Chapter 3: High resolution digital video aerial survey methods
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Emily E. Connelly, Melissa Duron, Iain J. Stenhouse, and Kathryn A. Williams

Biodiversity Research Institute, Portland, ME

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Chapter 3 Highlights

Methods used to conduct high resolution digital video aerial surveys.

Context[1]

High resolution digital video aerial surveys are a new method for collecting distribution and abundance data on animals, and the Mid-Atlantic Baseline Studies and Maryland Project surveys were the first to use this method on a broad scale in the U.S. The technology was developed by HiDef Aerial Surveying, Ltd., in the U.K. These methods have largely replaced visual aerial surveys for offshore wind energy research in Europe, as they are safer for the pilot and crew, reduce or eliminate disturbance to wildlife during surveys, and produce archivable and auditable data. This chapter briefly describes the methods used to collect and analyze the survey data. Chapter 4 describes the data management, object identification, and audit processes conducted for digital video aerial survey data in further detail. Basic results from the digital video aerial surveys are summarized in Chapter 5, and the data are analyzed alongside boat survey data in Chapters 10-14 of this report.

Study goal/objectives addressed in this chapter

Provide the methods for data collection and analysis for the high resolution digital video aerial surveys.

Highlights

- Fourteen digital video aerial surveys were flown in the broader Mid-Atlantic Baseline Studies (MABS) study area over two years (March 2012-May 2014).
- Surveys from March 2013 to May 2014 expanded the high density survey coverage inshore and south of the Maryland Wind Energy Area (WEA). An additional 15th survey of the Maryland study area (including both the expansion area and the WEA) was flown in August 2013.
- Planes flew at a speed of approximately 250 km/hr and at an altitude of 610 m. Using camera technology developed by HiDef Aerial Surveying, Ltd. of the United Kingdom, four super high-definition video cameras captured a 200 m wide transect strip.
- Video data were analyzed by two teams to locate and identify objects in the footage.
- Flight heights were estimated for flying animals using a patented extended parallax method.
- Audit processes, including blind re-review of 20% of video data, were carried out as part of both the object location and identification procedures.
- Completed datasets are available online at our website and are also included in the U.S. Fish and Wildlife Service's Northwest Atlantic Seabird Catalog.

Implications

Results from the data collected following these methods are presented in Chapter 5 and Part IV of this report.

[1] For more detailed context for this chapter, please see the introduction to Part II of this report.

Abstract

This chapter presents methods used to collect and analyze high resolution digital video aerial survey data. Fifteen high resolution digital video aerial surveys were conducted by Biodiversity Research Institute (BRI) and HiDef Aerial Surveying, Ltd. (hereafter, HiDef, the company that developed this technology in the United Kingdom) as part of a broader project to collect observations of marine birds, mammals, turtles, and other wildlife, and to inform siting and permitting processes for offshore wind energy development. Aerial transects were flown at high densities within the Delaware, Maryland, and Virginia Wind Energy Areas (WEAs); the remainder of the study area was surveyed on an efficient sawtooth transect path to provide broad-scale context for the intensive WEA surveys. As part of the Maryland Project, high-density surveys were also conducted adjacent to the Maryland WEA in 2013-2014. Precise wildlife locations, taxonomic identities, animal behaviors, and flight heights were determined from the resulting video images. Details on the analyses are found in the Video Aerial Survey Data Protocol in Chapter 4. Flight heights were calculated from video footage for flying animals using extended parallax methods developed by HiDef.

Introduction

Digital aerial survey technologies, using either video or still photography, have been developed and successfully deployed in Europe to assess marine wildlife populations in relation to offshore wind energy development (e.g., Buckland et al., 2012; Groom et al., 2013; Thaxter and Burton, 2009). Though they have become common practice for offshore wind energy planning and monitoring in Europe (Buckland et al., 2012), this study is the first to use these methods on a broad spatial and temporal scale in the United States. Digital aerial surveys have a high cost efficiency on broad spatial scales, and it has been suggested that they may eventually largely replace traditional visual surveys, by boat or aircraft, to collect distribution and abundance data on animals in the offshore environment in Europe (Buckland et al., 2012). Importantly, the data collected using digital surveys are recorded, allowing for species identification verifications, the application of rigorous audit protocols, and archiving of footage for later review.

High resolution digital video aerial surveys (hereafter, digital video aerial surveys) were conducted on the Mid-Atlantic Outer Continental Shelf offshore of Delaware, Maryland, and Virginia in 2012-2014 to inform siting and permitting processes for offshore wind energy development. In particular, aerial surveys were focused on obtaining detailed data on wildlife distributions in three federally designated Wind Energy Areas (WEAs). In the second year of surveys, this focus was extended west and south of the Maryland WEA to collect further information on wildlife offshore of Maryland. Wildlife locations, taxonomic identifications, animal behaviors, and flight heights were determined from the video images (discussed in additional detail in Chapter 4), and these data were used in further analyses, which are presented in Part IV of this report.

Data collection

As part of the Mid-Atlantic Baseline Studies Project (MABS), observations of marine birds, mammals, and turtles were collected in large-scale surveys across a 13,245 km^2 study area using super high-definition video on an aerial platform (Figure 3-1). Fourteen offshore surveys were flown by HiDef across the broader MABS study area from March 2012 to May 2014. Aerial transects were flown at high densities (1 km spacing, or 20% ground coverage) within the Maryland, Delaware, and Virginia WEAs. Beginning in Year 2 of the study (March 2013), the footprint of high density surveys was extended west of the Maryland WEA to the shoreline, and 10 km south of the Maryland WEA, with funding from the state of Maryland (Figure 3-1, Figure 3-2). These Maryland Project transects were the only video aerial transects that extended into state waters (e.g., within 3 miles of shore). The remainder of the MABS study area was surveyed using an efficient ‘sawtooth’ transect path to provide broad-scale context for the intensive WEA surveys (at about 2.1% ground coverage, beginning in September 2012; Figure 3-1). Early surveys included video footage at 2 cm GSR for the transects within the WEAs, and 3 cm GSR for the broader sawtooth survey; however, species identifications were problematic for 3 cm footage in early surveys, due to poor image clarity and color rendition, and this issue was addressed by project collaborators by discontinuing all use of 3 cm GSR for surveys beginning in September 2012 (Duron et al., 2015). The Maryland extension of the survey transects added about 21% of additional transect length to the existing study design, with total combined transect length for each survey at approximately 2,866 km in Year 1, and 3,613 km in Year 2. An eighth annual survey was also added in Year 2 of the study, with funding from the state of Maryland; this survey included only the Maryland WEA and Maryland extension transects, totaling approximately 1,088 km in length, and was flown in August 2013. The “Maryland study area,” as referenced throughout this report (and indicated in Figure 3-1 and Figure 3-2), includes survey transects in the Maryland WEA and Maryland extension transects, as well as all MABS sawtooth transects offshore of the state of Maryland.

In addition to the fifteen surveys described above, HiDef also flew a survey specifically designed to allow for a comparison of aerial and boat-based data collection. The flight occurred during one of the regularly scheduled boat surveys (March 2013), and followed the paths of several of the boat transects, rather than the aerial transects used in other surveys. Details regarding this comparison study can be found in Williams et al. (2015).

HiDef worked with their video aerial survey vendor to outfit the survey aircraft and organize and schedule flights in the MABS and Maryland study areas (Figure 3-1, Figure 3-2). Each survey was completed using two small commercial aircraft, allowing complete coverage of the study areas in two to three days (weather permitting). The aircraft were twin-engined Cessnas, with long range fuel tanks to enhance safety when operating at sea, and had specially designed frames attached to the lower fuselage for survey cameras. Due to the height at which surveys were flown, no permits were required from the National Marine Fisheries Service (NMFS), but flights complied with all Federal Aviation Administration (FAA) regulations.

Each survey was conducted at approximately 250 km/hr and at 610 m (2,000 ft) above sea level using four super high-definition (five times HD) video cameras, angled at 30-45° from vertical and integrated with onboard navigation systems and server storage (Figure 3-3). Cameras captured up to 15 frames per second, and images were duplicated and stored onto a disk array of heavy duty disk drives or solid state recording devices within the aircraft. Video footage was shipped to the HiDef office in the UK by the video aerial survey vendor, and as a precaution video footage was also copied onto hard drives by the video aerial survey vendor and shipped to the BRI office in Gorham, Maine.

Each of the four cameras captured video images at a 50 meter strip width at sea level, resulting in a 200 meter wide transect strip (Figure 3-3). Surveys were flown under Visual Flight Rule (VFR) conditions and were completed in weather conditions appropriate for observations (<6 Beaufort with no low cloud cover, mist, or fog). All surveys were flown using GPS to ensure location accuracy.

Digital video data analyses

The HiDef team reviewed each frame of the recorded footage to mark visible objects and note object categories (e.g., Bird, Buoy, Fish). These data were output to an Excel spreadsheet and marker files were generated and saved for object identifications for the BRI team (see Chapter 4 for more details). HiDef observers re-reviewed 20% of the frames in each survey to determine the rate of agreement between observers; agreement had to be at least 90% for the audit to pass. If the audit did not pass that observer's recent data were examined for consistent errors and issues were addressed. Data spreadsheets and markers for all objects that were found by the original observer and the auditor were sent to BRI staff for further analyses.

Trained BRI staff identified the objects to species, taxonomic group, or general category (e.g., flotsam and jetsam), and described animal behaviors. Identifications were based on size, shape, color, movement pattern, and clarity of the image, and confidence of identification was noted for each object. "Definite" indicated >95% certainty, "probable" indicated <95% but >50% certainty, and "possible" indicated <50% certainty in the identification. For example, if a reviewer could not substantiate that an object was a "possible Wilson's Storm-Petrel," then that object might be coded as a "definite unidentified storm-petrel," based on the specific criteria used for identifications of that species or category (size, color, shape, flight pattern, clarity of image, etc., see Chapter 3 for more details). Some animals and objects were submerged underwater. Reviewers could see at some depth, but visibility of submerged objects varied based on turbidity and weather, and no formal steps were made to verify the range of depths within which animals could be accurately identified. All non-avian animals in the water column were marked as either submerged or surfacing. Completed data sheets with identification information were returned to HiDef in the UK for georeferencing and parallax calculations. Twenty percent of the identification data were audited by BRI, with at least 90% agreement required to pass. Detailed object ID, data management, and audit protocols for BRI analysis procedures are included in Chapter 4.

HiDef calculated flight altitude for moving targets using the measurement of "parallax" in the aerial video. Parallax is the apparent motion of an elevated object against a distant background due to the movement of the observer. With a known distance to the background and motion of the observer, the parallax was measured from relative positions in digital video frames and used to estimate the height of the object above the background (Hatch et al., 2013). Most objects were observed in at least eight video frames at the altitude and speed at which digital video aerial surveys were conducted. Flight height could not be accurately estimated using this approach when the animal was flying parallel to the plane and no displacement was detectable, or the animal was flying at high altitudes and was present in fewer video frames.

HiDef also georeferenced each video frame containing an animal, using GPS data from the survey flight and offset calculations to account for camera angles. Directions of movement were also translated into cardinal directions, based on the direction in which each camera was pointed during the recording time. Spreadsheets with flight height, animal direction of movement, and georeferenced data were returned to BRI to be joined with audited identification data by the data manager.

Aerial effort data were built from either the georeferenced camera reel data files or raw backup GPS data files. We preferentially built effort data from the georeferenced camera reels, which included a position for every camera frame while the survey cameras were active. This was the most accurate positional data from which to generate the effort data, as these files were only generated while the cameras were actively filming and collecting data. Early in the project, there were several partial surveys where the GPS associated with the cameras was not working properly and there were no positions associated with camera reels. However, backup GPS positioning was available, and we used these data along with planned transect lines to generate the effort for these transects. Custom scripts were written in Python for ArcGIS 10.2 (ESRI, Inc., Redlands, CA) to derive the effort lines from the camera reel geo-references and/or the backup GPS. We also generated effort polygons for the four camera stripes using another custom Python script; these stripes were derived from the transect lines, with the proper spacing between cameras (50m) and width of the cameras' field of view (50m each)[2]. Effort data were further associated with survey observations in post-processing.

Additional information

The complete digital video aerial survey dataset is available for download on the project website[3]. It has also been added to the Northwest Atlantic Seabird Catalog (formerly the Compendium of Avian Information; O'Connell et al., 2009), a publicly held database housed by the USFWS that is the main repository for observations and survey data collected in Atlantic waters from Florida to Maine since 1906 (including data on marine mammals, sea turtles, and other wildlife, as well as seabirds).

This study represents the first application of high resolution digital video aerial survey technology in North America, and was also the first broad-scale application of any type of digital aerial survey in the United States. A more detailed description of video data analysis and management procedures is available in the following chapter of this report (Chapter 4). The digital video aerial survey data are summarized in Chapter 5, and used alongside boat survey data in analyses in Chapters 10-14 of this report.

[2] On the first three surveys, the sawtooth transect was flown at 3cm GSR, so the transect width was 75m and the spacing between cameras was 25m.

[3] www.briloon.org/mabs/data

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Figures

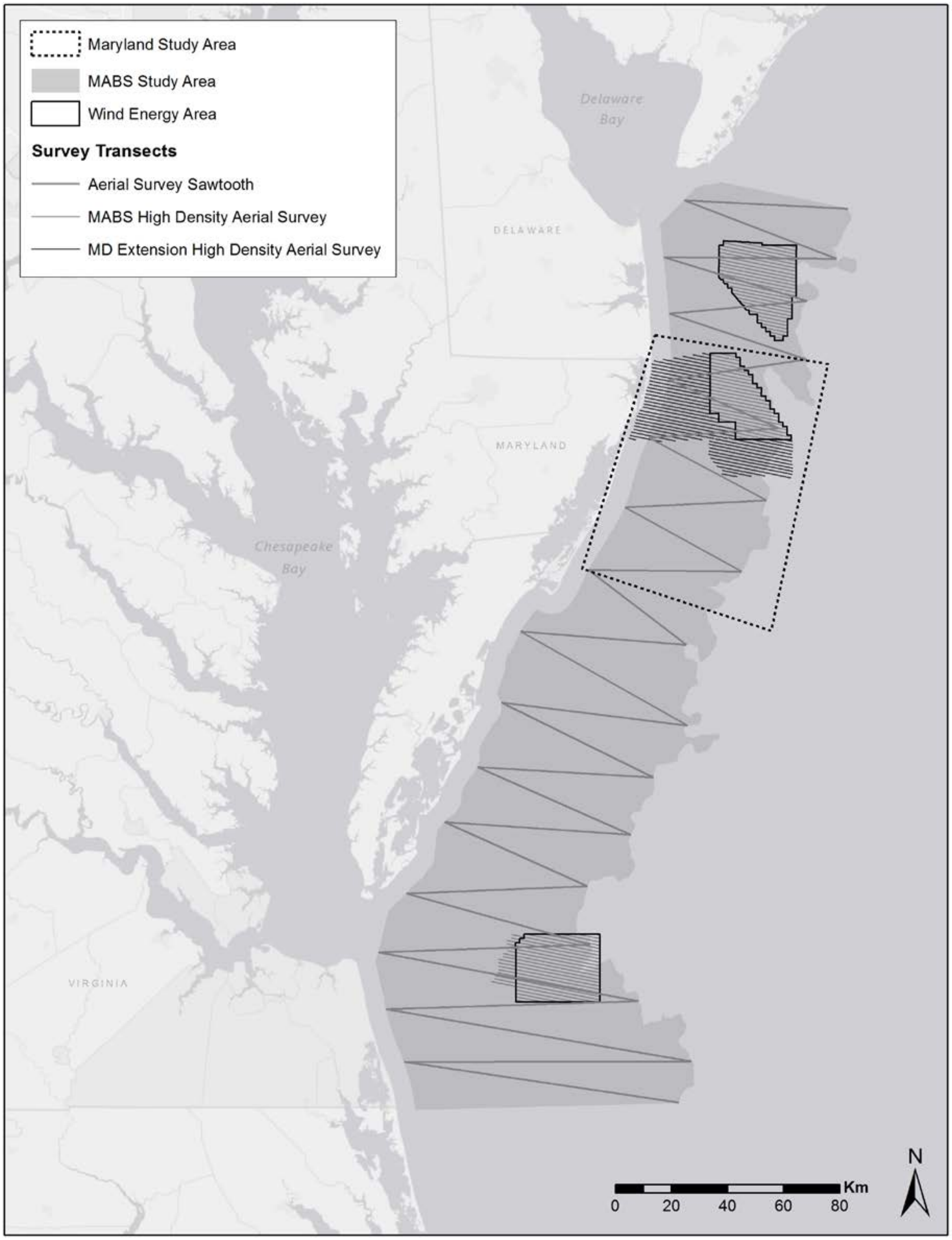

Figure 3-1. Map of digital video aerial survey transects for the Mid-Atlantic Baseline Studies and Maryland Projects (2012-2014). Mid-Atlantic Baseline Studies transects are shown in light gray. High-density Maryland transects are shown in dark gray.

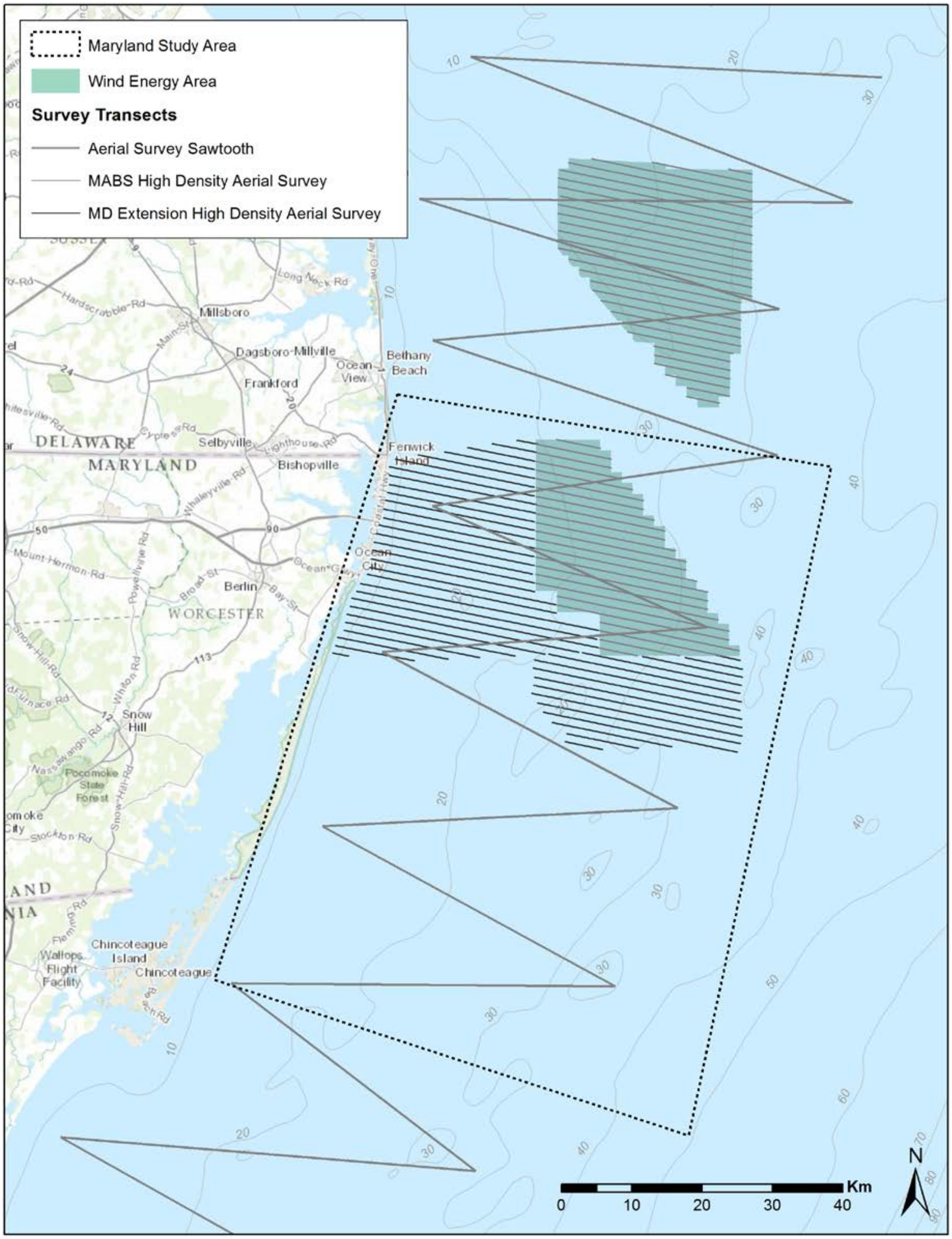

Figure 3-2. Detailed map of aerial survey transects within the Maryland study area. Mid-Atlantic Baseline Studies transects are shown in light gray. High-density Maryland transects are shown in dark gray.

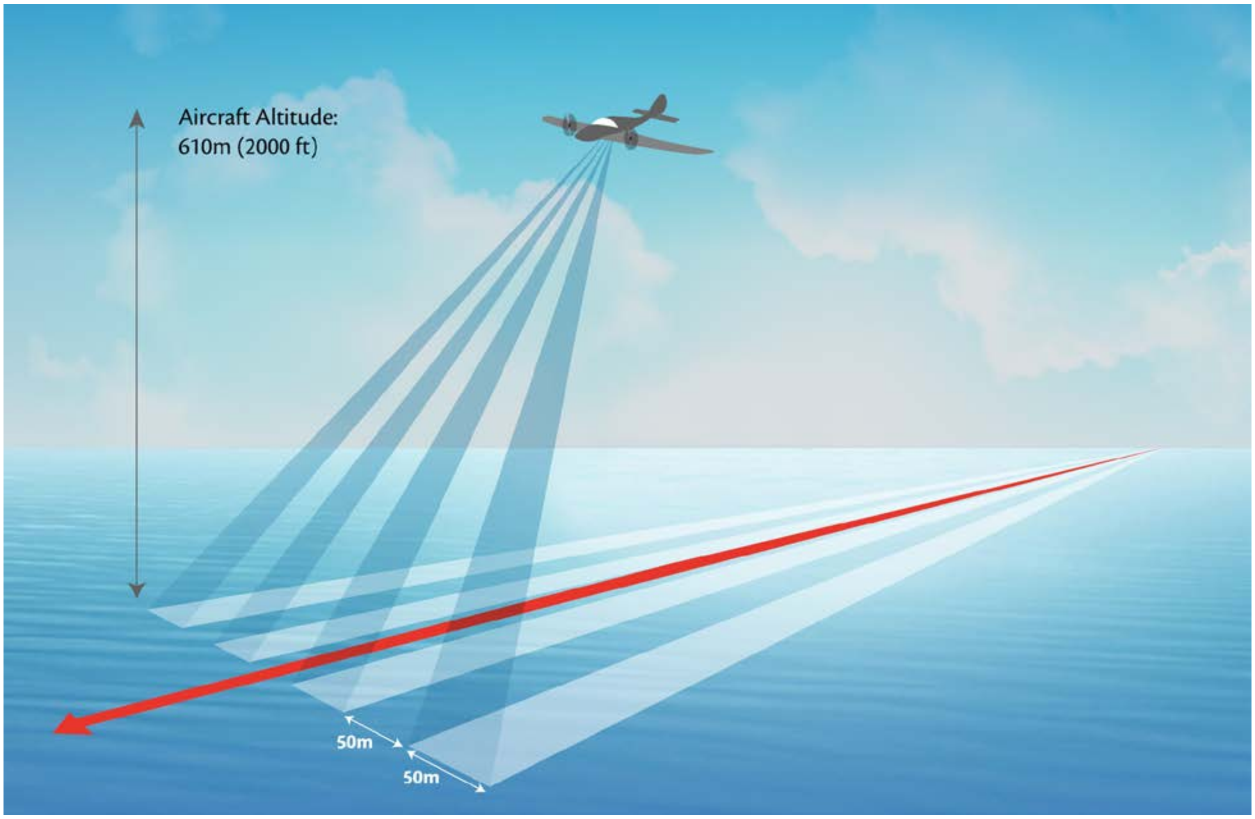

Figure 3-3. Digital video aerial surveys were flown at 610 meters using a twin-engine aircraft with four belly mounted cameras. These cameras recorded non-overlapping 50 meter transect strips for a total transect strip width of 200 meters. (Image created by Linda Mirabile and Glen Halliday).