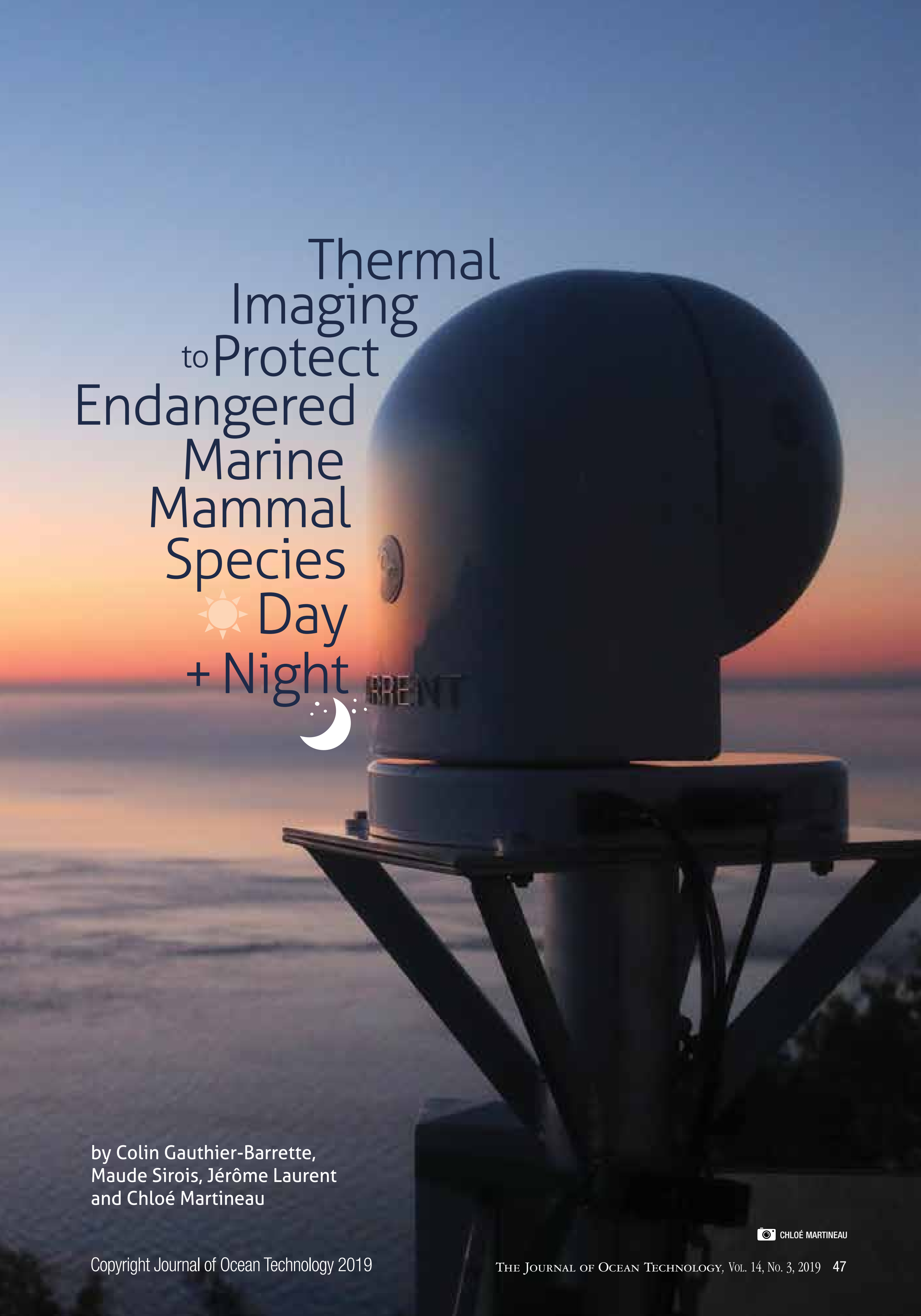

Thermal Imaging to Protect Endangered Marine Mammal Species Day + Night

by Colin Gauthier-Barrette, Maude Sirois, Jérôme Laurent and Chloé Martineau

CHLOÉ MARTINEAU

Figure 1: The Night Navigator 6030 thermal camera is controlled in two-axis rotation by a joystick or placed in automatic scanning mode.

Introduction

A team of professionals at Merinov – Canada's largest integrated centre for applied research in fishing, aquaculture, and the processing and development of aquatic products located in Gaspé, Quebec – relied on the use of a thermal camera in order to detect marine mammals at the surface of the water. One of the main uses of the thermal camera is night vision. Since this device captures infrared rays rather than visible light, there is no difference between a picture taken during the day or at night, apart from a slight decrease in surface temperatures after the sun sets. Merinov believes that an efficient marine mammal infrared detection system could be beneficial in many sectors of activity in Canada.

For example, coastal and offshore works in Canada are required to hire marine mammal observers to monitor the surrounding area and to note the presence of marine mammals. When a marine mammal is detected too close to the site, work must immediately be stopped and not continued until the animal has left the exclusion zone. Since the observers must be able to do their jobs efficiently, work must also be stopped when visibility is reduced in foggy weather, agitated water, sun glare, or at night. The longer the work on a site is delayed, the longer the project will take, which increases its impact on the surrounding environment.

Traditionally, these observational activities are conducted from an outside observation point providing the best coverage possible of the exclusion zone and are performed with the naked eye and binoculars. Merinov hopes to eventually integrate the thermal camera in observers' practices to enable them to perform their work effectively at night. This would lead to a considerable reduction in the duration of the offshore operations, thus reducing the anthropic pressure it exerts on the cetaceans.

Acquisition of the System and First Tests

In order to test its hypothesis, Merinov acquired in 2017, thanks to the financial help of NSERC, a thermal camera – the Night Navigator 6030 – manufactured and sold by the Canadian company Current Scientific Corporation. Originally designed for search and rescue activities, the device is controlled in two-axis rotation by a joystick or placed in automatic scanning mode in addition to offering a 6x zoom (Figure 1). Merinov coupled the camera with a video recorder, allowing real-time footage to be viewed on a screen and exported in video format.

The team was able to test its system for the first time as part of a pilot project carried out during dredging activities completed by the Société des traversiers du Québec (STQ) in the fall of 2017 near the Rivière-du-Loup wharf, where the company operates a crossing to the North Shore of the Saint Lawrence Estuary. The objective of this first project was to test the thermal camera system's ability to detect marine mammals and to compare its performances with those of visual observers under various visibility conditions. The camera was installed directly on the dredge for the duration of the work (Figure 2). For about two weeks, an observer was dedicated to the camera observation for a total of 52 hours. This first field outing with the camera helped tame its operation, its sensitivity, and its various functions; but its effectiveness could not be clearly confirmed due to a scarcity of marine mammals during the dredging project.

Figure 2: The camera was directly installed on a dredge during dredging activities near the Rivière-du-Loup wharf.

CHLOÉ MARTINEAU

This first demonstration, nevertheless, greatly marked the interest of the STQ, who saw great potential through additional development efforts. Thanks to its financial support, Merinov's team was able to refine the system and return to the field in the fall of 2018 and spring of 2019 to continue testing.

Results

In several weeks spread over two seasons, Merinov's thermal imaging acquisition system travelled between Tadoussac and Rivière-du-Loup along the Saint Lawrence Estuary. The first observation session took place in

Figure 3: The thermal camera was installed at the (A) Pointe-Noire Interpretation and Observation Centre and (B) aboard a Parks Canada boat, *Alliance*.

September 2018 in the Saguenay-St. Lawrence Marine Park, a world-famous location for marine mammal observation. The camera was first installed for six days at the Pointe-Noire Interpretation and Observation Centre (Figure 3A) and then for two days aboard the *Alliance*, a Parks Canada boat (Figure 3B).

The choice of the marine park proved very judicious because it made it possible to observe more than 200 individuals, mainly belugas but also some minke whales, humpback whales, and finback whales. Although most of the observations were made during the day, some images taken at night clearly demonstrated the advantage of the camera over the human eye in the absence of natural light. A second observation phase was organized at the Rivière-du-Loup wharf in early June 2019. The choice of the time of year and the location are not arbitrary: it is a period where the beluga whales are very active in the region (Figure 4A). The team confirmed multiple intensive feeding sessions by dozens of individuals, both day and night. This field campaign allowed the team to not only assert even more firmly the effectiveness of the tool at night, but also to build a considerable bank of video sequences showing belugas in thermal imaging from distances between 20 and 2,000 metres. The team even caught on camera several rare and spectacular behaviours like the spy hopping, when a beluga whale shifts to a vertical position and sticks its head out of the water (Figure 4B).

The device, nevertheless, has its limits. For example, thermal imaging becomes very blurry during times of rain, drizzle, or fog because these meteorological phenomena

CHLOÉ MARTINEAU

block or reorient the infrared rays emitted by the different surfaces filmed by the camera. In addition, marine mammals, all having a thick outer layer of fat, sometimes find themselves with a surface temperature close to the one of water, therefore limiting the contrast seen by the camera as the animal breaches out to breathe. That happens mostly when the surface water is warm after a long sunny day or when the animal returns from several minutes underwater, where it is colder. However, the team noticed during its tests that the cetacean's spout was often very visible because of its higher temperature (Figure 4C). This is a considerable advantage for observations at greater distances and in rough waters where marine mammals' bodies may not be visible. The camera's narrow field of view compared to that of a human eye represents another limitation of the system. In order to test the impact of this factor on the efficiency of marine mammal detection, the team conducted a daytime comparative analysis during its most recent trip to Rivière-du-Loup in the presence of a group of about 20 feeding belugas distributed between 1,000 and 2,000 m. The experiment was designed to count the observations made on the screen of the video recorder and those made by a visual observer located outside. It concluded that although the visual observer saw many more belugas than the camera in a given time, it is estimated that the vast majority of the individuals in the group were captured by the camera after a few sweepbacks. Therefore, the team believes that a thermal imaging camera functioning in a sweep installed during offshore work and operating at night may be slower, but eventually detects all marine mammals approaching the exclusion zone.

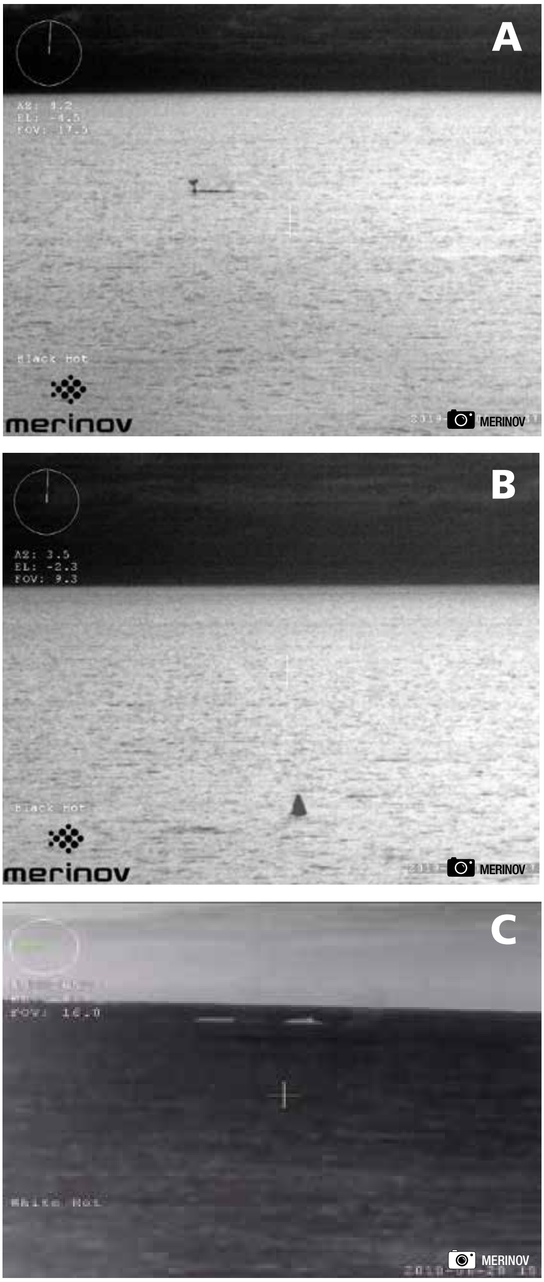

Figure 4: (A) Beluga whales are very active in the Rivière-du-Loup wharf area. (B) The camera captured several rare and spectacular behaviours including spy hopping – when beluga whales shift to a vertical position and stick their heads out of the water. (C) A cetacean's spout is captured by the thermal camera.

Perspectives

Even with the positive results obtained during the most recent outings, Merinov does not intend to stop there in the development of the thermal camera system. Although more effective than the human eye at night, watching a screen for several hours searching for a thermal trace at the surface of the water can be a demanding task for a marine mammal observer. Therefore, Merinov intends to tackle the automation of the system by analyzing the video feed using an algorithm. The latter views and processes thermal imaging in real-time in the search of an anomaly at the surface of the water. When it detects one, a warning is issued, and an observer can quickly verify the veracity of the report. The development and integration of such an algorithm would not only greatly limit eye strain, but could also potentially improve system performance significantly due to the increased analysis capabilities of computers over humans.

In conclusion, the use of a thermal camera in the context of site monitoring is only the tip of the iceberg. Indeed, once the detection technology is well developed, it is transferable in a variety of other sectors of activity. One can think of the surveillance of major sea lanes by installing cameras on buoys or even directly on ships. The development of a drone equipped with such a system would open even more doors while providing a higher point of observation. Finally, the costly monitoring of the right whale each summer in fishing zones could be supported using thermal cameras.

Colin Gauthier-Barrette is a Research Professional at Merinov in Gaspe. He has a degree in mechanical engineering and has been working in the marine environment ever since his graduation. His involvement at Merinov touches lobster fishing and holding, algae harvesting, and technology development to protect endangered marine species such as the beluga whale and right whale.

Jérôme Laurent is an Industrial Researcher at Merinov. He has a M.Sc degree in marine resource management. For more than 10 years, he managed applied research projects in fishing gear optimization and fishing practices. Since the recent events of North Atlantic right whale mortality, he develops projects aimed at improving the cohabitation between marine mammals and human activities.

Maude Sirois is a Research Professional at Merinov in Gaspe. She has a M.Sc. degree in oceanography. She is working on multiple projects at Merinov on marine biotechnology, residual materials management, and technology for marine mammals monitoring.

Chloé Martineau is a master student at Université de Sherbrooke in geomatics and works on species distribution modelling of Peary caribou. She has a bachelor's degree in biology that led her to work on many projects using different scientific equipment such as thermal cameras.