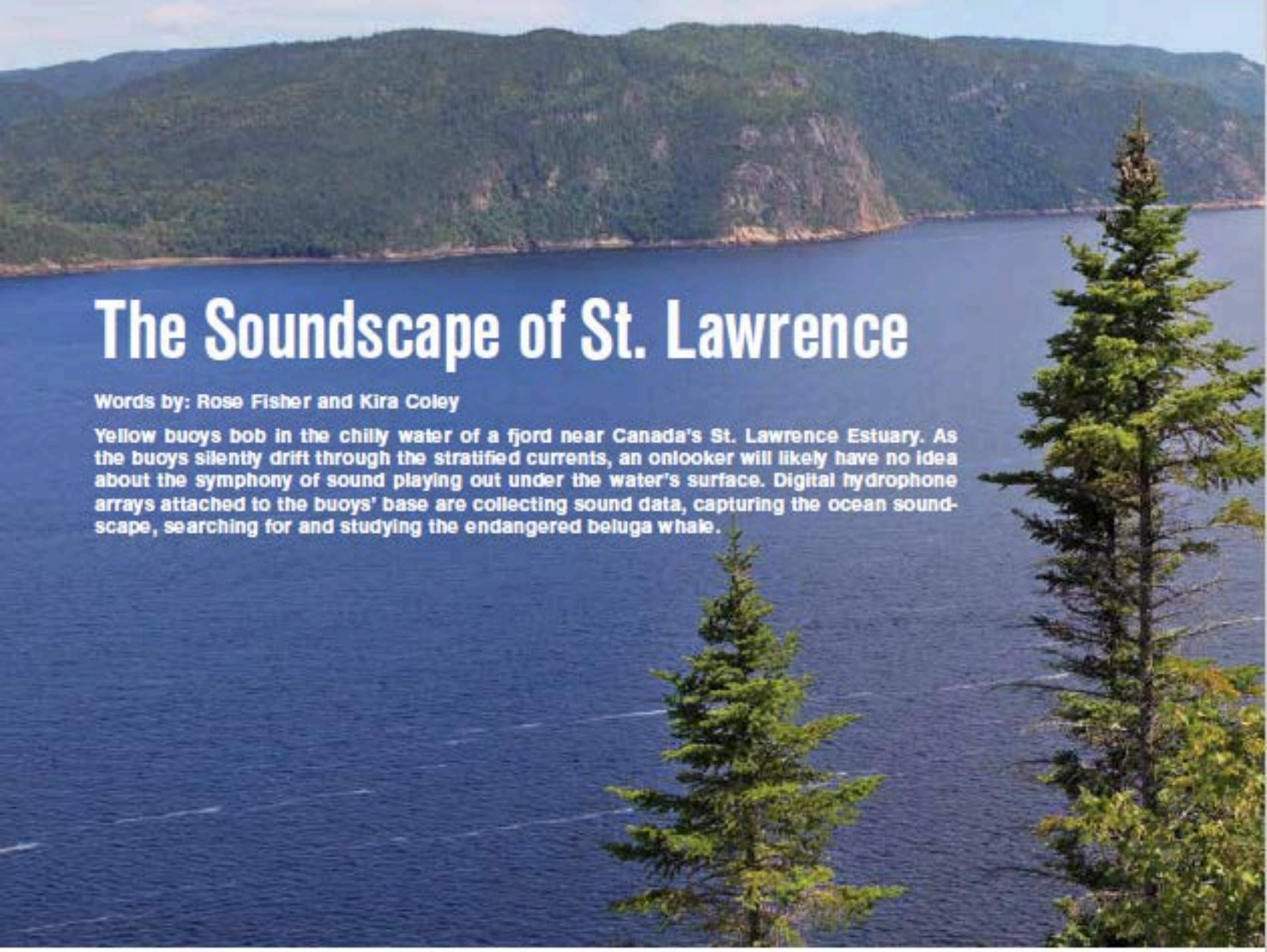

# The Soundscape of St. Lawrence

**Words by: Rose Fisher and Kira Coley**

**Yellow buoys bob in the chilly water of a fjord near Canada's St. Lawrence Estuary. As the buoys silently drift through the stratified currents, an onlooker will likely have no idea about the symphony of sound playing out under the water's surface. Digital hydrophone arrays attached to the buoys' base are collecting sound data, capturing the ocean soundscape, searching for and studying the endangered beluga whale.**

Canada's east coast is home to some of the best whale-watching sites in the world. Every spring, thousands of whales leave the Atlantic Ocean and enter the St. Lawrence Estuary. Teeming with fish and plankton, the estuary is the summer feeding ground for up to thirteen different whale species, the more frequent of which includes the blue, fin, humpback, and minke whale, and the resident beluga. These whale species are regularly seen in the estuary from May to November, explains Clément Chion, Professor in the Department of Natural Sciences at the University of Quebec in Outaouais (UQO). "But among these top five, under the Species at Risk Act in Canada, the beluga and blue whale have an *endangered* status and the fin whale is *of special concern*." Clément is part of the Maritime Transportation and Marine Mammal Protection working group formed in 2011 that is exploring solutions to help mitigate the risks of shipping on marine mammals.

In addition to its rich biodiversity, the St. Lawrence Estuary is a major seaway linking the Atlantic Ocean to the Great Lakes. Each year, merchant ships conduct about 5000 transits through the estuary to which are added thousands of trips by whale-watching boats, ferries and pleasure crafts. "The resulting co-occurrences between boats and whales have raised concerns about negative impacts including both collisions and exposure to underwater noise," adds Clément.

Ship traffic around the world has increased at an accelerated pace and shows no signs of slowing down. As Arctic ice continues to melt, shipping channels are opening, placing previously undisturbed species at risk for vessel strikes, and communication and navigation issues through noise pollution, as well as other anthropogenically introduced threats.

The warming climate also has an effect on food availability and migration and breeding habits for a number of species. Canada's marine wildlife has struggled to adapt to these challenges. The declining numbers and deteriorating health of these populations have resulted in a lack of response to recovery efforts, further demonstrating the detrimental effects our actions can have on environments.

## Regulating the St. Lawrence Estuary

The Canadian government identified the need for collaborative and directed protection measures as early as the mid-1990s. In 1996, Canada's 'Ocean Act' was created, leading to Canada's Ocean Management Strategy. It was through this strategy that a number of Large Ocean Management Areas, or LOMAs, were identified. There are LOMAs located on all three coasts: the east and west coasts, as well as the Arctic waterways. The strategy aimed to help regulators set guidelines and rules to promote the economic prosperity of these areas without harming the natural environment and the diverse wildlife that call Canada's oceans home.

The Gulf of St. Lawrence, one of five identified LOMAs, is a hot spot for marine industries including shipping, tourism, aquaculture, and fishing. Five of Canada's ten provinces border the gulf, making the gulf and its estuary culturally and economically important.

The St. Lawrence Estuary, the largest in the world, was traditionally a whale hunting and fishing area for the region's First Nations as well as the entry to some of Canada's first shipping routes used to deliver goods to European settlers. In 2018, St. Lawrence remains a crucial area for the fishing industry and port for shipped goods; however, it is likely best known for its iconic population of resident beluga whales.

After the ban on beluga whaling in 1979, the gregarious whales were expected to recover their population, however, that has not been the case. The number of individuals has remained critically low, with calf mortality increasing in recent years and poor health threatening the population at large. It's not known what is causing this failure to thrive, but habitat degradation, diminished food supply, noise pollution and human disturbance have been identified as possible causes. A concerted effort is being made by the Department of Fisheries and Oceans and their partners to uncover the cause of the beluga population decline.

Following two years of collaboration, the Working Group for Maritime Transportation and Marine Mammal Protection involving stakeholders from the public, private, NGO, and academic sectors decided to first assess collision risks between large ships and baleen whales.

Clément continues, "The group co-constructed 10 management scenarios, and we tested their likely efficiency and impacts on shipping activities using the Marine Mammal and Maritime Traffic Simulator (3MTSim)."

Clément started to develop the 3MTSim in 2006 as part of his Ph.D. and continued to improve it over the years. The simulator was designed to assess the impacts of different management scenarios proposed by the working group which led to the implementation of voluntary mitigation measures in 2013. The 3MTSim provided quantitative estimates and also served as a mediation tool to support the discussions between stakeholders with different background and objectives.

The voluntary measures consist of a caution area, slow-down area, no-go area and a recommended route to prevent collisions between large ships and baleen whales in the frequently used areas of the whales' feeding ground. The decision to go with a voluntary framework (instead of regulations) was motivated by the commitment of the maritime industry from the outset of the working process.

"The hypothesis was that beluga whales are fast swimmers, so it is believed that they can easily avoid large slow ships with few abrupt changes in course. Therefore, the reported collisions are more likely attributable to fast-moving small vessels (tourist boats and pleasure crafts) that frequently and quickly change their course in unpredictable ways," explains Clément. "On the noise issue, we cannot assert that belugas are more vulnerable than other whales. However, what we do know is that belugas are very vocal and social animals. They use a wide range of frequencies for vital activities including communication (e.g. mother-calf contact calls), socialization, mate selection, hunting, and echolocation."

As of today, industry voluntary compliance with the mitigation measures allowed the reduction of the risk of lethal ship strikes with baleen whales by up to 40 percent in areas where animals congregate.

While belugas are a prominent species in the estuary and surrounding gulf, they are not the only at-risk species to frequent the St. Lawrence region. Fin whales, humpback whales, and to a lesser extent the critically endangered North Atlantic right whales are also spotted regularly in the estuary.

Following the death of a number of endangered North Atlantic Right Whales, 12 mortalities in 2017 alone, the Government of Canada has now created mandatory speed restrictions for vessels operating downstream of the estuary, in the Gulf of St. Lawrence. Mandatory speed restrictions came into effect in April 2018 and will end in November, voluntary speed restrictions for large vessels operating in the area are suggested for the winter months.

The hope is that by slowing a vessel down, the likelihood of that vessel coming into contact with an at-risk or endangered species is decreased, as is the amount of anthropogenic noise being introduced into the environment, as slower vessels tend to be much quieter. But only 'relatively recently' has work begun to better understand the noise impacts from navigation in this area, added Clément.

## The Underwater Soundscape

While the negative impacts of collisions are obvious, underwater noise impacts on whales can cause unseen behavioral changes in beluga such as affecting foraging, the reduced ability to socialize and locate prey, and hearing loss. In the St. Lawrence Estuary, such threats are identified as potentially limiting the recovery of the North Atlantic blue whale and the St. Lawrence beluga population.

To help enforce these regulations as well as monitor their success, a number of tools have been implemented to effectively supervise the area. Sound is essential to the wellbeing and survival of marine wildlife, so among the tools being used are smart acoustic sensors. Located in the estuary are multiple digital hydrophones. These hydrophones listen around the clock to the sounds of the estuary environment. As ships pass and mammals feed, breed and chatter, these hydrophones collect real-time data, transmitting it to researchers, eager to obtain more insight into the complex underwater ecosystem. Employing hydrophone technology to better understand the whales while undisturbed in their habitat is among the most effective ways to study their behavior. Acoustic

*Sight seeing ship in Tadoussac*

*Delphinapterus leucas in the wild*

sound data has become an essential tool in helping researchers better understand intricate ocean environments.

In order to collect the highest quality data without further distressing the whale population, Ocean Sonics created a buoy, able to drift quietly through the whales' habitat, collecting sound data through the attached 4-hydrophone array. The hydrophones record the sound of the belugas as they dive and swim in the area, looking for prey and communicating with their peers. With two buoys deployed, each equipped with a hydrophone array and GPS time sync, researchers are able to discern diving time and depth, feeding, and breeding behaviors and learn more about inter-pod communication.

A similar project has been ongoing on Canada's west coast where Southern Resident Killer Whales (SKRW) are under threat. The population has remained critically low since conservation efforts began in 1975, with a total population of only 75 individuals this summer between all three pods; J, K, and L. Many things have changed in the SRKW's habitat: increased shipping, declining food supply and the looming threat of a large pipeline all threaten the already scant population.

In 2016, Canada's Whale Tracking Network began activities to learn more about the changing environment and the role we play in it. A large hydrophone array consisting of 28 hydrophones arranged in nine nodes was deployed in the areas frequented by the SRKWs. The pod's unique vocalizations allowed researchers to track the animals in real time, identifying one pod from the next. The hydrophones are used to create an accurate representation of the orca's behaviors, where and when they travel, what they eat and where they find their prey. The hydrophones also gather data on ship traffic and the amount of noise it introduces into this environment.

Back at the St. Lawrence Estuary, Clément and his team continue to research in collaboration with the federal government, who are conducting field campaigns that include the use of hydrophones, whale tracking data, and modeling. With this data, Clément has coupled the 3MTSim with an acoustic model of ship noise and sound propagation to test how the ship strike mitigation measures are likely to influence the exposure of beluga whales to shipping noise. "This was our first attempt to combine an agent-based model of ship and whale movements with acoustic models of underwater noise sources and propagation," he said.

The team is planning on improving the model of beluga movements based on new data including tracking data and group-follow data. Improvements will also be made to noise source modeling for ships along with 3D models of underwater propagation. "The objective is to be able to accurately inform the working group so they can recommend measures to the federal agencies to reduce the exposure of belugas to shipping noise."

The principal collaborators for these further developments will include Fisheries and Oceans Canada, Parks Canada, and the Group for Research and Education on Marine Mammals (GREMM).

"Collaboration with the shipping industry is of paramount importance to identify short, medium, and long-term solutions to mitigate the impact of shipping on marine life," explains Clément. "For instance, we need to better understand the efficiency of noise-reduction technologies along with the effects of ship maintenance operations [such as hull and propeller] on radiated noise. We also need to deepen the collaborations between scientists and researchers from academia and the government to improve this efficiency. On the biological side, more research is required to better understand impacts of anthropogenic underwater noise on different species of whales, the various sources of anthropogenic noise and the relation between noise and collision risks."

"Such problems have no easy solution, so decision tools must provide quantitative estimates to explore alternative scenarios by estimating the trade-offs between environmental, economic and social values. We must keep in mind that shipping is the least energy consuming option to transport commercial goods over long distances and that supports the need to continue working in collaboration to find the best mitigation solutions. It is crucial, especially for endangered whales."

The goal of these ocean management areas is to develop a better understanding of the marine ecosystems that exist within these regions, as well as the prevalence and impact of human activities. Many of Canada's iconic whale populations are in decline. As pollution levels escalate, water temperatures warm, and ship traffic continues to increase around the globe, our oceans are becoming inhospitable to the creatures that call them home. This collaborative effort ensures the best resolutions for all stakeholders: effective and minimally invasive shipping traffic and thriving, robust ocean ecosystems.