Sea Duck Joint Venture
Annual Project Summary
FY25 (October 1, 2024 – September 30, 2025).

Project Title: Unifying the coast: Advancing image-based surveys to support sea duck conservation along the Pacific Flyway, SDJV Project #173.

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Project Description*:* For most of their annual cycle, North American sea ducks are densely distributed in estuaries and along the coastal nearshore where they are susceptible to oil spills, development, changing ocean conditions, and other potential threats. Observer-based aerial surveys have been an important tool for evaluating coastal distribution and population abundances of sea ducks. However, safety, expense, observer bias and lack of methodological consistency are rising concerns associated with observer-based surveys, making it imperative to transition to more sustainable methods. Digital aerial surveys (DAS) that automate counts from aerial imagery using convolutional neural network (CNN) models are one way to improve survey safety and count accuracy. We are developing a standardized DAS for the lower Pacific Flyway to help maximize safety, while improving data consistency and model accuracy among important regions within the Flyway. To accomplish this goal, we are collecting imagery of Pacific Coast sea ducks using standardized DAS hardware and imagery collection methodology, retraining an existing Pacific Coast seabird CNN model using an iterative reclassification process to create a sea duck-specific model, and conducting DAS at key sea duck sites in the Pacific Flyway to quantify sea duck abundances and species composition. We are focusing our work in two Sea Duck Key Habitat Sites, the Puget Sound and San Francisco Bay (SFB), where we can leverage secured funding for observer-based aerial surveys to help develop robust DAS methods that will be transferrable across the Pacific Flyway.

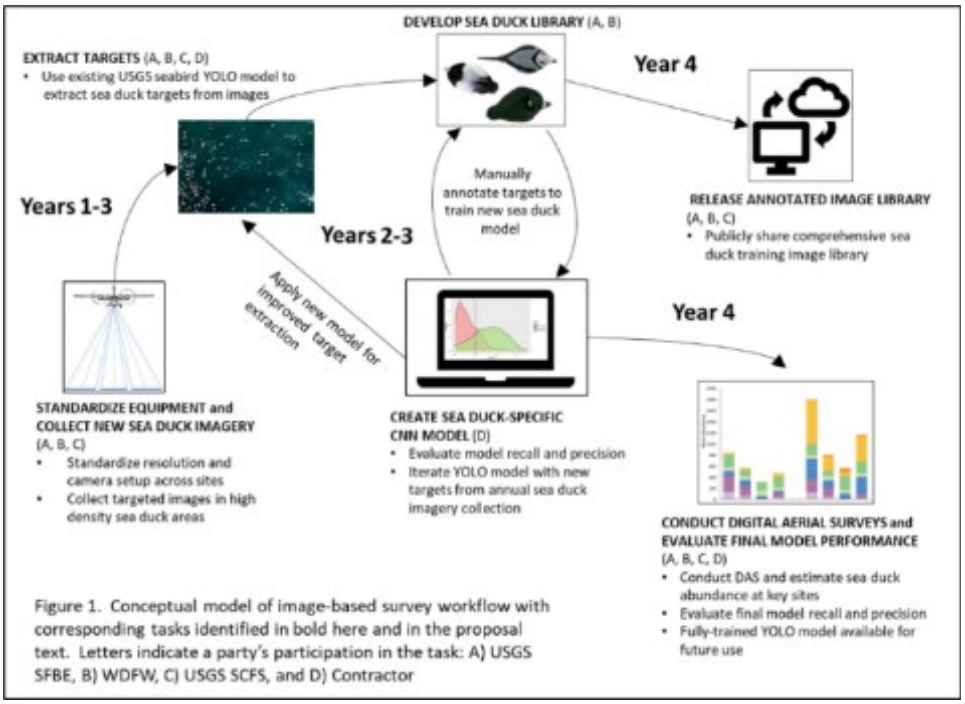

Figure 1. Conceptual model of image-based survey workflow with corresponding tasks identified in bold here and in the proposal text. Letters indicate a party's participation in the task: A) USGS SFBE, B) WDFW, C) USGS SCFS, and D) Contractor

Project Objectives: The long-term, overarching goal of our project is to develop standardized, imagery-based DAS methodology for the lower Pacific Flyway to help maximize safety, while improving data consistency and model accuracy among important regions within the Flyway (Fig. 1). Specifically, our objectives are:

1. Develop and use standardized DAS hardware and imagery collection methodology to obtain Pacific Coast sea duck images;
2. Retrain an existing Pacific Coast seabird CNN model using an iterative reclassification process to create a sea duck-specific model;
3. Conduct DAS at key sea duck sites in the Pacific Flyway to quantify sea duck abundances and species composition.

Preliminary Results: In FY25, both WDFW and USGS continued image collection for Objective 1 (Fig. 1). We used a twin-engine, high-wing aircraft (Partenavia P-68) outfitted with a belly port for each flight. High-resolution RGB still images were collected using two oblique (+/-16º) and one nadir (0º) downward facing cameras affixed to a custom mount spanning the belly port (Fig. 2). Flights were conducted at a ground speed of approximately 194 km per hour (105 kts) at an elevation of 262 m (860 ft) above sea level (ASL). Camera and lens equipment, flight speed and altitude were monitored using radar altimeter sensors to maintain a consistent image area and an average ground sampling distance (GSD) resolution within the range of 0.81- 0.93 (Table 1). The cameras were triggered simultaneously every one to three seconds with an intervalometer. The camera configuration, angle and photo interval produced gaps between adjacent and successive photos, with a resulting nominal total image area of 259×54 m assuming a level camera mount. Image acquisition flights were conducted by WDFW in the Salish Sea, WA during 14, 15, and 21 November 2024, 27 December 2024, and 10-11 March 2025 (Fig. 3A-C). During the three flight periods, WDFW collected 164,086 images. USGS collected 27,111 training images from Monterey Bay and 25,698 images San Francisco Bay, CA during 17-19 December 2024 (Fig. 4A-B). Both teams collected standardized images with similar GSD (Fig. 5A-B) to enable model training.

Figure 2. Photo of USGS camera setup in the belly window of a Partenavia.

WDFW also worked on development of an advanced version of their image acquisition system which aims to: 1) integrate Vectornav VN-310 GNSS aided Inertial Navigation System (X/Y/Z and yaw/pitch/roll location data streamed up to 400Hz with cm level precision); 2)

integrate AinStein LR-D1 Radar Altimeter (altitude data streamed at 40Hz with 0.365m level precision); and 3) programmatically trigger camera shutters based on location data with consistent spatial gaps between shutter sequence image footprints. In addition, WDFW worked on expanding the flexibility of their camera mounting system, originally developed for use on a Partenavia aircraft, so that it can be used on a dHC-2T Beaver aircraft.

Table 1. Camera and aircraft parameters for flights conducted by each project collaborator (USGS, WDFW) that captured standardized digital aerial images to train CNN models to identify sea ducks and other waterfowl.

	Camera	Resolution (pixels)	Lenses	GSD Nadir	GSD Left & Right	Mean GSD	Speed (kmh)	Altitude (m ASL)	Capture Interval (s)
USGS	Canon EOS 5Ds R (x3)	8688 x 5792	Canon EF 135mm f/2L USM	0.80 - 0.81	0.81 - 0.88	0.83	167	262	3 seconds
WDFW	Canon EOS R5 (x3)	8192 x 5464	Canon RF 135mm f/1.8 L IS USM	0.85 - 0.86	0.86 - 0.93	0.88	194	262	1 second

For Objective 2, USGS worked with Conservation Metrics, Inc. to process nearly 150,000 images using an existing Pacific Coast seabird detector model developed in You Only Look Once (YOLO). USGS set up cloud storage in Amazon Web Services (AWS) and integrated it with Computer Vision Annotation Tool (CVAT) to enable image annotation in the cloud. Using CVAT, USGS began annotating the bird images identified by the detector model to species using a standardized list of species labels developed in conjunction with WDFW. Annotated images from both USGS and WDFW imagery will be used to retrain the YOLO seabird model for sea duck detection. WDFW also evaluated a workflow that uses three models: 1) a Deep Forest bird detector model that identifies birds in images; 2) a YOLO object bird classifier model that checks bird detections from the first model to rule out false positives; and 3) a YOLO multi-species classifier model to identify waterfowl to species. WDFW retrained the detection model using 67,242 annotations from 1,340 images with a 60:20:20 train:validate:test data split. The bird classifier model was trained using 77,977 bird detections and 84,284 non-bird (false positive) detections with a 70:15:15 train:validate:test data split. The multi-species classifier model was trained using a total of 40,594 detections across 26 species-sex categories again using a 70:15:15 train:validate:test data split. Future work will include further comparison and refinement of workflows to enable standardization across the Pacific Flyway.

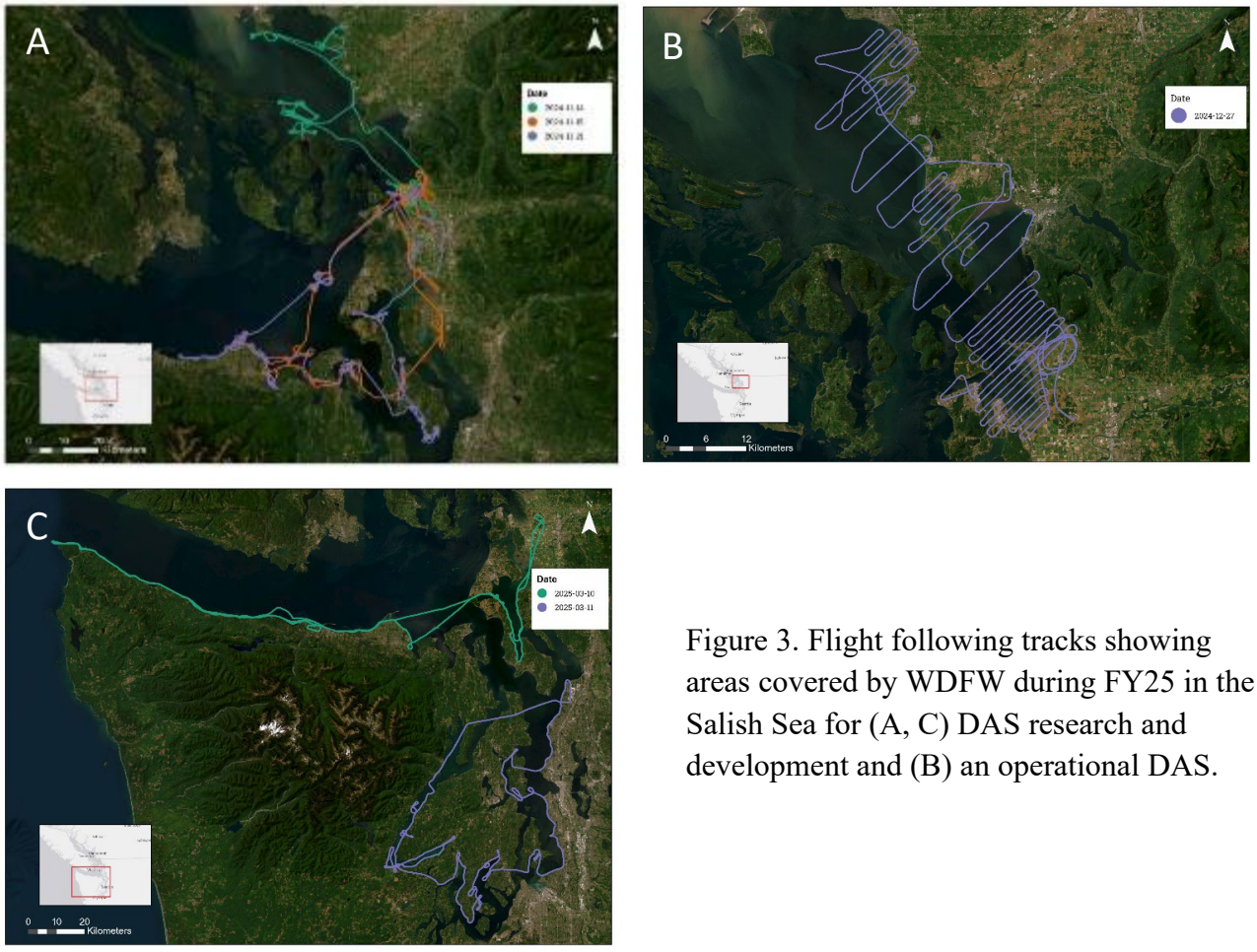

Figure 3. Flight following tracks showing areas covered by WDFW during FY25 in the Salish Sea for (A, C) DAS research and development and (B) an operational DAS.

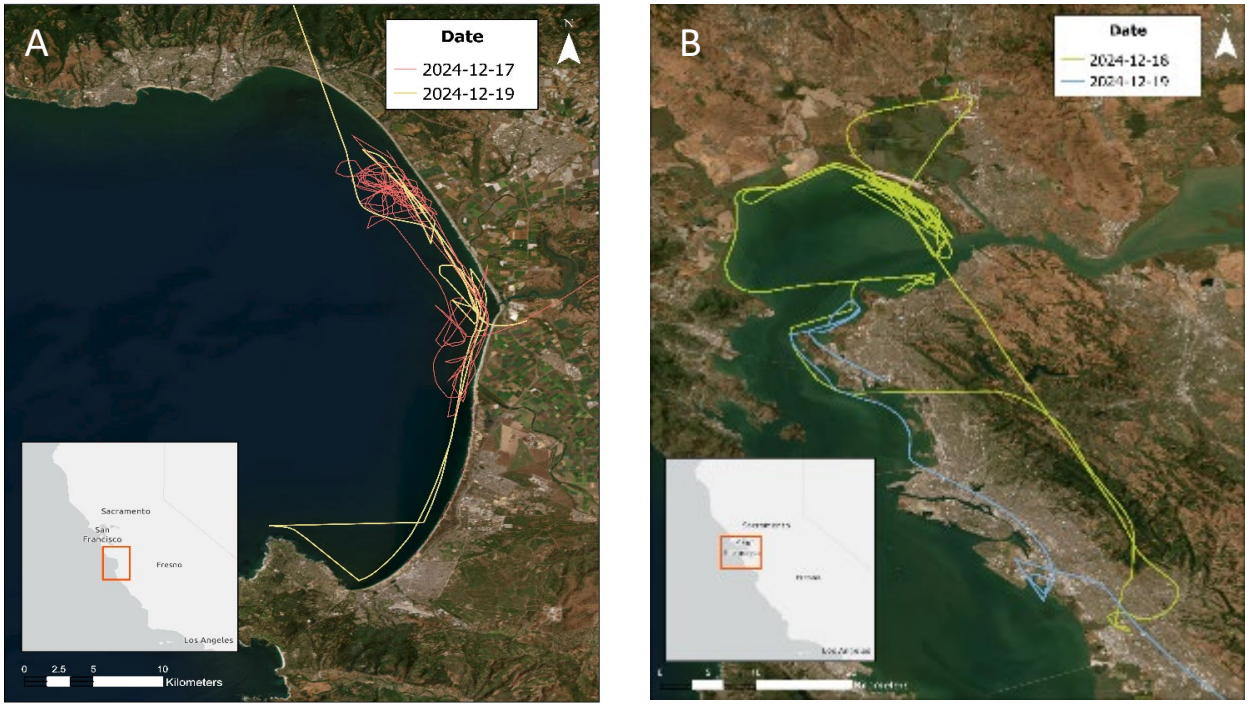

Figure 4. Flight following tracks showing areas covered by USGS during FY25 in (A) Monterey Bay and (B) San Francisco Bay for DAS research and development.

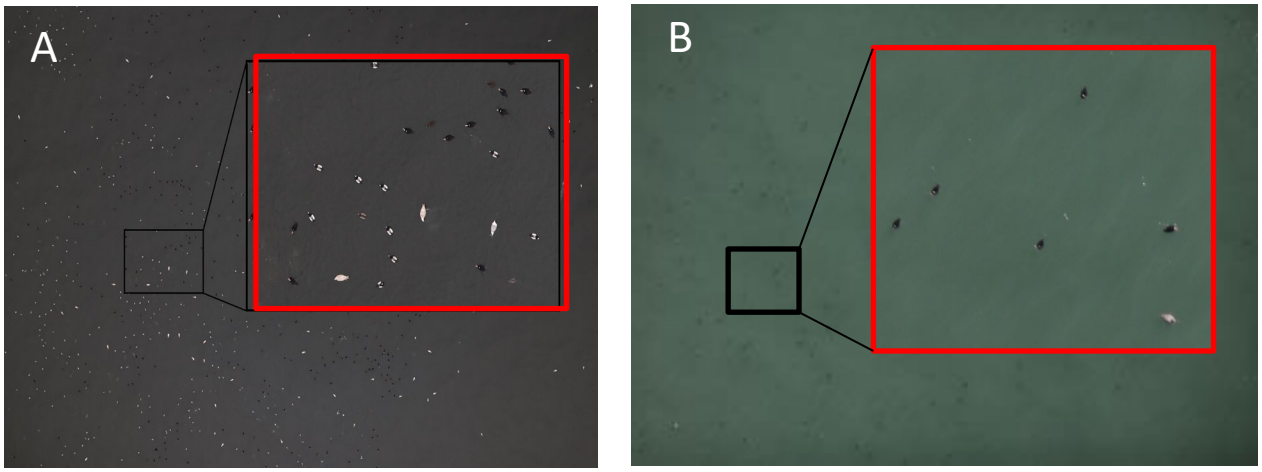

Figure 5. Examples of collected imagery with zoom-in regions showing surf scoters, scaup, and gulls from A) the Salish Sea and B) San Francisco Bay.

Project Status*:* In FY25 our project team accomplished all tasks planned for the year under Objectives 1 and 2 of the project. In a parallel project, WDFW successfully developed an operational DAS for brant *(Branta bernicla)* in Samish, Padilla, and Fidalgo Bays in Skagit County, WA during FY25 (Evenson et al. 2025). The workflow and methods developed to enumerate brant for this survey are now being used as a template for many steps in sea duck model development. In FY26, both USGS and WDFW will continue image acquisition to expand the image library ensuring adequate coverage for Pacific Flyway waterfowl species and a variety of background conditions to complete Objective 1. WDFW plans to complete two operational DAS in winter of FY26 (Skagit/Whatcom county's brant survey and sea duck survey throughout the Salish Sea in Washington State) where they will further develop and refine their camera and mounting system, survey software and hardware integration, and machine learning YOLO models. All permits are now in place to allow USGS to conduct DAS flights below 1000 asl in both the Greater Farallones National Marine Sanctuary and the Monterey Bay National Marine Sanctuary in California. In addition, both groups will continue annotating images with species identifications to improve YOLO model accuracy for sea ducks (Fig 1, Objective 2). Finally, we are planning a technical working group meeting in spring of FY26 to share results to date, lessons learned and to seek input on locations and priorities for future DAS efforts.

Project Funding Sources:

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)
$88,860					SDJV (USFWS)
		$64,952			California Wildlife Conservation Board
		$112,828			Washington Dept of Fish and Wildlife (In-Kind)
	$52,146				US Geological Survey (In-Kind)

Contributions (US$).

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)				**$318,786**	**$318,786**
Research					

References:

Evenson, J., M. Hamer and A. Annanie. 2025. Brant digital aerial survey (DAS) development and initial deployment: 2024-25. Washington Department of Fish and Wildlife, Olympia, WA.