The impact of noise on passive monitoring of marine mammals in the Bay of Fundy

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I. Introduction

Passive acoustic systems to detect and track marine mammals have been developed for a variety of purposes, from mitigation to habitat studies. These systems have been used for a wide range of species and acoustic environments. The ultimate purpose of the system, and the environment it will be deployed in, will affect the system design and its capabilities. The system designer, however, has no control over many of the parameters affecting detection range and probabilities of detection, such as ambient noise, transmission loss, and frequency range and source level of the species of interest. Using an example based in the Bay of Fundy, we will discuss the impact of noise on the detectability of North Atlantic right whales (*Eubalaena Glacialis*).

II. Example Case – the Bay of Fundy

A percentage of the North Atlantic right whale population migrates to the Bay of Fundy in the late summer months. They are typically seen in the Grand Manan Basin (Fig. 1), an area ~180 m at its deepest. The seabed is characterized by an acoustically-absorbent surficial layer of LaHave clay that is progressively thicker towards the deeper basin (up to ~30 m thick). A shipping lane (white lines in Fig. 1) goes through the area.

III. Results

Let's assume passive detection using omnidirectional sensors. The signal excess (*SE*) for a detection is:

$$SE = SL - (TL + AN), \tag{1}$$

where *SL* is the source level, *TL* is the transmission loss, and *AN* is the ambient noise. It should be remembered that *AN* and *TL* are not always independent variables. Environments with large transmission losses will typically display low ambient noise levels.

Though ambient noise levels on the Scotian Shelf are relatively well documented, very few ambient noise data have been reported for the Bay of Fundy. DRDC Atlantic has made a few measurements using air-deployed sonobuoys in July 1999, and with various equipment during subsequent sea trials in the bay (2000–2005). Though the measurements are sparse, it was found that ambient noise levels in the deeper part of the bay are generally high at low frequencies (< 1000 Hz), even for low sea states and wind speeds, due to the high shipping traffic in the area. Significant variations occur throughout the day as whale-watching tour boats and pleasure vessels frequent the area, and commercial and other traffic transit through the nearby traffic lanes. Outside of local shipping occurrences, the noise levels in the 100–200 Hz band are representative of moderate to heavy shipping, similar to levels measured near the shipping lanes in the approaches to Halifax Harbour [1]. The 200–800-Hz noise levels have been amongst the highest measured on the shelf in that frequency band [1, 2]. It is assumed that shipping noise is contaminating the generally wind-dominated noise levels above 200 Hz. Despite the differences in surficial sediments at the location of the various sensors, no significant differences in noise levels were found between the various stations. Sonobuoy stations nearer to the shipping lane had, on average, slightly higher standard deviations over the 3-hr recording period, due to the passage of ships. For the purpose of designing a real-time monitoring system, the ambient noise levels of Hazen and Desharnais [1] can be effectively used below 200 Hz. Above these frequencies, the shallow water Wenz curves [3] can be used to predict noise levels

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in the Bay of Fundy; an additional 2-5 dB may be required to account for high shipping levels.

The variability of the background noise levels as a function of depth was investigated with the energy-flux model of Desharnais and Chapman [4]. Based on the sound speed profiles observed during the noise measurements, it was found that the noise levels are not expected to vary by more than 0.5 dB between 30 and 180 m depth.

Transmission loss was modeled with a Parabolic Equation model (based on the description in [5]). We selected 150 and 500 Hz as representative of the low-frequency moans and mid-frequency vocalizations of the North Atlantic right whales. The seabed model was a three-layer representation of the sediment types found in the deeper part of the bay: a 25-m layer of LaHave clay (1490 m/s), overlying 75 m of Scotian Shelf till (1745 m/s), and an acoustic half-space of sandstone (4650 m/s). Table I shows an example of signal excess for North Atlantic right whales in the Bay of Fundy, based on average values for transmission loss (computed at a range of 10 km), ambient noise and source level within specific bands of vocalizations. The source levels for the species were taken from [6].

In this sample case, right whale sounds can be detected well beyond 10 km in the 100-200 Hz band, but their higher-frequency vocalizations are soon lost in the high ambient noise background. In effect, right whale vocalizations have been detected and localized in this environment up to ranges well in excess of 10 km. This is partly due to the range-dependent environment: the thick clay sediment progressively thins out, reducing the transmission loss for sources and receivers that are closer to the shipping lanes. Directional sensors have also been used to improve the signal-to-noise ratio for sources located away from discrete noise sources such as ships. Source levels for right whales also vary significantly.

References

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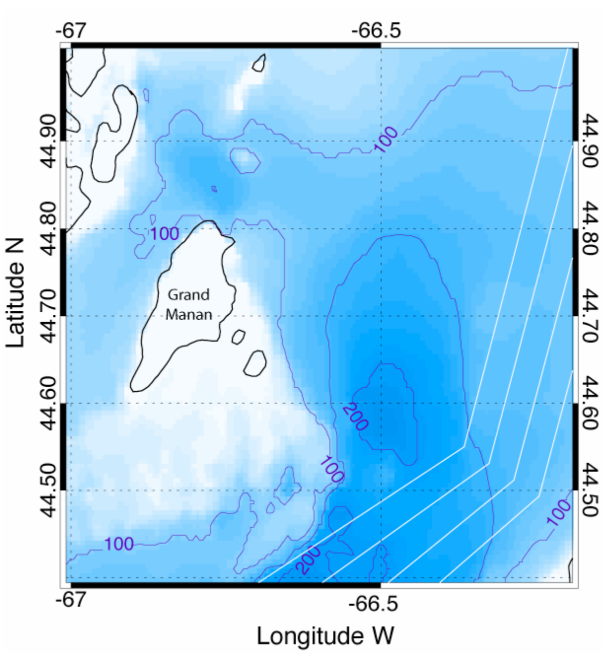

Fig. 1. Grand Manan Basin, Bay of Fundy. Shipping lanes are shown as white lines.

Table I. Examples of signal excess.

Frequency band [Hz]	100-200	200-800
Source level [dB re 1 μPa @ 1 m]	175	160
Ambient noise level [dB]	82	72
Transmission loss [dB]	70	85
Signal Excess [dB]	23	3