Fisheries and Oceans
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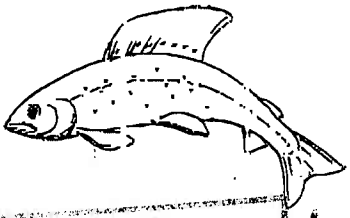
Western Arctic Area
Fish Habitat Management
P.O. Box 1871,
Inuvik, Northwest Territories, X0E 0T0



June 19, 2002

TO/A: **FAX**

Marty Swagar- Western Geco **Hand Delivered**

Copy:

Laura Van Ham- NEB	(403) 292-5876
Ed Mclean - FJMC	(867) 777-2610
Linda Graf- EISC	(867) 777-2610
Melanie Van Gerwen-Toyne- GRRB	(867) 777-4260
Jody Snortland- SRRB	(867) 588-3324
Al Gibson/ Jason McNeill- RWED	(867) 873-0221
Joe Acorn- MVEIRB	(867) 766-7074

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RE: WesternGeco, Mackenzie River/ Delta 2D Seismic Program 2002- Proposed Acoustic and Fish Monitoring Program: DFO Comments

FROM/DE:

Bruce Hanna
Habitat Biologist
Western Arctic Area

Telephone (867) 669-4931
Facsimile (867) 669-4940
Hannab@dfo-mpo.gc.ca

Canada

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Fish Habitat Management
P.O. Box 1871
Inuvik, Northwest Territories
X0E 0T0

Your file *Votre référence*

Our file *Notre référence*
SC02019&SC01196

June 16, 2002

Marty Swagar
WesternGeco
Suite 2300, 645-7th Ave SW
Calgary, Alberta
T2P 4G8

RE: WesternGeco, Mackenzie River/ Delta 2D Seismic Program 2002 – Proposed Acoustic and Fish Monitoring Program: DFO Comments

Dear Mr. Swagar

The Department of Fisheries and Oceans, Western Arctic Area (DFO) has reviewed the *DRAFT* proposed acoustic and fish monitoring program and is providing the following comments. These comments (including questions) are raised by and compiled from within DFO as well as from outside experts in acoustics, and are intended to assist in the development of the monitoring program.

1. Modeling the behaviour of sound in water is difficult enough in the open ocean, it becomes much more so in a highly variable environment such as a river.

2. Section 2.2.2 and 2.3.2: It is proposed to measure ambient noise levels at 4 locations along the study section of the river. In the ocean, where the environment is comparatively homogenous, ambient noise levels tend to be homogenous over relatively wide areas as well. Such is not the case in rivers because they are extremely dynamic. Ambient noise levels can vary in time with human activity (boat traffic, etc.). They also vary greatly with changes in environmental conditions (rain, wind, current velocity, sediment load, ice cover, etc.) Ambient noise levels can also vary substantially with location. In the open ocean, sound essentially travels uninterrupted through a homogenous medium whereas in a river the sound is confined by the shape of the riverbed and the surface of the water. Changes in the shape and characteristics of the riverbed and changes in the surface state by wind, rain, and ice can create multiple sound pathways that change dramatically both spatially and temporally. To further complicate the issue, all of these variables are frequency sensitive. That is, a change may occur at one frequency but not another. The problem is that WesternGeco does not put any constraints on the scope of their intended measurements. **Why are they measuring ambient noise levels? What frequencies are important both to their acoustic**

systems and the fish? How will they select the 4 proposed locations? How long will they measure noise levels at each site? What 'human' sources of noise will be measured? WesternGeco does not discuss 'reverberation' at all in the proposal. Reverberation is the reflection of sound by 'non-target' material in the water (ex. air bubbles, sediment, detritus, etc.) and can have significant impacts on the operation of their acoustic systems particularly the scientific sounder and can also impact fish by creating multiple sound pathways that can prevent fish from localizing the sound source at long range.

3. Sections 2.2.3 and 2.3.3: It is proposed to measure sound attenuation. This is a critical measurement because it determines the range that the sound being produced by the air gun will be detected by fish beyond background (ambient) noise level. This in turn will determine the escape time available to fish and the range at which fish potentially may be physiologically impacted by the seismic sound source. However, attenuation is subject to the same sort of variability as ambient noise. In fact, ambient noise levels will affect sound detection by fish and therefore it becomes one more variable in the multivariate problem of attenuation. The concerns here are similar to those for the proposed measurement of ambient noise levels. Localized changes in bottom shape, turbulence, water velocity, sediment load, river surface state, temperature, etc. are all going to affect attenuation. A measurement in a particular location is not necessarily transferable to another. **The experimental trials at different sound source levels should be done over the same section of river under the same environmental conditions (flow rate, wind speed, no rain, etc.) so they are directly comparable. Second, it is critical to make sure that sound levels are measured in 3-dimensions.** It is assumed that the term "perpendicular azimuth means across the channel as the vessel moves upstream. This is a critical direction because many fish will probably try to move down and to the side as the vessel passes. It would be valuable to know the acoustic pattern around the survey vessel itself as it is by no means uniform and it could significantly impact the behaviour of the fish to the vessel and the seismic sound source.

4. From DFO's perspective, the behaviour of the fish to the vessel is a critical issue. Ideally, if all of the fish would simply move out of the way as the vessel went by it would prevent any lethal or sub-lethal effects from the seismic sound source. The experiment outlined in the 'Contingency Plan' is essential. A series of cage tests is proposed as contingencies if their acoustic monitoring does not work but, in fact, these are probably more useful and conservative tests, though longer-term, than the proposed methods. The first step of this whole project should be to look at the lethal and sub-lethal effects of the sound at different intensities. It is only with this information that an assessment of the effects of the seismic survey can be judged. These experiments should ideally include all species but practically should include priority species as established by DFO. They should also include as wide a range of sizes as possible because the sound may have widely different effects on different sizes. As proposed, the fish should be held for at least 2 days after

exposure to measure mortality but the surviving fish should also be examined by a fish physiologist to determine if any sub-lethal effects have occurred (the swim bladder is the organ most likely to be affected and while damage may not be directly lethal it may be sufficient to lead to behavioural difficulties that could result in the death of the fish much later).

5. Section 3.1, Estimation of avoidance of fish to insonification: **Where will the stationary transducer be positioned to document fish avoidance? How will this be correlated to the previous section determining pressure attenuation?**

6. It is proposed to measure vessel avoidance by using a BioSonics split-beam scientific sounder. There are a number of issues that need to be considered before success is likely. First, the range of these systems is very limited. The reason is noise. Rivers are relatively noisy places compared to oceans and lakes. At high noise levels, the range that fish can be detected is limited. At the frequency being proposed (200 kHz) and making an educated guess at the noise levels in the river, it is doubtful whether even the largest fish will be detectable at more than 30-m range. Smaller fish are much smaller targets and would be detectable to much shorter range (perhaps leading to a perceived bias that more smaller fish were seen closer to the transducer). The width of the beam using the proposed 8dg transducer would only be 4.22 m wide at 30 meters, proportionally less a shorter ranges. To reliably track fish, it must be detected on at least three successive pings. Therefore, in order to count the majority of fish they must not swim any faster than 4.22 m in the time it takes the transceiver to ping three times. At closer ranges or for fish near the edge of the circular beam this tracking process becomes much more difficult. Furthermore, the 'effective' beam angle is reduced in high noise environments so in fact the 'useable' beam angle is reduced from the theoretical beam angle. A confounding problem is that if the edge of acoustic beam touches either the surface or bottom the echo is so strong nothing past this point can be detected. Therefore, to make maximum use of the beam the slope of the riverbed must be at least 8dg or 4.22 m depth in the 30 meters range. The riverbed must also be smooth and even because fish could pass by the transducer in bottom irregularities where the acoustic beam cannot 'see'. **The basic problem is that the transducer being proposed is the wrong one for the work. The best option to use would be elliptical beam transducers that are flat vertically (2 dg to 4 dg) and wide horizontally (10 dg to 12 dg) so that they fit in the river better and have a better chance of detecting the fish on successive pings.** A further problem is that fish typically move down and away from sound sources. This puts most fish close to the bottom where they are the most difficult to detect.

7. WesternGeco proposes to be able to provide size range from the acoustic data. Again this is problematic because the intensity of the echo varies with the orientation of the fish in the beam. For example, a fish that is a right angles to the beam will create a much larger echo than one parallel to the beam. Where

acoustics have been used in rivers in Alaska, Canada, and the continental United States, considerable effort is put into selecting the right site under the right conditions with the right equipment even to the point of modifying the riverbed to make it suitable for acoustic counting. Even under these very controlled conditions success is not guaranteed. The split-beam project proposed may provide some useful information; however, it probably will not come anywhere near providing the results hoped for.

8. Acoustic tags and an acoustic receiving array may be a better approach to achieve the program's objectives. Using such a system would allow the monitoring of the position and movements of individual fish as the seismic vessel approaches. Only a limited number of fish could be monitored at any one time but much higher quality data could be collected. Similar information could be collected using radio tags although the position accuracy and frequency would be less.

9. Section 3.2: It is proposed to measure the distribution and abundance of fish along a series of transects to determine how quickly the fish re-establish their original configuration. **Unfortunately, no details are provided on how this will be accomplished. Will this be by net survey or acoustics? If by acoustics, there are a whole series of problems with doing this type of work in shallow water rivers not the least of which are vessel avoidance and narrow beam angles.** DFO has had considerable experience with these types of surveys through the co-operative work that we have done the Pacific Salmon Commission at Mission, BC. While the Mission program has and continues to be successful, it has taken a lot of effort over many years to make it so. Embarking on a similar sort of program on the Mackenzie and hoping to get useable and defensible results in the first year is optimistic.

10. Section 2.3.1: *"A nearfield phone will then be placed at a distance of 5 metres below the centre of the array to test and verify the maximum out-put pressure in bar-m."* **What frequencies are going to be used here? If nearfield is defined as within wavelength/2 pi, then only pretty low frequencies (maybe 75 Hz) would be in the nearfield at 5 m.** *"Far field measurements will be taken at a distance of 250 metres from the centre of the source."* **Will this involve the same instrument as above? Or will a pressure hydrophone be used?**

11. Section 3.1: *"Fish are expected to avoid water insonified by the air gun seismic array as the program proceeds up the river"* What is the scientific basis for this statement? And, what is defined as avoidance? It should be noted that different fish species respond very differently to an aversive stimulus. Some may swim away, while others may freeze and not move and those that freeze will receive a great deal of sound.

12. Section 3.1: *"The fish will be able to hear the approach of the vessels and the air guns for given period of time before the vessels actually reach the fishes*

location. This is expected to allow time for the fish to avoid the oncoming noise sources" How much is heard, and how far in advance, depends upon the species. Different species hear different sound levels. Salmonids, for example, do not hear very well and, depending upon frequency, they may not hear the air-guns till they are pretty close to the fish. Other species may hear the sounds at considerable distances. The comments here should be species-specific, and where threshold data are available, it should be possible to predict the distance at which the fish will detect the air-gun sounds (see comment above as to whether avoidance will occur). Moreover, since fishes may swim at different rates, it is possible that they will not easily get away if the source is moving to them at a faster rate then they can swim.

13. Section 3.1: *"The ramping-up procedure is expected to allow time for the fish to avoid the noise source over the several minutes that it takes to complete the ramp-up"* This is all hypothetical. It must be noted that there is absolutely no data that ramping up has any value for fish, or for marine mammals for that matter. The Gausland 2000 article only states that "It is standard industry practice to ramp up airguns when starting a survey to warn fish and marine mammals in the area" It does not state that it is proven and effective.

14. Section 3.2: *"If fish avoid the discharge of the seismic survey air guns, WesternGeco assumes that the return to normal distribution will occur soon after the survey vessel has passed. McCauley et al. (2000) has documented a return to normal behavior patterns within 14-30 minutes after air gun operations ceased"* But work by Engas et al in 1996 in Norway showed that gadids did not return to their normal fishing grounds for up to a week after air-gun tests. And with McCauley et al., the response was for caged fish that could not get away from the source, rather than free-ranging fish which might have avoided returning to an ensonified area once scared away. Moreover, since there are great species difference in behavior, one has to be careful in extrapolating between the behavioral results from McCauley and the species ensonified in this work. While McCauley et al may have shown behavioral responses that appeared normal, it is possible that there were stress effects (e.g, increased corticosteroid levels) that would not have shown up in behavior. As well, there is evidence (report in preparation) that there were long-term and dramatic impacts on the ears of the fishes exposed in the McCauley et al study. These would not have shown up in even 24 hours, but over several weeks.

15. Section 5.0: WesternGeco proposes to measure mortalities through direct observation. This will be a minimum estimate at best and can in no way be extrapolated to estimate total mortalities. Also, if no dead or injured fish are caught, it does not mean there weren't any just that they weren't observed. The scientific value of these observations is questionable.

16. Section 3.2: *"By relating mortality and movement (passage through the beam insonified by the 200kHz echosounder) to dB, we expect to be able to infer fish*

response from assumptions (or measurement) of pressure (i.e., we will have a model by which we can estimate fish response)." **How will mortality be determined?**

17. Section 3.3: "*This test will provide a relation of fish mortality with exposure to sound (measured as dB) for the duration of exposure (e.g., ramp-up plus full strength pulses every 8 seconds for 1 minute). After exposure, fish from each reference point at each site will be pooled (6-10 specimens per reference point) and held for an additional 48 hrs to assess "residual" mortality.*" Mortality is only one tiny segment of potential impact of the sounds. In a study conducted with McCauley it has shown (paper to be submitted), there are dramatic long-term effects of these sounds that would not be seen for a while, but which could dramatically impact survival of the fish.

18. Section 3.3: "*This experiment would provide a worst case relation of short-term (and "residual") mortality of a sensitive fish species over the range of insonification encountered by fishes as a result of the WesternGeco program.*" Just as bad would be long-term effects mentioned above.

19. Section 4.0: "*In conjunction with the above fisheries studies, observations by biologists, monitors, or Project personnel, of any aquatic and/or semi-aquatic mammals (e.g., beaver, muskrat, otter, beaver) that occur within the study area, and the reactions to the program, would be noted. Direct observation during the program was determined to be the most practical way to determine impacts to these species. A standard observation form would be completed by the monitors.*" Would these persons be trained to find and watch these animals? How will they determine if underwater behavior is hampered by the sounds, or if the animals are spending more time at the surface or out of the water (for those species that can leave the water) in response to the sounds? It seems to be that this needs to be quantified in some way and not just casual observations by untrained observers.

20. Section 6.0: "*Suspension of activities if aquatic mammals are observed within 200 m of the air guns*" But how will animals underwater be monitored?

21. Section 6.0: "*Suspension of activities for 1 hr and subsequent ramp-up if Project induced fish mortality is proven*" What will this do and, as stated earlier, how will mortality be determined?

22. 2.3.3 Attenuation over distance: "*During the survey, a hydrophone will be deployed at recorded distances from the source generator*" Shouldn't more than one hydrophone be used for this? "*Measured positions will be plotted on a map*" should be identified on a map that includes the test locations as part of the program submission.

23. It is stated in the draft monitoring program: "*if study components show conclusive evidence of success (e.g., fish avoidance) in the first study area*

(i.e., Norman Wells), WesternGeco would seek approval to amend or delete those same components in the Delta." These areas are of different character and content and therefore similar test components should not be amended or deleted based on the results from one test site.

24. 3.2 Estimation of distribution resumption by fishes: *"We expect to be able to infer fish response from assumptions (or measurement) of pressure (i.e., we will have a model by which we can estimate fish response)."* **Is the model derived from assumptions or measurements?** A model that may provide an inferred fish avoidance from assumed values would be much less useful than one using actual measurements.

25. **How many scout boats will be used and how far ahead and behind the seismic vessels will they be deployed?**

26. 6.0 Mitigation: **Sensitive fish habitat areas should be identified ahead of time as well as the areas that will be avoided. How soon after the monitoring program will the summary report be submitted? Results from the test programs must be submitted to DFO prior to the initiation of the seismic program.**

27. What is the time table for the test programs?

DFO looks forward to continuing to work together with WesternGeco to develop a comprehensive and effective acoustic and fish monitoring program.

If you have any questions feel free to contact me at (867) 669-4911 or Pete Cott at (867) 777-7520.

Bruce Hanna
Habitat Biologist
Fish Habitat Management
Department of Fisheries and Oceans - Western Arctic Area

Copy:
DFO Western Arctic Area staff
Laura Van Ham- NEB
Al Gibson, Jason McNeill- RWED
Melanie Van Gerwen-Toyne – GRRB
Jody Snortland- SRRB
Joe Acorn – MVEIRB
Ed McLean – FJMC
Linda Graf - EISC