DEMONSTRATING THE FEASIBILITY OF NEAR-REAL-TIME VESSEL NOISE MAPPING TO MANAGE MARINE MAMMAL NOISE IMPACTS

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Résumé

Le bruit produit par l'homme dans les océans peut provoquer des séquelles physiques et des perturbations comportementales chez les créatures marines. Chez les mammifères marins, il gêne leurs utilisations des sons pour la recherche de nourriture, la communication, la navigation, la socialisation et la reproduction. Les progrès dans les enregistreurs acoustiques, les observatoires océaniques, le suivi des navires, et la modélisation du bruit nous permettent d'étudier et contrôler les effets du bruit généré par le trafic maritime sur la vie marine. Cet article traite d'une étude pour l'agence spatiale canadienne visant à examiner la faisabilité d'une interface web contrôlée par l'utilisateur qui fournit une prédiction en temps quasi-réel du bruit du trafic maritime dans les habitats de vie marine. '*ShipNoiseView*' intègre la position en direct du navire depuis le système d'identification automatique par satellite (AIS) avec la télédétection en temps réel des données océanographiques et les modèles validés de propagation du bruit de navire. Grâce à cet outil, il est possible d'estimer les niveaux sonores cumulatifs du navire et de contrôler l'effet du bruit sur la vie marine grâce au suivi et l'atténuation en temps réel.

Mots clés: bruit océanique anthropique, mammifères marins, modélisation, navigation

Abstract

Man-made ocean noise can cause physical injury and behavioral disturbance to marine life. It hampers marine mammals' use of sound for foraging, communicating, navigating, socializing, and mating. Advancements in acoustic recorders, ocean observatories, vessel tracking, and noise modelling allow us to study and manage the effects of vessel noise on marine life. This paper discusses a study for the Canadian Space Agency to investigate the feasibility of a user-controlled web interface that provides near-real-time prediction of vessel noise in marine life habitats. '*ShipNoiseView*' integrates live vessel position data from the Satellite-Automatic Identification System (S-AIS) with real-time remote sensing of oceanographic data and verified vessel noise propagation models to assess cumulative vessel sound levels and to manage the effect of noise on marine life through real-time monitoring and mitigation.

Keywords: anthropogenic ocean noise, marine mammals, modelling, shipping

1 Introduction

Vessel traffic is a leading cause of ocean noise and increases stress hormones in marine mammals.[1] The ocean ecosystem is critical to the health of our planet and the future of our fisheries, and marine mammals hold important balancing roles in maintaining its stability. Predicting and measuring noise fields from vessels offers a chance to manage noise emissions using the International Maritime Organization's system of speed restrictions, areas-to-be-avoided, Notices to Mariners, and vessel traffic lanes. [2]

JASCO Applied Sciences completed a study for the Canadian Space Agency investigating the feasibility of developing a vessel traffic control system based on real-time prediction of vessel noise to evaluate the cumulative effects of shipping in a region and to propose mitigation actions to reduce the noise and impacts to marine life. A prototype tool was developed and implemented for a case study in the Saguenay-St. Lawrence Marine Park, QC, which is a region of interest due to the proximity of shipping lanes to protected critical beluga habitat.

2 Method

Prototype Tool: ShipNoiseView

ShipNoiseView is a web-based map interface for users to view the sound contributions from one or more transiting vessels and explore alternate transit scenarios to mitigate noise impacts. It uses modern web services and map displays to integrate S-AIS tracks, remote sensing data, and an acoustic propagation modeling expert system. The model, which requires no manual data handling to run, is hosted on a remote server and deployed in real time via web-based user input.

Using the modelled acoustic field results, a user can assess the impact to marine life from a vessel transit (Figure 1). If sound levels exceed recommended thresholds, the watch officer may explore noise-reducing options for the vessel track, such as reducing speed, changing the route, grouping vessels together or changing propulsion systems for hybrid vessels.

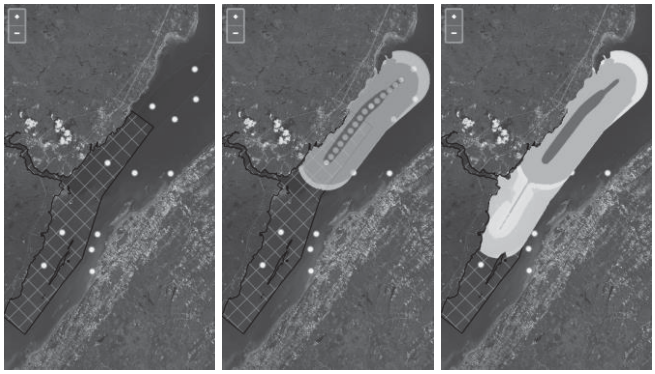

Figure 1: *ShipNoiseView* mitigation scenario: Current vessel locations (left), sound field for selected vessel track (middle), and reduced sound field with mitigation by speed reduction (right).

Acoustic Model

The vessel noise footprints are predicted using JASCO's Cumulative Vessel Noise Model, which was developed to calculate regional sound fields from multiple vessel tracks using precomputed propagation loss (PL) curves unique to a regional environment. The PL curves are modelled using JASCO's Marine Operations Noise Model (MONM), an in-house parabolic equation based propagation model based on the USN Range-dependent Acoustic Model (RAM). The curves define how sound attenuates as it travels through water and sediments, independent of the sound source. The study area is divided into 14 acoustic 'zones,' characterized by their depth and bottom type. Each zone's PL curves are calculated for a variety of propagation scenarios that depend on range, deci-decade frequency band, source and receiver depths, and the sound speed profile. Modelling the PL curves is the most computationally heavy step in calculating the sound field, so precomputing and storing them as easily accessible tables allows the Cumulative Vessel Noise Model to generate the user-requested sound fields in near-real-time by selecting and combining the appropriate PL curves for each vessel track scenario.

The Cumulative Vessel Noise Model divides the vessel track data into a series of time steps and calculates the regional sound field for each using a gridded representation of the region. A 100x100 m grid is overlaid on the acoustic propagation zones, and each vessel source is centred in the appropriate grid cell. The vessel's source signature is applied and propagated into adjacent grid cells using a weighted average of PL curves for the acoustic zones crossed along its path. The radial sound field for each source is summed across all grid cells for each time step, resulting in an instantaneous regional sound field for the time snapshot with contributions from all vessel tracks submitted to the model (Figure 2). The regional fields are then summed temporally to get the cumulative sound field for the full duration of the vessel tracks.

3 Discussion

3.1 Continuing Development

In addition to the run-time benefits, precomputing PL curves by fully characterizing the environment in advance makes the Cumulative Vessel Noise Model extremely versatile in its ability to accept input data from a variety of sources. The model currently uses static and historical average environmental data. It could easily include in-situ measurements or real-time remote sensing to more accurately select environmental propagation conditions. Its resolution can be easily improved by dividing the study area into finer depth and geo-acoustic zones.

Similarly, the prototype *ShipNoiseView* assigns frequency-dependent vessel source signatures from a list of published modelled and measured surrogate spectra based on the vessel type, size, and speed. Acoustic recorders could be employed to provide vessel-specific measured source levels, as well as data for marine mammal detections, ambient noise, and model verification.

Vessel noise is persistent and regional, and its affect on mammals in different hearing groups is based on the frequency of the noise being produced. It therefore must be assessed on a cumulative scale considering the auditory characteristics of specific mammal types in the region. The acoustic model can provide marine mammal audio-weighted cumulative acoustic fields and ranges to injury and disturbance thresholds based on published impact criteria. In addition to mitigating noise from targeted high-risk vessel transits, assessing cumulative noise emissions over long timescales highlights variations caused by vessel traffic patterns or seasonal environmental changes.

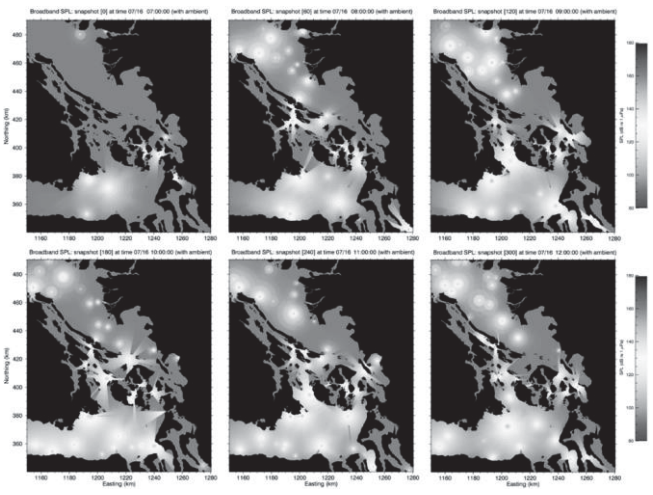

Figure 2: Cumulative Vessel Noise Model time 'snapshot' acoustic fields in the Salish Sea, BC. Time step is 1 hour between successive snapshots. [3]

3.2 Implementation and Integration

The Canadian Coast Guard's Marine Communication and Traffic Service (MCTS) monitor thousands of vessels transiting Canadian waterways daily. *ShipNoiseView* has been proven to be feasible as a stand-alone system, but could also be used in an existing marine traffic communication network capable of sending real-time navigation aids for mitigating ocean noise impacts. Using 96-hour Pre-Arrival Information Reports provided to Transport Canada along with the S-AIS position reports, the

model could run automatically in the background as soon as vessels are identified as proceeding to Canadian waters and ports, with alerts sent to MCTS operators when the model calculates that specific sound level thresholds will be exceeded.

Comprehensive ocean noise management will require ongoing research and centralized data from many scientific efforts, including real-time marine mammal monitoring, detailed vessel traffic reporting, reliable vessel source sound level measurements, live remote sensing of environmental data, and acoustic monitoring for model verification and regional ambient noise conditions. Together with advancements in data acquisition and availability, as well as state of the art technologies for communication and management, an innovative real-time noise prediction tool such as S*hipNoiseView* could play a key role in transforming data from scientific and government sectors into operational decision aids for mitigating the impacts of ocean noise on marine life.

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