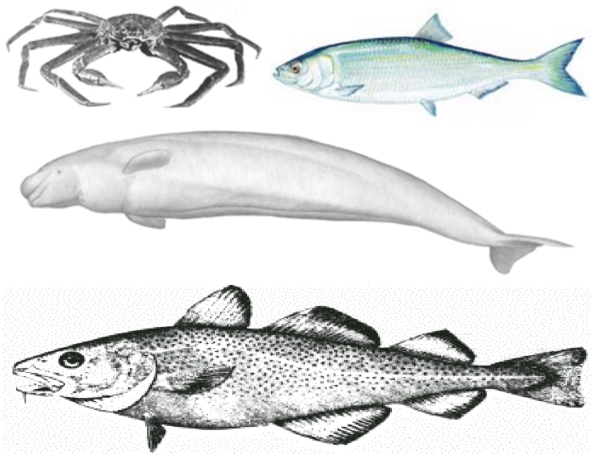

A Framework to Assist DFO Consideration of Requests for Review of Seismic Testing Proposals

Background

Seismic testing for hydrocarbon deposits can create opportunities for economic development and energy security. However, like all anthropogenic activities in marine ecosystems, it must be conducted sustainably. Although the details of governance of offshore oil and gas activities differs around the coasts of Canada, in all cases, the Department of Fisheries and Oceans does have a jurisdictional role. Proposals for permits for seismic testing come to DFO for evaluation, comments, and recommendations for actions by the management authority. Consideration of these referrals is coordinated by Habitat Management, but often requires substantial support from Science and/or Fisheries Management and Oceans Policy. The nature of the support required necessarily depends on the geographic area for which a permit is sought, the scale of the proposed seismic activities, and details of the proposed operations. The purpose of this HSR is to provide a general framework for use by DFO officers when considering these referrals, particularly with regard to science issues that form a central part of those considerations.

Introduction

This HSR is the result of a meeting of science experts and managers from Canada and international agencies with particular expertise in evaluation of potential impacts of seismic testing on marine ecosystems and their components. The meeting was to develop a general framework and guidelines for the DFO evaluations. The framework and guidelines do not attempt to determine what level of impact would or would not be acceptable, nor would be likely to result from seismic activities. Further meetings and, in many cases new research and/or further review of global experience with consequences of seismic testing will be necessary to set evaluation standards to apply in specific referrals. Therefore this HSR should be viewed as a step towards a systematic and comprehensive approach to DFO's evaluation of seismic referrals, to be augmented by Status Reports produced by future meetings.

Habitat Concern

<u>The Role of Science Support</u>

When DFO receives referrals regarding permits for seismic testing, Habitat Management generally coordinates DFO's response, with input as appropriate from other

Sectors. As with many other types of referrals DFO's response must address several questions about the proposal and its possible consequences. Each question needs science support, but the nature of the support varies. Those questions, and the nature of the scientific support for each of them was codified as follows:

1. WHAT IS THE WORK OR UNDERTAKING?

The description of the work should specify the current and planned monitoring and mitigation activities.
(What is the **source** of the potential impacts?)

Science support needed: Evaluate the completeness and accuracy of description of the undertaking from the proponent (Quality Control).

2. WHAT IS THE LOCATION OF THE WORK?

The description should specify location in space (3-Dimensions), acoustic environment, and time (diurnal, seasonal).
(What is the **propagation area** in which the impacts may occur?)

Science support needed: Evaluate the completeness and accuracy of proponent's description (Quality Control).

3. WHAT ARE THE BIOLOGICAL RESOURCES?

The description of biological resources should include species (sensitivities, special values, ability to escape), fisheries or subsistence uses[1] of the species, and, to the extent appropriate, ecosystem properties of special concern or importance.
(What are the potential **receptors** for the impacts?)

Science support needed: Evaluate the completeness and accuracy of the descriptions provided by the proponent and those provided by other intervenors, if any (Quality Control).

4. WHAT ARE THE PHYSICAL ACTIVITIES?

Among the things that should be described for a seismic testing program are:
Airgun capacity, duration of bursts and of full program, Survey line density, Propagation characteristics, etc.

Science support needed: Evaluate the completeness and accuracy of the description from the proponent (Quality Control).

5. WHAT ARE THE POTENTIAL / EXPECTED EFFECTS OF THE ACTIVITIES?

The description should address:

- Species specific & location specific consequences;
- Individual, population and community level effects;
- Lethal, sublethal, and cumulative effects.

Science Support Needed: Is the description of effects received from the proponent(s) complete? Accurate? Are uncertainties well described? Are externalities and interactions well considered?

The evaluation should be relative to DFO **mandated conservation responsibilities** for populations, species, habitats and ecosystems.

6. WHAT ARE THE IMPLICATIONS / CONSEQUENCES OF THE EFFECTS?

The description should address the magnitude & duration of effects, and second-order effects as well as direct ones.

Science Support Needed: Professional evaluation using "best available information", which may not be local studies. Key concerns to be addressed in DFO's evaluation include:

- Are the possible effects "serious or irreversible" ("significance" and the need for precaution rather than just good risk management)?

[1] Fisheries Management and other sectors may also have advisory/informative role here.

- Do the likely effects have implications for other human activities in the same area (synergies, interactions, cumulative effects)?

Here DFO may need to step beyond its strictly defined mandates to examine economic implications of reduced landings, effects on whale watching enterprises, etc., regardless of any harm that may or may not occur to the stocks and species themselves.

Science products should use clear statements that have direct interpretation in risk-based management advice and decision-making. Science evaluations and management actions should consider:

- Fisheries Act Section 35(2) – Destruction or harmful alterations to habitat;
- Fisheries Act Section 32 – Killing of fish by means other than fishing SARA – Achievement of recovery objectives; compliance with provisions regarding harm and harassment;
- Fisheries Act – marine mammal regulations;
- Overall DFO Mandate.

7. HABITAT MANAGERS' DECISION

The decision of the habitat (or fisheries) manager usually is not whether the proposed under-taking proceeds or does not proceed. However, there are likely to be decisions regarding DFO's recommendation to the Board or other governance agency regarding approval or rejection of the proposal (including rejection because the information provided by the applicant is an inadequate basis for evaluating the possible consequences of the proposed undertaking), desired mitigation and monitoring requirements, and needs for further research or other information.

Science support is necessary with regard to:

- Need for and application of precaution;
- Need and options for mitigation requests / requirements;
- Design of effective Environmental Effects Monitoring programs and;
- Opportunities for adaptive management (options, monitoring, feedback evaluation).

Considerations for DFO Evaluation

DFO evaluations should take account of potential impacts of seismic testing on marine mammals, marine turtles, invertebrates, and fish. Evaluations of potential impacts of fish should consider effects on both egg and larval stages and on juvenile and adult life history stages. Within each species group, the evaluation should consider possible effects on several scales from risk of direct mortality to effects on behaviour and ecology. The specific factors to consider are tabulated below. It is stressed that the table is to be used for guidance in evaluations, and not as a rigid list of necessary criteria. Evaluations of individual proposals very rarely will give equal weight to all the tabulated entries. For example, if marine turtles are not even expected to be present in the area and season of a proposed seismic operation, the habitat manager and science advisors would be expected to exclude that entire column in their evaluation. The important aspect of sound evaluations is that clear and valid reasons are given for applying differential weight to individual entries in the evaluation table. (See table 1)

It is also stressed that entries in the table 1 reflect the current knowledge and sources of uncertainties. It is expected that table entries will change over time, and Canadian and global knowledge continues to increase.

Risk Management and Risk Aversion

When conducting evaluations of requests for permits for seismic testing the appropriate degree of risk aversion depends on both the severity of the impacts of concern and their likelihoods. In situations of high scientific uncertainty and risk of serious or irreversible harm, the federal framework on the Application of Precaution justifies decision making and other actions that are more risk

averse than under the application of normal risk management procedures.
When considering applications for permits for seismic testing, the criterion of high scientific uncertainty about potential consequences will often be met. However, there will be many situations where the consequences of seismic testing, were it to occur, would be unlikely to be serious or irreversible. Also, there is not yet an empirical nor theoretical scientific basis for assuming that seismic testing would have lasting effects on many ecosystem components that are nonetheless of interest.

Because of the uncertainties about the likelihood of impacts, their severity, and their duration, habitat managers and science advisors will have to exercise professional judgement in many situations. This evaluation framework will provide some guidance for consistent and reasoned practice, although the appropriate level of risk aversion will vary with the particular circumstances of each application. The following factors are important influences on the degree of risk aversion justified in various applications. It is also stressed that if the circumstances of a particular seismic program warrant more risk averse actions by DFO, then more intensive or comprehensive monitoring and provision of extra mitigation measures usually will be necessary as well.

- Are there factors that alter the ability of mobile organism to avoid the activity? (natural or anthropogenic barriers, inability to locate sound source)

Rationale: One of the more common and effective ways that mobile animals reduce the potentially negative impacts of airguns or other sources of seismic signals is simply to leave the area while the testing is going on. If they cannot readily escape the vicinity of the sound sources, or display very strong behavioural or instinctual site fidelity (perhaps to feeding or spawning sites that are of limited availability) then it is justified to be more risk averse in exposure levels and frequencies.

- Is there a likelihood of multiple exposures of animals of concern to seismic testing? (survey design and duration, multiple surveys)

Rationale: Good risk management includes considering cumulative effects. If it is likely that organisms will be exposed to seismic signals multiple times, cumulative effects could be greater than effects of a single exposure. In such situations it is justified to be more risk averse with regard to the magnitude and/or duration of the individual exposures.

- Are there other unusual sources of stress going on at the same time?

Rationale: Good risk management includes considering cumulative effects. If it is likely that organisms will be under stress from other activities, either anthropogenic (e.g. land based pollution, contaminant loads) or natural (e.g. anomalously cold or warm water, high parasite loads) their ability to tolerate effects of seismic disturbances could be reduced. In such situations it is justified to be more risk averse with regard to exposure levels and frequencies.

- Are there special designations of areas or species that might be exposed to the activity? (Species at risk, Marine Protected Area, Species with Rebuilding Programs)

Rationale: The justification for giving special designation to areas or species is to enhance the degree of protection they receive from disturbance, especially from anthropogenic sources. Exercising greater risk aversion in such cases is simply complying with the goals of the initial designations. In many cases, the management plans for protected areas or recovery plans for protected species will include explicit objectives, which will be useful as guidance on the nature and degree of risk aversion that should be applied in considering seismic testing programs. The protection required for species designated as at risk under SARA will usually be served better by measures to avoid exposing individuals to seismic testing (e.g. appropriate scheduling) than by diverting the species from the area of seismic operations. It is currently unclear if even conventional techniques to divert species from the area of a seismic survey (e.g. chase boats, ramping up of seismic energy) might be interpreted as "harassment" as defined in species-at-risk legislation. As the legal interpretations of those provisions of the act become clearer, even some measures taken to mitigate possible effects of seismic testing could be considered violations of the intended measures of protection for species at risk.

There is uncertainty about the role that ambient noise level should have in setting the appropriate level of risk aversion when evaluating a referral on seismic testing. On one hand, marine mammals and fish which communicate or orient with sound probably habituate to some (usually unknown) extent to ambient noise levels in their environment. However, arguments can be made that such habituation might either increase the tolerance of such marine organisms for seismic testing (just one more noise in a noisy background), or increase their vulnerability to harm (increase tolerance means they don't leave the area of testing soon enough to avoid harm). Currently no guidance can be given regarding how risk aversion for seismic energy sources should vary with ambient noise, but further investigations in this area are needed.

Uncertainties

<u>Communicating Risk and Uncertainty</u>

Actions will have to be taken despite the uncertainties noted above, and it is essential that the nature and magnitude of these uncertainties are communicated effectively. Past failures to communicate uncertainty effectively have often frustrated both the clients of science advice and the experts providing it.

The communication of risk and uncertainty is particularly informed by both relevant federal policies, frameworks, and guidelines, and the practical experiences and reports from expert groups which have been grappling with exactly this challenge. The relevant federal frameworks and guidelines address the roles of both science advice in government effectiveness (SAGE principles) and the management of risk and application of precaution in decision-making. These sources and experience emphasise that the communication of uncertainty requires presenting clearly BOTH the:

- Strength of evidence for a conclusion and;
- Diversity or universality of Professional View/Interpretation regarding the topic on which advice is provided.

The science community generally has tried to explain how weak or strong the science basis for advice really is, and opportunities for improvements are often found in clearer phrasing and better use of supporting figures and tabular materials. Science's performance has been somewhat more spotty with regard to presenting clearly the diversity of professional views and interpretations. Interpreted correctly, "consensus advice" means that meeting participants have achieved two things:

- Agreed on which interpretations or hypotheses can be rejected on the basis of convincing evidence and;
- If more than one interpretation or hypothesis is not rejected, agreed on what evidence is consistent with each hypotheses and what evidence is difficult to reconcile with each hypotheses (even if the suite of hypotheses cannot all be true).

In the latter case, the request for advice may require the advisory group to develop further consensus on which interpretations or hypotheses are favoured or not favoured by the weight of scientific evidence. This may be the case in many applications for permits for seismic testing. In such cases, there is still a responsibility to inform those receiving the advice regarding the possible alternatives that cannot be rejected, and to the extent possible, their likelihoods and consequences.

Sometimes science advisory groups have misinterpreted what "consensus" advice is – and sought a single statement to which all participants can agree. This strategy often produces either vague generalities or "least common denominators", which give little guidance to habitat and fisheries managers. Other times, particularly when advice has a quantitative basis, advisors have provided the average or median (quantitatively or qualitatively) of divergent results, which can be quite misleading with regard to risks. Those who interpret and make use of consensus-based science advice must also be well informed as to, and clearly understand, the true meaning of "consensus" in this regard. "Consensus advice" should not be inadvertently misused or misrepresented as assuming either unanimity not certainty on the part of the science advisors where a single viewpoint or full scientific certainty is not implied and does not exist.

In formulating consensus science advice, a hierarchy of sources of uncertainties exists, and the position of specific cases in this hierarchy needs to be communicated well.

When results of **multiple directly relevant studies** are available and studies are of species and under conditions that are comparable to the current advisory issue, uncertainty can be lowest. However, even in this situation, uncertainties can be large.

Uncertainties are least when:

- Studies consistently show similar effects (or lack of effects).

Uncertainties become greater as:

- Specific effects are only sometimes present, but if present are always similar in nature, and;
- Effects are not always present, and when present, could show effects of very different magnitudes or even different directions.

If uncertainty is communicated well in advice from an information-rich situation, users of the science advice will know where the situation falls in this sequence of increasing uncertainty, and not just have a statement of the degree of certainty of the scientists.

In addition to the pattern of increase in uncertainty across the tiers related to consistency of results, uncertainty will necessarily be larger when there are **few directly relevant studies**. There are several reasons why there may be few directly relevant studies:

- There are a number of good scientific studies but ability to extrapolate results to the specific advisory setting is tenuous because the species were quite different, the geographic area was not comparable and/or the operational setting for the undertaking is different.
- There are a number of good studies, but results are only available from studies under controlled laboratory conditions, and their relevance to the field situation is undocumented.
- There is sound theory supported by a strong consensus among professionals in the field but empirical support for the theory has not yet been acquired.

Again, effective science advice needs to make sure users of the advice know which of those situations apply in the particular advisory situation. Depending on the geographic area where seismic testing is proposed and on the ecosystem components of interest, around the coasts of Canada there are likely to be proposals that fall into each of these three categories. Therefore in specific cases, the scientific support needs to be clear which one(s) apply to the various components of the scientific support that is provided.

Uncertainty can be present for yet another reason; that **available studies are interpreted differently by credible professionals,** regardless of whether the studies are numerous and consistent or few in number and inconsistent. In that context it is particularly important that the science advisors provide the competing interpretations and a concise summary of the evidence consistent and inconsistent with each. This presupposes that the various interpretations have all received objective and rigorous peer review, and compelling reasons for rejecting any of them have not been found. In such case the advice is still "consensus", but as noted above the consensus is not based on accepting one of the interpretations and rejecting all others. Rather, all participants agree that the diverse interpretations can each be at least partially reconciled with the available data and all agree on the implications and risks if each interpretation is true.

Uncertainty is highest when there is no credible scientific basis on which to even advise on possible consequences. Such circumstances are likely to lead to:

- High science priority for new work, to address the greatest knowledge gaps;
- Requirements for extra monitoring and/or pilot projects, with management responsive to feedback as information is acquired.

In situations where the initial science advice is that information is inadequate to advise on the likelihood of possible consequences, there may be a follow-up request for "science opinion". The basis for, and status of, such science opinions are still under development.

Management Considerations

<u>Conclusions</u>

When dealing with applications for permits for seismic testing, habitat, and in some cases fisheries managers science support is required in all steps. The support includes evaluating several factors:

- The completeness and accuracy of descriptive material about the project and the ecosystem, whether submitted by the proponent or other sources: (Quality Control).
- The completeness and accuracy of the inventory of impacts / risks associated with the proposed testing, as it is proposed to be conducted, relative to DFO's mandated conservation responsibilities for populations, species, habitats and ecosystems.
- The risk/likelihood that impacts of the proposed testing may be "serious or irreversible", or have interactions with other human activities in the same area.
- The need for application of precaution, requirements or options for mitigation actions by the proponent, and opportunities for adaptive management (when actions of the Managers proceed to this step).

Science products should use clear statements that have direct interpretation in risk-based management advice and decision-making.

DFO evaluations should take account of potential impacts of seismic testing on marine mammals, marine turtles, invertebrates, and fish, as well as habitats and protected areas.

Evaluations of potential impacts of fish should consider effects on both egg and larval stages and on juvenile and adult life history stages.

Within each species group, the evaluation should consider possible effects on several scales, including risks of:

- Direct mortality ;
- Physical effects;
- Perceptual effects;
- Behavioural effects;
- Chronic effects;
- Indirect (ecosystem effects) and;
- Effects on other areas for which DFO is responsible.

Current specific factors to consider for each taxonomic group are tabulated in this report. Entries in this tabulation are expected to evolve as knowledge of seismic impacts accumulated.

Much work remains to be done in the short, medium and long-term with regard to setting standards for acceptable and unacceptable impacts for case-specific applications of the framework.

Science advice in all cases will have high uncertainty about risks and impacts. The degree of risk aversion appropriate for individual applications will vary with:

- Factors that alter the ability of mobile organism to avoid the activity;
- Likelihood of multiple exposures of animals of concern to seismic testing;
- Other unusual sources of stress going on at the same time, and;
- Special designations of areas or species that might be exposed to the activity.

There is uncertainty about the role that ambient noise level should have in setting the appropriate level of risk aversion when evaluating a referral on seismic testing. Currently no guidance can be given regarding how risk aversion for seismic energy sources should vary with ambient noise, but further investigations in this area are needed.

The clear communication of the nature and magnitude of risk and uncertainty is particularly important in science advice to managers regarding possible impacts of seismic testing. This includes presenting clear information about both the:

- Strength of evidence for a conclusion, and;
- Diversity or unanimity of Professional View/Interpretation regarding the topic on which advice is provided.

Within this framework, consensus advice should reflect that meeting participants have achieved two things:

- Agreed on which interpretations or hypotheses can be rejected on the basis of convincing evidence, and;
- If more than one interpretation or hypothesis is not rejected, agreed on what evidence is consistent with each hypotheses and what evidence is difficult to reconcile with each hypotheses (even if the suite of hypotheses cannot all be true).

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Table 1. Tabulation of effects to be considered by DFO officers in fulfilling their responsibilities with regard to referrals of requests for seismic permits.

	Marine Mammals	Finfish (adult & juv.)	Finfish (eggs & larvae)	Invertebrates	Marine Turtles
Direct Mortality	Any occurrence	Any occurrence	Measurable rate	Measurable rate	Any occurrence
Physical Effects Observed damage to tissues, organs, physiological systems.	• Structural damage to ears or other auditory structures. • Permanent threshold shift (reduction in auditory sensitivity from which there is no recovery). • Temporary threshold shift (reduction in auditory sensitivity with eventual recovery). • Damage to other body tissues.	• Structural damage to sensory organs. • Permanent threshold shift (reduction in organ modality sensitivity from which there is no recovery). • Temporary threshold shift (reduction in organ modality sensitivity with eventual recovery). • Damage to swim bladder. • Rupture of blood vessels. • Damage to other body tissues.	• Structural damage to sensory organs. • Damage to other body tissues. • Delay or redirection of developmental sequences.	• Structural damage to sensory organs. • Damage to external protective body parts. • Damage to other body tissues. • Delay or redirection of developmental sequences. • Interference with normal moulting sequences. • Re-absorption of eggs due to stress.	• Structural damage to ears or auditory structures. • Permanent threshold shift (reduction in auditory sensitivity from which there is no recovery). • Temporary threshold shift (reduction in auditory sensitivity with eventual recovery). • Damage to other body tissues.
Perceptual effects Masking of biologically significant noise	• Communication signals. • Echolocation. • Sounds associated with finding prey or avoiding predators. • Sounds used in	• Sounds used by predators in feeding. • Sounds prey detect in predator avoidance. • Sounds used in maintaining social groups.	• Sounds used by predators in feeding (*not documented but possibility is of concern).* • Sounds prey detect in predator avoidance.	• Sounds used by predators in feeding. • Sounds prey detect in predator avoidance.	• Communication signals. • Echolocation. • Sounds associated with finding prey or avoiding predators. • Sounds used in avoiding human threats such as

	Marine Mammals	Finfish (adult & juv.)	Finfish (eggs & larvae)	Invertebrates	Marine Turtles
Direct Mortality	Any occurrence	Any occurrence	Measurable rate	Measurable rate	Any occurrence
	avoiding human threats such as shipping. • Sounds associated with parental care, protection, and bonding.				shipping.
Behavioural effects Disrupting normal behavioural interactions	• Avoidance of a particular area. • Altered dive and respiratory patterns. • Diversion from "normal" migration or feeding pattern. • Changing suitability of the area for courtship & breeding. • Interference in adult – juvenile social interactions. • Other documented behavioural effects.	• Diversion from "normal" migration or feeding location. • Interference with courtship, spawning etc. • Interference with schooling. • Interference with predator avoidance patterns. • Disruption of other normal behaviours (e.g. avoidance of a particular area).	• Diversion from "normal" transport, diurnal migration or feeding location. • Interference with predator avoidance patterns. • Disruption of other normal behaviours (e.g. avoidance of a particular area).	• Diversion from "normal" transport, diurnal or season migration routes, or feeding location. • Interference with predator avoidance patterns. • Interference with courtship, spawning etc. • Interference with schooling. • Disruption of other normal behaviours (e.g. avoidance of a particular area). • Stunning.	• Avoidance of a particular area. • Asking a slow-moving animal to avoid the vessel as source of stress. • Altered dive and respiratory patterns. • Diversion from "normal" migration or feeding pattern. • Other behavioural effects – to be specified).

	Marine Mammals	Finfish (adult & juv.)	Finfish (eggs & larvae)	Invertebrates	Marine Turtles
Direct Mortality	Any occurrence	Any occurrence	Measurable rate	Measurable rate	Any occurrence
Chronic Effects Stress related effects	• Reduced reproductive capability/ motivation. • Reduced viability and increased susceptibility to disease.	• Reduced reproductive capability/ motivation. • Reduced viability and increased susceptibility to disease.	*Inadequate basis for evaluation of sound-induced stress in fish larvae.*	• Stress leading to reduced viability and increased susceptibility to disease. • Re-absorption of eggs, shedding of eggs as possible impacts	• Stress leading to reduced viability and increased susceptibility to disease.
Indirect Effects	• Reduced prey availability resulting in reduced feeding rates.	• Reduced prey availability resulting in reduced feeding. • Attraction of predators.	• Reduced prey availability resulting in reduced feeding rates. • Attraction of predators.	• Reduced prey availability resulting in reduced feeding rates. • Attraction of predators.	• Reduced prey availability resulting in reduced feeding rates.
Effects on other things for which DFO has accountability or faces high public expectation.	• Subsistence harvesting & aboriginal requirements within DFO mandate. • Whale-watching. • Compliance with SARA provisions for listed marine mammals.	• Subsistence harvesting**. • Changes in catchability. • Interference with IFMPs (e.g. gear interactions). • Effort displacement (increase bycatch, ecosystem impacts). • Displacement of research surveys & projects. • Aquaculture. • Direct and indirect effects on species at risk.	• Displacement of research surveys & projects. • Aquaculture? • Affecting larvae or food of species at risk.	• Subsistence harvesting**. • Changes in catchability. • Interference with IFMPs (gear interactions). • Effort displacement (bycatch). ecosystem impacts • Displacement of research surveys & projects. • Aquaculture? *Eventually there may be species-at-risk*	