Automated Detection of Gray Whales Using Infrared Video

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1 Introduction

This memo discusses the characteristics of a shore-based infrared system for detecting whales and the possible transition of this technology to a ship-based system. In Section 2 we describe the shore-based system as it has been used at Granite Canyon and more recently in the Santa Barbara Channel. In Section 3 we discuss possible deployment of this system to a ship.

2 Shore-based Whale Detection System Developed for NOAA

Toyon has developed a shore-based system for detecting and counting gray whales that pass by the NOAA Granite Canyon facility. A screenshot from the computer display at this shore-based facility is shown in the below figure. The three upper windows show the live video feeds from three infrared cameras. These windows also show overlays of automatically detected whale blows as seen by the detection that is present in the window on the right (red box indicates location of automatically-detected blow). A map display is also shown which indicates the estimated state of the whales in terms of their position, velocity, and respiration. We use measurements of detected whale blows and *a priori* respiration statistics and contextual knowledge to infer the number of whales that are present as well as their states. The probability density function (pdf) of the whale position can be seen by the cluster of green and black dots that are shown in the map display in the lower part of the figure. The color of the dots indicates a hypothesized respiration state of the whale. The three black wedges indicate the location of the fields of view of the three cameras.

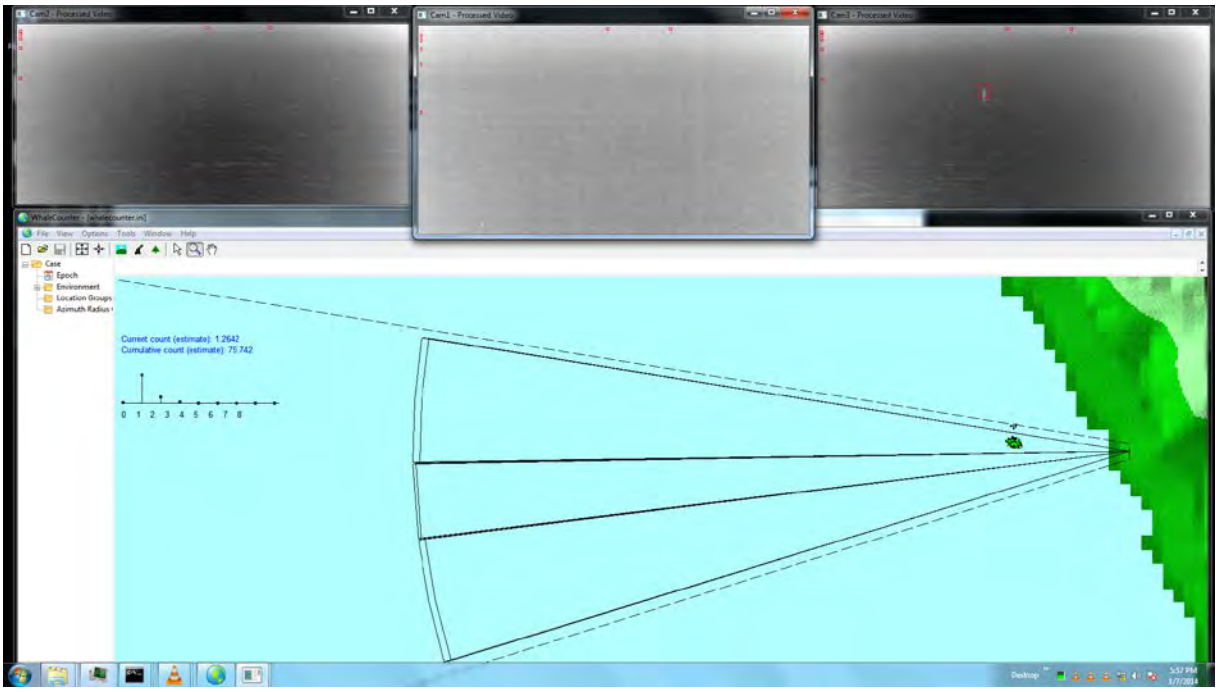

Figure 1: Snapshot from Granite Canyon Shore-based Whale Detection System Display

In January 2014, NOAA performed a test of our system to verify its performance. The test included a team of marine mammal observers who maintained watch with the naked eye and binoculars from 7:30am to 4:30pm each day. The number of gray whales spotted by the team of observers was recorded and is shown in the plot on the left side of the below figure. Simultaneously operating with the team of observers, the automated infrared system was also running. The detections reported by the automated system were filtered using the Toyon-developed WAVE tool and the resulting detections were sent through the WADE counting software to create the plot on the right side of the below figure. Note that although there is some variation over short periods of time, the total number of whales that were reported matches quite well. Some variation in the count is to be expected because the humans were looking towards the north and observing blows that were different than the blows that were observed by the machines which were looking towards the west.

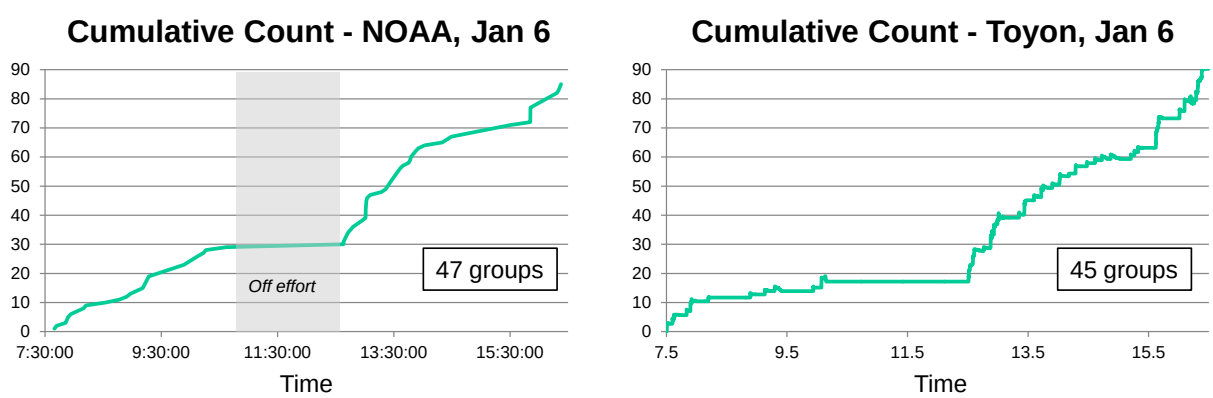

Figure 2: Comparison of Whale Counts by Human Marine Mammal Team (left) and Semi-automated System (right)

The results in Figure 2 show that the semi-automated system compares well with a team of human marine mammal observers during the daytime. At night, the humans cannot, of course, detect anything, but the infrared system works better than during the daytime.

In addition to testing at Granite Canyon, Toyon has recently performed a test in the Santa Barbara Channel. For this test, we had to first create a portable system that uses three ten degree field of view LWIR cameras mounted on a stable tripod. We collected video using this portable system at both Coal Oil Point and further west near Arroyo Hondo. A team of MMOs was operating simultaneously with the infrared system. Video from UAVs and imagery from satellites was also collected infrequently. We are currently processing the data from this collection, but we expect to get similar performance as was shown at granite Canyon and presented in Figure 2.

3 Automated Ship-based IR Whale Detection

We are interested in creating a ship-based system that can automatically detect and track gray whales. Such a system could be used for ship-based mitigation of acoustical disturbance to marine mammals or for ship-strike prevention. The key issue to address when transferring to a ship is compensation for the motion of the camera. We expect that mechanical stabilization of the camera will be required. Mechanically-stabilized gimbals are commercially available for this purpose and cost in the neighborhood of $10-50,000. These gimbals have the ability to hold more than one camera and different camera types can be connected allowing for a modular deployment capability. We expect that for ship-strike a single gimbal could support enough cameras to provide effective coverage. For the broader coverage required for acoustic disturbance mitigation, we expect that four gimbals would be required for 360 degree coverage. We expect that when using the ship-based system with mechanical stabilization, performance will be roughly equivalent to the shore-based system after some minor modifications to the algorithms and software.

We expect that a system for preventing ship strike would have a different display than what is used by the shore-based system. We envision that the user display for ship strike prevention would show a map relative to the bow of the ship indicating the location of whales. Integration with the ship's chart plotter should ultimately be possible allowing for clear situational awareness for the ship operator. A short, few-second video clip showing the object believed to be a whale by the computer would be shown to the operator on a separate display for verification that a whale or some other object of potential interest is present.