Status and Summary of the 2013 WDFW Winter Sea Duck Aerial Survey Detectability Project - Phase 3

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Introduction

A three phase approach was implemented to investigate the utility of digital imaging equipment in assessing the detectability of sea ducks during aerial surveys. Phase 1 was implemented during winter 2011 with the goal of testing various imaging equipment on board the survey aircraft (de Havilland DHC-2) to evaluate their effectiveness in being able to document sea ducks along a 50 m transect strip; please see Appendix 1 (Proposal to SDJV: Estimating Detectability of WDFW/PSAMP Aerial Sea Duck Surveys to Correct Estimates of Abundance from Current and Past Surveys in Puget Sound, Washington State) and Appendix 2 (Report to SDJV: Summary of the Winter 2011 WDFW/PSAMP Aerial Survey Sea Duck Detectability Project - Phase 1), at the end of this document for more information related to the goals, objectives, and problem statement, and a summary of the findings of Phase 1. Applying lessons learned in phase 1, we implemented phase 2 in November 2011 and March 2012 by conducting aerial survey flights over 8 survey days; of these, 5 were useable for data analysis. Days 1 and 2 were used as test flights and resulted in the need to modify the aircraft window by removing the glass located in front of the POV camera lens, as images shot through this window were obscured. Day 3 was not useable due to misalignment of imaging equipment. Phase 3, digital image processing and data analysis, was initiated in November 2012 and is summarized in this preliminary report. This report summarizes the progress and status of Phase 3, only, and is not intended to be a detailed or final report for this project (detectability rates reported should not be cited). A detailed report will be provided upon completion of the project.

Methods

During November 2011 and March 2012 we flew eight days of transect flights imaging a 50m transect strip both ahead and abeam of the aircraft, while two observers recorded observations on the same side of the aircraft for the same transect strip. Please see Appendix 3 (Report to SDJV: Summary of the 2012 WDFW Winter Sea Duck Aerial Survey Detectability Project - Phase 2).

From these flights a total of 657 usable transects were acquired, resulting in 161,396 images. Calibration images, used to delineate the survey transect boundaries on all images, were taken at the beginning of each survey day. Transects were generally 44 seconds in length, comprising up to 340 images each (two cameras (point of view (POV) and forward facing (FF) shooting 3.9 frames per second each). We designated observations from each platform (POV, FF, and each observer (OBS1 and OBS2)) and assigned an observation ID within their respective transect ID's. Species were identified and counted for all observations.

The first phase of image/data processing was to estimate the average time it would take to process each transect. From this exercise we estimated we could process about 2.5 transects per 8-hour work day. With this estimate it could take up to 14 months to process all transects. Without sufficient resources to process all transects, we identified transects where the observers had sea duck observations (for each sea duck species), to rank transects to process. This would ensure we were not processing transects with no sea duck observations from any platform (FF, POV, OBS1, or OBS2). Additionally, we could maximize transects with multiple species, increasing our sample for each species with less effort, and would ensure the highest possible sample of those species observed in limited transects (i.e. harlequin duck, Barrow's goldeneye) without sampling all transects.

The concern with this approach is that there was the possibility of biasing the estimates of detectability high as we may have been selecting for transects with optimal observational conditions (combinations of Beaufort sea-state and glare/reflection effects on the water). In addition, it may also bias estimates of detectability high as the selection process is driven by observer observations. To rectify these issues the following steps were followed, after the initial selection of transects were processed, for each sea duck species/species group:

- calculated processed sample size for each survey condition
- calculated number of processed transects with no observer observations but that had FF observations
- identified remaining unprocessed transects for each survey condition
- identified remaining unprocessed transects spatially that were more likely to have sea duck observations that were not selected for initially

From this exercise we identified a final set of transects to process to increase sample sizes within survey conditions with small sample sizes, and to potentially increase the sample of transects with no observer observations but with FF observations, for each species/species group.

Initial Results

As of 23 August, 2013, a total of 381 transects have been processed (58% of all transects and 92% of transects identified for processing).

Table 1 summarizes initial estimates of detectability of the sea ducks. These estimates should be treated as preliminary and will likely change; we have not completed transect processing, and observational condition is not accounted for (all observational conditions are pooled). In addition, effects of seating arrangement of observers have not been analyzed. These estimates were derived by comparing average species/species group densities from FF, OBS1, and OBS2, from transects where at least one platform had observations, per species/species group.

Next Steps

- Complete processing of sea duck transects.
- Estimate a general rate of detectability for each species/species group combining all survey conditions.
- Estimate detectability rates by survey condition for each species/species groups, where possible.
- Apply rates of detection to past Puget Sound winter aerial survey efforts

- Investigate mechanisms that influence detection; these could include, but are not limited to:
    - Evaluate species classification / mis-classification. Using the FF vs. Observer we estimate a detectability correction factor, which takes into account mis-classification by estimating an overall average of observer observations and comparing them to FF observations. However, it would be useful to document how species misclassification influences detection rates, and for what species/species groups. For instance, an observer may be classifying a certain proportion of horned grebes as bufflehead. This will in turn influence the detection rates higher for bufflehead (as they will be observing bufflehead that the forward facing camera is not detecting), while at the same time influence the detection rates lower for horned-grebe, while still "detecting" the bird.
    - Evaluate how flock size and/or density influence detection rates.
    - Evaluate species relationships - which species are associated together, and which species "disappear" within these groupings (observer does not see the odd species within the larger group). It has become apparent during transect/image processing that this occurs.
- Report our findings to both the SDJV and for publication.

Table 1. Summary of initial rates of detection of sea duck species from March 2012 detection surveys in the Puget Sound.

		Average Density by Platform			Detection Rate (proportion of FF)	
Species	N of Transects	FF	OBS1	OBS2	OBS1	OBS2
Harlequin Duck	16	45.5	11.9	21.3	0.26	0.47
Scoters Species						
Black Scoter	*Not Observed*					
White-winged Scoter	47	105.6	26.9	39.0	0.25	0.37
Surf Scoter	138	77.1	47.9	61.1	0.62	0.79
All Scoters Combined	157	106.1	65.8	76.0	0.62	0.72
Long-tailed Duck	111	42.8	27.5	33.5	0.64	0.78
Goldeneye Species						
Common Goldeneye	38	29.5	6.9	24.1	0.24	0.82
Barrow's Goldeneye	6	10.0	11.9	11.7	1.19*	1.17*
All Goldeneyes Combined	58	26.3	13.7	18.8	0.52	0.72
Bufflehead	118	188.8	113.4	137.0	0.60	0.73
Mergansers	48	66.1	27.4	38.1	0.41	0.58

*BAGO detection rates were > 1; this is due to a small sample size, and misclassification.

APPENDIX 1

PROPOSAL TO SDJV FOR DETECTABILITY STUDY

Estimating Detectability of WDFW/PSAMP Aerial Sea Duck Surveys to Correct Estimates of Abundance from Current and Past Surveys in Puget Sound, Washington State.

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Request for Funding and Endorsement
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Problem/Issue Statement

The Washington Department of Fish and Wildlife (WDFW) has been conducting aerial surveys for sea ducks within the Puget Sound / Strait of Georgia (PS/SG) since 1992. From these surveys we have estimated trends in relative abundance, but estimating actual abundance or density is not possible without addressing issues of detectability. Currently, there are also sea duck surveys being conducted on the Atlantic coast of North America, with potential future surveys on the Pacific Coast. None of these survey efforts have addressed issues associated with detectability. To address these issues, we develop a novel method for addressing detectability that will have broad applicability, and will enhance confidence in distribution, abundance, and trend data of the sea ducks. Specifically, we develop and propose to test techniques for examining issues associated with group identification and enumeration.

SDJV Population(s) Targeted

North American Pacific populations of surf scoter (*Melanitta perspicillata*), white-winged scoter (*M. fusca deglandi*), black scoter (*M.nigra americana*), harlequin duck (*Histrionicus histrionicus*), long-tailed duck (*Clangula hyemalis*), Barrow's goldeneye (*Bucephala islandica),* common goldeneye (*B. clangula americana*), bufflehead (*B. albeola*), common merganser (*Mergus merganser americanus*), red-breasted merganser (*M. serrator*), hooded merganser (*Lophodytes cucullatus*).

Justification

Ongoing aerial survey efforts on both coasts of the U.S. have not adequately addressed issues of detectability. As a result, we don't have estimates of birds missed along aerial transects, we don't know whether or not birds are correctly enumerated and identified, and we don't understand the influence of group size on enumeration or group detectability. Finally and perhaps most importantly, we don't know if changes in abundance or detections over time reflect actual changes in population abundance or simply reflect changes in detectability. Detectability can influence estimates of abundance/density because of differences in observer abilities, because of changes in environmental conditions (wind, glare, swell, wave, etc.) between sampling efforts, because of changes in sampling platforms (aircraft types), changes in elevation and speed, and so on. Recent research on marine bird detectability from boats indicate that even within 150 m of the transect line in relatively calm conditions, anywhere between 25 and 90% of bird groups on the water may be detected depending on species, year and/or observer (e.g., Ronconi and Burger 2009). Fortunately, new methods have been developed to address detectability and to include covariates to minimize heterogeneity in detection probability (e.g., Thompson 2002). In addition, recent advances in imaging technology are providing tools to estimate wildlife abundance from aerial surveys (Hedley et al. 2007, Mellor and Maher, 2008, Shelden et al. 2008, Burt, et al. 2009, Thaxter and Burton, 2009). Estimates of abundance and detectability of sea ducks will benefit from these techniques.

We have documented declines in several marine bird species over the past 19 years (Nysewander et al. 2003, 2005, Evenson, unpub. data). Of the sea ducks, Scoters have demonstrated the largest declines with a decrease of 57% ($P < 0.001$) from 1979 through 1999 (Nysewander et al. 2003, 2005), with roughly another 50% decline from 1999 through 2010

(Evenson, unpub. data). We are fairly confident that these trends are accurate because we have used the same sampling protocol, platform and survey crew for the past 19 years. However, estimates of detectability are needed to determine true population sizes, which are needed for management decisions. We also will switch crews in the future (retirements, changes in job status) or change platforms; it is essential that we address issues of detectability in order to compare data collected before and after such changes. Coast-wide efforts are even more likely to involve varying models of aircraft and different crews within and among years – indicating the need to address detectability if the goal is to assess population trends or derive population estimates.

For the PS/SG region, our data strongly indicate population declines but we don't know what proportion of the flyway population the wintering PS/SG scoters comprise. Without an estimate of detectability we are limited to documenting a decline without understanding the significance of the decline to overall scoter populations on a flyway scale. In addition, without having a more defined estimate of population, it is difficult to effectively manage sea duck species based on the needs and requirements of local populations. An understanding of issues associate with detectability will help us begin to understand the relative importance of local populations.

Other studies have addressed detectability by comparing vessel surveys to aerial surveys (Henkel et al. 2007, Nysewander et al. 2005). Recent research suggests that vessel surveys have their own biases and are not reflective of actual abundance (Ronconi and Burger 2009, Hyrenbach et al. 2001, Spear et al. 2004). Aerial-vessel comparisons have varying results which are dependent on both the types of vessel and aircraft utilized (some comparison's show higher rates of detectability for vessels, while in some comparisons the aircraft rates are higher). The other issue with these comparisons is that different species react differently to both vessels and aircraft.

In addition to detectability, a better method of determining species composition of grouped species scoters, goldeneyes, and mergansers is needed. Current WDFW observers have many years experience identifying sea ducks to species (1996 to present). However, even with this long-term experience, since 2004 (when our observers had sufficient experience that unidentified species remained below 30%), the proportion of scoters, goldeneyes, and mergansers that are unidentified to species have ranged from 10-21% ($\bar{x}$=15%), 8-25% ($\bar{x}$=16%), and 9-26% ($\bar{x}$=21%), respectively (Evenson, unpub. data). It is crucial to understand species ratios for lumped species groups to understand the rates of change of each individual species. For example, surf scoters have comprised ~75% of all scoters from between 2008-2010. Due to the high proportions of surf scoters, changes in surf scoter abundance, either up or down, will drive the trend for all scoters, thus eliminating the ability to detect changes in the less abundant scoter species. For example, the PS/SG population of white-winged scoters could be declining, but with a stable to slightly increasing surf scoter population, this decline would go undetected. In fact, our PS/SG sea duck species ratio vessel surveys (2008-2010) indicate that both surf and white-winged scoters contribute to scoter declines (Evenson, unpub. data). During the winter of 2010 surf scoter numbers stabilized, while the white-winged scoters have continued to decline (Evenson, unpub. data). Without reliable estimates of species ratios these changes would go undetected. Due to the costs and time involved to conduct vessel surveys of species ratios, it will not be feasible to continue them in the future.

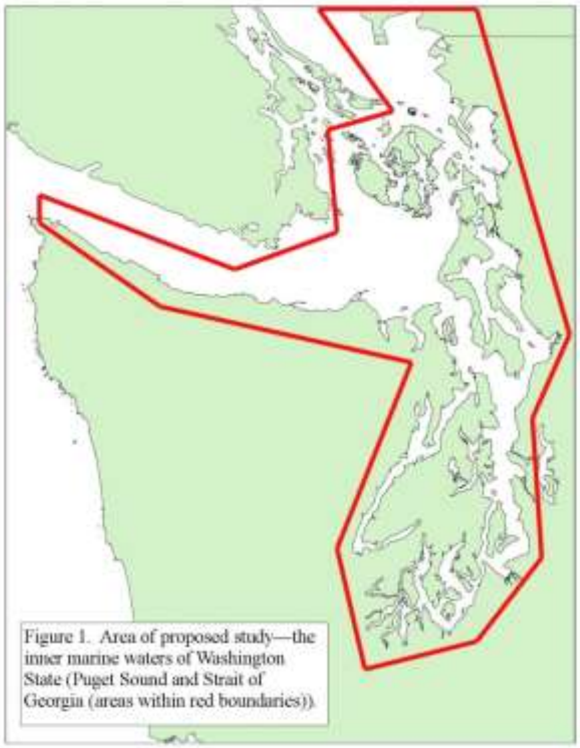

Figure 1. Area of proposed study—the inner marine waters of Washington State (Puget Sound and Strait of Georgia (areas within red boundaries)).

In 2010, WDFW implemented a sea duck management plan that relies on the accuracy of the WDFW/PSAMP surveys to accurately estimate population. Currently, population thresholds of scoters have been established to dictate harvest rates for many of the sea duck species in western Washington (Kraege and Evenson, 2010). The proposed research will allow us to derive population estimates that address issues of detectability and address factors that are likely to affect our ability to accurately detect and reflect population trends – a critical information gap.

OBJECTIVES OR HYPOTHESES

Our goal is to derive a correction factor for observed counts to make them more reflective of the actual number of birds on the water. We do this by: (1) estimating the effect of the airplane on sea duck availability; (2) determining the probability that an observer correctly detected groups; (3) quantifying the relationship between actual group size and the counted value; and (4) assess the utility of the double observer method for addressing issues of detectability. We will accomplish objective one using a forward facing camera and objectives 2-4 using a double observer approach in combination with a video "observer" as described below.

SCOPE AND LOCATION

The principal study area will encompass the PS/SG; this will include the Puget Sound, Strait of Juan de Fuca and southern Strait of Georgia (Figure 1.). This area has served as important wintering habitat for sea ducks along the Pacific coast, and is the same area flown annually for the WDFW/PSAMP surveys (Nysewander et al. 2005). Transects will be flown along the shoreline, and in open water covering varying depth zones occupied by sea ducks. By distributing transects across the study area we will insure that the correction factors derived are reflective of the sea duck species composition and patterns of abundance in the region,.

EXPERIMENTAL DESIGN

<u>Aerial Methodology</u>

We will randomly select transects from a list stratified by evaluating past documented sea duck distributions to ensure coverage of low through high concentrations of the sea ducks, and will cover both shoreline and open-water areas. We will fly using the same aircraft and survey methodology used during past WDFW/PSMAP surveys (aircraft = DHC-2 Beaver on floats; altitude = 200' AGL; speed = 85-90 knots; Survey Strip = 50m {edge of the floats (58º) to a ¼ inch poly line tied to the wing-strut at 33º}) (Nysewander et al. 2005). DLOG 3 (R.G. Ford

Consultants) will be used to log transects routes, location data, and environmental conditions (sea state, and glare per observer). An opaque isolation screen will be placed between observers to block any visual cues between them (what they are viewing, if recording, etc). The observers will also be audibly isolated by a combination of helmets and aircraft noise. Observers will be randomly rotate positions (forward and rear seats) while ensuring equal time spent in each position during areas of low and high concentrations. A total of 20 hours flight time will be budgeted for the main detectability flights, of which 65-70% of the time would be actually spent surveying. This will equal 1900-2200 linear Km of transects.

Concurrent double observer / HD point of view imaging (POVI) video transects

- An HD video camera with image stabilizing features (Table 1, effective 3rd-observer) will be mounted within the aircraft at the same eye-height as the observers so that the field of view is the same between observer and camera;
- Observers will record observations (species, count, time) onto digital recorders;
- Observer glare and Beaufort sea-state will be recorded onto a log file and applied to each observation;
- Aircraft heading and angle to the sun will be calculated for each observation;
- Vocal observations will also be concurrently recorded onto video audio recording, one channel (left or right) per observer.

Table 1. POVI HD video camera resolution specifications – 35mm lens, side mounted, format 16:9.

Resolution	1080 x 1920				Pixels/body length										
Altitude (ft)	200	Width(m)	Pixels/cm	cm/Pix	WWSC	SUSC	BLSC	HADU	LTDU	BAGO	COGO	BUFF	COME	RBME	HOME
DistMid(m)	63	33	0.3	3.1	17.3	16.7	15.7	13.7	13.4	15.1	15.4	11.1	20.9	19.0	15.1

Forward Facing Imaging (FFI)

We will conduct an initial flight to estimate a general maximum distance that sea ducks react to the aircraft to determine the appropriate imaging equipment to use. We will estimate this distance by flying at survey altitude (200' AGL) along pre-defined transects at 85 knots ground speed. An observer in the forward (co-pilot) seat will be looking from the front and side windows of the aircraft as far forward as can be viewed. Groups of sea ducks at the forward limit of visibility will be identified, then an angle will be recorded when the 1st avoidance behavior is noted (diving or flying). Species will also be noted. We will obtain distance readings for the following species each (scoters, goldeneye, and bufflehead). The furthest distance will then be used to determine distance the forward facing cameras need to be focused on.

In the following sections we assume a maximum reaction distance of 300m, however, equipment will be used that fits the actual maximum reaction distance estimated above.

We will employ two imaging methods to assess sea duck reaction to the aircraft (determining the number of birds on the transect strip, before an avoidance reaction, and comparing those numbers to the number of birds remaining within the transect strip when perpendicular to the aircraft, as seen in the POVI imagery). We will test a fixed forward facing HD video camera, and fixed forward facing DSLR camera, which will be mounted on a wing-strut or float of the aircraft to record the transect strip forward of the aircraft. There is some concern that aircraft vibration will affect video capture of the forward transect strip; video may be preferred to still photographs, thus both HD video and DSLR imagery methods will be compared.

HD video will run concurrent with defined transects utilized for the double and POVI 3rd observer method described above. HD video will, at a minimum, conform to resolution specifications listed in table 2.

Table 2. Resolution options of forward facing HD video camera utilizing either a 100mm or 75 mm lens.

100mm Lens

Resolution	1080 x 1920				Pixels/body length										
Altitude (ft)	200	Width(m)	Pixels/cm	cm/Pix	WWSC	SUSC	BLSC	HADU	LTDU	BAGO	COGO	BUFF	COME	RBME	HOME
DistMid(m)	300	53.0	0.4	2.8	19.2	18.5	17.4	15.2	14.8	16.7	17.0	12.3	23.2	21.0	16.7
DistNear(m)	237.7	42.5	0.5	2.2	24.0	23.1	21.7	19.0	18.5	20.8	21.3	15.4	28.9	26.2	20.8
DistFar(m)	396.2	69.5	0.3	3.6	14.6	14.1	13.3	11.6	11.3	12.7	13.0	9.4	17.7	16.0	12.7

75 mm Lens

Resolution	1080 x 1920				Pixels/body length										
Altitude (ft)	200	Width(m)	Pixels/cm	cm/Pix	WWSC	SUSC	BLSC	HADU	LTDU	BAGO	COGO	BUFF	COME	RBME	HOME
DistMid(m)	300	70.7	0.3	3.7	14.4	13.8	13.0	11.4	11.1	12.5	12.8	9.2	17.4	15.7	12.5
DistNear(m)	237.7	56.7	0.3	3.0	17.9	17.3	16.3	14.2	13.9	15.6	15.9	11.5	21.7	19.6	15.6
DistFar(m)	396.2	92.6	0.2	4.8	11.0	10.6	10.0	8.7	8.5	9.5	9.7	7.1	13.3	12.0	9.5

When using a DSLR FFI camera, images of the survey strip, ahead of the aircraft, will be acquired at a standardized rate that is a minimum of one image per second. With a focal length of 105mm, capturing a focal point 300m on the transect strip, ahead of the aircraft, will provide a width of 64m, and a vertical height of 9º; this will provide sufficient resolution (1.5 cm/pixel at 300m, Table 3) while providing overlap between concurrent images while flying at 85 knots GS (the aircraft will be traveling at roughly 44m/sec). Images will be exposed for a minimum of 1/800th second (0.054m of forward movement), to reduce blur. Information recorded for each image will include date, precise time (HH:MM:SS.s), heading, angle to the sun, cloud cover, ground speed, and GPS potion (Lat/Lon).

Table 3. Image resolution of forward facing DSLR camera using 105mm lens, 200ft altitude, focal point 300m ahead on the transect strip, within the center of the image.

Camera (Nikon)	Pixels/cm	cm/Pix	Pixels/body length										
			WWSC	SUSC	BLSC	HADU	LTDU	BAGO	COGO	BUFF	COME	RBME	HOME
D300S	0.7	1.5	35.5	34.2	32.2	28.1	27.5	30.8	31.5	22.8	42.9	38.9	30.8

Imagery specifications

We will maintain the following minimum video and still imagery specifications as reported by Thaxter and Burton, 2009: 1) Video imagery must obtain a minimum of 5 images per individual spanning 0.5 sec; 2) All imagery will maintain a minimum resolution of 5 cm to allow for species identification; 3) All imagery (video and stills) exposure will be optimized for sea duck species, with an exposure chosen that maximizes the number of species identified.

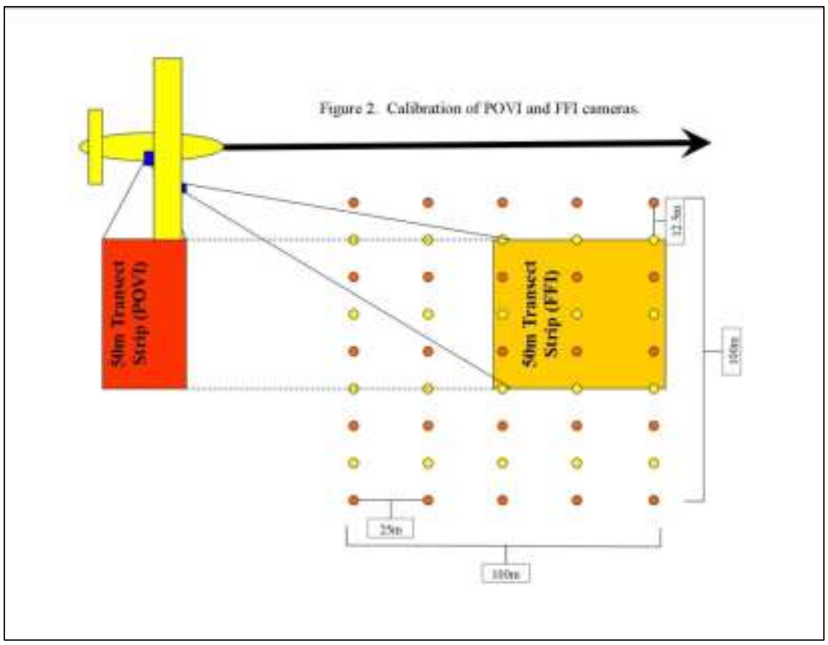

Figure 2. Calibration of POVI and FFI cameras.

Calibration of POVI and FFI

We will calibrate the FFI and POVI cameras to ensure they are viewing the same 50m transect strip. This will be done in the field at a location that is both flat and sufficiently remote so continued passes of the aircraft do not pose any disturbance to the public. A grid of floats/markers will be placed 12.5m apart (left to right) and 25m apart (forward to back) in relation to aircraft direction of travel (Figure 2). We will fly repeated passes with the aircraft to line up the floats that pass through the FFI camera with the POVI camera (and respective observer for that side of the aircraft). We will make adjustments to the FFI until the 50m transect strip within each camera (FFI and POVI) matches. Positions of the transect strip boundary will also be noted on the FFI image, as it will be recording a wider strip than 50m. Once positioning of the FFI camera is established it will be locked in place.

POVI / observer comparison

We will view POVI video for each transect. Sea state and glare conditions will be recorded and each sea duck group will be identified to species, and sex (if possible), and enumerated. We will evaluate observer audio at the time of the A/V recording to determine if each sea duck group is observed, properly categorized, and enumerated.

Comparison of POVI and FFI

We will evaluate FFI imagery by counting all sea ducks to species, and sex (if possible) within the survey strip forward of the aircraft. We will evaluate speed to determine the lag between these images, and when the respective areas come into view on the POVI video. We will compare counts between the FFI and the POVI for each set of transects to determine proportion of birds that avoided the aircraft, thus were not detectable by observers. We will also evaluate angle to the sun to determine if it effects sea duck reaction to the aircraft.

Data Analysis

To address the first objective, quantifying availability, we will perform the following analyses for each species. Regression will be used to predict the number of birds observed in the FFI from the number observed in the POVI. The total number of birds of all species, will also be investigated as a possible covariate. Second, ratio estimation will be used to estimate the proportion of individuals that are observed in the POVI camera of those observed in the FFI camera. Logistic regression will be used to test for effects of the flock size, both the number of birds of the target species and the total number of birds across all species, on availability.

The following analyses will be used to address the second set of objectives. Logistic regression will be used to predict the probability that a group (of one or more birds) visible in the POVI is detected using the following explanatory variables: observer, glare, Beaufort scale, group size. For each observer; the mean squared error (MSE) between group size recorded by the observer and on the POVI. Regression will be used to predict MSE from group size, glare, and Beaufort scale. Regression will also be used to predict the number of birds on the POVI from the number recorded by each observer, as well as glare and Beaufort scale. We will estimate error (MSE) and detection rates on a per-observer basis.

ANTICIPATED OUTPUT

The final results from this study will provide correction factors to apply to past WDFW winter aerial survey data, and will be applied to future surveys. They will also provide an approach to addressing the important issue of detectability, and will enhance confidence in distribution, abundance, and trend data of the sea ducks within the PS/SG, as well as other sea duck surveys.

We will apply the POV observer/video detectability methodology to future surveys, each year, to address annual variation per observer, as well as to estimate detectability of new observers. The forward facing imaging methodology to estimate sea duck reaction to aircraft will be employed if/when survey platform changes. Recorded video of the POV surveys will be utilized as training videos to agency staff to significantly reduce flight hours to train new observers. These videos will be shared with other waterbird survey researchers as training aids.

This study will also result in one publication describing the methods employed, the estimates of detectability by species, and updated population estimates. These updated estimates will also be shared with the Washington State Puget Sound Partnership Agency, and will be used to direct sea duck management decisions within Washington State. Finally, results of the study will also be published on the WDFW website for public consumption.

MANAGEMENT IMPLICATIONS

The findings of this study have several important management implications which will provide:

- Correction factors for past PS/SG data to refine population estimates and harvest management strategies;
- An approach for addressing some of the detectability issues associated aerial surveys throughout U.S. and Canada and result in more robust estimates of abundance and increase our ability to accurately assess population trends;
- Reductions in future survey training costs as POVI video will serve as a training aid related to identification and enumeration, without the costs of using aircraft;
- New video and still photographic technology in an innovative approach applicable to other surveys.

RELATIONSHIP TO OTHER PROJECTS

Remote monitoring of waterfowl populations has been limited in the past by technological capabilities. The proposal will utilize several new technologies that show promise in refining current survey techniques. Thousands of hours are spent each year throughout North America in estimating waterfowl abundance and species composition using aerial techniques, and this study will have broad applicability to a wide variety of current survey efforts.

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Personnel

Joseph R. Evenson – Principal Investigator

Joe has experience with a variety of marine bird, and waterfowl projects over the last 21 years. He coordinates the WDFW/PSAMP winter aerial surveys of marine birds, and was the project lead for the 2007-9 scoter survival study in Puget Sound and the Strait of Georgia by capturing scoters, and oversees other studies of sea ducks throughout Puget Sound.

Shannon Knapp – Principal Investigator

Shannon is the Wildlife Biometrician for WDFW. She received a Ph.D. in Statistics from Purdue University, a M.S. in Wildlife Science from Virginia Tech, and a B.S. in Biology from American University.

Scott Pearson – Principal Investigator

Senior research Scientist with Washington Department of Fish and Wildlife. Scott has >18 years of research experience including designing and publishing studies on population status and trends, habitat selection, and diet. Scott currently coordinates WDFW's at-sea surveys for the marbled murrelet using line transect of DISTANCE surveys, and is assessing the status and trends of tufted puffin, rhinoceros auklet and western snowy plover.

Don Kraege – Principal Investigator

Don has worked as the Waterfowl Section Manager for Washington Department of Fish and Wildlife (WDFW) since 1983, overseeing all work related to waterfowl management and research. During that time he has coordinated and participated in numerous banding and marking projects throughout the Pacific Flyway, ranging from banding lesser snow geese on Wrangel Island, Russia to banding harlequin ducks in northern Puget Sound.

Tom Cyra and Bryan Murphie

Bryan and Tom have served as key field staff in all of WDFW's sea duck projects. They both specialize in marine field work and aerial surveys, and have served as the principal observers for the WDFW/PSAMP flights since 1996 and 1997 respectively.

Schedule

- Late November – early December 2011 – Set up aircraft with POVI imaging equipment
- December 1, 2010 – January 31, 2011 – Fly mid-winter transects of the entire study area as part of the annual PSAMP / Midwinter Aerial Survey. Apply concurrent 2^{nd} observer video capture of the transect strip, and employ forward facing imagery capture as established by survey protocols
- Late January 2011 – Set up aircraft with FFI imagery equipment and test, calibrate.
- February 1-20, 2011 – Fly concurrent double observer and video transects, while applying forward facing video/image capture
- April 30, 2011 – Data/image processing complete
- July 31, 2011 – Data analysis complete
- August 31, 2011 – Correction factors applied to past surveys
- September 29, 2011 – Submit SDJV annual report
- Spring 2012 – Manuscript completed

APPENDIX 2

REPORT FOR PHASE 1

Summary of the Winter 2011 WDFW/PSAMP Aerial Survey Sea Duck Detectability Project - Phase 1

Joseph Evenson, Tom Cyra, Bryan Murphie, and Don Kraege

August 2011

Washington Department of FISH and WILDLIFE

Introduction

This effort was implemented to investigate technologies to assist in answering detectability of sea ducks from aerial surveys. The goal of this first phase of the project was to test various imaging equipment on board our survey aircraft (a de Havilland DHC-2) to evaluate effectiveness in being able to document sea ducks along the 50 m transect strip; please see the Proposal submitted to the SDJV at the end of this document for more information related to the goals, objectives, and problem statement. This summary report is not intended to be a detailed report, but instead is to be used as a brief summary on the first phase of the project.

Methods

All test flights were conducted using a de Havilland DHC-2 Beaver on floats. Some imaging equipment was initially tested during the December-January WDFW/PSAMP marine bird surveys, but we found it difficult to adequately test equipment while conducting the surveys. Dedicated flights were flown in February and March, 2011, to test imaging equipment and mounting platforms.

POV (Observer Point of View) Cameras

To document sea ducks along the transect strip from same point of view as the observers during surveys we tested both video and DSLR still cameras. All POV cameras tested were mounted either to a tripod or to suction cup mounts on the windows. The use of tripods was stopped after the first test, as excessive vibration travelled through the floor of the aircraft to the camera. Even with image stabilization (IS) active the vibration was too severe for useful imaging. We found that the suction cup mounts and suction cup window mounted tripods worked quite well, as vibration was not a factor when these were used.

We tested several video cameras for their effectiveness in capturing the transect strip along the side of the aircraft. We began with HD 1080i CMOS sensor video cameras, using both image stabilized and non-stabilized modes. CMOS sensor equipped video cameras were not effective for this application due to the blur ("wave affect") on the sensor from moving objects; as the entire image is moving, the effect was severe. HD 10801 CCD sensor equipped cameras were also tested. Due to the speed of the aircraft (85 knots), and the frame rates of the cameras first tested (60 frames/sec), birds entered and exited the field of view (FOV) too quickly to be identified. For the FOV to be completely represented in the camera image area, birds would cross the FOV in 0.75 to 1.5 seconds, depending if the camera was oriented portrait of landscape. At 60 frames/sec, there was still blurring around birds on the water; a crisp outline of a bird was never observed, instead the birds were elongated when viewing each frame independently.

The final test of video cameras included a professional RedCam studio quality camera (we also hired professional technicians to assist in setting up and testing this camera) (Figure 1). The RedCam has the ability to record at 120 frames/sec and has better controls for processing lighting, and also offered a much wider field of view, allowing birds passing through the FOV to be captured for >2 seconds. The initial results from these tests were promising, but there was still a small amount of blurring around the sea ducks imaged when viewing individual frames. Positive identification of birds passing through the FOV was not possible unless the images of birds were observed at the frame level, and zoomed in to the area of the respective target bird. Even doing this, many images were still not quite crisp enough to provide confidence in consistent species classification.

At the same time we tested video cameras we also concurrently tested a DSLR still camera, the CANON EOS 5D Mark II equipped with a Canon EF 24-105mm f/4L IS USM lens. The results from this camera/lens combination were superior to all video images tested due to the high resolution (21mp), fast shutter speed (we found it best to shoot at 1/800second or faster), combined with continuous shooting at 3.9 frames/second. The camera was oriented to shoot on its side (portrait orientation) thus each frame captured the FOV of 55-60m deep by 40m wide. This configuration provided four frames of each bird passing through the FOV. We also attached black fabric around the lens, and then to the window, to eliminate any reflection on the glass from objects within the aircraft. Figures 2 & 3 show the mounted Canon POV camera.

FF (Forward Facing) Camera

We did not field test any video camera for FF except for test filming from within the aircraft facing forward. Curvature on the aircraft windshield made this not a viable option. Our first objective was to determine the feasibility of video imaging along complete transect strip inside the aircraft (during the POV tests) before applying the technology to the outside of the aircraft. We also did not want to manufacture mounting devices on the outside of the aircraft for equipment that may not work. We did, however, look into outside-of-aircraft mounting and configuration of existing HD Video cameras used on DHC-2 Beavers. During an interview with a pilot/technician, who has one of these mounts and a HD video camera, we were discouraged from attaching anything to the wing-strut due to vibration. He did encourage us to consider his float mounted device, however, we decided against utilizing this until the question of video feasibility had been answered.

With the effectiveness of the Canon EOS 5D Mark II in the POV tests we tested a second Canon equipped with a Canon EF 70-200mm f/4L IS USM lens. This camera was mounted high on the wing strut close to the point of attachment to the wing to reduce vibration from the strut cowling. Attachment high on the wing-strut also put the camera away from turbulence from the aircraft propeller, as well as potential water spray during take-off and landings. In addition, we found that this high placement reduced the amount of rainfall coming in contact with the protective lens filter. Figures 4-6 show the mounted FF camera.

We were able to effectively capture the transect strip ahead of the aircraft (250-300 m) and image groups and individual sea ducks that were identifiable to species during testing of the FF camera. In some situations lighting was an issue, especially later in the day during overcast situations. A faster lens providing a stop or two of extra light would rectify this.

Camera Set Up Notes

- Each camera was equipped with SanDisk Extreme 32GB 60MB/sec UDMA memory card. We found these cards were fast enough to capture all images while shooting continuously. A faster card is not necessary as the speed of the card is faster than the cameras internal buffer, which prohibits it from shooting over 40-45 seconds without a break (A slower card however, would likely not work). A 64 GB card would be better as it would allow the ability to survey twice the area before transferring image files to a PC.
- Each camera was equipped with a wired remote control. The camera operator would activate continuous shooting on the FF camera, then after 5 seconds begin continuous shooting on the POV camera (The POV is delayed as it takes 6-8 seconds for the area captured on the FF camera to reach perpendicular to the aircraft. Each camera would be shut off after 40 seconds of continuous shooting each. After a 5 second pause, this step would be restarted. This pause was necessary to clear the internal camera buffer.
- External Power supply. The FF camera was equipped with an external power supply to eliminate the need to change batteries. During the upcoming 2011-12 phase of the study we plan on using external power on both cameras.
- The time (to the second) was synchronized on both cameras as well as observer watches. Image file naming was set to <date> + <time> (to the second). By using this naming structure the POV and FF images could be calibrated, and they could be matched up with the recorded times of the observer observations.
- We did not use polarizing filters during this phase of the project, but we plan on using them on both cameras during the second phase of the project. This will reduce the effects of glare on the images, and we have found that high-quality filters do not have a significant effect on lighting.

Notes on Calibrating Cameras to the Transect Strip

Initially we set up a 300 m X 80 m grid using flagging on the agricultural lands adjacent to Skagit Bay. 200 m of this grid were denoted by flagging markers every 25 m on the strip edges. The 100 m X 80 m end section of the grid was marked with flagging every 10 x 10 m. The plan was to calibrate the FF and POV cameras to this grid by flying over, imaging, and making necessary adjustments to the orientation and zoom level of each camera.

The problem with this design is that the grid is fixed and cannot be moved to adjust for winds. With even a slight breeze in any direction except directly at the nose or tail, the aircraft will not fly straight; the aircraft would instead be turned slightly to maintain a straight flight path. Because of this, it would not be possible for the FF camera to capture the transect strip directly ahead of the aircraft. To correct for this we set the grid on the water where it could be adjusted to line up with the wind. The on-water grid would be setup close to a navigation buoy, using this buoy as the 1st object on the grid, and then using our boat as the end point of the grid, 300 m past the buoy. We would position large red floats between the buoy and boat, and along a parallel line offset 50 m.

We found this technique effective and relatively quick to set up. If the wind did change we could reposition the grid in about 30-45 minutes. Figure 6-7 shows FF views of this grid.

Results from the calibration worked well, and individual birds, and/or groups of birds, were recognizable in both the FF and POV frames (Figure 8-X)

Image Processing and Calibrating with Observations from the Observers

At this point we have not calibrated the images with the observations during the test flights. The primary goal of the 1st phase of the project was to evaluate the feasibility of identifying technology that would capture images in a way that images the entire transect strip for both POV and FF. We were able to do this, as well as determine how to situate the observers in the aircraft

Image processing is going to be one of the more time-consuming tasks during the second phase of the project. With both cameras shooting, we will acquire a total of 9,360 images from 30 transect segments 40 seconds in length, totaling 20 minutes of survey effort. In a given test day we could feasibly accumulate two hours of transects, which would total roughly 24,000 images for the day. That said, we did find that images could be scanned quite quickly; time was only needed on a given frame when birds were present. Many of the frames would likely not have birds present.

Conclusion

We are optimistic with the results from this initial phase of the project. We plan to make a few changes and improvements during the 2nd phase of the project this coming winter. These include:

- Using high-quality polarizing filters on both POV and FF cameras.
- Using higher capacity (64GB) memory cards for more storage. At least use one of these cards on the FF camera while using the smaller 32GB cards on the POV camera inside the aircraft.
- Investigate RAID high-speed hard drives for faster data transfer from memory cards to PC's. The aircraft needs to land to transfer data and the process we found took an extremely long time using the EOS PC utility which preserves the naming convention used.
- Look into a different wing-strut mount. The mount we used worked well, however it took landing the aircraft and making manual adjustments, then re-flying the grid to test for calibration. There is a remote-controlled mount in England that is designed for Cessna wing-struts, and we are looking into if we can have one made to fit the Beaver.

Figure 1. POV testing RedCam studio quality camera. With the suction cup mounting system, vibration was not an issue, even with a camera of this size and weight.

Figure 2. POV Camera (CANON EOS 5D Mark II equipped with Canon EF 24-105mm f/4L IS USM lens) configured to image the transect strip.

Figure 3. POV Camera (CANON EOS 5D Mark II equipped with Canon EF 24-105mm f/4L IS USM lens) showing the three-point suction cup tripod.

Figure 4. FF Camera. Wing strut mounted CANON EOS 5D Mark II equipped with Canon EF 70-200mm f/4L IS USM lens; lens is uncovered to show perspective.

Figure 5. FF Camera. Wing strut mounted (Figure 2. POV Camera (CANON EOS 5D Mark II equipped with Canon EF 70-200mm f/4L IS USM lens) Camera and Lens is uncovered to show set up and attachment.

Figure 5. FF Camera. Wing strut mounted FF Camera (CANON EOS 5D Mark II equipped with Canon EF 70-200mm f/4L IS USM lens) showing protective cover over camera and lens.

Figure 6. Overlay of four images showing the 50 m transect strip of the FF camera.

Figure 7. From image above zoomed to 100%.

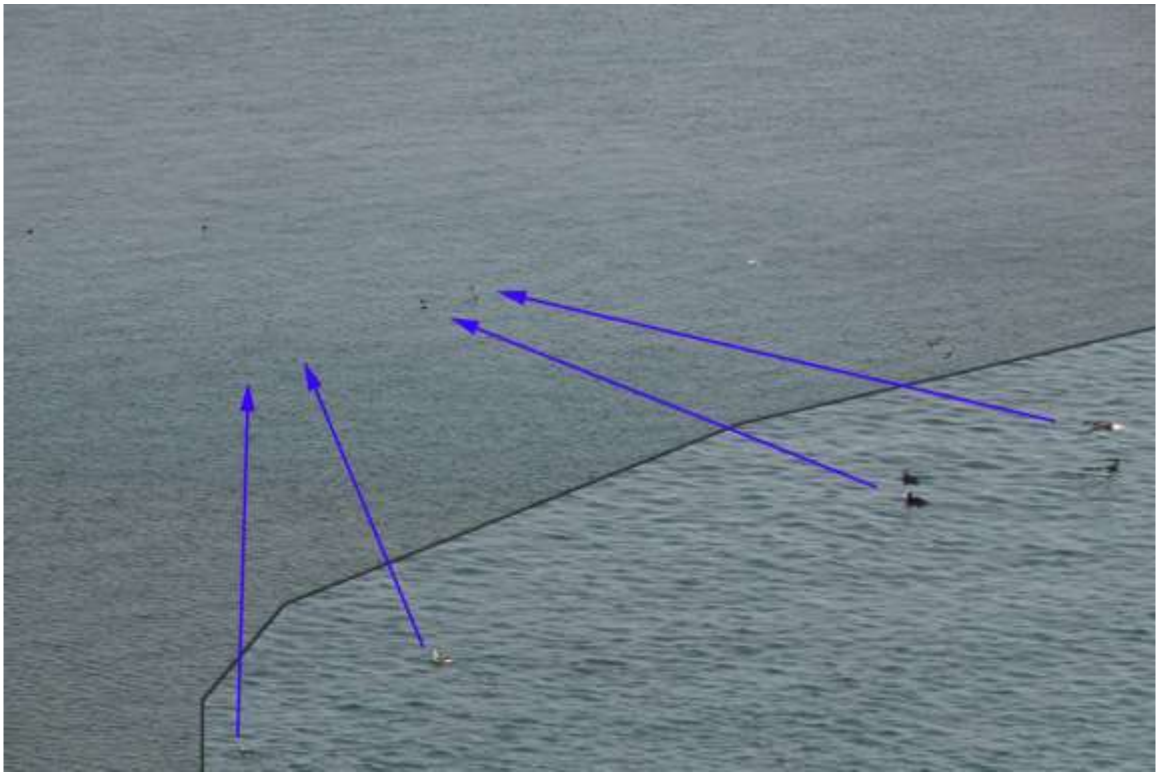


Figure 8. Example of full scale FF image with zoomed in area (lower right) to show species classification. These birds were not captured by the POV camera; they had either moved or dove.

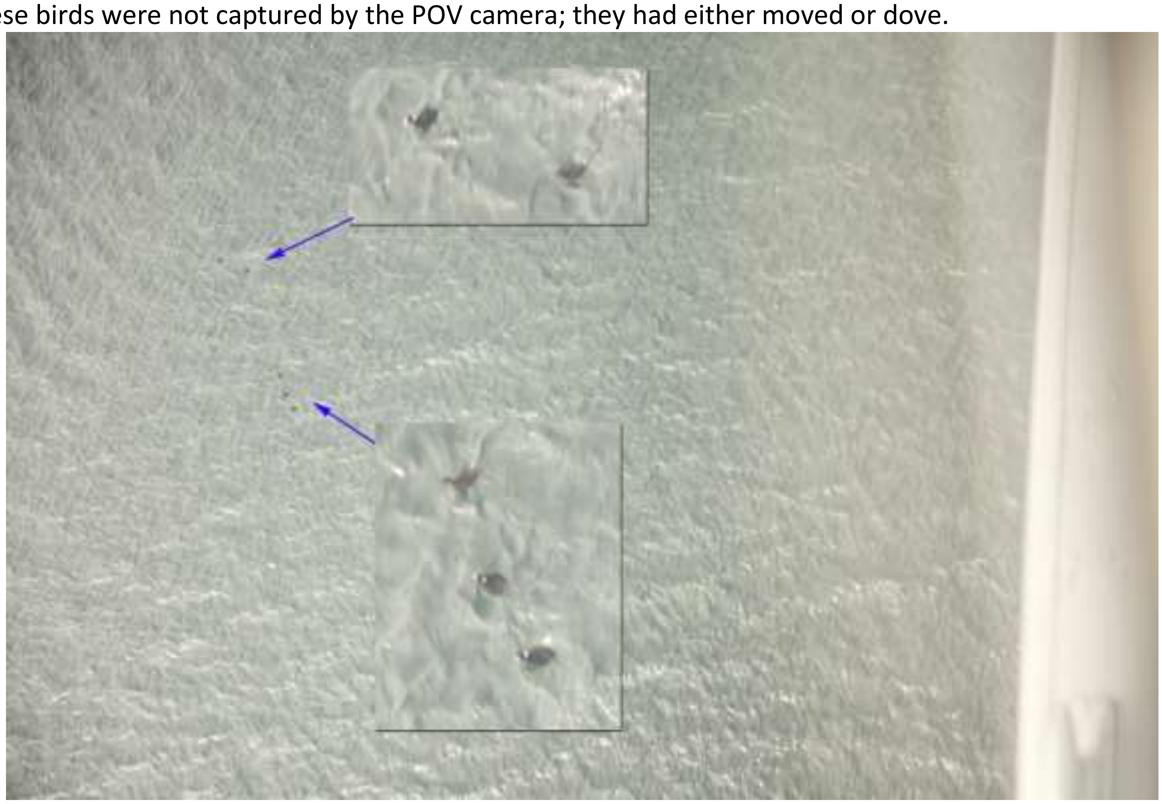


Figure 9. Surf scoters from the POV camera. This image was looking into heavy glare. A polarizing filter would help this image greatly. Post-processing would also improve the quality of this image.

Figure 10. POV images of sea ducks zoomed in for detail. Species include common goldeneye, surf scoter, bufflehead, and horned grebe.

APPENDIX 3

REPORT FOR PHASE 2

Summary of the 2012 WDFW Winter Sea Duck Aerial Survey Detectability Project - Phase 2

Joseph Evenson, Bryan Murphie, Tom Cyra, and Don Kraege

30 August 2012

Washington Department of FISH and WILDLIFE

INTRODUCTION

This effort was implemented to investigate technologies to assist in answering detectability of sea ducks from aerial surveys. Phase 1 was implemented during winter 2011 with the goal of testing various imaging equipment on board the survey aircraft (de Havilland DHC-2) to evaluate effectiveness in being able to document sea ducks along a 50 m transect strip; please see the Proposal submitted to the SDJV at the end of this document for more information related to the goals, objectives, and problem statement. During winter 2012 we implemented phase 2 of the project to fly detectability surveys utilizing what we learned during the 1st phase of the project. This summary report is not intended to be a detailed report, but instead is to be used as a brief summary on the second phase of the project. A more detailed report will be provided as a product from the third and final phase of the project.

METHODS

We utilized a de Havilland DHC-2 "Beaver" aircraft on floats for all surveys. This is the same type of aircraft used for the Washington winter sea duck surveys since 1993-4. The aircraft was equipped with large windows that permitted viewing from the middle row seat (normally used during surveys) as well as from the rear seat, that was used for the double-observer portion of these efforts. The rear window of the aircraft was also large enough to house the POV camera.

Each camera was remotely controlled by remote shutter controls, used during transect flights, and laptop computers to assess camera alignment, adjust focal length and focus.

Software was developed to log the trackline (GPS fix every second), automatically assign transect numbers to transects, track frame count and memory card usage for each camera, and indicate to the camera operator when to turn off and on the POV and FF cameras. This software was run on the POV laptop and viewed on a separate monitor.

Transects were flown directly into the wind to ensure the orientation of the aircraft was true forward. During days with light winds we also flew transects with the wind directly at the tail of the aircraft. Transects were flown at 85 knots at 61m AGL.

We selected areas to fly transects that fit the following criteria:

- Provided area for long and uninterrupted track lines where we could get at least two subsequent transect lines completed before having to initiate a turn;
- Are known to support varying densities of sea ducks;

- Are known to host sea ducks so we would get an adequate sample of all sea duck species encountered during the winter survey efforts;
- Would provide us with a sample of varying Beaufort and glare conditions.

POV (Observer Point of View) Camera

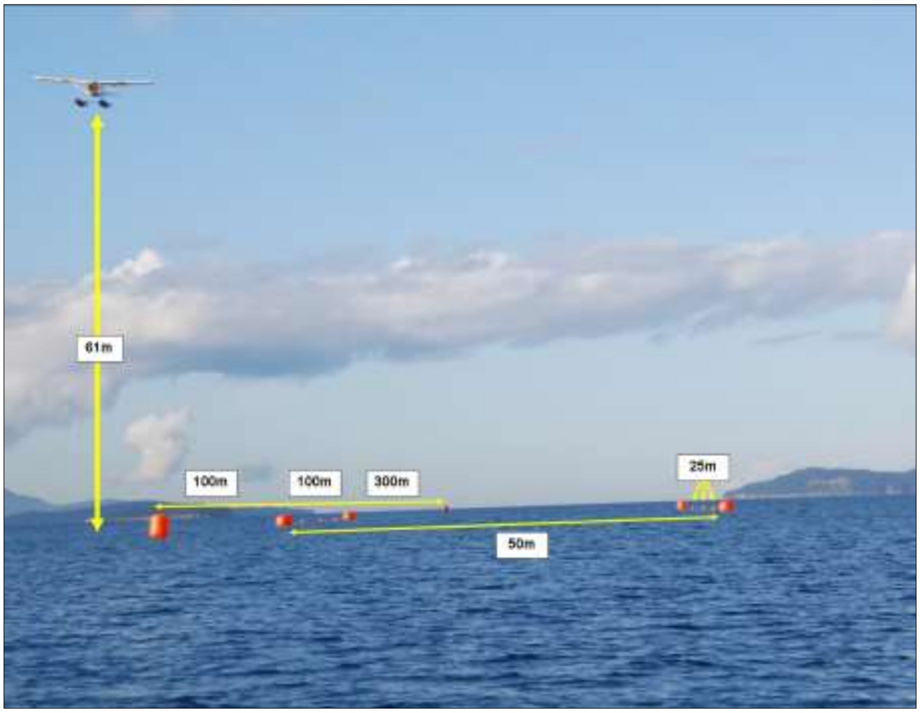
We used a Canon EOS 5D Mark II equipped with a Canon EF 24-105mm f/4L IS USM lens mounted to the rear window on the left side of the aircraft. This camera was aligned and focal length was set to image roughly 5 meters beyond the 50 meter transect strip adjacent to the aircraft, and was directions slightly forward, with a vertical (portrait) orientation.

After our initial test flight in November 2011 we were not able to obtain the image clarity and shutter speed that we had expected from the previous year’s (phase 1) results. We discovered

that the aircraft had windows that were slightly tinted, which resulted in a slower shutter speed and created some image blur. The project was delayed to have a window built and installed that would allow the camera lens to protrude past the window through a hole, eliminating any visual obstruction.

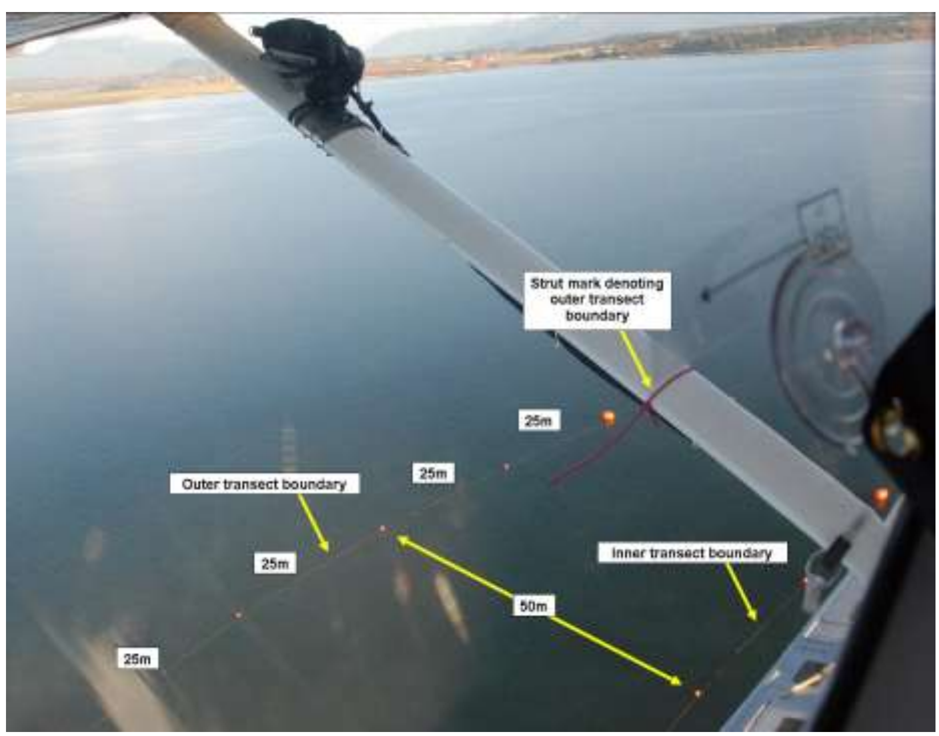
FF (FORWARD FACING) CAMERA

We used a Canon EOS 5D Mark II equipped with a Canon EF 70-200mm f/2.8L IS USM lens mounted to the left wing strut of the aircraft. This camera was aligned and focal length was set to image the 50 meter transect strip 250-300 meters ahead of the aircraft. The camera was also aligned to image a horizontal (landscape) orientation. This camera was mounted high on the wing strut close to the point of attachment to the wing to reduce vibration from the strut cowling. Attachment high on the wing-strut also put the camera away from turbulence from the aircraft propeller, as well as potential water spray during take-off and landings. In addition, we found that this high placement reduced the amount of rainfall coming in contact with the protective lens filter when rain was present.



CALIBRATING CAMERAS TO THE TRANSECT STRIP

We utilized an on-water grid that could be adjusted to line up with the orientation of the wind. The on-water grid was setup using orange sailing race marks (2m high X 1.5m wide) connected together with yellow floating polypropylene line to delineate transect boundaries. We used a series of race marks to



delineate the inner-edge of the transect strip, spanning 500 meters. One race mark was used to mark the beginning of the transect edge, and a second race mark was positioned 300 meters further along the span marking the beginning of the 100m x 50m transect grid. Three smaller floats were positioned 25 meters apart along the inner transect edge followed by another race mark 25m further along the span. The inner edge of the transect strip was marked with a final race mark positioned 100m past the previous race mark.

The outer edge of the transect strip was marked with race marks at either end of a 100m span, with three smaller markers positioned 25 meters apart. These marks were positioned perpendicular from the same marks from the inner transect strip markers, and ran parallel to them, denoting the outer edge of the 100m x 50m grid.

Before each survey day the grid was setup and the aircraft was flown over the grid to align the FF and POV cameras to the transect strip, and to delineate within the frames of each respective camera view the transect boundaries.

The issue we encountered with this method was the time it took to set up and disassemble the on-water grid reduced the survey time per day. On the second survey day, after the grid was set up, we flew (at varying altitudes) over straight highways and railway lines that were oriented along the direction of the wind to test if we could use these other features to delineate the inner and outer transect boundaries. We reviewed the images from these tests with the images from the grid flights from the same day and found no difference between them. After the second survey day we utilized highways and railway lines oriented with the wind to delineate transect boundaries on the FF and POV image frames, thus doubling the survey effort each day.

IMAGE COLLECTION AND OBSERVER METHODS DURING TRANSECTS

The time (to the second) was synchronized on both cameras as well as observer watches. Image file naming was set to <date> + <"POV" or "FF", respectively> + <time (to the second)>+<sequential number (beginning with 1 for each day)>. By using this naming structure the POV and FF images could be calibrated, and they could be matched up with the recorded times of the observer observations and the GPS log.

Each camera was equipped with a wired remote control. The camera operator would activate continuous shooting (3.9 frames/sec) on the FF camera, and then after 5 seconds begin continuous shooting on the POV camera (the POV was delayed as it takes 6-8 seconds for the area captured on the FF camera to reach perpendicular to the aircraft). Each camera would be shut off for 5 seconds, after 45 seconds of continuous shooting each. After this 5 second pause, imaging would be restarted, beginning the next transect. This pause was necessary to clear the internal camera buffer.

Observers were seated on the left side of the aircraft in the middle “front” seat (normally used during aerial surveys), and the rear seat. There observers were isolated both audibly and visually.

Each camera was equipped with two 128GB and one 32GB SanDisk Extreme 60MB/sec UDMA memory cards. We would fly transects and image the transect strip until a card was nearly filled. We would then land to replace full memory cards with empty cards per camera, and to swap observer positions (front observer to the rear position, and rear observer to the front position). Observers recorded all observations within the transect strip to the second.

TRANSECTS FLOWN

A total of one test flight day and seven survey days were flown (31.1 flight hours):

1. 11-Nov-2011 Test Flight 5,799 Images
2. 15-Nov-2011 Survey Flight 3,816 Images
3. 07-Mar-2012 Survey Flight 9311 Images
4. 08-Mar-2012 Survey Flight 36,906 Images
5. 09-Mar-2012 Survey Flight 28,682 Images
6. 18-Mar-2012 Survey Flight 41,451 Images
7. 25-Mar-2012 Survey Flight 27,772 Images
8. 26-Mar-2012 Survey Flight 40,869 Images

NEXT STEPS – PHASE 3

The third and final phase of the project is to process all survey images (185,000 images) to classify species and counts during transects, then analyze the data to estimate detectability rates of sea ducks. The final results of these efforts will provide correction factors to apply to past WDFW winter aerial survey data of sea ducks, and will also be applied to future surveys. With financial support, we would like to begin this phase in November, 2012, hiring a temporary staff member to assist in these efforts. Without continued financial support, completion of this phase would be delayed until time of permanent project staff can be dedicated to these efforts, and/or other funding sources can be found to implement this work.