ATTEMPTS TO DETECT WHALES IN EAST ANTARCTICAUSING AERIAL PHOTOGRAPHS: A PILOT STUDY

Kelly, N.[1,2,#] and Peel, D.[1,2]
1 CSIRO Mathematical, Informatics and Statistics and Wealth from Oceans National Research Flagship, Castray Esplanade, Hobart, Tasmania, 7000, Australia
[2] Australian Marine Mammal Centre, Australian Antarctic Division, Channel Highway, Kingston, Tasmania, 7050, Australia
[#] Contact email: Natalie.Kelly@csiro.au

Abstract

A camera system was previously developed to augment an aerial survey programme which targeted Antarctic minke whales in East Antarctica. The purpose of this camera system was to record the presence of whales beneath the aircraft and to provide information regarding local sea ice conditions. Although this aerial survey programme has finished, we arranged for flights to take photographs of potential whale habitat within Vincennes Bay (East Antarctica 66º 24'S 110º 18'E) when aircraft time allowed during the normal summer aviation schedule of the Australian Antarctic Division. Digital photographs of potential whale habitat were derived from two flights on 2 and 23 January, 2011, covering around 47 and 42 km^2 of sea surface, respectively. Unfortunately photographs from both flights did not yield any whale sightings. This result is compared and contrasted to whale sightings in photographs taken during a single day of an aerial survey during the 2008/09 summer season. It is hoped more flights in coming summer seasons, using Australian Antarctic Division aircraft, can be dedicated to photographing whale habitat in order to both develop 'observerless' aerial survey methods and to study whale populations in pack ice in East Antarctica.

Introduction

An aerial survey project targeting Antarctic minke whales has been conducted over and around Vincennes Bay (66º 24'S 110º 18'E), adjacent to the Australian Casey station, for three summers (2007/8 (Kelly *et al.* 2008), 2008/9 (Kelly *et al.* 2009) and 2009/10 (Kelly *et al.* 2010) summer seasons). Please see previously cited papers for further details on our aerial survey programme.

For these surveys, a video and digital camera system was developed and housed within CASA-212 aircraft with the aim of recording the presence of whales in the area under the aircraft inaccessible to the human observers and to record pack-ice information along track. The digital-still camera component consisted of three Nikon D-200 cameras, one in the bottom of the fuselage and two mounted obliquely at windows on either side of the aircraft to provide wide coverage under the aircraft and replicating the observers' field-of-view (30º to 60º from the horizon). The cameras took images approximately every second which, at survey speed and altitude, gave complete coverage along track. This system was successful in recording the presence of a number of whale species during flights in the 2008/9 and 2009/10 surveys, although this data is yet to be formally analysed as a 'third platform' for subsequent use in abundance estimation.

Although our aerial survey programme was successful in being able to locate and count whales in pack ice in East Antarctica (focussing on Antarctic minke whales), the operation was expensive and is unlikely to run again in the foreseeable future. However, as the camera system remains intact and there are increasing advances in the field of unmanned aerial vehicles (UAVs), we sort to extend the aerial survey programme without human observers and to test the performance of the camera system as a platform to detect whales in pack ice. During the 2010/2011 summer season, there was an opportunity to run part of this camera system during times when the schedules of the Australian Antarctic Division aviation programme were free (i.e., in between inter-station personnel and cargo movements, other science projects, medical evacuations, etc). This brief note describes the protocols for these flights and the results and compares these to photographic results from a previous aerial survey.

Methods

Survey location and protocols

To increase the chance of being allotted 'opportunistic' flying time, we selected areas in the east of Vincennes Bay, close to Casey station (with short transit times, the task could more easily blend into existing flight schedule). Fortunately, this area also corresponded to relatively high whale sighting rates during the 2008/09 and 2009/10 aerial surveys and to the location of a large number of minke whales during the 2007/08 summer season (Kelly *et al.* 2009; Kelly *et al.* 2010). A reasonably annual fast ice feature in the east of Vincennes Bay occurs above a bathymetric feature known as Petersen Bank (65º 45'S 109º 55'E), which is likely provide an edge against which zooplankton is concentrated. The coastline south of Petersen Bank also hosts many Adelie penguin colonies. There are deep holes in the bathymetry of Vincennes Bay, going down below 2000 m in depth, which are likely important habitat for fish species such as Antarctic toothfish and Antarctic silverfish. If this is the case, it is these fish that are the focus of large groups of type-C killer whales during summer (Kelly *et al.* 2009b).

Transects were manually selected to run along the southern edge of Petersen Bank and out perpendicular from the coastline. Due to the opportunistic nature of any potential flights and the actual date of flying being unknown, the location of transects was set the day before or on the day of flying, using AMSR-E sea ice data (http://www.iup.unibremen.de:8084/amsr/amsre.html). Like the previous aerial survey flights, survey altitude was 750 ft and velocity 110 knts. Flights for this project were only to go ahead during bright day-light hours and with calm-low wind conditions.

Camera system

A single Nikon D200 camera was housed in the base of the CASA-212 aircraft, behind a Perspex window that was flush with the fuselage. The camera was oriented directly down. The shutter-release for the camera was operated externally using a 'Mumford Time Machine' unit, which allows shutter-release to be timed. Depending on aircraft altitude and camera lens, shutter-release can be timed to achieve continuous coverage along-track beneath the aircraft. A large-size file format was selected for images, focus set to infinity, and image settings given to account for high-light, high-contrast environments. As a 50mm lens was used, uninterrupted coverage along the trackline was achieved, according to the velocity and altitude given above, with a shutter-release of around 1 photograph per second. This gave swath width of around 107 m.

In addition to GPS/altitude data being imbedded in each image, flight data, including geographical position, velocity and altitude was also available.

Image checking

After the image files were returned to Australia on the completion of the Antarctic operational season, the set was split into two and were checked for whales by two observers (the authors), i.e., each image was checked only once. It took, on average, around 2 hours to examine 3 000 images. It is also possible to derive an estimate of local (i.e., area covered by the photograph) sea ice concentration and chunk-size composition, but this has not been done. The presence of other animal species was also recorded, but not identified to the species level.

Results

The 2010/11 operations schedule at Casey station allowed for two flights to take pictures of whale habitat: the first on 2 January and the other 23 January, 2011. Both days were deemed to have low wind conditions, although windy conditions were experienced during the second flight when a transect approached the Vanderford Glacier. For the 2 January flight, 436.6 km of photographic effort was achieved, yielding around 6 300 photographs. The flight on 23 January achieved 391.2 km of photographic effort, with around 5 600 photographs. With a swathe width of 107 m, this corresponds to an area covered by the photographs of around 46.7 km^2 and 41.9 km^2 for the two flights, respectively. Tracks for both flights are given in Figures 1 and 2.

No whales were located in any photograph from either flight. However, a minke whale was seen and photographed from a small vessel near Casey station at the same time the 2 January flight was underway (see Figures 1 (yellow star) and 4); killer whales were also photographed from the cockpit by the pilots upon approach to the Casey skiway after the final transect was completed (Figure 5). The photographs yielded many sightings of penguins (both hauled out and in the water) and seals (see Figures 1 and 2).

Discussion

It was disappointing that no whales were observed in nearly 12 000 photographs taken in Vincennes Bay in January 2011, despite incidental sightings of both minke and killer whales nearby (on 2 January). In addition, we counted many penguins and seals in the vicinity (see Figure 6 and 7), indicating overall productivity levels in Vincennes Bay may be at least similar to those in previous summers. However, looking to the numbers of whales observed in photographs taken on one day during our 2008/09 aerial survey may provide some perspective.

On 30 December, 2008 around 1 422 km of survey effort was flown in Vincennes Bay, resulting in sightings of 23 minke whales (in 20 sightings) and 110 killer whales (in 23 sightings) (see Figure 3) (Kelly *et al.* 2009). This survey had an effective strip width of around 420 m (averaging over sighting covariates; see Kelly et al. 2011; SC/63/IA3 for further details of the calculation of effective strip width), so the observers covered an effective area of around 1194.5 km^2 (observers were located on both sides of the aircraft). In a very simple sense, this would yield a point-estimate of density of around 0.035 whale sightings per km^2 for the area covered by those transects. Also during that flight, 25 330 images were taken by a Nikon D200 in the same configuration as the January 2011 flights, but flying at a height of 700 ft. These photographs were taken with a 35 mm lens, and so would have had a swathe width of 143 m; around 203.3 km^2 would have been covered by these photographs. However, from these photographs, detections of only four minke whales (in two groups) (see Figure 8 and 9), one killer whale and 3 Southern bottlenose whales were made. Again, in a very simple sense, this would yield a point-estimate of density of around 0.019 whale sightings per km^2 for the area covered by those transects for photographs. Making the assumption that overall whale densities are similar from year-to-year (this assumption is likely to be quite wrong, but it will suffice for this line of logic), then the numbers of sightings of whales we could have expected on 2 and 23 January 2011 flights would be 0.89 and 0.79 sightings, respectively. So, it is not unreasonable, given the relatively small area that was covered by the photographs taken during the two flights in January 2010 that no whales were observed due to chance, despite whales being observed nearby and despite the transects being manually located over areas of Vincennes Bay that have previously supported higher densities of whales.

There may be other reasons we did not identify whales in these photographs. Unfortunately, the camera settings used this season were often unsuccessful in dealing with the high-light contrast in areas of $\geq$ 40% sea ice concentration. This caused the water to appear very dark, which may have prevented whales to be seen if they were not directly at the surface. A colour altering algorithm was used in this study to try to lighten the photographs, but this was not satisfactory. Furthermore, whale movement and blow

formation is important to drawing the attention of observers when either *in situ* or watching video footage and this is not a benefit available in photographs.

We are hopeful of being able to repeat this study in future summers in East Antarctica, subject to the constraints in the operations schedule of the CASA-212 aircraft. This present study is useful for being able to estimate minimum effort required to detect whale groups in pack ice (i.e., that anything less than a certain commitment would not warrant the effort). Furthermore, a 35 mm lens will be used in order to expand the width of the swath. We also hope to use two extra cameras which would be angled obliquely from the rear windows of the CASA-212 aircraft; these two oblique-looking cameras were used successfully during the 2009/10 survey. However, unfortunately, this last strategy may not gain approval as these cameras need to be manually installed after take-off and removed before landing; tasks the pilots certainly do not have time to do. Regardless, given the cost and logistic difficulty of traditional aerial surveys over pack ice around Antarctica, we believe there is a strong case for developing alternative photographic methods in order to detect, count and monitor whale populations.

Acknowledgements

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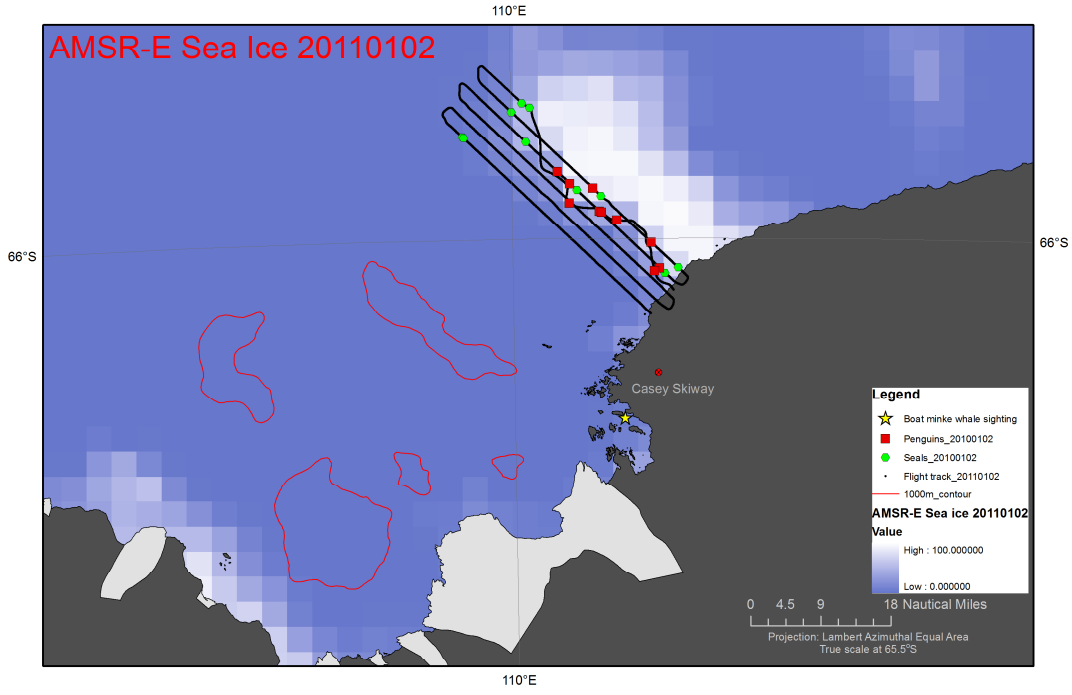

Figure 1 Transects flown on 2 January 2011 in order to take digital photographs of potential whale habitat in Vincennes Bay. Presence of penguins and seals in photographs is also mapped. Sea ice concentrations are shown using AMSR-E satellite data: blue is open water through to white as solid ice. Petersen Bank is the linear ice feature running north-west from the coast. Location of Antarctic minke whale sighting from small vessel also given as yellow star.

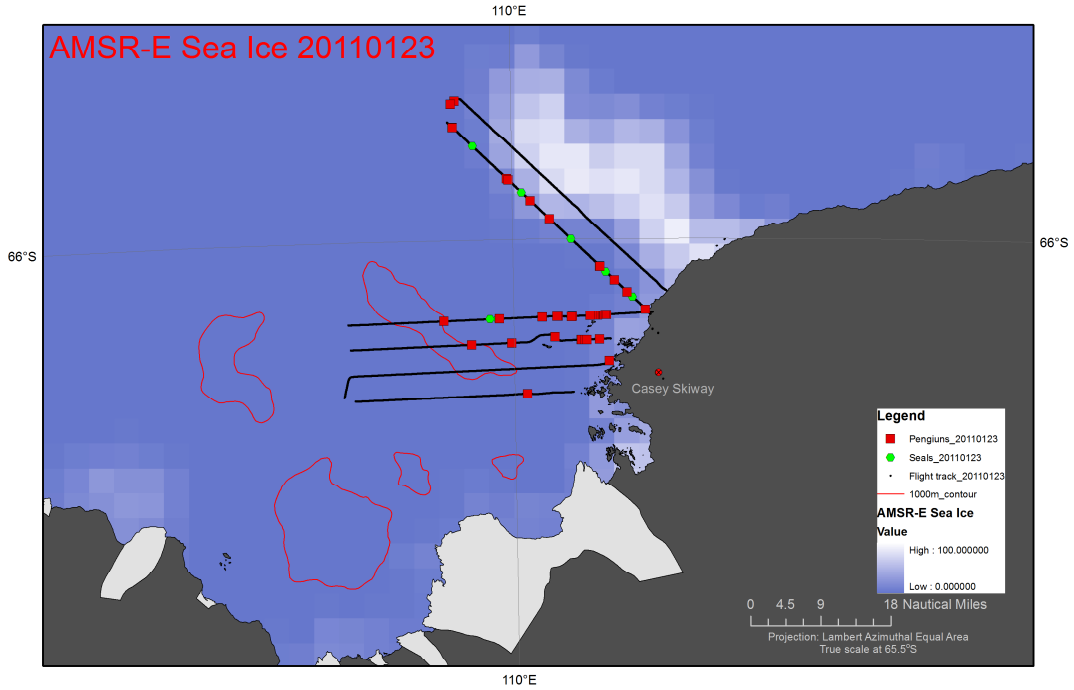

Figure 2 Transects flown on 23 January 2011 in order to take digital photographs of potential whale habitat in Vincennes Bay. Presence of penguins and seals in photographs is also mapped. Sea ice concentrations are shown using AMSR-E satellite data: blue is open water through to white as solid ice. Petersen Bank is the linear ice feature running north-west from the coast.

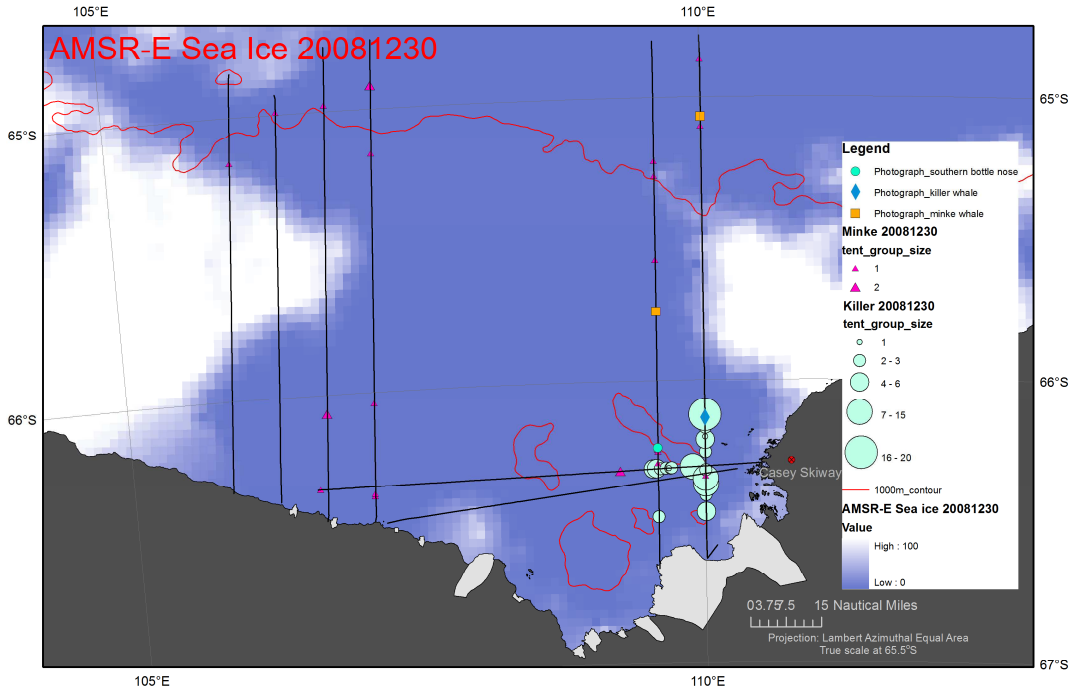

Figure 3 Flight tracks, observer sightings and locations of photographs of various species of whales in Vincennes Bay on 30 December 2008 (i.e., during 2008/09 aerial survey). Sea ice concentrations are shown using AMSR-E satellite data: blue is open water through to white as solid ice.

Figure 4 Antarctic minke whale spotted during iceberg tour around 2.30pm on 2 January 2011, in Penney Bay (Photograph: M. Goldstein). Location of this sighting is given in Figure 2.

Figure 5 Killer whales near Casey station, photographed on 2 January 2011 by pilots from a cockpit window just after planned transects had been completed (Photograph: J. Lee-Steere.)

Figure 6 Group of seals detected by camera system (cropped and zoomed image) on 23 January 2011.

Figure 7 Group of penguins detected by camera system (cropped and zoomed image) on 23 January 2011.

Figure 8 Single Antarctic minke whale detected by camera system during the 2008/09 season (cropped and zoomed image). Photograph taken 30 December 2008.

Figure 9 Group of Antarctic minke whales detected by camera system during the 2008/09 season (cropped and zoomed image). Photograph taken 30 December 2008.