach must necessarily be accompanied with a meticulous analysis that takes into account the state of knowledge, the cumulative effects of other activities carried out in the area and the value of the components of the environment. This approach should lead the authorities in charge to show caution, in particular in the case of species having a precarious status or that are of concern and for which the uncertainties have a much higher relative weight.

6. CONCLUSION

Following its analysis, the Committee of experts feels that the seismic activities in the Gulf and estuary of the St. Lawrence raise major socioeconomic and environmental issues.

The current state of scientific knowledge does not make it possible to establish clear relations between the use of seismic survey equipment and its potential effects on the marine environment and its resources. However, we know that in general high-intensity sound waves can cause disturbances and damages to certain species of the marine environment, in particular the hearing system of marine mammals. Indeed, some species appear to be more sensitive to the sound waves emitted by airguns. This is the case of certain marine mammals for which behavioural

changes and, in some cases, damages to the hearing system, have been noted. In the Committee's opinion, as marine mammals are the most vulnerable wildlife species, their protection must be ensured through the meticulous application of the best mitigation measures known. Indeed, experts recognize that these mitigation measures are effective and that they make it possible to minimize the impacts of seismic surveys.

The preservation of commercial, sport and traditional fisheries is a decisive socioeconomic issue given the importance that these activities represent for the communities and the coastal regions of the estuary and Gulf of St. Lawrence. The recreational tourism industry of these maritime regions is also very dependent on the presence of marine mammals, the success of sportfishing and the quality of the marine environment.

Moreover, the perspective of being able to resort to Québec resources for gas and oil procurement is a decisive socioeconomic issue, for it points to significant economic benefits, such as investments, job creation, revenue for governments, both for the resource regions directly concerned and for Québec as a whole.

As for seismic surveys, the Committee is of the opinion that the choice of technologies and precautions to be taken must minimize the disturbances of and possible damages to the environment. The equipment used must be as efficient as possible in this respect. Environmental security rules should be established by drawing inspiration from the practices implemented in other sectors of the gulf, the Atlantic Ocean or elsewhere in the world. They should be based on similar projects and involve risk thresholds that must not be exceeded and protection perimeters that should be preserved for the welfare of the marine species present near the seismic survey sites.

The Committee has ascertained the decline of several species of fish and marine mammals and the precarious status of some of them. Although it is difficult to identify the precise causes of this situation, it is possible to consider that all of the human activities result in a certain pressure on the marine ecosystems that may lead to a weakening of them. It should however be noted that with the exception of the Old Harry site, there has been no seismic survey in the Québec portion

of the estuary and Gulf of St. Lawrence since 1983. Under these conditions, it is difficult to discern, among the various activities and the deterioration of the environment, the effect of the seismic surveys. Notwithstanding this observation, the precariousness of several species dictates that we act with precaution before beginning any human activity that can lead to an increase in the pressure on biological resources.

The Committee of experts is of the opinion that the preventive approach requires first resorting to tangible and effective mitigation measures to minimize the impacts of seismic survey campaigns.

In this respect, the Committee's work has allowed the Committee to identify certain mitigation measures making it possible to avoid or reduce the impacts of sound waves on the biological components, in particular on marine mammals, during seismic surveys. Several of these mitigation measures have been successfully applied in eastern Canada and elsewhere in the world. However, they involve some uncertainties in the specific context of the Gulf of St. Lawrence. The carrying out of seismic survey campaigns having an experimental dimension would make it possible, among other things, to validate the signal mitigation model and to specify the dimensions of the security corridor. The report insists on the caution that must be shown when envisaging and applying such measures, taking into account the comments and knowledge that will be added at the time of the public consultations.

Meanwhile, the development of knowledge on the natural environments of the estuary and Gulf of St. Lawrence would promote a vision and understanding of the socioeconomic and environmental dimensions of these environments within a sustainable development perspective. The acquisition of new knowledge on the marine environment during seismic surveys would permit, as the case may be, the development of adapted environmental management tools to provide a framework for these activities. The Committee believes that it is important to promote the sustainable use of the resources of the estuary and Gulf of St. Lawrence by ensuring the protection of its ecosystems and by improving the quality of life of the coastal communities.