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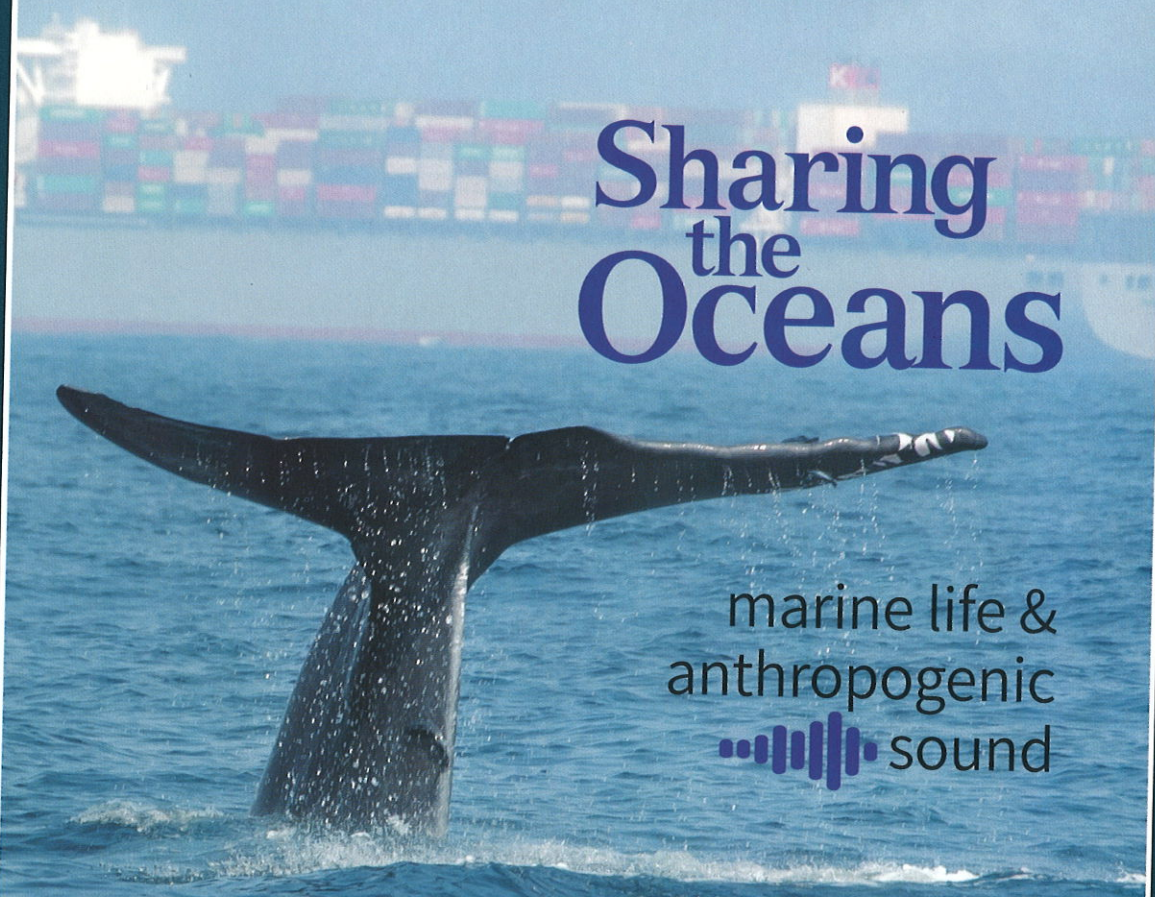

Sharing the Oceans

marine life & anthropogenic sound

In this Issue

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Reducing the Impacts of Shipping on the St. Lawrence Estuary Beluga Population

Modelling and Prediction of Whale Exposure to Vessel Noise under Prospective Scenarios

by Clément Chion, Tyler R. Bonnell, Dominic Lagrois, Robert Michaud, and Angélique Dupuch

The underwater noise emitted by shipping is one of the main sources of anthropogenic noise affecting aquatic life. This noise pollution interferes with some vital activities and biological functions of numerous wildlife species, including marine mammals. The effects of vessel noise on marine mammals include behaviour change, elevated stress, vocalization and echolocation masking, and can extend to physical damage such as a temporary or permanent shift in animals' hearing capabilities. The potential adverse effects of vessel noise are concerning for highly acoustic species, particularly for those listed as species at risk such as the endangered St. Lawrence Estuary beluga population.

Belugas' exposure to navigation noise is identified as one of the major threats to their recovery. Therefore, the traffic increase during the summer months into the critical habitat of endangered belugas needs effective management actions in order to comply with the legal requirement to protect this population under the Canadian Species at Risk Act. In order to explore the likely outcomes of vessel noise mitigation options, our research team at Université du Québec en Outaouais is working on the development of a simulator reproducing the spatiotemporal dynamics of whales and boats in the St. Lawrence Estuary and the Saguenay River. This simulator is designed to simulate the impacts of a variety of scenarios such as vessel noise mitigation measures and alternative scenarios of increased shipping transits at the individual whale scale. The simulator is composed of three interconnected modules: The *Whale* module, the *Boat* module, and the *Environment* module.

The *Whale* module represents the 3D movements of different whale species at the individual level. The *Beluga* submodule is based on several databases shared by a variety of collaborators (Group for Research and Education on Marine Mammals, Fisheries and Oceans Canada, and Parks Canada) collecting ecological data for up to 30 years. To reproduce beluga displacement behaviour, data collected from tags placed on focal beluga have been used to develop statistical movement models. Long-term photo identification data have been used to characterize both the social structuring in the beluga population and the spatially restricted use of the St. Lawrence. Using these data, the *Beluga* submodule aims to reproduce spatial-social structuring in this population to accurately estimate the distribution of exposure to noise.

The *Boat* module represents the movements of the marine traffic operating in the belugas' summer habitat. Four types of vessels account for the vast majority of boat movements in the study area; namely merchant ships, whale-watching excursions, ferries, and recreational boats. Data from the Automatic Identification System (AIS) provide the information to model the static and spatiotemporal characteristics of the transits from merchant ships, whale


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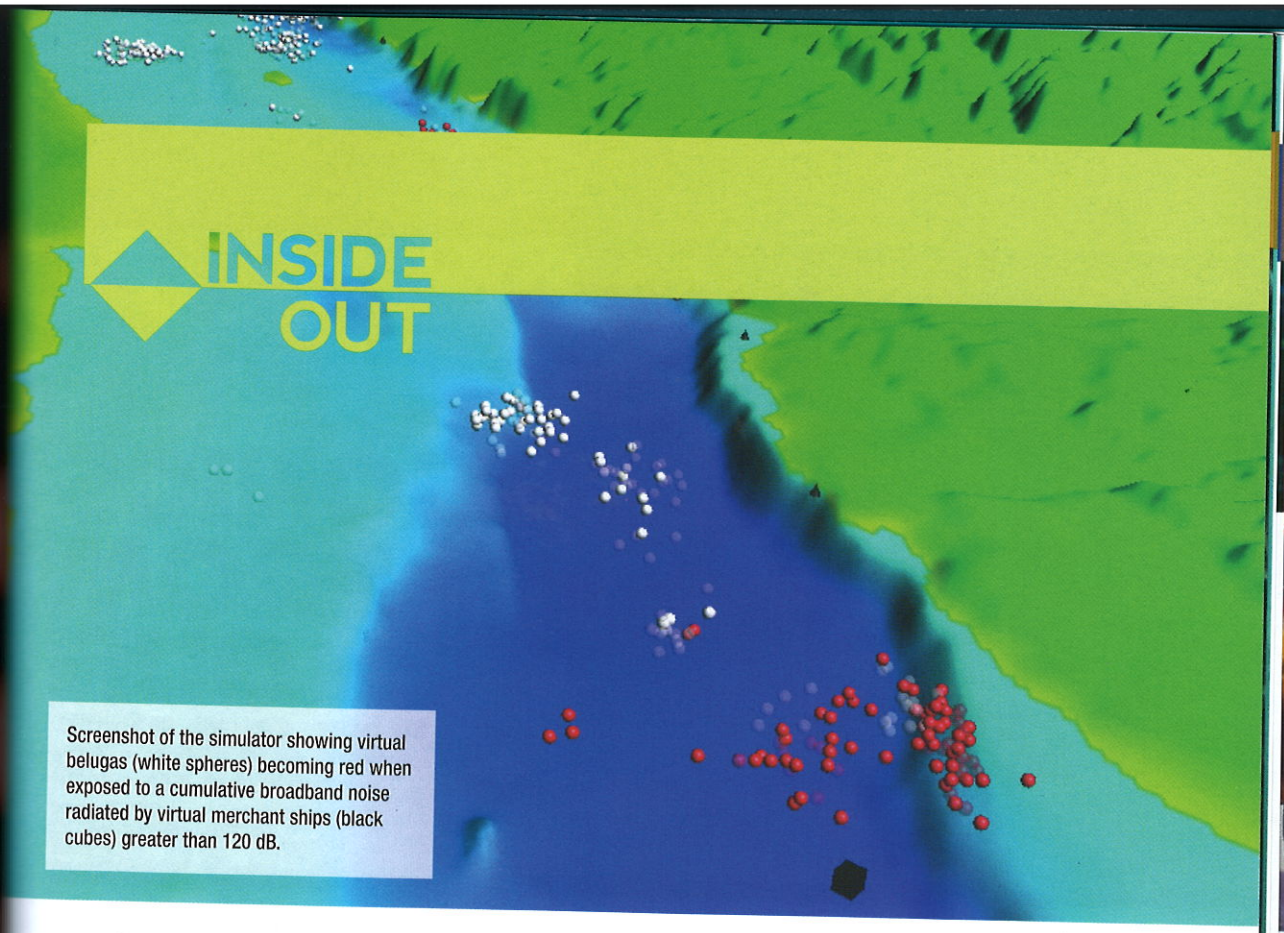

Screenshot of the simulator showing virtual belugas (white spheres) becoming red when exposed to a cumulative broadband noise radiated by virtual merchant ships (black cubes) greater than 120 dB.

watching boats, and ferries. However, modelling the movements of recreational boats requires a separate investigation since most of them are not required to carry an AIS transponder on board. The level of noise emitted by boats (SL) is also implemented into the simulator based on models derived from hydrophone data acquisition campaigns.

Finally, the *Environment* module must integrate the characteristics of the biophysical environment that are relevant to model whale and boat behaviours along with underwater noise propagation, such as bathymetry, tides, currents, and the geophysical properties of the seabed. The RAM parabolic equation solver is used to iteratively model acoustic transmission losses from each boat (source) to each whale (receiver). Transmission loss is thus subtracted from boat SL given by empirical models, yielding the acoustical power received by each whale in the frequency domain. For validation purposes, the accuracy of these simulated levels of noise received by belugas will ultimately be assessed using hydrophone data obtained from Dtags attached to individual belugas (collected by collaborators).

The agent-based modelling paradigm used in this project is a unique integrative approach that allows the fusion of multiple datasets of different types into the same simulation environment. A previous version of this simulator successfully informed a multi-stakeholder working group to reduce the risk of collisions between ships and baleen whales in the St. Lawrence Estuary. Once validated, the upcoming version of this simulator will serve as a tool to inform a multi-stakeholder process to reduce the level of noise received by the belugas in their summer critical habitat.

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