Environmental Studies Program: Ongoing Study

Field	Study Information
Title	Automated Detection and Classification of Wildlife Targets in Digital Aerial Imagery – Phase II (NT-22-04)
Administered by	Office of Environmental Programs
BOEM Contact(s)	Timothy White (timothy.white@boem.gov)
Procurement Type(s)	Interagency Agreement
Conducting Organization(s)	United States Geological Survey
Total BOEM Cost	$400,000
Performance Period	FY 2022–2024
Final Report Due	September 2025
Date Revised	October 30, 2023
Problem	A significant challenge for integrating remote sensing methods for population surveys is the tremendous volume of data collected during image-based surveys and the lack of suitable tools for automated detection, classification, and counting of wildlife targets collected on at-sea transects. The current methodology requires experts to manually identify all species on an image-by-image basis, a strategy that will soon be untenable due to the magnitude of necessary datasets to process by a limited number of expert teams.
Intervention	Phase I of this project accomplished automating detection using convolutional neural networks (Ke et al. 2021). In Phase II – we will develop the classification and counting architecture of the algorithm.
Comparison	This method will use marine wildlife images collected on BOEM-funded studies to train the algorithm and compare classification efficiency across species and dynamic survey conditions.
Outcome	This project will produce a transferrable computer vision algorithm to identify and count marine wildlife in imagery collected on aerial survey operations.
Context	This project applies to all BOEM regions if the imagery is available.

BOEM Information Need(s): High-resolution camera systems are now deployed on nearly all aerial surveys to capture transect-level imagery of seabirds, sea turtles, and marine mammals. This project will develop and evaluate strategies for efficiently automating wildlife counts in aerial photographs and will reduce the costs of long-term monitoring programs through rapid data processing. This approach will also improve species identification, particularly species challenging to identify by observers on aerial surveys. Automating detection and classification with deep learning workflows will improve NEPA and similar analyses by expediting information to the manger. BOEM and multiple other agencies are collecting large volumes of aerial survey data that require years to process by hand. High-resolution imagery coupled with precise classification algorithms, as proposed by this study, will lead to more precise population estimates and species identification than visual surveys methods, while increasing safety of the scientists in the aircraft.

Background: Federal, State, and Provincial wildlife management agencies in North America have a long history of using aircraft to monitor the population abundance of marine wildlife at sea. Improved sensor, computing, and image processing technologies offer promise in enhancing marine animal population surveys' safety while improving the quality of data derived and creating a permanent, georeferenced record of observations. Automation of marine animal detections and classification is critical if remote sensing solutions are to be cost-efficient (Groom et al. 2013, Chabot et al. 2016).

In phase one of this project, we developed automated convolutional neural networks to filter out empty water imagery from large volumes of data and to accurately detect wildlife objects within the filtered results (Ke et al. 2021). In phase two, we propose to continue algorithm development to classify and count seabirds, turtles, and marine mammals in imagery automatically.

This project will partner with study AT-20-02 (AMAPPS III - Photogrammetric Aerial Surveys to Improve Detection and Classification of Seabirds, Cetaceans, and Sea Turtles). FWS (Mark Koneff) developed a high-resolution multi-array camera system to collect marine wildlife imagery at quantified multi-species hotspots (created by T. White) to improve our imagery catalog. We will also use imagery acquired by study NT-21-02 (Imagery Acquisition to Support and Enhance BOEM's Deep Learning Projects) to improve the algorithms.

Objectives: The goal of this project is to continue the development of automating detection and classification algorithms of marine wildlife (e.g., cetaceans, seabirds, and sea turtles) in digital aerial imagery. In phase 2, we will focus heavily on classification and counts. Specific objectives include the following:

1. Populate the annotated digital aerial imagery library with a higher diversity of species and environmental backgrounds that will strengthen the algorithms.
2. Develop classification and counting algorithms with a broader suite of imagery captured on AMAPPS III, NYSERDA aerial surveys and other projects that we are in the process of identifying.
3. Provide recommendations and guidance on image and environmental characteristics that maximize detection and classification accuracy.
4. Test detection and classification algorithms with a BOEM funded in-flight processing system currently in development by FWS (Mark Koneff) for AMAPPS III. When fully realized, inflight processing will use the algorithms developed by this project to detect and classify object in real time while on transect.

Methods:

- Acquire currently accessible digital aerial imagery from BOEM funded studies, and partners (e.g., FWS).
- Continue development of training algorithms using extant imagery.
- Develop and apply computer vision and machine learning algorithms to classify target wildlife species across a range of conditions affecting difficulty in classification.

Specific Research Question(s): Can an efficient and reliable algorithm be developed to accurately detect, classify, and count a wide variety marine species in digital imagery collected by offshore aerial surveys?

Current Status:

- Wildlife Annotation Tool (WAT) deployed on USGS servers and currently in use by a team of subject matter experts to annotate imagery of seabirds, sea turtles and marine mammals.
- An AL/ML wildlife object detector is functional and accurate. Species classification algorithms are in development.
- A benchmark dataset of imagery is near publication for the scientific community to experiment with.

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:

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

Groom G, Stjernholm M, Nielsen RD, Fleetwood A, Petersen IB. 2013. Remote sensing image data and automated analysis to describe marine bird distributions and abundances. Ecological Informatics 14:2–8.

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.