United States Department of the Interior
U.S. GEOLOGICAL SURVEY
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, WI 54603

MEMORANDUM

Date: September 27, 2021

To: Kate Martin, Sea Duck Joint Venture, U.S. Coordinator
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

MARK GAIKOWSKI Digitally signed by MARK GAIKOWSKI Date: 2021.09.27 11:18:14 -05'00'

From: Mark Gaikowski, Director

Subject: Memorandum of Compliance for the Inter-Agency Agreement titled '*Visibility correction factors for multiple species of sea ducks and diving duck using an aerial remote sensing approach*', October 1, 2020 to September 30, 2021.

This memorandum documents how the U.S. Geological Survey Upper Midwest Environmental Sciences (UMESC) fulfilled tasks associated with the Inter-Agency Agreement for the project titled '*Visibility correction factors for multiple species of sea ducks and diving duck using an aerial remote sensing approach*' during Fiscal Year 2021, October 1, 2020 to September 30, 2021.

Sea Duck Joint Venture
Annual Project Summary
FY2021 (October 1, 2020 – September 30, 2021)

Project Title: Visibility correction factors for multiple species of sea ducks and diving ducks using an aerial remote sensing approach (SDJV Project #160)

Principal Investigators:
Luke Fara, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, lfara@usgs.gov
William Beatty, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, wbeatty@usgs.gov
Drew Fowler, Wisconsin Department of Natural Resources – Office of Applied Sciences, drew.fowler@wisconsin.gov
Taylor Finger, Wisconsin Department of Natural Resources – Bureau of Wildlife Management, Taylor.Finger@wisconsin.gov
Brian Gray, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, brgray@usgs.gov
Steven Houdek, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, shoudek@usgs.gov
Benjamin Finley, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, bfinley@usgs.gov
Janis Ruhser, U.S. Geological Survey – Upper Midwest Environmental Sciences Center, jruhser@usgs.gov
Mark Koneff, U.S. Fish and Wildlife Service – Division of Migratory Bird Management, mark_koneff@fws.gov
Brian Lubinski, U.S. Fish and Wildlife Service – Division of Migratory Bird Management, Brian_lubinski@fws.gov

Partners:
Josh Martinez, Wisconsin Department of Natural Resources – Bureau of Wildlife Management, Joshua.Martinez@wisconsin.gov
Larry Waskow, Wisconsin Department of Natural Resources – Division of Forestry, Lawrence.Waskow@wisconsin.gov

Project Description *(issue being addressed, location, general methodology):*

This project addresses the following high priority science needs identified by the Sea Duck Joint Venture: 1) develop or refine techniques to estimate detection probabilities, misidentification rates, and biases during aerial sea duck surveys andevaluate methods to improve the accuracy and reliability of aerial, boat and ground survey methods, especially aspects relevant to sea and diving ducks and for areas outside of traditional survey areas, 2) contribute to developing and/or evaluating methods for efficiently automating counts of birds in aerial photographs of flocks, including birds with varying distributions and density patterns, and uniform vs. sexual dimorphic plumages, 3) contribute to testing feasibility of determining age and sex ratios (over a broad range) using ground surveys and/or aerial photos on fall/wintering areas to obtain an index of annual productivity for some species, specifically long-tailed ducks, and 4) contribute to identifying and characterizing attributes of key wintering and staging areas for long-tailed ducks at flyway or continental scale. In addition, the project is expected to address the following: 1) support Upper Mississippi River and Great Lake Region Joint Venture research objectives relating to understanding the importance of wintering locations for bird populations that may be dependent on habitats within the Joint Venture region, and 2) support Wisconsin Department of Natural Resources efforts to increase surveys of waterfowl during the non-breeding period.

Scope and Location

This study will take place on the Wisconsin waters of Green Bay, identified as an important stopover location to a variety of migrating waterfowl species (Prince et al. 1992; Harris 1998; Wisconsin Department of Natural Resources 2019). Due to the expansiveness and widespread use of waterbirds throughout the study area, aerial surveys provide the most efficient means of documenting waterbird use and distributions (Harris 1998).

Activities and Methods

Image collection will be flown by U.S. Fish and Wildlife Service – Migratory Bird Management Division pilots. The Kodiak aircraft (2008 Kodiak 100) used to conduct these collections is equipped with a seven-by-one camera array of Lucid Atlas 31-megapixel CMOS cameras in combination with an Applanix POS AV 510M positioning and navigation system. The sensor array, placed in a 3-axis Somag gyro-stabilized mount, can produce directly geo-referenced imagery. Flight speed will be 170 km/hr at an altitude of approximately 305 m above ground level [AGL]) that results in a 1.0 cm ground sampling distance (GSD) that covers an approximately 400 m-wide swath. Imagery will be collected along fixed transects 4.8 km apart (n = 7 per survey) in Wisconsin waters of Green Bay (Figure 1).

Targets (i.e., birds) in the imagery will be annotated to the lowest taxonomic level and with other attributes (e.g., gender, age, activity) when resolvable. We will use a mixed method of manual and machine learning algorithms to annotate images. Use of machine learning algorithms will be dependent on algorithm development and all images will be manually verified before comparing to ocular counts.

We will fly concurrent ocular surveys immediately following image collection. Ocular surveys will be flown along the same fixed-width transects within 1 hr of imagery collection and will be flown with Wisconsin DNR aircraft (Cessna Skymaster 337). Ocular surveys will be flown at 60 m AGL and at 170 km/hr. During the ocular survey, trained observers, both on the same side of the plane, will identify and tally all waterbirds within a 200 m-wide strip transect following standard waterfowl aerial survey protocols (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1987; Smith 1995; Bowman 2014). Observations will be recorded using an integrated GPS voice recording system (Hodges and Thorpe 2002), which will allow for georeferencing of each observation that is recorded and identified within the transect survey area.

To estimate visibility correction factors, we will follow previously established methods developed by Cochran (1977) and revised by Smith (1995). Recent research has demonstrated how spatial and temporal variability along with waterfowl density influences visibility correction factor estimates (Lewis et al. 2019). Therefore, we will evaluate differences in visibility correction factor estimates that are derived from covariates that include survey date, transect location, and waterfowl density of transects. Although we expect to encounter a variety of sea duck and diving duck species, we anticipate variable abundances of individual species which could result in differential levels of precision in visibility correction factor estimates (coefficient of variation <0.20). Accordingly, we will identify species that have sufficient data available to develop visibility correction factor estimates that can be used for survey correction.

Project Objectives:

The goal of this project is to determine visibility correction factors for multiple species of sea ducks and diving ducks that migrate through Green Bay. We propose to use advanced aerial remote sensors to develop visibility correction factors that can be applied to previous and future ocular surveys throughout the Great Lakes region. Specific objectives are to:

1. Collect high-resolution (1-1.5 cm) color imagery using advanced aerial remote sensors.
2. Annotate avian targets from collected imagery to the lowest taxonomic level. Incorporate annotated imagery to existing databases for training machine learning algorithms that would automate enumeration and classification of targets.
3. Conduct temporally paired fixed-width aerial ocular surveys with remotely sensed surveys allowing for the estimation of visibility correction factors and their uncertainties.
4. Evaluate visibility correction factors derived at variable spatial and temporal scales. Explore the impact of variable waterfowl density on visibility correction factors.
5. Derive baseline relative abundance and spatial distribution estimates for multiple species of waterfowl and waterbirds in the Wisconsin waters of Green Bay using data from both methods.

Preliminary Results *(include maps, photos, figures/tables as appropriate):*

Figures 2-5 provide example images collected during September 2020 when testing the image sensors over Green Bay and the northern portions of Lake Michigan.

Project Status *(e.g., did you accomplish objectives, encounter any obstacles, what are your future plans):*

We were unable to conduct our flight missions during fall 2020 and spring 2021 due to concerns and restrictions associated with the SARS-CoV-2 (COVID-19) pandemic. We are hopeful that restrictions will be reduced and that we can conduct our flight missions during fall 2021 and spring 2022.

Project Funding Sources (US$). Complete only if funded by SDJV in FY21. This is used to document: 1) how SDJV-appropriated funds are matched, and 2) how much partner resources are going into sea duck work. You may include approximate dollar value of in-kind contributions in costs. Add rows as needed for additional partners.

SDJV (USFWS) Contribution	Other U.S. federal contributions	U.S. non-federal contributions	Canadian federal contributions	Canadian non-federal contributions	Source of funding (name of agency or organization)

Total Expenditures by Category (SDJV plus all partner contributions; US$). Complete only if project was funded by SDJV in FY21; total dollar amounts should match those in previous table.

ACTIVITY	BREEDING	MOLTING	MIGRATION	WINTERING	TOTAL
Banding (include only if this was a major element of study)					
Surveys (include only if this was a major element of study)					
Research					

Literature Cited:

Bowman, T. D. 2014. Aerial Observer's Guide to North American Waterfowl. USFWS publication FW6003. Denver, CO, USA.

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 1987. Standard Operation Procedures [SOP] for Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America; revised; unpublished report.

Cochran, W. G. 1977. Sampling techniques. Third edition. Wiley, New York. 428 pp.

Harris, V. A. 1998. Waterfowl Use of Lower Green Bay Before (1977-78) and After (1994-97) Zebra Mussel Invasion. MSc Thesis. University of Wisconsin – Green Bay. 97 pp.

Hodges, J., and P. Thorpe. 2002. Voice/GPS Survey Program Manual for Breeding Population and Production Surveys. U.S. Fish and Wildlife Service, unpublished survey manual.

Lewis, T. L., M. A. Swaim, J. A. Schumtz, and J. B. Fischer. 2019. Improving population estimates of threatened spectacled eiders: correcting aerial counts for visibility bias. Endangered Species Research 39:191-206. DOI: 10.3354/esr00959.

Prince, H. H., P. I. Padding, and R. W. Knapton. 1992. Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research 18(4):673-699.

Smith, G. W. 1995. A Critical Review of the Aerial and Ground Surveys of Breeding Waterfowl in North America. U.S. Department of Interior Biological Science Report 5, Washington, D.C.

Wisconsin Department of Natural Resources. 2019. Wisconsin Waterfowl Surveys. https://dnr.wi.gov/topic/WildlifeHabitat/wfsurveys.html.

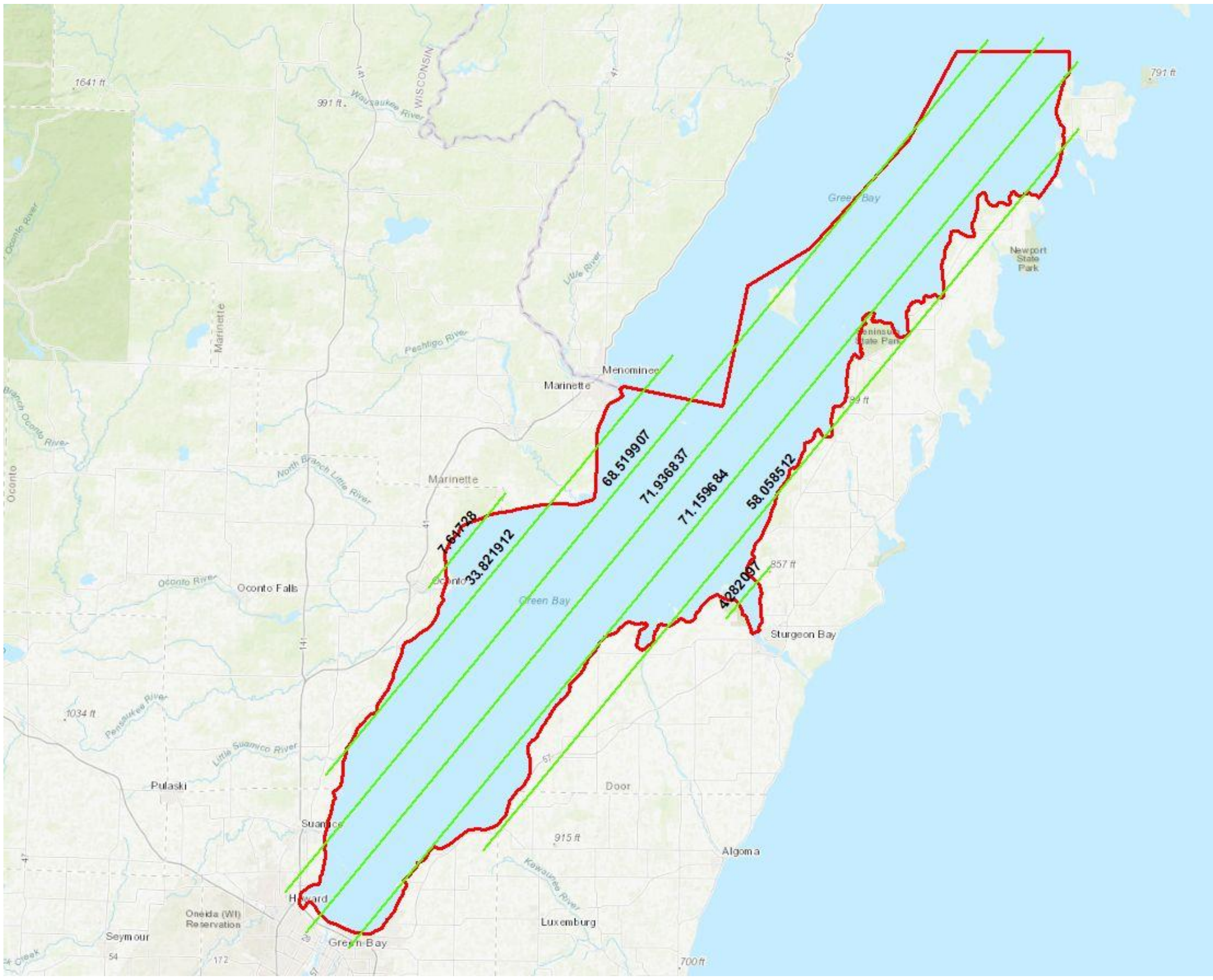

Figure 1. Map of Green Bay with proposed transects (green lines) in Wisconsin waters. Red boundary represents the total survey area.

Figure 2. Image of scaup species (*Aythya* spp.) and redhead ducks (*Aythya americana*) taken 25 September 2020 at 541 feet above ground level with a ground sample distance of 5.5 mm.

Figure 3. Image of Canada geese (*Branta canadensis*) taken 23 September 2020 at 583 feet above ground level with a ground sample distance of 5.5 mm.

Figure 4. Image of common loons (*Gavia immer*) taken 22 September 2020 at 389 feet above ground level with a ground sample distance of 4 mm.

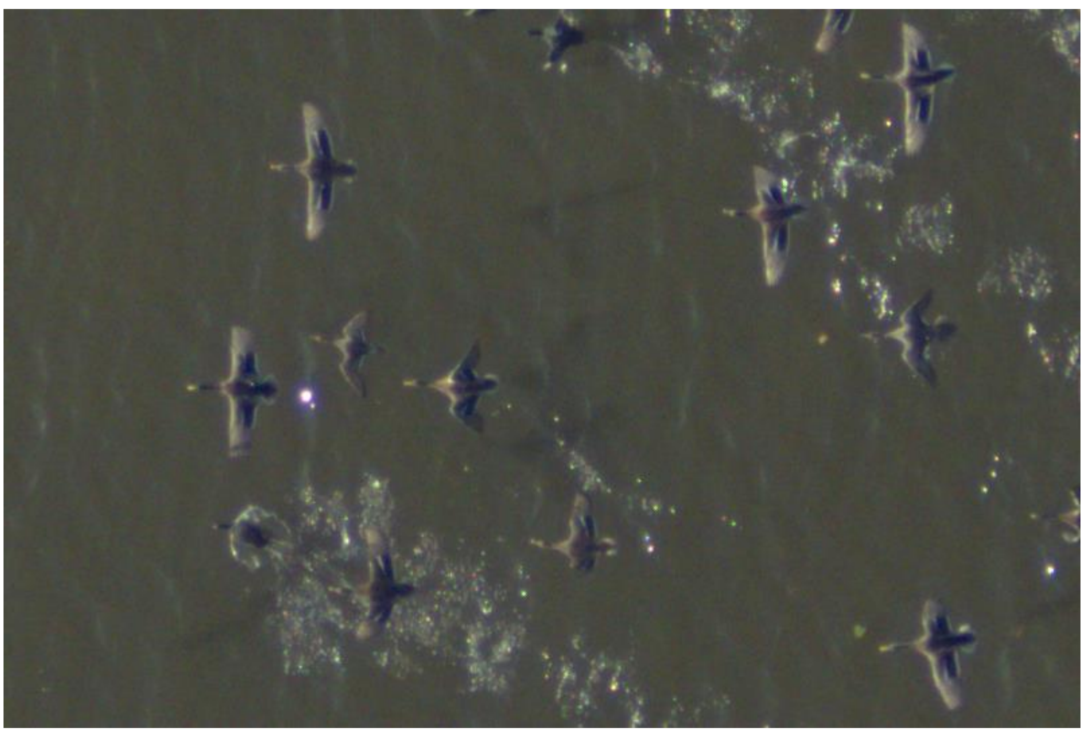

Figure 5. Image of mallards (*Anas platyrhynchos*), northern pintails (*Anas acuta*), and American coot (*Fulica americana*) taken on 25 September 2020 at 732 feet above ground level with a ground sample distance of 8 mm.