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Ext Publisher Publication Date: October 2014

Defence Research and Development Canada

External Literature (N)
DRDC-RDDC-2018-N016
March 2018

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Canada

IMPORTANT INFORMATIVE STATEMENTS

UNDERWATER ICE CRACKING NOISE MEASUREMENTS IN YELLOWKNIFE BAY, GREAT SLAVE LAKE, NEAR THE DETAH ICE ROAD

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1 INTRODUCTION

An opportunity arose on April 14, 2013 to go out on to the frozen ice road on Great Slave Lake, Northwest Territories, and attempt to measure the underwater ambient noise in Yellowknife Bay. Figure 1 shows the outline of Yellowknife Bay with the dotted line being a GPS track along the ice road. The '+' symbol denotes the location of the recording system, which was just beside the ice road. During the recording, the conditions were -12C, 6 kmh wind, the ice was 128 cm thick with a hard 20-cm snow cover, the water depth was 25 m with the hydrophone at 22 m depth, and the sun had risen 2.7 hr earlier, but was very low in the sky. The sun is estimated to be between 7 and 10 degrees above the horizon during the measurements.

A DRDC-built low-noise hydrophone and recording system were available for use along with a *hot box* to keep the electronics warm in the cold air. The recordings were made at a time when vehicular traffic on the ice road was at a minimum. Unfortunately, several vehicles did pass during the recording period. These vehicles resulted in strong overloading and the records containing the vehicle noise were not useful for the current purpose. These records were not used and have resulted in gaps in the hour-long data record.

The remainder of this document describes the equipment and presents the results of measurements of ice-cracking noise events during the one-hour recording period.

2 EQUIPMENT

The sensing and recording equipment consisted of a custom built hydrophone, with a sensitivity of -203 dB, based on a Channel Industries C-5500 piezo-electric cylinder. The cylinder was closed with stiff carbon-fibre hemispherical endcaps. A 30 dB pre-amplifier with a self-noise of 1.6 nV/root-Hz was included inside the hydrophone with additional amplification located in a small pressure canister approximately 1 m distant. The amplifiers provided a 20 Hz high-pass frequency and a 30 kHz low-pass frequency filter. The minimum system gain of 60 dB was used for all recordings. The hydrophone is useful to a minimum sound pressure level (SPL) of approximately 27 dB//1μPa for frequencies from under 100 Hz to more than 20 kHz.

A National Instruments USB-9233, 24-bit analogue-to-digital (A/D) converter was used to sample the hydrophone signal at 50000 samples/sec. This A/D has a 102 dB dynamic range and a ± 5 V input range. This implies that the useable SPL range of the recording system at 60 dB gain is 55–157 dB//1μPa.

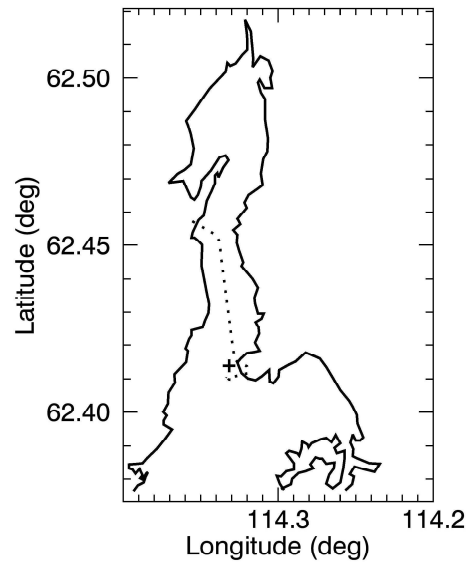

FIGURE 1 – Sketch map of Yellowknife Bay, the Detah Ice Road route (dotted line), and the measurement site location denoted by the plus sign.

An Acer Aspire One netbook running Windows XP was programmed with NI Labview to collect a series of thirty 2-min long data files. These data files were subsequently converted to WAV format and were analyzed to provide the ice-crack rate of occurrence and spectral content.

3 RESULTS

Data files were inspected for vehicle noise contamination and interrupted recordings resulting in short files. Out of 30 files, 22 were retained for analysis. From each of these files, the number of crack events in the first 30-seconds were counted.

Cracks were manually counted using three different criteria : 1. Cracks were detected in the time series by recognizing the oscillatory nature and reverberation combined with aurally listening to ensure the signals were ice crack events, 2. A sonagram (frequency vs. time and intensity image) was

created for each period and cracks were detected by searching for wideband short duration signals in the frequency band 1–5 kHz with particular attention to signals near 1.5 kHz, and 3. The number of signals strong enough to overload the system (more than 5V at the A/D) were counted in the full 2-minute file length (there were few overloads and a longer observation time was needed).

Each of these criteria result in a different rate of crack detection. The spectral method is most sensitive and results in the highest crack rate results. The time series method is strongly dependent on the general noise level and misses many cracks in the reverberation periods. The overload criterion produces the lowest crack rates and it can be assumed that the overloads are mostly counting the cracks that occur at short range from the hydrophone. The results of the three crack counting methods are shown in Fig. 2.

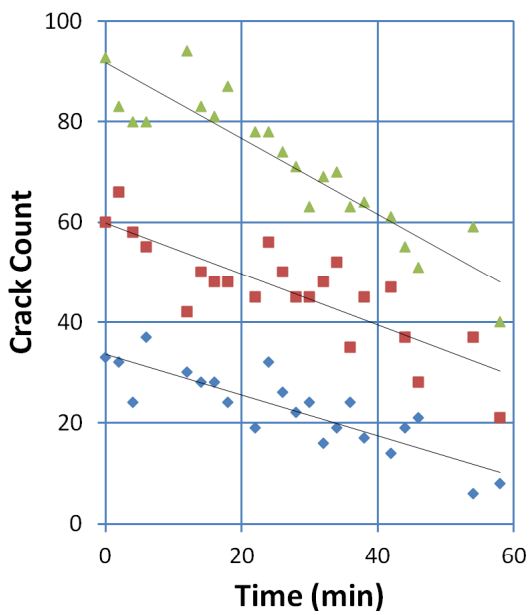

FIGURE 2 – Ice cracks as detected by three methods versus recording time. Crack events were counted using the spectral method (triangles), time-series waveform (squares), and input overloads (diamonds).

All three methods show that the crack rate is decreasing with time during the one-hour observation period. All three methods fit well with a linear decrease in the crack count versus time. The spectral method is the most sensitive and provides the best fit to the data with a linear trend. On average, the spectral and time-series methods produce consistent results, with the spectral method returning 1.5 times more crack events than the time-series method. This represents approximately 4 dB improvement for the spectral method.

Unfortunately, it isn't possible to determine the areal crack density from our single sensor as the detection range of either method cannot be determined. We also cannot determine the crack source level distribution, since the range to crack events cannot be determined. A number of the crack events do exceed the system dynamic range, so we can say that the peak source levels of the larger crack events are considerably higher than 157 dB. The spectrum levels for a period near the beginning of the hour-long data and for a second period near the end of the record are shown in Fig. 3. SPL's clearly reduce across the band as the sun rises. Most of the crack energy is below 1500 Hz, but crack energy remains appreciable up to 20 kHz. In general, noise conditions were high throughout the recording interval.

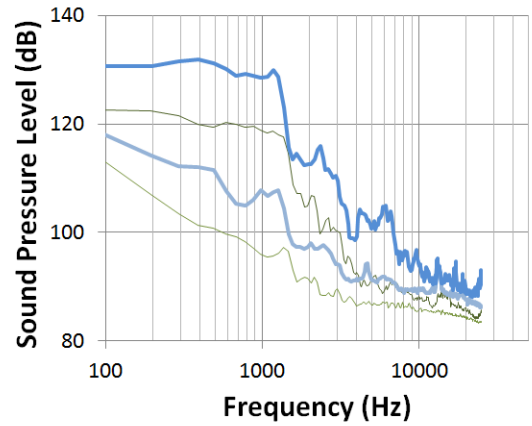

FIGURE 3 – Sound Pressure Levels for one interval near the beginning of the data record and another near the end. Thick lines (blue) represent a quiet period and a cracking noise period near the start of the data record, while thin lines (green) represent the same near the end of the record.

4 CONCLUSION

Ice-cracking events dominate the underwater ambient noise in Yellowknife Bay. The cracks were observed to occur at a rate of 1–2 a second during our 1-hour observation. The crack rate constantly reduced during the observation and it is presumed that this is due to the ice adjusting to the impact of solar heating. Detection of ice-crack sounds is not a simple matter, but three straight-forward approaches were described. The spectral content method was the most sensitive.

Unfortunately, location and areal density of cracks cannot be determined from our single omnidirectional hydrophone data. We can say that a range of ice-crack source levels are to be expected and a peak instantaneous level well above 157 dB//1μPa has been repeatedly observed.

ACKNOWLEDGEMENTS

Thanks to Joint Task Force North and 1 Canadian Ranger Patrol for supporting this work.

DOCUMENT CONTROL DATA

*Security markings for the title, authors, abstract and keywords must be entered when the document is sensitive

1. ORIGINATOR (Name and address of the organization preparing the document. A DRDC Centre sponsoring a contractor's report, or tasking agency, is entered in Section 8.) DRDC – Atlantic Research Centre Defence Research and Development Canada 9 Grove Street P.O. Box 1012 Dartmouth, Nova Scotia B2Y 3Z7 Canada	2a. SECURITY MARKING (Overall security marking of the document including special supplemental markings if applicable.) CAN UNCLASSIFIED 2b. CONTROLLED GOODS NON-CONTROLLED GOODS DMC A

3. TITLE (The document title and sub-title as indicated on the title page.)

Underwater ice cracking noise measurements in Yellowknife Bay, Great Slave Lake, near the Detah ice road

4. AUTHORS (last name, followed by initials – ranks, titles, etc., not to be used)

Heard, G.J.; Dittman, R.; Pelavas, N.; Schattschneider, G.

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total pages, including Annexes, excluding DCD, covering and verso pages.)	6b. NO. OF REFS (Total references cited.)
March 2018	2	0

7. DOCUMENT CATEGORY (e.g., Scientific Report, Contract Report, Scientific Letter.)

External Literature (N)

8. SPONSORING CENTRE (The name and address of the department project office or laboratory sponsoring the research and development.)

DRDC – Atlantic Research Centre
Defence Research and Development Canada
9 Grove Street
P.O. Box 1012
Dartmouth, Nova Scotia B2Y 3Z7
Canada

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. DRDC PUBLICATION NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.) DRDC-RDDC-2018-N016	10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11a. FUTURE DISTRIBUTION WITHIN CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

Public release

11b. FUTURE DISTRIBUTION OUTSIDE CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

12. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Use semi-colon as a delimiter.)
underwater; noise; ice
13. ABSTRACT/RESUME (When available in the document, the French version of the abstract must be included here.)