Environmental Studies Program: Ongoing Study

Field	Study Information
Title	Atlantic Marine Assessment Program for Protected Species (AMAPPS) - Photogrammetric Aerial Surveys to Improve Detection and Classification of Seabirds, Cetaceans, and Sea Turtles (AT-20-02)
Administered by	Office of Renewable Energy Programs
BOEM Contact(s)	Timothy White (timothy.white@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	U.S. Fish and Wildlife Service
Total BOEM Cost	$800,000
Performance Period	FY 2020–2025
Final Report Due	September 2025
Date Revised	October 30, 2023
Problem	Visual surveys, involving multiple air crews and observers must include methods to minimize or estimate significant biases, including those known to vary widely among observers such as detection, misclassification, group-size estimation and sample area determination.
Intervention	Integration of airborne remote sensing (e.g., high-resolution camera systems fixed to survey aircraft) as a primary data collection tool or as a means of reducing errors in counting and improved species detection.
Comparison	The study builds on a decade of AMAPSS observer-based aerial surveys conducted by the USFWS. BOEM has identified problematic species on these surveys (e.g., > 90% of terns unidentified to the species level). We will compare species identification accuracy using high-resolution imagery with previous AMAPPS observer-based data.
Outcome	This project will conduct aerial surveys to collect georeferenced imagery to advance the accuracy of species detections and counts through the application of computer vision and automated detection and classification algorithms.
Context	Targeted locations off the Atlantic coast and offshore areas.

BOEM Information Need(s): Frequent misclassification of marine wildlife on agency wildlife aerial surveys likely results from a combination of observer experience, high observer turnover rates, and species with similar morphologies. Advanced remote sensing technologies combined with automation through machine learning and computer vision will improve aerial survey data collections (Edney and Wood, 2020).

Background: Low-level aerial surveys can cover large areas in a relatively short time frame and serve a critical component in BOEM’s monitoring framework. Aerial operations can mobilize faster than ship-based surveys and can reach locations hazardous to ships, but essential to marine wildlife. From 2010–2019 the USFWS, in coordination with BOEM, conducted systematic high fixed-wing aerial surveys from

Florida to Maine, focused on seabirds, sea turtles, and marine mammals. However, despite the enormous survey effort, bountiful records of low taxonomic classification exist in the Northwest Atlantic Seabird Catalog (NWASC) collected by USFWS for AMAPPS. Many instances of low ranking occur in areas with a high probability of encountering endangered species. For example, aerial observers classified > 90% of Cape Cod terns to the genus level, making it impossible to tease out the distribution of the endangered Roseate Tern from Common Terns. These inaccuracies frequently result in classification of endangered species to lower taxonomic levels than desirable for National Environmental Policy Act analyses.

Visual surveys involving multiple aircrews must include methods to minimize biases that are known to vary widely among observers such as detection (i.e., perception), misclassification, group-size estimation, and sample area determination. Although AMAPPS aerial surveys conducted by the USFWS are spatially and temporally comprehensive and systematic, they suffer from high observer turnover and varying observer experience levels. Collection and integration of high-resolution, spatially-explicit photogrammetry as a primary data collection tool on AMAPPS and on other BOEM projects can maximize survey effort by improving detection and counts of all species encountered on at-sea transects. Automation of computer vision algorithms is currently in development through BOEM/U.S. Geological Survey (USGS) collaboration per study NT-19-04 (*Automated Detection and Classification of Wildlife Targets in Digital Aerial Imagery*). Archiving this proposed new collection of imagery will improve confidence in species-specific maps for offshore planning purposes and will provide a permanent and open source imagery archive for when advances occur in the fields of computer vision and unmanned aircraft systems (UAS).

Objectives: The objective of AMAPPS is to provide baseline data on regional and seasonal species abundance and distribution in the nearshore and offshore environments to aid decision-making with respect to offshore development, transportation, military exercises, and conservation. The AMAPPS collaboration has entered its third phase. The overarching goal this third phase is to develop cost-efficient remote sensing- and machine learning-based methods to survey and monitor marine birds and other wildlife in order to improve the quality of population estimates and distribution mapping while enhancing personnel safety. The primary aim of this segment of the study is to conduct photogrammetric aerial surveys in targeted areas offshore. We will build a database of annotated photos to train deep learning computer vision algorithms (currently in development by study NT-19-04) to count and identify all species of marine mammals, sea turtles, and seabirds encountered on at-sea transects coordinated by BOEM. Once trained, deep learning models will automatically detect and count species in new imagery. A similar approach was successfully applied to automated detection of individual endangered right whales with 87% accuracy (Bogucki et al., 2018); birds (Chabot and Francis, 2016); and sea turtles (Gray et al., 2019).

Methods:

- USFWS will conduct aerial surveys at least once per season to target breeding, wintering, staging, migrating species, and mixed-species groups during the study period.
- Develop cost-efficient remote sensing & machine learning methods to survey marine mammals, sea turtles, and seabirds to improve population estimates & distribution mapping while enhancing personnel safety
- USFWS will collect imagery in hotspot areas identified by BOEM using distribution and abundance data collected on AMAPPS I and II.

- BOEM and USFWS will continue to develop and annotate a digital aerial imagery archive with Upper Midwest Environmental Sciences Center-USGS under study NT-19-04 to train deep learning algorithms on imagery of seabirds, marine mammals, and sea turtles. The archive will include a range of pixel ground sample distances (GSDs) and environmental conditions affecting sea state and sun glare as the two principal factors affecting detection and classification at sea.

Specific Research Question(s): How do we integrate results from different observational methodologies?

Current Status:

- SEABirD1 (Safe, Efficient, Aerial, Bird Detection, 1st system) is a multi-camera array consisting of seven 31.4 megapixel digital cameras and a 2.3 megapixel overview camera. The project team is testing new lenses and sensor heads that will provide sub-centimeter resolution at higher altitudes.
- Targeted imagery collection and testing of systems currently underway in the Gulf of Maine, mid-Atlantic and South Atlantic Bight. For example, in August 2021, total flight time for imagery acquisition in the Gulf of Maine was approximately 17.6 flight hours. Approximately 300,000 images were captured equaling around 10 terabytes (TB) of data. August 17 consisted of two flights, August 18 one flight, August 28 two flights, and August 29 one flight.

Publications Completed:

Tsung-Wei K, Yu SX, Koneff MD, Fronczak DL, Fara LJ, Harrison TJ, Landolt KL, Hlavacek EJ, Lubinski BR, White TP. In press. Deep learning workflow to support in-flight processing of digital aerial imagery for wildlife population surveys. PLOS One.

Miao Z, Yu SX, Landolt KL, Koneff MD, White TP, Fara LJ, Hlavacek EJ, Pickens BA, Harrison TJ, Getz WM. 2023. Challenges and solutions for automated avian recognition in aerial imagery. Remote Sensing in Ecology and Conservation. 9(4)439–453.

Kim D-J, Miao Z, Guo Y, Yu SX. 2023. Modeling semantic correlation and hierarchy for real-world wildlife recognition. IEEE Signal Processing Letters. 30:259–263.

Affiliated WWW Sites:

https://www.usgs.gov/centers/upper-midwest-environmental-sciences-center/science/deep-learning-automated-detection-and

https://eros.usgs.gov/doi-remote-sensing-activities/2020/usgs/automated-detection-wildlife-targets-aerial-imagery

References:

Bogucki R, Cygan M, Khan CB, Klimek M, Milczek JK, Mucha M. 2018. Applying deep learning to right whale photo identification. Conservation Biology. 33(3):676–684.

Chabot D, Francis CM. 2016. Computer-automated bird detection and counts in high-resolution aerial images: a review. Journal of Field Ornithology. 87:343–359.

Edney AJ, Wood MJ. 2020. Applications of digital imaging and analysis in seabird monitoring and research. IBIS. 163(2):317–337.

Gray PC, Fleishman AB, Klein DJ, McKown MW, Bézy VS, Lohmann KJ, Johnston DW. 2019. A convolutional neural network for detecting sea turtles in drone imagery. Methods in Ecology and Evolution. 10(3):345–355.