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June 28, 2002

022-2219

Fisheries and Oceans Canada
Fish Habitat Management
Yellowknife District Office
P.O. Box 2310
Yellowknife, NWT X1A 1E2

Attention: Bruce Hanna, Habitat Biologist

RE: Response to DFO Comments on the Proposed Acoustic and Fish Monitoring Program

Dear Mr. Hanna:

WesternGeco appreciates the comments provided by the Department of Fisheries and Oceans (DFO). Responses to the comments and questions, as compiled by WesternGeco, Canning and Pitt Associates, and IMG-Golder fisheries biologists, are provided in the same numbering sequence for reference.

1. WesternGeco recognizes that modelling the behavior of sound is difficult in variable environmental conditions, and depends to varying degrees on rain, wind (wave action) current velocity and sediment loads, sound channels, water temperature, water depth and varying water depths, gun array depth and solidity, although we are hoping that ice conditions are not an influence on noise attenuation in the proposed survey area. Throughout the project description WesternGeco has at best given "worst case" (higher than expected) values to sound propagation calculations in the range and amplitude domains. These calculations are normally used to compute the effect that one would expect to see in deeper water environments. We would expect to see the amplitude of sound degrading at a greater rate "faster" in shallow water. As was noted last year during acoustic measurements recorded in the Beaufort Sea, sound propagated further when travelling from a shallow water environment to a deeper water environment, when in fact you might expect the opposite due to the "funneling" effect of the water depth, or any influences.

It is hoped that by analyzing the results from the acoustic test program we can add value to the lack of data and research on sound propagation in shallow water environments. But it should also be remembered that this is a test program, and not an exhaustive scientific research program into shallow water sound propagation which would require an astronomical amount of data sets, using a wide variety of amplitudes in the frequency domain, and not just the suggested source level. There are so many variables to why sound attenuation differs in different environments that it would be impossible to

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pinpoint actual cause, unless you could change individual effects and create differing conditions simultaneously.

2. The ambient noise levels measured during the acoustic testing stage of the proposed program will be recorded within the water column, and without human influence.

The question asked by the author, "**Why are they measuring ambient noise levels**", has been answered by the author of question 3. Where the author states that sound attenuation is critical because it determines the range that the sound being produced by the airgun will be detected beyond background (ambient) noise. WesternGeco understands the author's concerns as to the scope and constraints of the intended measurements. WesternGeco's primary reason for recording ambient noise is to monitor this data while measuring sound propagation of the seismic signal. To measure ambient noise at all locations down the river would become an exhaustive time consuming program, geological and climatic conditions, would have to be monitored at all times, and a program of this magnitude is outside the scope of the proposed acoustic test program.

We also believe that the ambient noise level data will be of value to the DFO and research bodies in a variety of possible future studies they may undertake on the Mackenzie.

We will be considering frequencies between 5Hz and 50kHz. Four areas will be selected with the DFO, and the criteria for selection will include varying geological and geographical conditions (see question 22 last paragraph).

Background, "human" sources will be the various types of noise generated by river traffic, and industry. We do not envisage being able to catch air traffic noise. We expect that most background noise will be generated within the water column, although we do expect to see some background noise from pumping equipment on drill islands and around built up areas near the Mackenzie River. This noise should be directional, fairly frequency limited and easy to locate.

WesternGeco believes that the author of this question is referring to the fish test program on the concern regarding reverberation, as reverberation will have no impact, significant or otherwise on the acoustic test program. Reverberation is the sum of all reflected sound, and this is what we propose recording.

WesternGeco fully understands the implications of reverberations or reflection anomalies during the sonar operation, fish test program. The equipment proposed will be calibrated on site by experts in this field and witnessed by the DFO. The equipment proposed is designed for this type of test program and is not new to this field.

3. It is agreed with the author that it is critical that sound monitoring will be done in a 3-dimensional plain and over the same stretch of river and hopefully during the same climatic conditions. We understand and agree with the authors concerns that local conditions will affect sound attenuation and we are hoping through the collection of this data, to be able to give good reasoning into the "combined conditional collective" cause

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of these variants in sound propagation in a shallow water environment. Localized conditions will become a critical part of the explanation for the known, measured and noted varying anomalies. To repeat these measurements at differing source sound levels would add scientific value to sound propagation research in general, but unfortunately this is outside the scope of and has no value to the test program proposed. The author understands the magnitude of this request, which would turn a test program into a research program requiring additional funding, from both within and outside of this industry.

4. WesternGeco feels that data has been presented within the EIAs that provides data on the levels of sound that produce behavioural and physiological responses. As such, the test program was designed to gather river specific acoustical information to form a framework within which to compare these reported findings. The behavioural studies were meant to augment the acoustical studies to show that fish were indeed behaving as observed in other studies.

WesternGeco agrees that the fish cage studies will yield additional information on the effects of acoustics on fish exposed to sound produced by the airguns. This is one of the reason it was retained in the study outline. However, WesternGeco also recognized that multiple species with multiple trials could easily result in the sacrifice of a potentially large number of fish, depending on the final study design (assuming of course that it would be possible to capture sufficient number of individuals of suitable size for the study). WesternGeco believed that the loss of this many fish would not be tolerated by the local communities who traditionally fish as part of their livelihood and culture. These losses are particularly difficult to justify when the acute and sublethal effects of sound on fish have been reasonably well justified. Admittedly, this work has not been done in the Mackenzie River on Mackenzie River fish, however we maintain that the effects of sound is comparable between those species tested, and those of the Mackenzie River.

However, should DFO insist that this study take place, and recognizing that fish will have to be sacrificed, the test program would contain the following three elements:

- The acoustic testing.
- The behavioral testing.
- The physiological testing.

The acoustic and behavioral testing is already well documented within the test program. The physiological impact is to be included at the insistence of the DFO, but we are proposing to use test species such as young common suckers, young pike and cyprinids, to limit the impact to fish. It is noted that the DFO felt that without physically measuring the physiological effects on fish, the DFO cannot give a "call of judgment on the limited impact of this program." It should also be noted that WesternGeco feels that the physiological testing of fish should be mitigation for the behaviour monitoring.

5. The transducer would be deployed to work with the hydrophones/sensors used by WesternGeco (see 2.3.1 and 2.3.3 of the monitoring plan). The area of the river in the

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vicinity of the airgun (e.g., transducer on the boat would be located approximately 100 m from the airgun location) to scan for fish before, during and after the ramp up.

The purpose of this portion of the test program is to determine the response of fish to the ramping up process. When fish are located in the vicinity of the guns, the scanning will determine their presence, and the subsequent point during the ramp up when the fish vacated the area. This would be correlated with the noise levels being generated at or near the airguns. However, the main function of this test is to determine if the ramping up scares fish out of the area, as predicted.

6. It is reasonable to suggest using the elliptical beam transducer for side looking; however, to do the before/after study, the dual beam transducer is appropriate. Therefore, as an all round tool, we feel that our approach is appropriate.

WesternGeco is planning to field test the equipment prior to use, and if feasible, both transducers will be tested.

WesternGeco notes that DFO states that "fish typically move down and away from sound sources", which is what we have been suggesting they would do to avoid the noise.

7. WesternGeco agrees. Target size is more important to the "before/after" study, and not the movement to/from the array. Again, if target sizing is important, and we think that it is, the dual beam system has the best all round characteristics to gather this information. WesternGeco agrees that the conditions are diverse, however, we feel that the proposed approach provides the best, practical solution to obtain data to answer questions posed by DFO, while limiting impacts to fish.

8. The dilemma(s) are: 1) radio vs ultrasonic transmitters - those fishes that remain shallow would require radio transmitters while those that may or will move into deeper water would require ultrasonic transmitters (i.e., dependent on the species and their behavior. 2) whether the fish(es) with transmitters (whatever the type) are insonified by the air gun - this would be hit or miss. Fish are much more mobile than most expect and assuming that a fish with a transmitter will cooperate (i.e., stay and be insonified by the air gun array), is questionable. For this to be effective, we would have to deploy many fish (>100) with both radio and ultrasonic tags and have two tracking systems. The results from this study would be hit or miss. An option (likely not workable from a practical point of view) would be to "chase" fish with transmitters, which are in the vicinity.

In addition, this process would entail capturing a number of fish of a given size to support the transmitters, completing the surgery to plant the transmitters, allowing the fish to recuperate for several days prior to release, and then release the fish prior to the tests and hope that they remain in the immediate vicinity.

9. WesternGeco proposes to use acoustics to determine the presence of fish (distribution) in the area of the river where the vessels passed through, post airgun activity. We would propose to survey an area of 200 m x 200 m directly centered on the vessel course.

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WesternGeco has no knowledge of studies that relate fish response to boat traffic, although there is much anecdotal evidence (and speculation). If the Mackenzie is 30m+ deep, we are likely to encounter more fish in the before/after study.

WesternGeco notes the referral to vessel avoidance by fish, which would seem to support our postulation that fish will avoid noise sources.

10. (maybe 75Hz) would be in the nearfield at 5 m.

We are considering frequencies from the 5Hz to 50kHz. The near field definition here is somewhat arbitrary. If we are concerned with the coherent sum of acoustic energy from the spatially distributed airgun array elements, then the nearfield extends much further, especially for frequencies with wavelengths much shorter than the array dimensions. This is important here, given the airgun array's total length is 19.1 m.

We propose to make measurements using calibrated Reson TC4034 hydrophones having sensitivity -218 dB/V/uPa and unity-gain preamplifiers. While we will endeavor to make absolute pressure measurements within 5m of the individual airguns, we are aware of the possibility of GTB saturating the hydrophone/recording system responses. It should be noted that these hydrophones were chosen specifically with low sensitivity in order to obtain the closest possible measurements. In all applicable cases we will scale the measured levels back to near-field distances. Our calibrated digital recording systems are capable of measuring pressure response through very wide frequency bandwidths: 5 Hz to 50 kHz.

We will only be endeavoring to make near field measurements at 5 metres, because we show a modelled near field at 5 meters display in the amplitude and frequency domains.

"Far field measurements will be taken at a distance of 250 meters from the center of the source. Will this involve the same instrument as above? Or will a pressure hydrophone be used?"

Response:

Pressure hydrophones will be used in all circumstances. Hydrophones with greater sensitivity: Reson TC 4043 hydrophones with nominal sensitivity -201 dB/V/uPa including internal 10 dB preamp, are used for longer-range measurements. We have used these successfully in the past for airgun measurements at ranges between 100 m and 20 km. We utilize calibrated post filter/amplifiers: Ithaco 451M and Reson VP2000 systems for programmable filtering and amplification to achieve best use of the available 16-bit recording bandwidth.

11. It is expected that as the boats move upstream, the first sounds that the fish are exposed to, would be barely above background, and rising as the airguns got closer to a given fishes location. As such, the rate and level of exposure will generally be gradual, with the predicted response of movement away from the disturbance as that given fishes tolerance to the noise was approached. Also see the response to question #13.

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12. WesternGeco agrees that there will be species specific differences. Other mitigation plans such as routing in the deepest part of the channel, non-continuous shooting, slow speed as the boats travel against the current and periods of no shooting during streamer adjustments are expected to limit the exposure potential.
13. The statement is based on the common-sense value of ramp-up and the strong tendency for motile organisms to try to escape aversive stimuli.

Ramp-up is not simply an "industry standard" but a standard implemented by regulators in Canada and elsewhere in the world. For example, ramp-up / soft-start is a requirement of the Canada-Nova Scotia Offshore Petroleum Board's "Mitigation and Operating Conditions" (Class Environmental Screening for Seismic Exploration on the Scotian Shelf, CNSOPB 1998), of the Western Australian Department of Minerals and Energy "Guidelines on minimising acoustic disturbance to marine fauna" (Petroleum Information Series Sheet 1, 2001) and the UK Joint Nature Conservation Committee (JNCC) "Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys" (April 1998).

We also note that Gausland 2000 states that "Due to the avoidance behaviour by free-swimming fish, they should not suffer physical damage from the airguns."

14. WesternGeco recognizes that there will likely be species differences in the rates of return to normal distribution for fishes within the Mackenzie River. The point that WesternGeco is attempting to make, is that fish use of the habitat within the river is expected to return to pre-disturbance conditions soon after the program has passed. The time for this return is expected to be in the range of a few hours or less, to a couple of days, depending on the species and the specific location, however, with the mitigation plans in place, the former is predicted to occur for the majority of the river. This suggests, as does the reference quoted by the DFO, that fish move out of the way of the disturbance, and then return once the disturbance is over.

The author raises various points in the comments that we would like to clarify.

- a) The return to "normal behaviour patterns" after the airguns ceased, observed by McCauley et al. (2000), was indeed for caged fish. Caging would have been necessary in order for the fish behaviour to have been continuously observed. However, this does not invalidate the observation that these fish – even despite being unable to escape – resumed normal behaviour within a very short time. This tends to support the prediction that – even if fish avoidance is somehow more constrained within a riverine setting – the planned array shut down periods will provide sufficient time for behaviour to normalize.
- b) The Engas et al. (1996) paper would suggest that returning fish took up to a week to return to the area. This raises two questions: 1. There was no control during this study and although it is suggested that the study focused on "returning fish" there is no way of knowing if these are indeed the same fish. 2. There is every possibility that the lack of fish stocks after the survey is actually due to a fish migratory reason.

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In any case, as the class screening study for the Canada-Nova Scotia Offshore Petroleum Board by Davis et al (1998) notes, "The study conducted by Engås et al. (1996) is the only one to report effects over such a large area and to show no recovery in catches" (p. 99).

- c) While the captive fish in the McCauley et al (2000) study might have experience a level of long-term hearing loss after being subjected to high sound levels, free swimming fish would not be expected to be exposed to these levels. As the DFO author suggests (citing the Engas et al. 1996 paper), free-swimming fish would be expected to be "scared away".
 - d) McCauley et al (2000, Section 2.4.3) did investigate physiological stress indicators in several species of caged finfish exposed to airgun arrays by measuring changes in cortisol levels. They report, for all species studied, "no significant increases in stress measurements which could be definitively associated with airgun exposure" in these species (p. 145). They thus concluded (p. 189) that there had been "no significant physiological stress increase" as a result of exposure.
- 15. WesternGeco is investigating the feasibility of a small seine or trawling net to sample after the passage of the vessels, however, we must recognize the size, depth and power of the Mackenzie River, and the related limitations to effectively sampling this watercourse. The use of direct observation of mortalities is related to effects to swim bladders or direct killing of fish, which would likely float to the surface. With the monitors being up to 2 km or more down stream of the vessels, this would allow a time lag for impacted fish to surface. Again, WesternGeco emphasizes that with the mitigation proposed, avoidance is expected, and mortality is predicted to be minimal.
 - 16. The discussion on mortality comes from the proposed cage studies that, were given lower priority in the draft proposal.
 - 17. WesternGeco generally agrees. Proposed mortality/distribution studies will not address long term effects. The studies are not designed to do so. As we stated, caged fish studies provide a worst case, short term scenario. The expectation is that avoidance behaviour will preclude such impacts for free-swimming fish.
 - 18. Please see the response to question #17.
 - 19. Yes, the monitors would be trained to find and watch these animals. WesternGeco has advertised for monitors that are familiar with fish and wildlife species in the region.

Determination of underwater behaviour by aquatic mammals would not be feasible in the outlined study. Avoidance distances have been proposed when shooting would be halted (e.g., 1000 m for beluga and seals, and 200 m for beaver and muskrat). WesternGeco expects conflicts to be minimal due to the location of the programs in the deepest channels and the related low potential to encounter aquatic mammals in these areas. Notes on formal data sheets will be maintained on each observation, with data related to

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species observed, distance from the airguns, observed behaviour and persistence of noted behavior changes.

20. WesternGeco expects limited exposure to submerged aquatic mammals, considering where the programs have been routed. Again, the mammals are expected to hear the program vessels approaching for a period of time that will allow them the opportunity to swim away from the noise.
21. WesternGeco does not expect fish mortalities, but has included this as a contingency. This is expected to limit the exposure of additional fish in that given area and allow them time to swim to the side, further upstream, or past the vessels. The ramp-up would be expected to expose fish in the area to increasing levels of noise to "drive" them away from the airguns.
22. A varying number of hydrophones will be used in the acoustic test program. This number is water depth, and channels available dependant. It must be noted that WesternGeco sees great value in the results of the acoustic test program and will be putting a lot of resources including time and money into obtaining good quality measurements.

To this end WesternGeco will be contracting the acoustic measuring to a consultant registered and approved by the US National Marine Fisheries Service (NMFS):

This company has undergone the approval processes for NMFS, including submission of personnel CV's, refereed publication listings and company project descriptions, to obtain clearance for performing acoustics tests and modeling services in support of their Incidental Harassment Authorization permitting.

One of the criteria for doing the acoustic measuring will be a change in the geology. This change would be noted by, amongst other factors, a change in the reflection of the seismic signal during acquisition. WesternGeco disagrees that the test positions should be included on a map during the project submission. This would in fact limit WesternGeco's ability to obtaining results only in predefined areas, and not necessarily the most valuable areas.

It is expected that the DFO will be present to monitor the calibration of equipment and to verify that the test program is being conducted to the DFO's satisfaction. (please see time line in question #27).

23. WesternGeco would complete the test program in all areas as requested, and would appreciate the assistance of regulators to facilitate these tests occurring in the summer of 2002. Please note that a third test area has been added to the program to address concerns by DFO and FJMC related to sample sizes, and limited areas of the river being tested. This additional area is located south of the Ramparts, between Tsiigehtchic and Little Chicago.

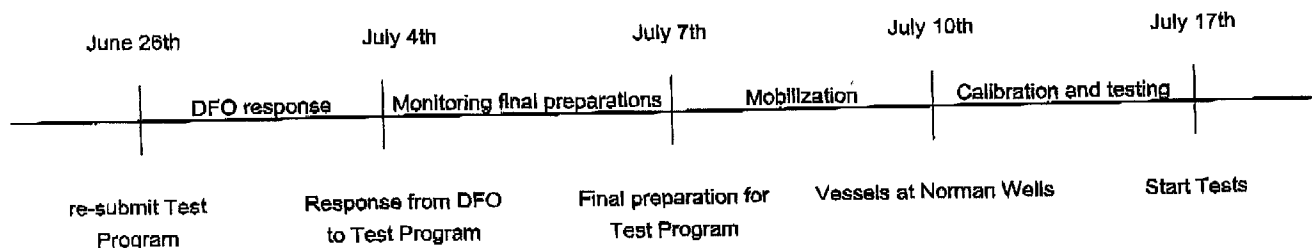
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24. The model would be derived from acoustic measurements and measured behavioral responses of fish. Relevant published data would also be used to strengthen the validity of the model as appropriate. The model could then be applied to areas of the river/delta that are not sampled.
25. One scout boat will be ahead of the vessels, and one scout boat will be behind the vessels. The separation distance will vary between approximately 2 km and 4 km, depending on the current, location on the river, and resulting noise generation. In addition, WesternGeco is proposing to have community monitors in boats that accompany the scout boats while the vessels are within their communities' traditional areas.
26. It is expected that the information in the EIAs will be augmented by the input from the environmental monitors, as well as information collected by the community liaisons that will visit the communities prior to the vessels reaching their traditional areas. As such, this information will allow appropriate sensitive areas to be identified before the vessels reach these areas. WesternGeco routed the project down the deepest channel of the river to limit the potential to encounter sensitive fish habitat during their programs.
27. The time lines for the test program are provided below:

Mackenzie River Tests Time Line



It would have been easier, and less time consuming to answer individual questions had the authors name been included along with the particular question. For reasons unknown to WesternGeco this request was turned down by the DFO. It is difficult to know to what depth of knowledge or interests the authors' have on a given subject matter, and this makes it almost impossible to gauge to what depth WesternGeco should answer that particular question, without either giving too little technical explanation or too much. WesternGeco would like to apologize if any or all questions have left the interested parties without a satisfactory explanation to their requests, valued suggestions or questions.

In addition, WesternGeco has recently found out that there have been marine seismic operations conducted on several reaches of the Mackenzie River, including the Delta, and Great Bear Lake, in the past. These programs were primarily completed in the 1960's and 1970's, with little to no

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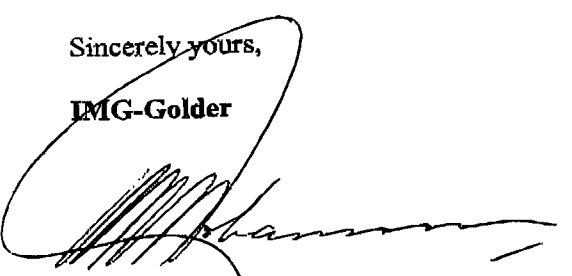
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information on source size (some programs used dynamite), and no environmental information presented.

We trust that the above answers and discussion provides the DFO with the information that will allow the test program to proceed. WesternGeco feels that DFO's involvement with the tests is necessary to ensure that all issues are addressed in a proactive manner. Should you have any concerns or comments, please contact Mr. Marty Swagar at (403) 509-4440, or the undersigned at (403) 299-5613.

Sincerely yours,

IMG-Golder



Daryl Johannesen, M.Sc., P.Biol.
Project Manager

cc:

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