Semi-automated Detection, Tracking, and Counting of Gray Whales (*Eschrichtius robustus*) off the California Coast

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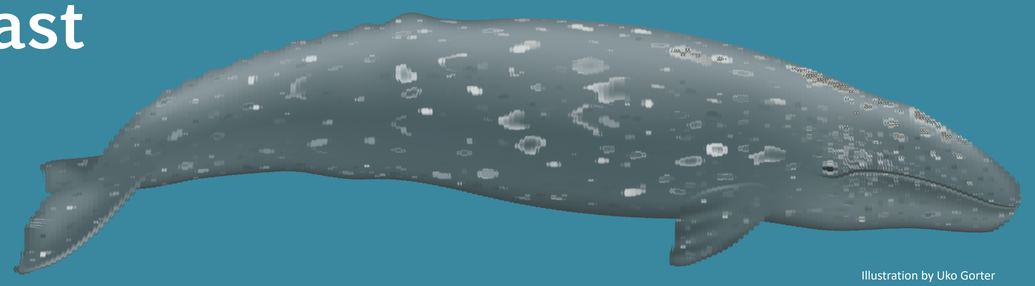


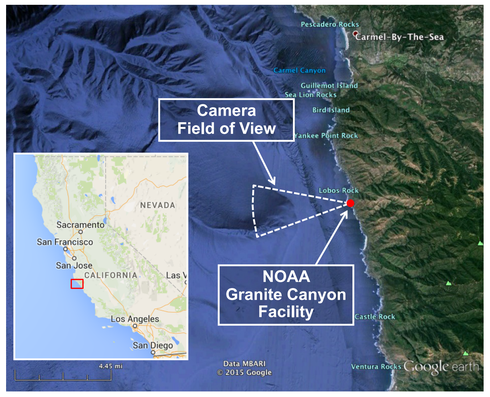
Illustration by Uko Gorter

Abstract

Gray whales in the eastern North Pacific migrate annually from high latitude feeding grounds to low latitude wintering areas. The coastal migratory route of these whales has allowed NOAA scientists to successfully estimate the abundance of the population since the late 1960s. During these surveys, land-based observers detect and record all whales passing by a research station located at Granite Canyon, California. Visual observations occur during daylight hours and under acceptable environmental conditions. In an effort to improve upon the time-tested visual count method and increase overall sample size, we have developed custom software that uses infrared (IR) cameras for automated detection of gray whales 24-hours a day and uses these detections to estimate the number of whales passing the research site. A description of our system and the results of a comparison of performance between the IR cameras and human observers are presented here. This IR camera system has successfully collected data during the 2013/2014 and 2014/2015 gray whale migrations and will be used again during the 2015/2016 migration.

Methods

Gray whale blows are automatically detected using video from three IR cameras stationed on shore at a NOAA research station at Granite Canyon, CA. The three cameras cover a combined 26-degree field of view (Figs. 1, 2). The automated system detects whale blows which can persist as briefly as 0.3s, but also detects occasional false alarms (e.g., white caps, dolphins) that are removed post-hoc using the Whale Analytics Verification Engine (WAVE) forensic tool. During post-processing of the data, this tool displays short video segments of putative blows to a human analyst who accepts or rejects the occurrence of a blow. This process allows an analyst to review hours (or days) of video footage quickly (e.g., 24 hours of video from three cameras reviewed in ten minutes). Using the sub-sample of confirmed detections along with a number of other behavioral priors including swim speed and respiration patterns, our automated tracking software then infers the number of whales present.



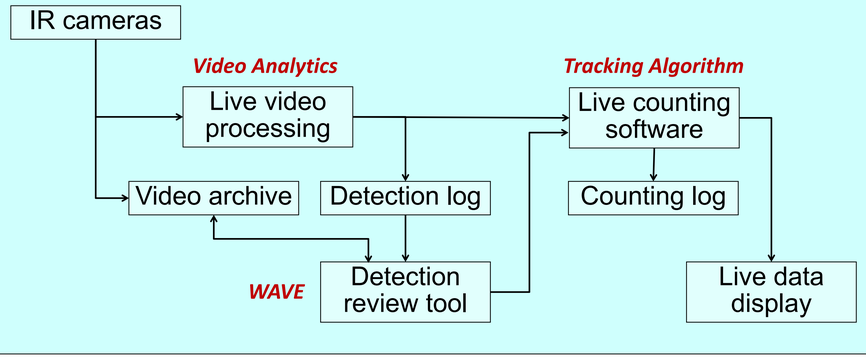


Fig. 1. Thermal infrared video data is processed by automated analysis software, generating whale blow detections that are logged, reviewed, and tracked to provide researchers with real-time information and a count of the number of whales migrating.

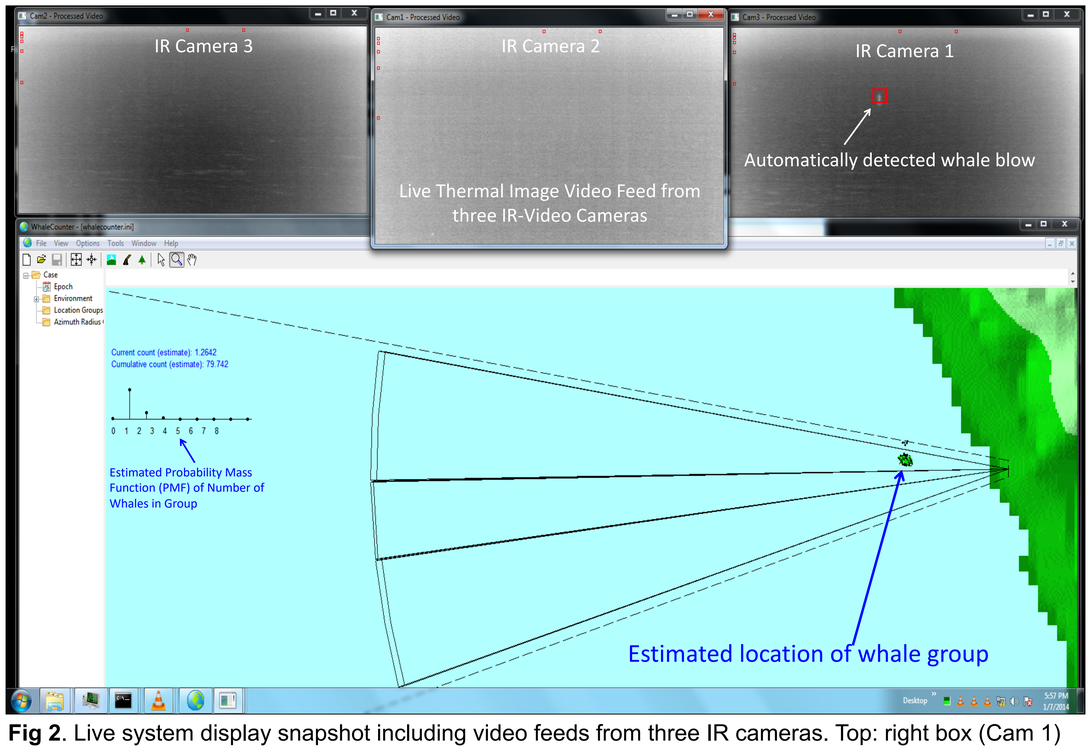


Fig 2. Live system display snapshot including video feeds from three IR cameras. Top: right box (Cam 1) shows an auto-detected whale blow indicated by a red circle. Bottom: approximate fields of view of the three IR cameras are outlined. The whale actively being tracked is represented by green and black pixels. The dynamic pixel display gives information on the whale's approximate location, velocity, and respiratory state.

Results

Whale detections gathered by the IR cameras were compared to results from a team of human observers scanning independently but concurrently in an overlapping search area. Close agreement between the two methods was apparent (Fig. 3). Time lags in the counts can be explained by the 26° field of view for the IR cameras as compared to the human observers that scanned a 50° field of view. Additionally, human observers scanned for approaching whales from the north as the whales migrated south, while the fixed-mount infrared cameras pointed directly toward the west.

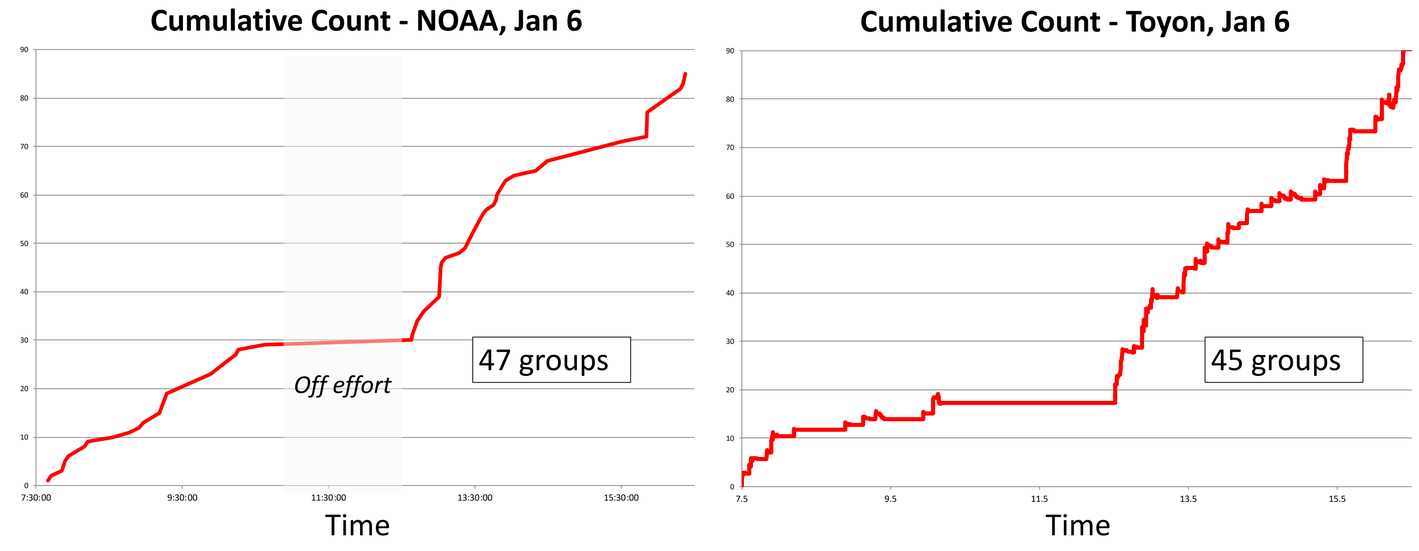


Fig. 3. Result of whale counts from human observers (left) and the IR camera system (right) during an eight-hour daytime period. The off effort period was due to unacceptable sighting conditions.

Implications

Auto-detection algorithms can be a cost-effective, reliable, and an efficient way to successfully detect, track, locate, and count whales day or night using video from infrared cameras. This technology has applications far beyond large whale census studies. It can be readily applied to detect a variety of marine mammal species and can be adapted for use aboard ships to assist in research as well as real-time mitigation of risk related to ship-strikes and other activities such as seismic surveys and military sonar testing.

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