Title	Atlantic Marine Assessment Program for Protected Species (AMAPPS) III B and C—Photogrammetric Aerial Surveys to Improve Detection and Classification of Seabirds, Cetaceans, and Sea Turtles
Administered by	Office of Renewable Energy Programs
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Procurement Type(s)	Intra-agency agreement with U.S. Fish & Wildlife Service (USFWS)
Performance Period	FY 2020–2023
Date Revised	February 25, 2019
PICOC Summary	Write one or two sentences for each of the following elements, as appropriate.
Problem	Observer accuracy when it comes to identifying and counting multiple species on marine wildlife aerial surveys varies widely. Frequently, distribution, and abundance datasets collected on aerial surveys are rife with records of unidentified species, and many classifications are grouped to lower taxonomic levels (*e.g.*, genus; family). Though abundant, these records are routinely unused in species-specific modeling exercises despite the tremendous amount of effort invested in acquiring these datasets at sea, and there is no way to reanalyze them due to the lack of photographic archive.
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 AMAPPS observer-based aerial surveys conducted by the USFWS. BOEM has identified problematic species identification on these surveys (*e.g.*, > 90% of terns are not identified to the species level). We will compare the accuracy of species identification using high-resolution imagery with previous AMAPPS observer-based data to quantify the performance of both methods.
Outcome	Improved accuracy of distribution and abundance datasets and maps, particularly of species that aerial observers have difficulty with during the identification process while surveying at-sea transects. 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): As energy development increases along the Atlantic Coast and across the Outer Continental Shelf (OCS), BOEM requires robust species and site-specific information concerning the seasonal distribution and abundance of seabirds, marine mammals, and sea turtles. Frequent misclassification of marine wildlife to the species level on AMAPPS aerial surveys likely results from a combination of observer experience, high observer turnover rates, and species sharing similar morphologies. Despite new observer training, we do not foresee an improvement in observer detection and accuracy of classification on AMAPPS aerial surveys, which require observers to identify seabirds and marine mammals rapidly. BOEM can improve detection and the classification of species recorded on low-level aerial surveys

through the collection of high-resolution imagery and the development of spatially explicit high-resolution photographic reference databases for automated deep learning algorithms to systematically process.

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 possess the ability to reach locations hazardous to ships, but essential to marine wildlife. From 2010–2019 the USFWS, in coordination with BOEM, has conducted systematic high fixed-wing aerial surveys from Florida to Maine, focused on seabirds, sea turtles, and marine mammals. However, despite the enormous level of survey effort, bountiful records of low taxonomic classification exist in the Northwest Atlantic Seabird Catalog (NWASC) collected by USFWS for AMAPPS. Some areas with records of low ranking occur in areas with a high probability of encountering endangered species (*e.g.*, 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 levels of observer experience. 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 the proposed new collection of imagery will improve confidence in species-specific maps for planning purposes, and 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 primary aim of this study is to conduct photogrammetric aerial surveys in targeted areas to build a database of annotated photos that will 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. This approach was successfully applied to automated detection of individual endangered right whales with 87% accuracy (Bogucki *et al.*, 2018); birds (Chapbot and Francis, 2016); and sea turtles (Gray *et al.*, 2019). These tools will improve confidence in distribution and abundance data collected on broad-scale AMAPPS aerial surveys, and in similar photogrammetric projects across the Federal government and industry.

Methods:

- USFWS will conduct aerial surveys at least once per season to target breeding, wintering, staging, and migrating species and mixed-species groups during the study period.

- USFWS aircraft will use high-resolution camera systems to collect spatially referenced targeted imagery on marine mammals, sea turtles, and seabirds to increase the taxonomic and seasonal coverage of the imagery and annotation archive.

- 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. Extending deep learning algorithms to include species in these taxonomic groups has advantages in making better use of archived data, as well as advancing the technology for future application and cost reduction. Annotation refers to the process of identifying individual birds and other wildlife to the species-level or the most refined taxonomic classification possible from the source imagery, and marking identified wildlife for future reference. 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 and in what locations should BOEM and partners acquire new imagery to train species-specific computer vision algorithms, that are in development, to detect, classify, and count species recorded on at-sea aerial transects?

References:

Bogucki, R., Cygan, M., Khan, C.B., Klimek, M., Milczek, J.K. and Mucha, M., 2018. Applying deep learning to right whale photo identification. *Conservation Biology*.

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

Gray, P.C., Fleishman, A.B., Klein, D.J., McKown, M.W., Bézy, V.S., Lohmann, K.J. and Johnston, D.W., 2019. A convolutional neural network for detecting sea turtles in drone imagery. *Methods in Ecology and Evolution*.