Comparing Estimates of Arctic Cetacean Density Derived from Manned and Unmanned Aerial Surveys

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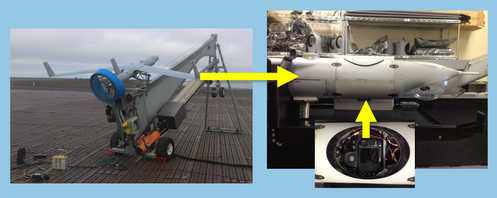
Abstract

Manned aerial surveys have been used successfully for decades to collect data to infer cetacean distribution and density. Unmanned aerial systems (UAS) have potential to augment or replace some manned aerial surveys for cetaceans in the future. To ascertain the utility of UAS for such missions, however, it is first necessary to define the specific scientific objective(s) and then compare the cost-benefit of alternative platforms and methodologies. NOAA led and conducted such a direct comparison of aerial surveys for cetaceans near Barrow, Alaska, during late summer 2015 via a collaborative effort that included the Bureau of Ocean Energy Management, US Navy, North Slope Borough Department of Wildlife Management, and Shell. We conducted a three-way comparison among visual observations made by human marine mammal observers aboard a Turbo Commander operated by Clearwater Air, Inc; imagery autonomously collected by a Nikon D810 camera system mounted on the belly of the Turbo Commander; and imagery collected by a similar camera system on a remotely-controlled ScanEagle operated by the Naval Surface Warfare Center Dahlgren Division. The platforms each conducted five flights within a 16,800 km^2 study area. Surveys from manned and unmanned platforms did not directly overlap geographically and temporally to maintain safety of flight; the two platforms operated as close as safely possible. The Turbo Commander collected 44,849 images in 26.7 flight hours, during which marine mammal observers simultaneously collected sighting data. The ScanEagle collected 24,600 images in 21.8 flight hours. Manual image processing and analysis by marine mammal photo analysts required 332.5 total hours, averaging 6.9 hours to analyze one flight hour, which involved reviewing every third image. In total, 8 bowhead whales (*Balaena mysticetus*) and 16 belugas (*Delphinapterus leucas*) were identified in the images from the Turbo Commander. Fifteen bowhead whales, six belugas, and three gray whales (*Eschrichtius robustus*) were identified in the UAS images. Sixty-one bowhead whales, 54 belugas, 9 gray whales, and 48 unidentified cetaceans were sighted by the marine mammal observers aboard the Turbo Commander. Resulting density estimates and associated coefficients of variation, logistical requirements, and costs of the three survey methods are discussed.

Objective: 3-way Comparison

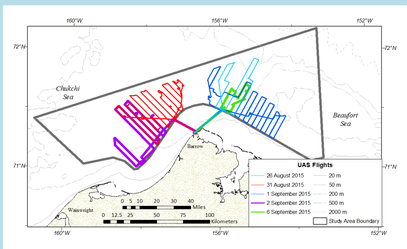
Marine mammal observers in the manned aircraft

Digital photographs from cameras mounted in the belly of the manned aircraft

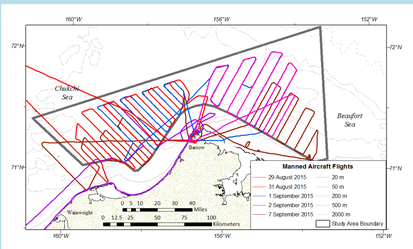


Digital photographs from cameras mounted to the unmanned aerial vehicle (UAV)

Key Operational Results



UAS survey flights conducted between 26 August and 6 September 2015



Manned aircraft flights conducted between 29 August and 7 September 2015

- UAV and manned aircraft observations of whales were limited by the same weather conditions
- Unlike the UAV, the manned aircraft could transit through precipitation to access areas with better weather
- UAV collected 24,600 images in 21.8 flight hrs
- Manned aircraft flew 26.7 hrs, collecting 44,849 images while marine mammal observers recorded visual line-transect data

- Manual processing and analysis of images from both aircraft required 332.5 hrs to review every third image (~6.9 hrs post-processing per flight hr)
- Image resolution was sufficient to differentiate bowhead whales, gray whales, belugas, and walruses. Higher resolution would be necessary to distinguish species with similar sighting characteristics.

Bowhead whale sighted in an image taken by the UAV camera

The recommendations and general content presented in this poster do not necessarily represent the views or official position of the Department of Commerce, the National Oceanic and Atmospheric Administration, or the National Marine Fisheries Service.

Analytical Results

Table 1. Number of whales detected, effective area covered, estimated total number of whales, and coefficient of variation (CV) of the estimated total number of whales in the west and east survey areas based on imagery data collected by the UAS and manned aircraft, and on marine mammal observer (MMO) data. ♣The numbers of sightings in this table represent the subset of the total number of sightings made within the boundaries of the west and east survey areas, in Beaufort Sea State ≤ 5 (bowhead and gray whales) or ≤ 4 (belugas), during level flight over the designated transect lines. The marine mammal observer sightings were limited to those made by primary observers.

	West Survey Area				East Survey Area			
	Images		MMOs		Images		MMOs	
	UAS	Manned Aircraft	Historical Dataset for ESW*	Limited Dataset for ESW*	UAS	Manned Aircraft	Historical Dataset for ESW*	Limited Dataset for ESW*
Bowhead Whales								
# Whales Detected♣	3	2	9	9	6	4	12	12
Area Covered (km^2)	525.4	646.0	5989.8	3729.7	448.5	645.9	5231.8	3257.7
Estimated Total # Whales	35	19	27	40	69	32	36	51
CV(Whales)	0.77	0.71	0.46	0.51	0.53	0.45	0.34	0.41
Belugas								
# Whales Detected♣	0	0	0	0	6	11	22	22
Area Covered (km^2)	525.4	646.0	2046.0	983.5	448.5	645.9	1661.4	798.6
Estimated Total # Whales	0	0	0	0	69	87	138	181
CV(Whales)					1.02	0.67	0.73	0.76
Gray Whales								
# Whales Detected♣	1	0	0	0	2	0	0	0
Area Covered (km^2)	525.4	646.0	■	■	448.5	645.9	■	■
Estimated Total # Whales	10	0	0	0	23	0	0	0
CV(Whales)	1.04				1.01			

*The effective strip half-width (ESW) is the distance on one side of the trackline that would contain the same number of sightings if detection probability were equal to 1.0 as were actually detected during the survey. The historical dataset included comparable data from 2009-2015. The limited dataset included only the five flights conducted between 29 August and 7 September 2015. ■Because the MMOs did not observe any gray whales, ESW and area covered could not be estimated.

- Human observers effectively searched a much larger area than was captured in the digital images from either aircraft. The effective strip half-width (ESW) derived from the historical dataset was estimated to be 1000 m for bowhead whales and 601 m for belugas. The ESW derived from the limited dataset was 655 m for bowhead whales and 422 m for belugas. The strip widths for the cameras in the UAS and manned aircraft at 305 m survey altitude were 547 m and 521 m, respectively.
- Variability in the estimated total number of whales, measured by CV, was almost always lower for estimates derived from the human observer data than from either imagery dataset
- The resulting CVs were higher than expected because of sample size. Weather limited the number of hours we expected to fly based on previous aerial surveys conducted in the study area.

Conclusions

- Conducting UAS and manned aircraft flights safely in close proximity (within ~ 15 nmi) and at the same altitude was challenging, even though technological and procedural methods for deconfliction were implemented.
- The UAS survey and associated data processing and analysis was approximately ten times more expensive than the comparable conventional manned aerial survey, data processing, and analyses. We expect that costs will decline as long range UAS surveys for cetaceans become established over time.
- Image processing was a significant challenge. Automated solutions are needed to reduce the time and cost of this task.
- The physical footprint, permitting, and personnel needs of the ScanEagle® UAS required substantial advance planning.
- Cetacean density and abundance can be estimated using imagery data. The resulting CVs will depend partially on sample size, which was considerably lower in our study for the imagery data due to the narrower strip width.
- The larger effective strip width for the marine mammal observers is particularly valuable for surveys in which the goal is to maximize the number of detections in the survey area.

Acknowledgments

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