

# Real-time detection of Cook Inlet beluga whales for military mitigation



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## BACKGROUND

Due to the endangered status of Cook Inlet belugas (*Delphinapterus leucas*), there is a requirement to monitor their presence in the coastal portion of the Joint Base Elmendorf Richardson (U.S. Army and U.S. Air Force) in Knik Arm, upper Cook Inlet, Alaska. In particular, due to proposed live firing into the Eagle River flats impact area (Fig. 1), both the Eagle River and adjacent Eagle Bay are areas of conservation concern for the military.

## OBJECTIVE

Test the performance of PAMBuoy™ real-time detection and wireless communication of beluga presence for mitigation purposes in the section of Eagle River crossing a U.S. Army live firing impact area and in the adjacent Eagle Bay area, in Cook Inlet, Alaska.

## METHODS

A PAMBuoy® system was deployed for 19 days in August 2012 at the mouth of the Eagle River, Alaska, close to the point at which the river flows out into Eagle Bay. The system was configured to detect, in real-time, both the echolocation clicks and the whistles of belugas known to be regular visitors to both the Bay and the River in summer.

**Data collection:** wired hydrophone to land base with WI-FI and 3G antenna for beluga detection transmission off site (Fig. 2).

**Beluga classification criteria:** 1,2,3

**Click detector:** process raw data (500kHz sample rate).

Target band: 30-120 kHz. Reference band: 10-25 kHz.

Peak & mean frequency within 25-80 kHz

**Event detector:** counts the number of clicks that had passed the beluga classification criteria (above) in a set time interval.

**Whistle detection:** raw data decimated to 50kHz searching for tonal vocalizations in 1-20kHz.

See Pambuoy™ poster for detection algorithm details.

**Data transmission:** 2.4GHz/900MHz wireless IP data link and near real-time (15 minute delay) 3G phone network to web server.

Real-time detections compared to:

- 1) **visual observations** (group size, distance, azimuth).
- 2) **human post-processing** (visual and aural inspection of spectrogram).

## RESULTS

A total of 273 hours of useful acoustic data and 91 hours of visual observations were collected. Acoustic detections occurred every deployment day and a total of 592 visual observations were recorded up to 1035 meters (Fig 3). A negligible false alarm rate and high efficiency could be achieved by applying an event detector, requiring multiple click detections within a short time window (e.g.; 20 clicks in 10s; Fig. 4). A count time of 5 or 10s with click counts of between 7 and 20 clicks could detect most beluga events picked out by a human with a low false detection rate and miss very few sightings. The precision and recall for automatic vs. human detections is shown in Figure 5. As the count time increases, or the required number of clicks is reduced, recall (detection efficiency) increases, but at the expense of a loss of precision (false alarm rate).



Figure 1: The U.S. Army conducts live fire exercises with indirect weapons systems (mortars and artillery) into a tidal estuary, the Eagle River Flats Impact Area, located on the Air Force-managed Joint Base Elmendorf-Richardson in Cook Inlet, Alaska. This image shows Eagle River flats and the last section of the river, an area commonly visited by the endangered Cook Inlet belugas.

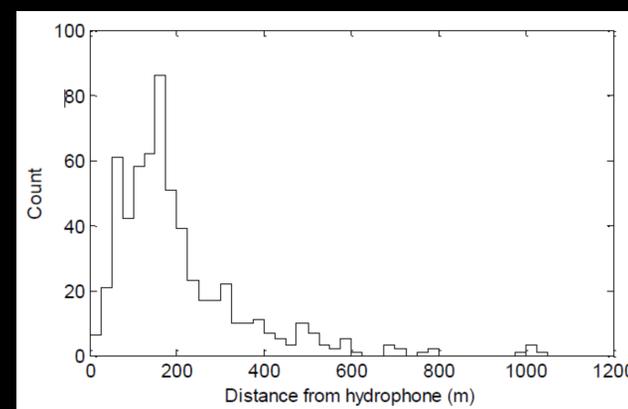


Figure 3: Distribution of all visual sighting ranges.



Figure 2: (left) Land base with transmitting station and visual observers and (right) hydrophone platform being installed at low tide in river mouth.

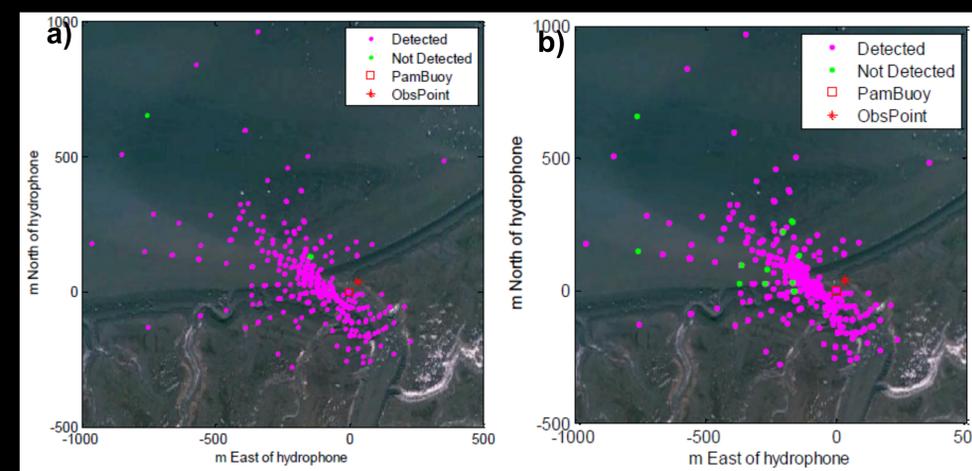


Figure 4: A comparison between visual sightings and automatic acoustic detections with the event detector requiring a) 20 clicks in 10s and b) 30 clicks in 10s.

## DISCUSSION

This pilot study demonstrated the feasibility of acoustic real-time monitoring in Eagle Bay and Eagle River (Cook Inlet, Alaska) during ice-free season. Beluga vocalizations, mostly echolocation, were clearly detected for much of the time and corresponded well to beluga presence in the river and up to at least 1 km from the river mouth into Eagle Bay. The system was effective at detecting both clicks and whistles during the trial period, successfully detecting all (100%) sightings from within the river and 430 out of all 432 (99.5%) recorded sightings at ranges varying from 10 to 1035m from both within and from outside the river. Best performance was achieved when the event detector was set up to allow at least 15 minutes between detections for a count time of 10s; with these settings, recall and precision reached over 98%. Missed detections corresponded to faint echolocation clicks from far away belugas or events with very few clicks, that had a peak frequency over 100kHz, causing them to fail to meet the beluga classification criteria. Raising the upper limit criterion to 120kHz allowed false triggers caused by a vessel's echo-sounder. Of eleven false detections examined in detail, two were click trains which seemed biological in nature and quite possibly did originate from beluga. Five were due to electrical noise and four appeared to be caused by a passing vessel. Echolocation clicks from a harbor porpoise (*Phocoena phocoena*), a species rarely observed in this location, were detected and correctly classified in one instance. These results indicate that PAMBuoy™ system efficiency is more than adequate for the primary purpose of detecting beluga presence in areas of conservation concern for the Joint Base Elmendorf Richardson in Cook Inlet.



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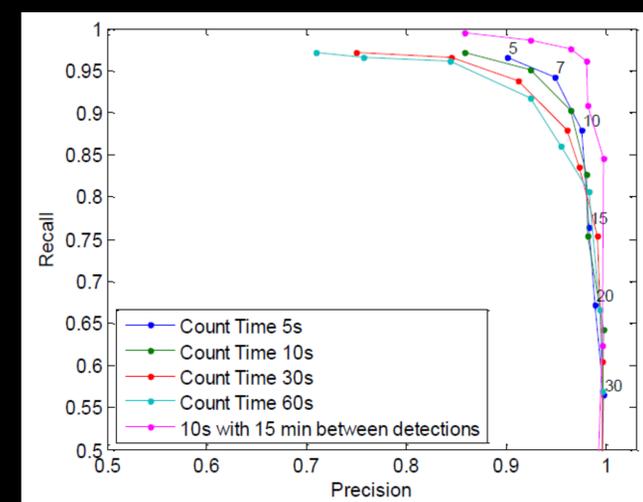


Figure 5: Precision (false alarm rate) and recall (detection efficiency) for real-time automatic acoustic detections compared with human post-processing detections. An automatic detection occurred if a minimum number of clicks was detected within some set time period (event detector settings). The numbers 5 through 30 are the numbers of clicks within a time interval (only shown for the 5s count time). Also in pink are results when at least 15 minute interval is allowed between detections.

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