TECHNICAL NOTE

"BLIMP-CAM": Aerial Video Observations of Marine Animals

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ABSTRACT

Conducting behavioral observations of obligate marine animals such as cetaceans and sirenians is challenging. These animals usually spend prolonged periods beneath the surface of the water out of view of a boat-based or land-based observer. Observations from high vantage points can overcome some of these difficulties by allowing the observer to look down through the water and view subsurface behaviors. I developed a "blimp-cam": a video camera mounted on a small ovoid-shape, helium-filled aerostat (blimp). This new style of blimp had a number of advantages over previous systems that have used the traditional zeppelin style, including being smaller, cheaper and easier to operate. The "blimp-cam" was flown at a height of 50 m, providing an overhead view of dugongs at water depths of up to 4 m and distances up to 200 m. I used the "blimp-cam" to obtain information on dugong behavior. I assess the advantages of this new style of aerial video observation system, its limitations and potential applications in the marine environment.

Introduction

The challenges inherent in studying obligate marine animals such as cetaceans and sirenians can make behavioral observations difficult. Animals under observation often undertake prolonged dives during which they disappear from a boat-based observer's view and leave few cues to trace their movements or behaviors (Mann, 1999). The appropriate techniques to overcome these limitations are dependent on the behavior of the animals, the nature of their environment and the research objectives. For example, remote tracking of animal movement using radio or satellite tags (see Stone and Kraus, 1998 for various examples), timed depth recorders (e.g., Chilvers et al., 2004) or DTAGs (Johnson and Tyack, 2003) can provide data on individual animals throughout diurnal and tidal cycles over days to months. However, the data are limited: (1) to individuals permitted for capture or by methods available to attach the devices, (2) by the assumptions made in the absence of visual observations, such as how dive profiles relate to behavior (Chilvers et al., 2004), and (3) by the degree of error related to technological limitations. Direct observations of animals provide information on individual movements and behavior in relation to con-specifics. Underwater observations by diving with still or video cameras (e.g., Edel and Winn, 1978; Rossbach and Herzing, 1997; Kubodera et al., 2007) or using Autonomous Underwater Vehicles (e.g., Iwakami et al., 2002), are limited to species or individual animals that tolerate this disturbance, and waters with good visibility. Heightened or aerial viewing platforms allow increased visibility from above the surface, through the water column, and thus prolong observations of subsurface behaviors while providing a broad perspective of animal groups.

A relatively new method for conducting aerial observations of marine mammals is the use of a video camera mounted on a tethered, helium-filled aerostat (blimp, or balloon), first described by Flamm (2000), and in more detail by Nowacek et al. (2001a). The video image is transmitted to a monitor on board the boat so that animals can be observed in real time and followed using a remotely controlled camera with a pan and tilt system. This system has been used to assess the life-stage structure of manatees (*Trichechus manatus latirostris*) (Flamm et al., 2000) and the foraging behavior of bottlenose dolphins (*Tursiops truncates*) (Nowacek et al., 2001b). It has also been used to observe the effects of boat traffic on the behavior of both species (Nowacek, 2002; Nowacek et al., 2004). Hain and Harris (2004), used a similar system to study the behavior of the North Atlantic right whale (*Eubalaena glacialis*). Nowacek et al.'s (2001a) and Hain and Harris' (2004) are the only two systems described in the literature so far.

I developed an alternative aerial observation system that incorporates a new blimp design, can be used in higher wind speeds, is smaller (making it easier to operate), and uses more off-the-shelf parts (hence is more economical) than the two systems previously described. I used my "blimp-cam" to undertake a comprehensive study of the behavior of dugongs (*Dugong dugon*) and to gain continuous, detailed information on individuals of all reproductive and life stages, as well as their interactions (Hodgson, 2004), and record their responses to boats (Hodgson and Marsh, 2007) and pingers (Hodgson et al., 2007). Here I describe the "blimp-cam" and compare it to previous systems (Nowacek et al., 2001a; Hain and Harris, 2004). This relatively new aerial observation technique has received a great deal of interest, particularly among marine mammal researchers. This paper adds to the limited information about alternative components, operation techniques and applications of these aerial observation systems. Recognizing the limitations of the "blimp-cam", I also suggest possible further applications for this system.

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Blimp-cam Design

Aerostat

I used a "Hi-Speed blimp" (Balloon Promoters, NZ) originally produced by Floatagraph Technologies (Indiana, USA). This ovoid shape blimp can withstand higher wind speeds than the traditional zeppelin style. A semi-circular net on its base acts as a sail, stabilizing the blimp by catching the wind and keeping it directional (Figure 1). Three webbed tether lines (2.5 cm in width) attached to a reinforced apex at the top of the balloon, wrapped around and joined approximately 2-3 m below the belly of the balloon. The base of the net is attached to one of these tether lines. From this point, two (one as back-up) 4.8 mm polyester braid, hard lay ropes connected the blimp to the boat. Small adjustments to the length of the three main tether lines changed the angle of the blimp, while adjusting the tightness of the net changed the stability such that the blimp could be 'tuned' for different wind conditions.

To attach the camera, the blimp had six small (2.5 cm webbed) tethers, two extending from the apex and four from the belly of the balloon. They were adjustable so that the camera hung straight down and had custom made metal clips that hooked firmly over metal bolts on the camera housing (Figure 1).

Video System

I used a standard, off-the-shelf, dome, single chip, digital security camera (Panasonic WV-CS854), with 4 to 83 mm zoom, and 480 lines horizontal resolution. The pan and tilt system provided with the camera had 360° continuous pan (to 300°/s) and 180° tilt (with digital flip), which were not mutually exclusive (both pan and tilt could operate simultaneously). The camera and pan and tilt system came with a plastic casing and plastic clear dome. This complete package was fitted into a cylinder-shaped waterproof housing, such that the dome protruded from the bottom end and was sealed with an o-ring (Figure 1). The cylinder could be opened at the top end and the camera removed. The advantage of using this commercially available product was that parts such as the clear dome (which when scratched could blur video images) could easily be replaced at minimal cost.

The pan, tilt, zoom, focus and iris aperture were adjusted remotely via a coaxial cable using a joystick controller (Pacom 2035 Intelligent CCTV keyboard, PC2035K2) that is commercially available and generally used for operating a network of security cameras. The footage from the camera was transmitted via coaxial cable to the research vessel where it was viewed on a monitor (Panasonic BTS1050Y) and selectively recorded on a digital video camcorder (Panasonic NVMX300). To eliminate the problem of glare, the monitor was housed in a darkened box which had a section cut out and eye goggles fitted. The "blimp-cam" operator and observers on the roof of the research vessel were equipped with hands-free radio transceivers. A dedicated transceiver was connected to the audio input of the camcorder via the microphone/earphone socket so that all commentary and additional boat-based observations were recorded with the video footage.

The whole system was run on 24 V AC via 2 x 12 V batteries with an inverter. The batteries were recharged nightly. Power was transmitted via the outer conductor of the coax cable that transmitted the data and video signals, together with an additional single wire. Both the coaxial cable and single wire were taped to the back-up tether to prevent breakage.

Operation

While not in operation, the blimp was kept inflated and stored in a tent. Transfer of the blimp between the tent and boat required two people to guide the balloon out of the tent; however, once in open space in low winds (< 10 knots) the blimp could be held easily by one person. The "blimp-cam" was operated from a 5.6 m double-barrel pontoon research vessel with a 40 HP engine. The stability of this vessel aided the stability of the blimp and consequently enhanced the quality of the video recordings. My study site was 18 km from the research station, and while in transit, the blimp was towed at approximately 10 m above the vessel without the camera attached. Both tethers of the blimp were on hand-reels and each was attached by carabiners to the boat at two places. The "blimp-cam" was raised and lowered by hand. Once at the field site, the camera was clipped onto the blimp and raised approximately 50 m above the research vessel for filming. I motored the boat around the field site with the camera attached.

FIGURE 1

The "blimp-cam", consisting of the new ovoid style blimp and off-the-shelf dome security camera within a custom made waterproof housing.

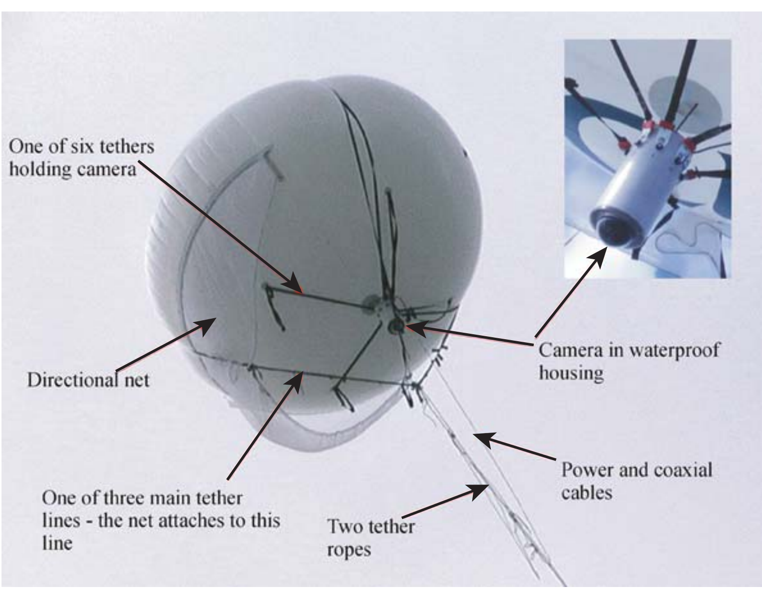

FIGURE 2

Images of a dugong (*Dugong dugon*) (a) herd, (b) sub-group, and (c) mother and calf (calf suckling) obtained using the "blimp-cam".

Application of the Blimp-cam to Observe Dugong Behavior

I used the "blimp-cam" to film 165 hours of dugong behavior. Dugongs are generally found in relatively shallow water (<10-15 m) due to their dependence on seagrass (Anderson, 1981) and, as bottom-feeders, spend little time at the water surface (Anderson and Birtles, 1978). They can be found in large herds of several hundred individuals, in smaller groups, or as solitary individuals (Anderson, 1981). It is possible to conduct boat-based behavioral observations on individual dugongs in small groups (e.g., Anderson, 1997). However, it is impossible to conduct focal animal observations of individual's in large herds, as dugongs lack the markings needed to identify individuals.

As dugongs are generally slow moving and remain within a relatively small area to feed for long periods, I conducted continuous focal animal observations of individual dugongs (Altmann, 1974) by anchoring the research boat near a herd of dugongs. The system's greatest advantage is that it provides an extended field of view, which reduces the need to follow animals closely in the research vessel. By adjusting the direction and zoom of the camera, I followed individuals for up to 30 min (mostly limited by my protocol of 15 min per individual) to a radius of approximately 200 m around the stationary boat, even when the individual was part of a large herd and not distinguishable by observers on the boat (for further details see Hodgson, 2004; Hodgson and Marsh, 2007). The "blimp-cam" provided a vantage point similar to that of an aircraft, but without noise-related disturbance, and allowed underwater observations of the animals (away from the blimp's shadow) without disturbing the dugongs or inducing an investigative response.

The "blimp-cam" system is flexible. I was able to film large sections of dugong herds containing several hundred animals and thus obtain information on herd structure and composition (Figure 2a). I could also zoom in on subgroups or individuals and observe specific behaviors such as suckling (Figure 2b & c). The depth of visibility through the water column is obviously dependent on the vertical water visibility at the study sight. I was able to record individual dugongs at depths of 3 to 4 m.

Comparisons with Previous Systems

The main differences between the "blimp-cam" and previous systems were the size and style of the blimp, and the size of the payload. Nowacek et al. (2001a) and Hain and Harris (2004) used 8.8 m long (42.5 m^3), traditional zeppelin-style blimps, whereas I used a 2.5 m diameter (11.3 m^3) ovoid blimp. The two advantages of the new ovoid designed blimp in comparison to the zeppelin style are: (1) it provides greater lift for the same amount of helium and (2) it can operate in higher wind speeds and recovers quickly from strong gusts.

The required size of a blimp is determined by the payload of the camera, housing and tether. I kept the payload to a minimum 7.6 kg, including 50 m of tether rope, which was approximately one third of the weight of Nowacek et al.'s (2001) system. This was achieved by using a single-chip digital camera, which was smaller and lighter than a three-chip camera, as was its pan and tilt system, thus requiring less lift and a smaller blimp. Keeping the payload and the size of the blimp to a minimum reduces operational costs by minimizing the helium required, as well as the number of people needed to operate the system. It also facilitates safe storage while the blimp is not being used. Nowacek et al. (2001) used a three-chip camera in order to obtain the highest quality footage possible. I have found the footage from the single-chip camera more than adequate to analyze the behavior of dugongs. However, my footage is not broadcast quality and still images extracted from the footage are of relatively low quality.

The smaller blimp, and a single-chip, off-the-shelf dome security camera, made my "blimp-cam" cheaper than that described by Nowacek et al. (2001a); ~ $US 11, 000 compared to ~ $US 19,000, respectively. The operational costs of the "blimp-cam" are also lower because it requires less people, less helium, and has off-the-shelf replaceable parts.

Limitations of the Blimp-cam

Although the blimp itself was not limited by moderate winds (I towed it against winds of up to 20 knots), footage of acceptable quality could only be obtained in winds up to 15 knots. Stronger winds reduced camera stability, decreased water clarity (by increasing surface chop) and caused too much vessel movement to safely rig the camera. While a self-stabilizing camera platform would increase the quality of footage in wind speeds greater than 15 knots, it would significantly increase the cost of the system and visibility would still be limited by water clarity. The "blimp-cam" was not used in the rain as rain reduced visibility and risked damaging exposed electrical equipment.

The application of this aerial observation platform is particularly suited to clear, shallow waters as it is limited by vertical water visibility. When looking directly down from 50 m, the field of view from the "blimp-cam" was 49 m x 36 m. The depth of view and field of view with the camera tilted depended on environmental conditions such as water clarity, wind speed, cloud cover and sun angle (glare).

Neither the "blimp-cam", nor previously described systems, has a mechanism to determine distances other than obtaining relative distances according to known lengths of objects within the video frame. The constantly changing position and height of the blimp, and angle and focal length of the video camera, makes determining distances very challenging. However, overcoming this limitation would greatly enhance the range of uses for this system.

No blimp flies well if there is any helium leakage. Although the "blimp-cam" could lift the camera to 50 m while it had a small, barely detectable leak, it was much more difficult to fly and tow behind the boat than when completely sealed. Small holes in the blimp could be detected by inspecting the blimp or using water and detergent and were easily repaired, however large rips need to be repaired by the manufacturer.

Animal Responses

The greatest advantage of the "blimp-cam" is that it caused minimal disturbance to the focal animals. However, the shadow of the blimp at times caused a minor disruption to the normal behavior of the dugongs. The dugongs usually avoided the shadow by swimming around it and continuing along the same path, or changing travel direction. In two instances when dugongs swam through the shadow it was faint and periodically disappearing as the cloud cover changed. On both days, other dugongs avoided the shadow. A strong response was observed on three occasions when movement of the blimp caused the shadow to pass suddenly over dugongs. The animals abruptly fled, but two out of the three returned to their original swim speed once approaching other dugongs (< 10 s). On the third occasion, six individuals (including two mother/calf pairs) abruptly fled from the moving shadow and disturbed a further four individuals, with all six fleeing out of view of the "blimp-cam". Sharks are dugongs' main predator, and the sharp shadow and size of the blimp shadow may have mimicked the shadow of a shark to some extent.

Further Applications for the Blimp-cam

The successful implementation of this aerial video system provides further evidence of how such systems can advance the study of large, yet cryptic marine animals. As a relatively benign research tool the "blimp-cam" is ideal for studying animals in reasonably clear water. There are now a number of studies demonstrating the use of these aerial observation systems for researching marine mammals including bottlenose dolphins (Nowacek et al., 2001a; Nowacek, 2002), North Atlantic right whales (Hain and Harris, 2004), manatees (Flamm et al., 2000; Nowacek et al., 2004) and dugongs (Hodgson and Marsh, 2007; Hodgson et al., 2007). Further applications could include observing pinnipeds on land and in the water near haul-out sites, or other species of coastal dolphins that are wary of boats and difficult to approach such as humpback dolphins (*Sousa sp.*). The "blimp-cam" would allow the researcher to remain further away from the animals than when observations are conducted directly from land (for seals) or a research vessel. This tool could also enhance the study of other large marine animals such as sharks or rays, which are not obligated to surface but are often within the upper portion of the water column.

Acknowledgments

Thank you to my supervisors, Helene Marsh and Louise Chilvers. I appreciate the help of my many volunteers. I received great advice about my equipment from Doug Nowacek, Glen Curuthers, Jan Aldenhoven, Richard Fitzpatric, Gavin Bunn and Daryl King. This project was funded by the Cooperative Research Center for the Great Barrier Reef World Heritage Area, James Cook University, the Australian Defense Force, the Great Barrier Reef Marine Park Authority, and Digital Blue Photography. Part of the funding for the blimp was obtained from an ARC Linkage Grant to Helene Marsh, for which the Industry Partners were the Great Barrier Reef Marine Park Authority and the Hope Vale Aboriginal Council. Thanks to Tangalooma Resort (Bruce and Betty Osborne) and in particular Trevor Hassard, for providing in-kind support. The project was approved by the James Cook University Ethics Review Committee (A646_01) and was conducted under Queensland Parks and Wildlife permits E6/000023/01/SAA, QS2001/CVL25, and QS2002/CVL25. This manuscript was improved by comments from Mike Noad.

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