Project Title: SDJV Project #115: Developmental Surveys for Breeding Scoters in Eastern North America

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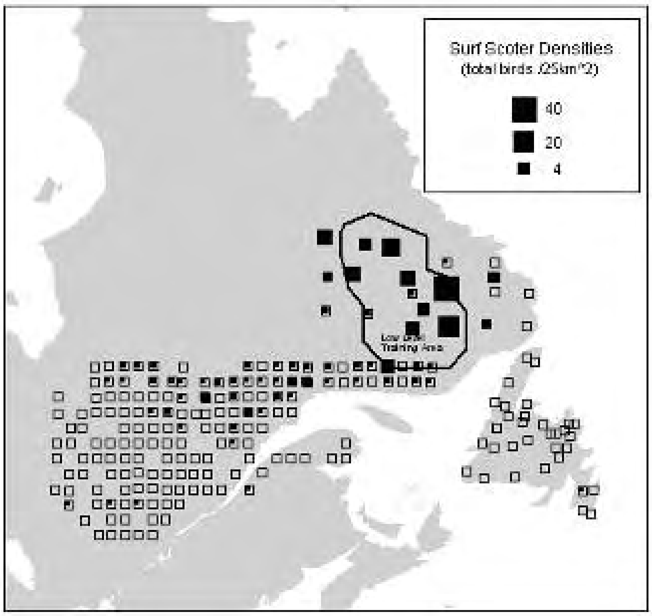
Project Description

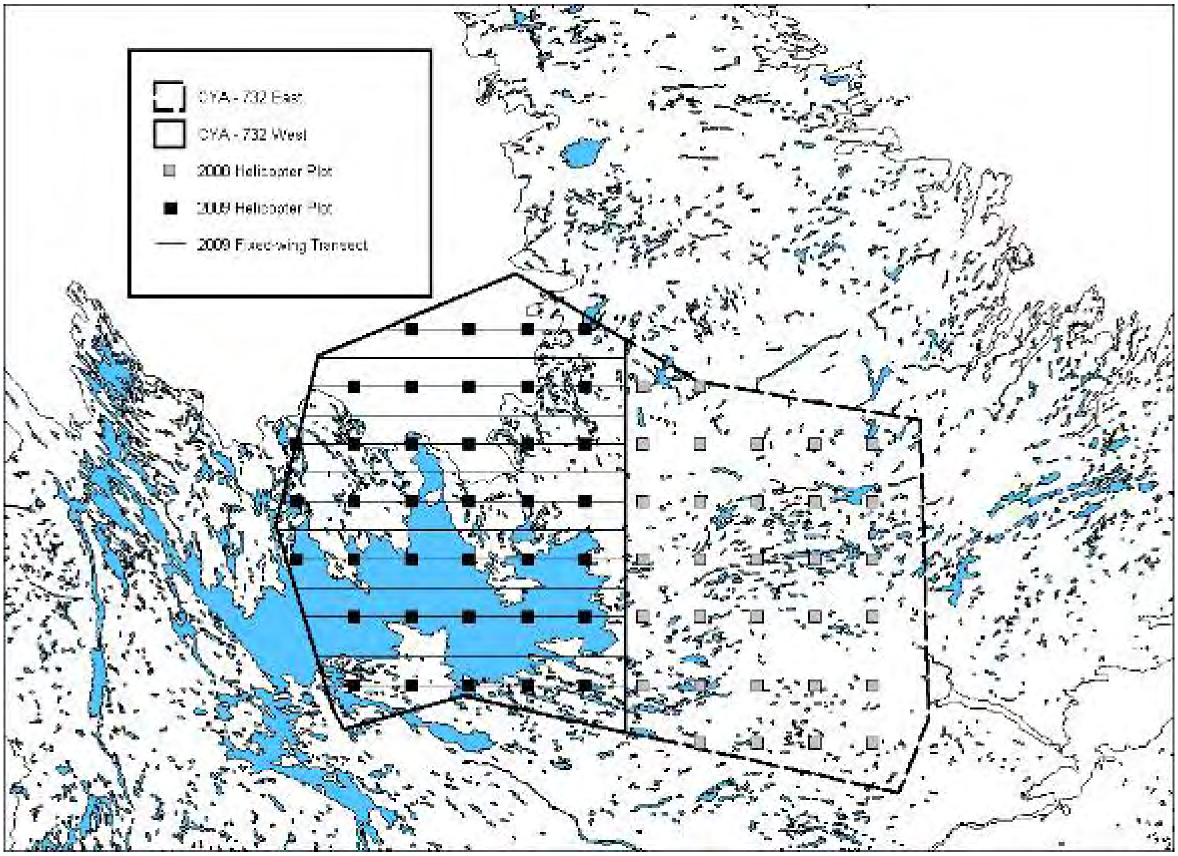
Numbers of scoters appears to have declined greatly in western North America, whereas population size or trend data are not available for the more heavily hunted eastern populations (Bordage and Savard 1995, Savard et al. 1998, Caithamer et al. 2000). Further, little is known about the demography and ecology of Surf Scoters or breeding habitat characteristics in eastern North America. Despite greater anthropogenic threats to scoter populations in eastern North America, their status in this region remains highly uncertain. The May breeding pair surveys cover only a very small portion of their breeding range. Scoters are regularly encountered on Eastern Waterfowl Survey (EWS) in Labrador and northeastern Quebec (Fig. 1), but can only be identified to species with accuracy in the helicopter segment of the survey. These surveys are conducted at the end of scoter migration and only marginally overlap with the breeding period. It is not known whether the timing of the current survey introduces an important bias in estimates of breeding population size and trend, but it is generally agreed that surveys timed for the early nesting stages provide the most reliable estimates breeding pair numbers (SDJV 2005). The EWS is generally conducted too early in this regard. High costs have so far precluded the implementation of large scale, systematic breeding population survey of scoters and other late-nesting waterfowl.

Figure 1. Location of the Eastern Waterfowl Survey plots (open squares), the Low Level Training area (black line), and average plot densities of Surf Scoters (black squares) in Quebec and Newfoundland and Labrador (Source: CWS unpublished data).



It was recently proposed to expand the Low-level Flight Training Program in Labrador in order to include supersonic activities. The impact of supersonic flights on migratory birds in Labrador has not been assessed. Preliminary data indicates that central Labrador is within the core breeding area for Surf Scoters in eastern Canada (Fig. 1). The study area was the western half of the 732 Training Block (Fig. 2) which covered an area of approximately 24,320 km^2. The vegetative cover within the study area varies from arctic tundra to boreal forest, with stands of large trees found along river valleys. The topography is diverse, varying from exposed bedrock in the upland areas to extensive areas of rolling terrain dominated by deep glacial till and glaciofluvial deposits in lower areas. Of particular interest for scoters is the relatively high density of small ponds and lakes that occurs through most of the 732 Training Block (Fig. 2).

Figure 2. Location of helicopter plots and fixed-wing strip transects for 2008 and 2009 within the low-level training area CYA-732 , Labrador.

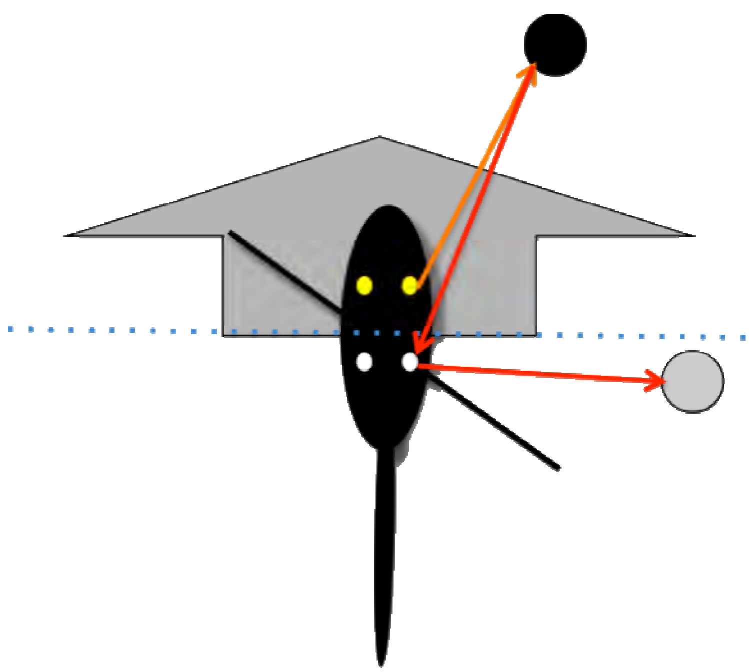


Surveys were conducted between 10 and 19 June 2009. The weather conditions were good throughout the survey.

Helicopter Survey. Helicopter surveys followed standard operating procedures used in the helicopter component of the EWS (see Bateman et al. in prep. for SOP). This survey used 25 km^2 plots that were all surveyed from a Bell 206L helicopter, at flight speeds of 60–100 km/h and from 15–50 m above ground level. Within a plot, all water bodies and wetlands were flown over to record counts, species, sex and location for each observation using the GPS-Voice recording software (PC-Mapper Airborne Inventory, version 3.0E2). Particular effort was made to discriminate between Lesser and Greater Scaups. We used 8 X 25 image stabilized binoculars to assist in species identification (see Appendix 1 for species codes and scientific names). We used a systematic sampling design based on the 2008 sampling frame (see Gilliland et al. 2008; Fig. 2). This resulted in a sampling grid of 997 potential plots from which 37 were systematically selected (Fig. 2). Due to logistical constraints, the most northerly line of plots (plots 1 to 4), and the western most plots on grid lines 3 (plot 10) and 4 (plot 16) were not surveyed. This resulted in a sample size of 31 plots for an overall sampling intensity of 3.1%. We used capture-recapture modelling to estimate detection probabilities from counts using multiple dependant observers (Cook and Jacobson 1979). Observations from the two front and two rear observers were combined, and treated as if there were only a single front and rear observer. One half of the double count surveys were flown with the front observers designated as the “primary observer” and the rear observers designated as the “secondary observer”. The primary observers notified the secondary observers of each observation detected while the secondary observers noted any observations not detected by the primary observers. The roles primary and secondary roles were reversed for the second half of the double count surveys. The double counting procedures described by Cook and Jacobson (1979) were modified in the following way to maintain compatibility between the results from the double count and regular helicopter surveys:

1) An imaginary line was drawn thought the helicopter, perpendicular the direction of travel and between the front and rear observers (Fig. 3). The primary observer was only allowed to record observations when detected forward of this line. Observations detected behind this imaginary line were attributed to the secondary observer.

Figure 3. Observations detected in front of the dotted line (e.g. black circle) were recorded as detected by the primary observer and were identified to the secondary observer. Once the observation passed the line (e.g. gray circle) it they could only be recorded as detected by the secondary observer and missed by the primary observer.



2) The front left observer navigated the helicopter through the plot ensuring that all water bodies and wetlands were flown over. On entering a wetland or water body,

the pilot was directed to cover the entire area efficiently with little direction from the navigator.

3) To ensure that species, age and sex of the birds were classified accurately the primary observers were able to direct the helicopter onto any observations made in front of the line, while the secondary observers were able to direct the helicopter onto any observations after it had passed the line.
4) On several occasions observations were missed by both the primary and secondary observers and were later noted when the helicopter was forced to make a second pass along a water body. These observations were recorded as not detected and excluded from subsequent analyses.

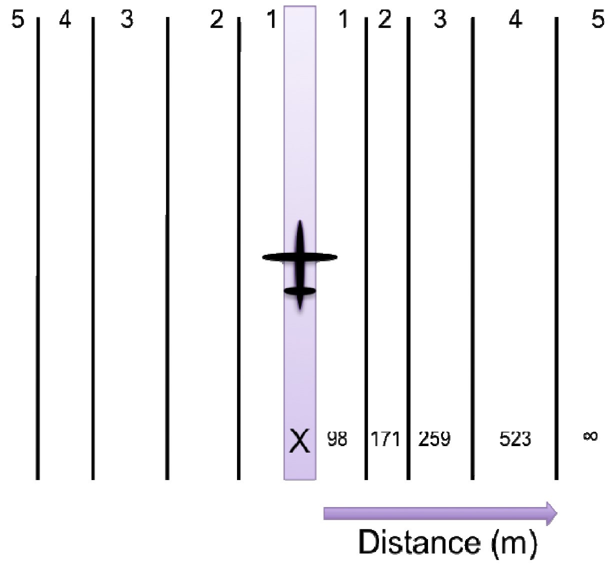
Fixed-wing Survey. We used distance sampling methods to estimate density for the fixed-wing survey (Buckland et al. 2001). This survey used line transects surveyed from a USFWS Partenavia (P.68C) fixed-wing aircraft equipped with a radar altimeter and GPS navigation system. Surveys were conducted at flight speeds of 170–200 km/h from an altitude of 45 m above ground level. Counts, species, sex and location of each observation were recorded independently by observers on each side of the aircraft using USFWS-GPS-Voice recording software. The sampling design was based on the helicopter grid. A series of east-west line transects were located such that one line transected the mid-point of each east-west line of helicopter plots, with an additional line falling half way between each line of helicopter plots (Fig. 2). This resulted in 13 line transects. Due to logistical constraints, the most northerly transect line (No. 1) was not surveyed reducing the sample size to 12 line transects totalling 715 linear km (Table 1) with an estimated sampling intensity of 2.8 % (assuming a strip-transect width of ~400 m).

Table 1. Line transect lengths for the fixed-wing survey

Transect Number	Length (km)
1	98.5
2	133.1
3	136.2
4	139.3
5	142.4
6	145.5
7	148.6
8	150.6
9	146.4
10	146.2
11	138.8
12	133.5
13	129.7
Total	1788.9

Observations were grouped into four distance intervals from the line transect (Fig. 4). Interval cutpoints were initially estimated assuming the underlying detection function was approximately half-normal (Buckland et al 2001).

Figure 4. Delimitation of the four distance intervals (1-4) from the transect line. Observations detected in the area under the aircraft (X) and interval 5 were excluded.



The cutpoints of the two inner most intervals were then modified slightly to be approximately 100 m and 200 m to make results compatible with the North American Waterfowl Breeding Population Survey (WBPS; see Smith 1999 for survey description). To make cutpoints easier for the observers to locate with an inclinometer, distances to the interval cutpoints were further adjusted to fall on increments of five degrees. This resulted in interval cutpoints of 98, 171, 259 and 523 m from the line transect (Table 2).

Table 2. Interval cutpoints for the fixed-wing Survey.

	Interval					
	X[a]	1	2	3	4	5
Distance (m)	14	98	171	259	523	∞
Angle (°)[b]	73	25	15	10	5	0

[a] Unobservable area under the plane.
[b] Angle from horizontal.

To aid observers in classifying observations into the correct distance interval the angle from the horizontal was marked on the window of the plane to delineate the boundaries between intervals. We used second interval markers that allowed observers to align their eyes correctly (Johnson and Lindsy *in* Buckland et al. 2001). The Partenavia aircraft has no wing-struts, and we used the window recess and transparent tape to create a second surface to mark the interval boundaries. The tape was placed on the inside of the plane over the window recess, and the tape was marked with the interval boundaries.

Observations that were detected near the cutpoints were recorded as such, and later split equally between the two adjacent intervals (Gates 1979). Observers were instructed to focus their effort in the first interval and have their head as close to the window as possible to minimize the unobservable area under the aircraft. Before the survey, we measured the angle demarking the restricted area under the aircraft for each observer and position. The resulting blind area was estimated to be 13 m for the front left observer, and 15 m for the left and right observer. We thus used 14 m either side.

Data Analysis. We converted counts of males, females and unsexed birds to indicated pairs (IP) using the rules in Appendix 2 (Bateman et al., in prep.). Total individuals (TI) was simply calculated as the sum of males, females and unsexed. Data were recorded in a condensed format that only contains records for wildlife species observed on a sampling unit (plot or transect). For species not observed on a sampling unit, there is no record for the species in the data (i.e. there are no zero counts). Zero counts were added to the data set before performing data analyses. We produced summaries of descriptive statistics (mean, SD) of species for densities of IP, males, females and TI. Confidence intervals for population estimates were calculated using the finite population correction (Cochran 1977). We estimated detection probabilities for the helicopter survey using program DOBSERV (Hines 2000). Species were lumped into groups, and detection probabilities were estimated for each group: 1) Divers (sea ducks, bay ducks and loons), 2) Puddle Ducks, 3) Geese and 4) Gulls and Terns. Detection probabilities for the fixed-wing distance data were estimated with program Distance (Laake et al. 2009). Before analyzing the data the inner distance interval was offset 14 m from the line to remove the unobservable area under the aircraft. Detection probabilities were estimated for each observer and species group. See Appendix 1 for scientific names and species codes.

Objectives

The aims of the project were to provide specific information on the distribution and abundance of scoters breeding within the proposed supersonic low-level training area in Labrador, and to provide the necessary data to properly develop a survey methodology for breeding scoters that will be more strategic, cost-effective and provide for future unbiased results. Specific objectives were:

1. Develop methodology for surveying scoters breeding in the eastern boreal forest using fixed-wing and helicopters.
2. Assess detection probabilities and effective transect width for fixed-wing surveys of breeding scoters.
3. Assess ability to speciate scoters, scaups and Ring-necked Ducks in relation to transect width from fixed-wing aircraft.
4. Provide density and population estimates for scoters in the central portion of their breeding range
5. Compare species composition and density estimates between fixed-wing (corrected for detection) and helicopter (uncorrected for detection) surveys.

Preliminary Results

Estimates of Detection Probabilities.

Helicopter Surveys. Estimates of detection probability from the helicopter for waterfowl were high (>0.97; see Plante and Bordage, in prep.; Table 3) suggesting that a negligible portion of the available waterfowl were missed during helicopter surveys.

Table 3. Detection probabilities (±SE) by species group for helicopter surveys estimated using dependent multiple observers

	Observers		
Species Group	Front	Rear	Overall
Diving Ducks[a]	0.59 ± 0.05	0.95 ± 0.03	0.98 ± 0.01
Puddle Ducks[b]	0.84 ± 0.02	0.87 ± 0.02	0.98 ± 0.02
Geese	0.75 ± 0.04	0.88 ± 0.04	0.97 ± 0.01
Gulls and Terns[c]	0.62 ± 0.09	1.00 ± 0.28	1.00 ± NA
Shore Birds[d]	0.22 ± 0.13	0.28 ± 0.17	0.82 ± 0.08

[a] Black Scoter, Common Goldeneye, Common Loon, Common Merganser, Greater Scaup, Hooded Merganser, Lesser Scaup, Red-throated Loon, Red-breasted Merganser, Surf Scoter, White-winged Scoter.

[b] American Black Duck, American Green-winged Teal, Northern Pintail.

[c] Herring Gull, unidentified terns.

[d] Common Snipe, Northern Phalarope, Spotted Sandpiper, unidentified Phalarope, unidentified Yellow-legs.

Detection probabilities of the front observers were lower than for observers in the rear of the helicopter. This suggests that the improved visibility in the front of the helicopter did not offset the attention the front observer requires for navigation and recording, and for the pilot, piloting the aircraft. Double counting procedures cannot account for birds that are not unavailable to be counted. For example, we may expect females to be unavailable if they are tending nests; however, we would expect the females' mate to be on territory and available to be detected. The most likely reason that birds might be unavailable to be detected by the helicopter was that an area was not searched. The survey protocol requires that all water bodies and wetlands be flown over. Sophisticated navigation equipments provide the navigator with an accurate picture of the path of the aircraft and location of detections. Hence, it is unlikely that obvious features like open water, and birds associated with these features (e.g. diving ducks), are missed. This may not be true for areas of wetland without standing water which are less likely to be searched completely, and there is a possibility that a larger portion of these populations are unavailable to be detected (e.g. shore birds and American Green-winged Teal).

Fixed-wing Surveys. Estimates of detection probability for diving ducks from the fixed-wing were low (0.31-0.37; Table 4).

Table 4. Detection probabilities for diving ducks[a] for fixed-wing surveys estimated using distance sampling

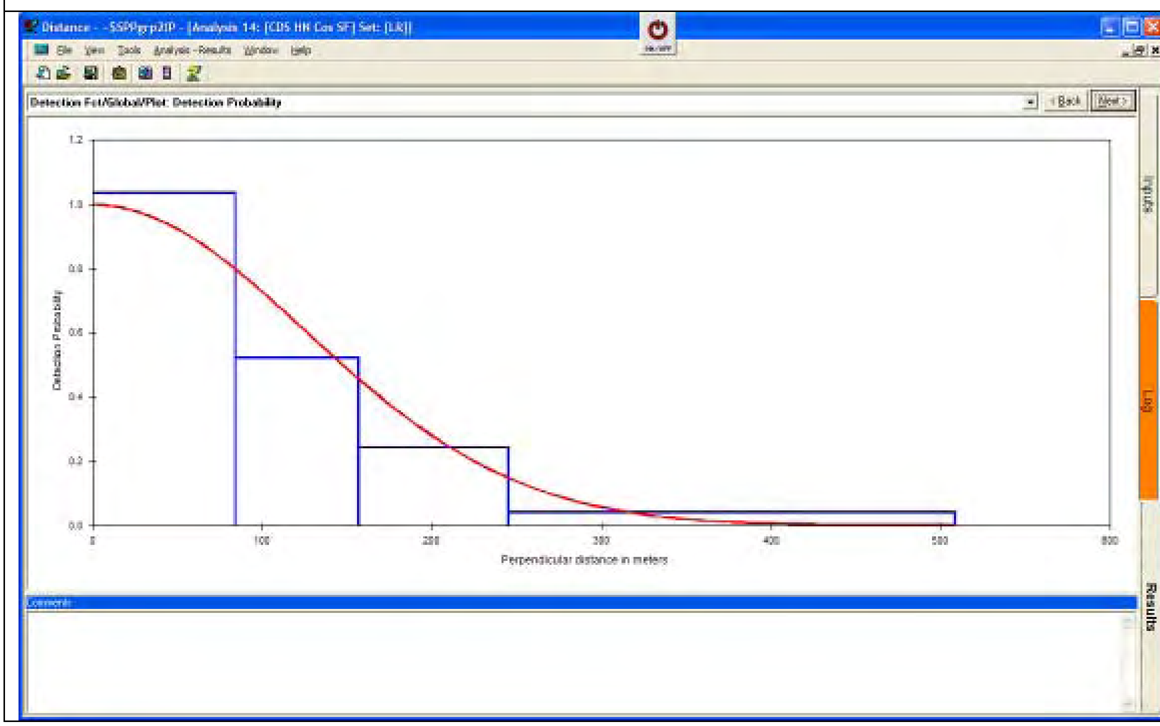
Observer	Transect width (m)[b]	Detection	Upper CI	Lower CI
Overall	186	0.37	0.33	0.41
Left-front	187	0.37	0.27	0.50
Right-rear	157	0.31	0.27	0.36

[a] Black Scoter, Common Goldeneye, Common Loon, Common Merganser, Greater Scaup, Red-breasted Merganser, Surf Scoter, Unidentified Scaups.

[b] Effective transect width.

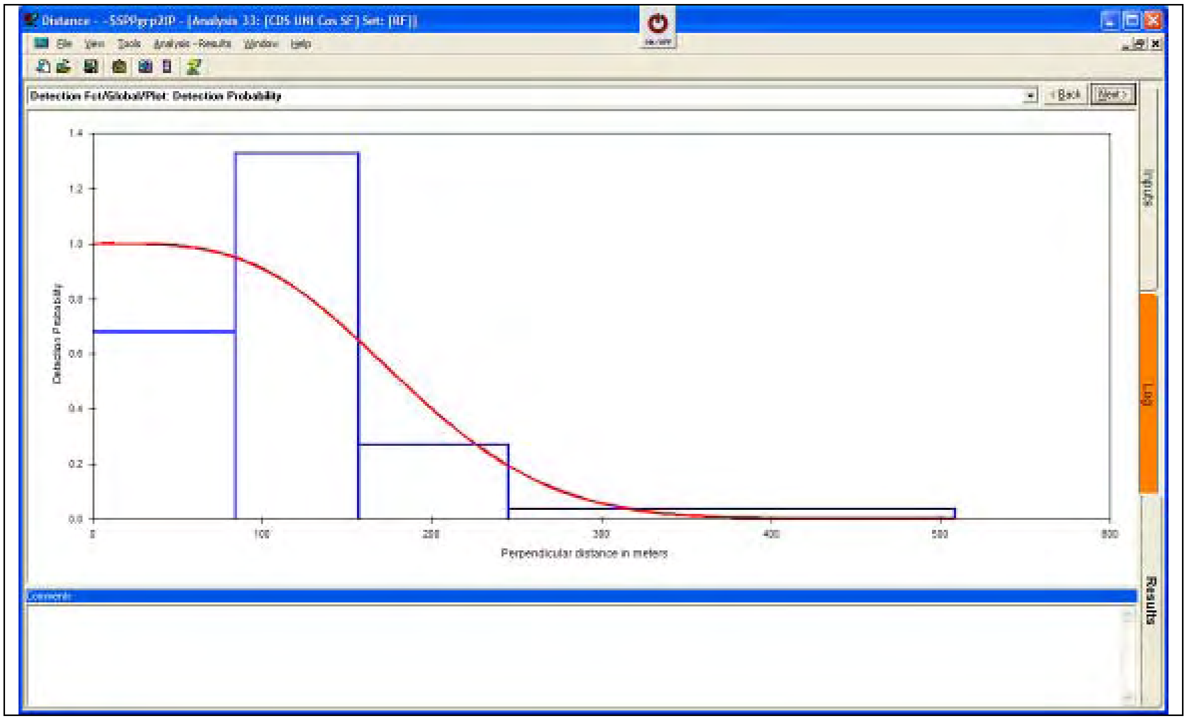
The effective transect width is the distance from the track line where the detection probability was estimated to have fallen to 0.5, and was about 185 m. Examination of the fit of the detection function for the right-rear does not suggest any problems with the data (Fig. 5).

Figure 5. Fit of detection function for the right-rear observer



However, the fit for left-front observer had too many detections in the second distance interval (Fig. 6). This can result if the detection rate near the track line was less than one, or if detections in the first interval were incorrectly assigned to the second interval. This results in an overestimation of detection probability and underestimation of density (Buckland et al. 2001). Hence we only used the detection estimate from the right-rear observer in density estimations.

Figure 6. Fit of detection function for the left-front observer



Estimates of Density

Helicopter Density Estimates. Detailed results of the helicopter surveys are given in Appendices 3-4, and mean densities (per 25 km^2), and population estimates for the western block of the low-level training area CYA-732 for indicated pairs of scoters and scaups are summarized in Table 5.

Table 5. Breeding pair densities (indicated pairs per 25 km^2) and population estimates, uncorrected for detection probability, for scoters and scaups in the western half of the low-level training area CYA-732 (24,320 km^2), Labrador 2009 (n = 31) measured from the helicopter plot surveys

	Scoters				Scaups		
Species[a]	BLSC	SUSC	WWSC	Scoters	GRSC	LESC	Scaups[b]
Mean	1.9	3.5	0.32	5.8	0.55	2.4	3.0
SD	2.8	4.3	0.98	6.4	0.96	3.8	4.4
CV (%)	1.5	1.2	3.1	1.1	1.7	1.6	1.5
Nhat	1848	3404	311	5642	535	2335	2918
95% CI	959	1473	336	2192	329	1301	1507

[a] See Appendix 1 for species codes.
[b] Scaups includes observations of unidentified scaups.

Densities varied considerably among and within species, there was considerable variability among plots. Of the late breeding waterfowl, Surf Scoters occurred at the highest densities (3.5 ± 4.3 IP per 25 km^2), followed by Lesser Scaups (2.4 ± 3.8 IP per 25 km^2), and Black Scoters (1.9 ± 2.8 IP per 25 km^2). White-winged Scoters, Greater Scaups, and Ring-necked Ducks were present, but uncommon. We estimated 5,642 ± 2,192 (± 95% CI) pairs of scoters and 2,918 ± 1,507 pairs of scaups occurred within the study area.

Breeding pair densities did not differ between years for Surf Scoters ($t = -0.7385$ IP, $df = 4$, $p = 0.5012$), Black Scoters ($t = -1$ IP, $df = 4$, $p = 0.3739$), Lesser Scaups ($t = -2.0925$ IP, $df = 4$, $p = 0.1045$) or Greater Scaups ($t = 0.5898$ IP, $df = 4$, $p = 0.587$). Although densities of scoters and scaups did not differ between years we observed 3 indicated pairs of Long-tailed Ducks on plot 30 in 2009 where none were observed in 2008.

Fixed-wing Density Estimates. To allow comparison of fixed-wing density estimates with other strip transect surveys, such as the WBPS, we estimated breeding pair densities using detections in the first two distance intervals (strip transect width ~340 m). Densities uncorrected for probability detection rates were 1.64 ± 0.28 for Black Scoters (IP per 25 km^2 ± SD, n = 12), 1.16 ± 0.33 for Surf Scoters, and combined densities of 1.88 ± 0.61, and 3.02 ± 0.74 for scaups and scoters, respectively (Table 6).

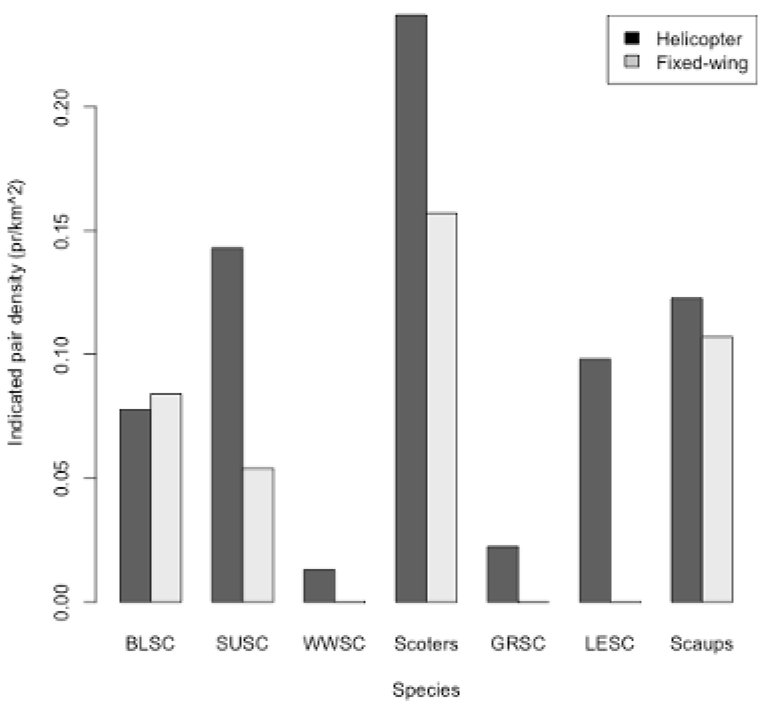
Table 6. Waterfowl breeding pair densities (indicated pairs per 25 km^2) and population estimates, uncorrected for detection probability, estimated with the first two distance intervals (342 m strip transect) in the western half of the low-level training area CYA-732 (24,320 km^2), Labrador 2009 measured from the fixed-wing strip transect surveys (n = 12)

	Indicated pairs	
Species	Per 25 km^2 ± SD	Population size ± CI
American Black Duck	1.68 ± 0.44	1638 ± 843
American Green-winged Teal	0.61 ± 0.16	595 ± 307
Black Scoter	1.64 ± 0.28	1593 ± 541
Canada Geese	1.92 ± 0.41	1869 ± 782
Goldeneyes	0.18 ± 0.12	172 ± 229
Common Loon	0.17 ± 0.09	161 ± 179
Common Merganser	0.54 ± 0.25	528 ± 471
Red-breasted Merganser	2.54 ± 0.59	2473 ± 1131
Ring-necked Duck	0.09 ± 0.06	86 ± 114
Surf Scoter	1.16 ± 0.33	1128 ± 631
Unidentified Merganser	0.31 ± 0.11	301 ± 201
Scaups	1.88 ± 0.61	1832 ± 1162
Scoters	3.02 ± 0.74	2942 ± 1413

Analyses of fixed-wing distance data are only partially completed. We assumed that detection probabilities were similar across all diver species densities. Densities corrected for detection probability suggested that Black Scoters occurred at the highest densities (2.1 IP per 25 km^2 [95% CI: 1.45-3.02]), followed by Surf Scoters (1.35 IP per 25 km^2 [95% CI: 0.75-6.85]); IP per 25 km^2 ± CI). Estimated pair densities for scaups were 3.98 [2.78 - 5.60] (IP per 25 km^2) IP per 25 km^2 ± CI and scoters were 2.67 [1.52-4.65]. Ring-necked Ducks were present, but uncommon. We estimated 3,829 (2,692-5,438; CIs) pairs of scoters and 2,598 (1,493-4,522; CIs) pairs of scaups occurred within the study area.

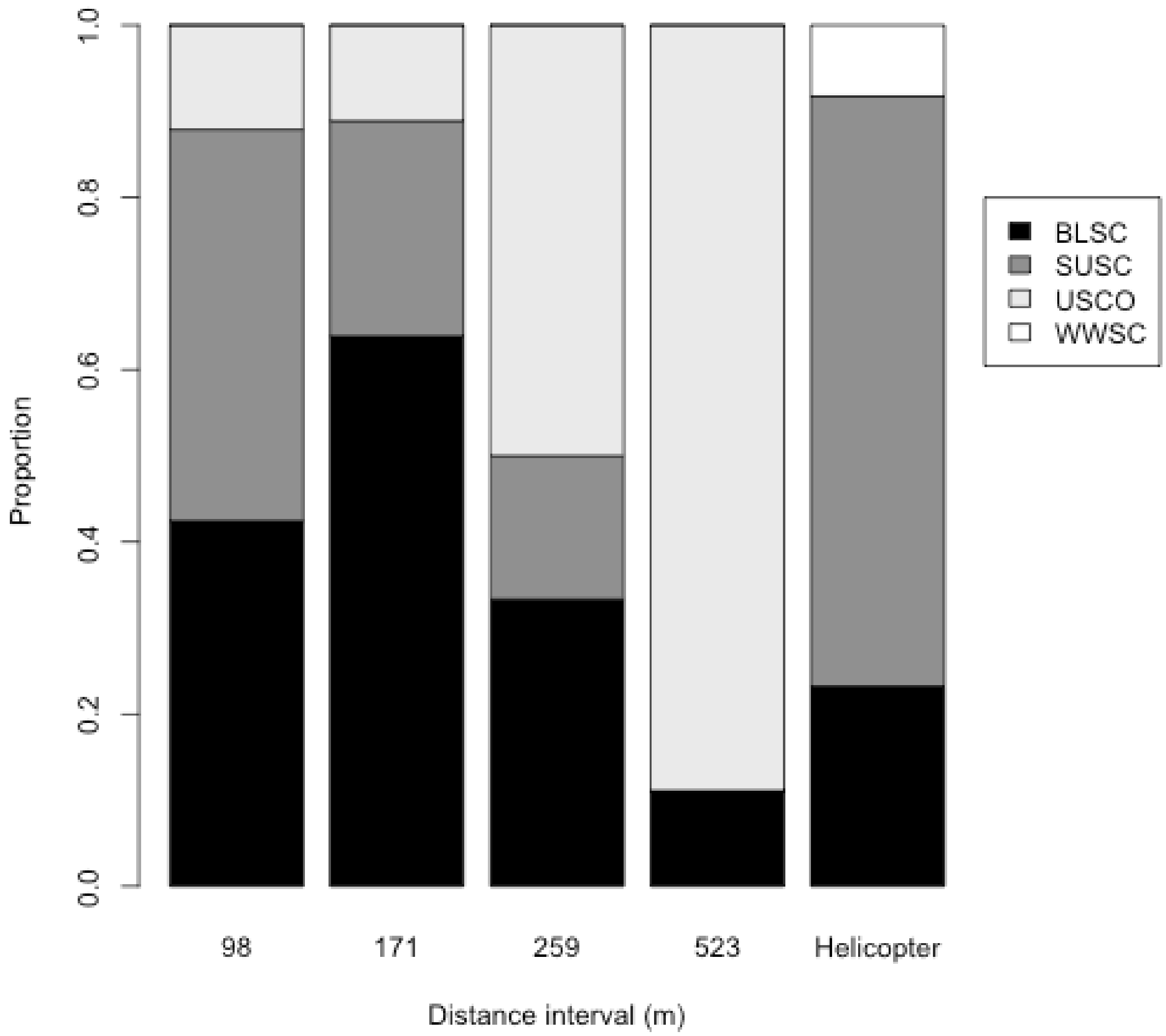
Comparisons between Fixed-wing and Helicopter Breeding Pair Densities. Estimated densities of Black Scoters and scaups were similar between the two survey platforms (Fig. 7). However, estimated breeding densities of Surf Scoters and scoters combined were 2.6 and 1.5 times greater in helicopter surveys (Fig. 7).

Figure 7. Indicated pair densities (pairs/km^2) from fixed-wing and helicopter surveys adjusted for detection probability for scoters and scaups in the CYA-732 west, Labrador.



Species Composition. In the fixed-wing survey, about 90% of the scoters were identified to species within 170 m of the aircraft but only 50% within 260 m (Fig. 8). The species composition of identified scoters within the inner distance interval (~100 m) consisted of about 1:1 Black to Surf Scoters. Species composition estimates differed considerably between the two survey types (Surf Scoter: 68% helicopter vs 45% fixed-wing; Black Scoter: 23% vs 42%; White-winged Scoter: 8% vs 0%; distance interval 1 used for the fixed-wing survey).

Figure 8. Species composition of scoter observations by distance from track line for the fixed-wing aircraft (n = 97) and from the helicopter (n = 375).



Species identification is more difficult from fixed-wings than helicopters, and we suspect that many Surf Scoters were misidentified as Black Scoters from fixed-wings. White-winged Scoters were not detected on the fixed-wing survey. Because sampling intensities for fixed-wing and helicopter surveys were similar we expect that White-winged Scoters likely occurred on fixed-wing transects. They were likely misidentified.

Management Implications

Preliminary results suggest that detection probabilities from the helicopter are high and only minor adjustments to density estimates are required for these surveys. Detection probabilities for fixed-wing surveys were low (<40%) indicating the need for major adjustments. Annual variability and inter survey variability in this coefficient are unknown at this time.

Errors in species identification on density estimation have not been estimated in most waterfowl survey programs. Results from our study suggest that in fixed-wing surveys, a large proportion of scoters cannot be identified to species and, more significantly, identified scoters are often misidentified. This results in inaccurate densities estimates for species (Fig. 7). This has been recognized in the western waterfowl survey where scoters are not identified to species. In addition, although not specifically discussed in this report, there appear to be similar patterns in miss-classification of species for puddle ducks and other species of divers.

Our preliminary analysis cast important doubts about the use of fixed-wing surveys for the monitoring of scoters and scaups at the species level. An important component of a continental monitoring program will be, helicopter (or similar) type survey like to those used in the Eastern Waterfowl Survey to adjust population estimates for species composition. .

LITERATURE CITED

Bateman, M.C., D. Bordage, R.K. Ross, B. Collins, C. Lepage, S. Gilliland, R.C. Cotter, and K.M. Dickson. In prep. Black Duck Joint Venture waterfowl breeding pair survey program in eastern Canada, 1990–2003 *in* Bordage, D., M.C. Bateman, R.K. Ross, and C. Lepage (eds.). Black Duck Joint Venture waterfowl survey program in eastern Canada and related studies. Can. Wildl. Serv. Occ. Pap. No. XXX, Canadian Wildlife Service, Ottawa.

Bordage, D. and J.-P. L. Savard. 1995. Black scoter (*Melanitta nigra*). *In* A.Poole and F.Gill, editors. The birds of North America, No.177.Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C., USA.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling. Oxford University Press, Oxford.

Caithamer, D.F., M. Otto, P.I. Padding, J.R. Sauer and G.H. Haas. 2000. Sea Ducks in the Atlantic Flyway: Population Status and a Review of Special Hunting Seasons. Unpubl. Rep., US Fish and Wildl. Serv., Laurel, MD 40pp.

Cochran, W.G. 1977. Sampling Techniques. Wiley, New York.

Cook., R.D. and J.O. Jacobson. 1979. A design for estimating visibility bias in aerial surveys. Biometrics 35: 735-742.

Gates, C.E. 1979. Line transect and related issues. *In* Cormack, R.M. G.P. Patil and D.S. Robson (eds), *Sampling Biological Populations*. International Co-operative Publishing House, Fairland, MD. pp 71-154.

Gilliland, S.G., C. Lepage, J.-P.L. Savard, D. Bordage, G.J. Robertson. 2008 An assessment of distribution and abundance of Surf and Black Scoters breeding within the eastern section of Labrador Low-level Flight Training Area 732. Final report submitted to the Institute for Environmental Monitoring and Research. 30 pp.

Gilliland, S.G. 2007. Eastern Canadian Waterfowl Survey in Newfoundland and Labrador, 1990 to 2002. Canadian Wildlife Service Technical Report Series No. XXX, Atlantic Region. iv + XX pp.

Hines, J. 2000. Program DOBSERV. http://www.mbr-pwrc.usgs.gov/software.html#a. Accessed 1 Sept 2009.

Krebs, C. J. 1989. Ecological methodology. HarperCollins Publishers, New York.

Krementz, D. G., J. E. Hines, and D. F. Caithamer. 1996. Survival and recovery rates of American eiders in eastern North America. J. Wildl. Manage. 60: 855-862.

Laake, T.L., J.L., Rexstad, E., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Burt, M.L., Hedley, S.L., Pollard, J.H., Bishop, J.R.B. and Marques, T.A. 2009. Distance 6.0. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/

Lopoukhine, N., N. A. Prout and H.E. Hirvonen. 1978. The Ecological Land Classification of Labrador; A Reconnaissance. Ecol. Land. Class. Ser. 4, Lands Directorate, Env. Manag. Serv., Fish. Env. Can., Halifax. 85 pp.

MapInfo. MapInfo Professional, Version 8.5. MapInfo Corporation.

PC-Mapper. PC-Mapper pour les relevés aériens, Version 3.0E2. Corvallis Microtechnology, Inc.

Plante, N. and D. Bordage In prep. Waterfowl and Common Loon population size estimates corrected for perception bias during the Black Duck Joint Venture survey program in Québec 1990–1993 *in* Bordage, D., M.C. Bateman, R.K. Ross, and C. Lepage (eds.). Black Duck Joint Venture waterfowl survey program in eastern Canada and related studies. Can. Wildl. Serv. Occ. Pap. No. XXX, Canadian Wildlife Service, Ottawa.

Savard, J.-P. L., D. Bordage, and A. Reed. 1998. Surf scoter (*Melanitta perspicillata*). Number 363 in A.Poole and F.Gill, editors.The birds of North America.The Birds of North America, Philadelphia, Pennsylvania, USA.

Sea Duck Joint Venture Management Board. 2001. Sea Duck Joint Venture Strategic Plan: 2001-2006. SDJV Continental team. Unpubl. Rept. USFWS, Anchorage, Alaska; CWS, Sackville, New Brunswick.

Sea Duck Joint Venture, 2003. Species Status Report. Continental technical team.

Sea Duck Joint Venture. 2005. Recommendations for monitoring North American Sea Ducks Populations. August 2005. Available at http://seaduckjv.org or U.S. Fish and Wildlife Service, Anchorage, Alaska or Canadian Wildlife Service, Sackville, New Brunswick.

Sea Duck Joint Venture Management Board. 2001. Sea Duck Joint Venture Strategic Plan: 2001-2006. SDJV Continental team. Unpubl. Rept. USFWS, Anchorage, Alaska; CWS, Sackville, New Brunswick.

Smith. G.W. 1995. A critical review of the aerial and ground surveys of breeding waterfowl in North America. Biological Science Report 5, National Biological Service,Washington, D.C. 250 pp.

Appendix 1. Species codes, common and scientific names used for the Eastern Waterfowl Survey database

Species Code[a]	Common Name	Scientific Name
ABDU	American Black Duck	*Anas rubripes*
AGWT	American Green-winged Teal	*Anas crecca*
AMBI	American Bittern	*Botaurus lentiginosus*
AMCR	American Crow	*Corvus brachyrhynchos*
AMWI	American Wigeon	*Anas americana*
ARHA	Arctic Hare	*Lepus arcticus*
ARTE	Arctic Tern	*Sterna paradisaea*
BAEA	Bald Eagle	*Haliaeetus leucocephalus*
BAGO	Barrow's Goldeneye	*Bucephala islandica*
BDMH	Black Duck-Mallard Hybrid	*Anas spp.*
BEAV	Beaver	*Castor canadensis*
BEKI	Belted Kingfisher	*Ceryle alcyon*
BLBE	Black Bear	*Ursus americanus*
BLML	Black Duck male * Mallard female	
BLSC	Black Scoter	*Melanitta nigra*
BUFF	Bufflehead	*Bucephela albeola*
BWTE	Blue-winged Teal	*Anas discors*
CAGO	Canada Goose	*Branta canadensis*
CARI	Caribou	*Rangifer tarandus*
CATE	Caspian Tern	*Sterna caspia*
COEI	Common Eider	*Somateria mollissima*
COGO	Common Goldeneye	*Bucephela clangula*
COLO	Common Loon	*Gavia immer*
COME	Common Merganser	*Mergus merganser*
CONI	Common Nighthawk	*Chordeiles minor*
CORA	Common Raven	*Corvus corax*
COSN	Common Snipe	*Gallinago gallinago*
COTE	Common Tern	*Sterna hirundo*
DCCO	Double-crested Cormorant	*Phalacrocorax auritus*
GADW	Gadwall	*Anas strepera*
GBBG	Great Black-backed Gull	*Larus marinus*
GHOW	Great Horned Owl	*Bufo virginianus*
GLGU	Glaucous Gull	*Larus hyperboreus*
GOEA	Golden Eagle	*Aquila chrysaetos*
GRSC	Greater Scaup	*Aythya marila*
GRYE	Greater Yellowlegs	*Tringa melanoleuca*
GYRF	Gyrfalcon	*Falco rusticolus*
HARD	Harlequin Duck	*Histrionicus histrionicus*
HERG	Herring Gull	*Larus argentatus*
HOME	Hooded Merganser	*Lophodytes cucullatus*
LESA	Least Sandpiper	*Calidris minutilla*
LESC	Lesser Scaup	*Aythya affinis*
MALL	Mallard	*Anas platyrhynchos*
MBDH	Mallard-Black Duck Hybrid	*Anas spp.*
MERL	Merlin	*Falco columbarius*
MLBL	Mallard male * Black Duck female	
MOOS	Moose	*Alces alces*
MUSK	Muskrat	*Ondatra zibethica*
NOGO	Northern Goshawk	*Accipiter gentilis*
NOHA	Northern Harrier	*Circus cyaneus*
NOHO	Northern Hawk-Owl	*Surnia ulula*
NOPI	Northern Pintail	*Anas acuta*
LTDU	Long-tailed Duck	*Clangula hyemalis*
OSPR	Osprey	*Pandion haliaetus*
PEFA	Peregrine Falcon	*Falco peregrinus*
PORC	Porcupine	*Erethizon dorsatum*
PUSA	Purple Sandpiper	*Calidris maritima*
RBGU	Ring-billed Gull	*Larus delawarensis*
RBME	Red-breasted Merganser	*Mergus serrator*
RFOX	Red Fox	*Vulpes vulpes*
RIOT	River Otter	*Lutra canadensis*
RLHA	Rough-legged Hawk	*Buteo lagopus*

Species Code[a]	Common Name	Scientific Name
RNDU	Ring-necked Duck	*Aythya collaris*
RNGR	Red- necked Grebe	*Podiceps grisegena*
RNPH	Red-necked (Northern) Phalarope	*Phalaropus lobatus*
ROPT	Rock Ptarmigan	*Lagopus mutus*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RTLO	Red-throated Loon	*Gavia stellata*
RUGR	Ruffed Grouse	*Bonasa umbellus*
RUTU	Ruddy Turnstone	*Arenaria interpres*
SEOW	Short-eared Owl	*Asio flammeus*
SEPL	Semipalmated Plover	*Charadrius hiaticula*
SESA	Semipalmated Sandpiper	*Calidris pusilla*
SNBU	Snow Bunting	*Plectrophenax nivalis*
SNGO	Snow Goose	*Anser caerulescens*
SNOW	Snowy Owl	*Nyctea scandiaca*
SOSA	Solitary Sandpiper	*Tringa solitaria*
SPGR	Spruce Grouse	*Dendragapus canadensis*
SPSA	Spotted Sandpiper	*Actitis macularia*
SSHA	Sharp-shinned Hawk	*Accipiter striatus*
SUSC	Surf Scoter	*Melanitta perspicillata*
TERN	Unidentified Tern species	
TIWO	Timber Wolf	*Canis lupus*
UNCO	Unidentified Cormorant species	*Phalacrocorax spp.*
UNDI	Unidentified Diving Duck species	
UNDU	Unifentified Duck species	
UNGO	Unidentified Goldeneye species	*Bucephala spp.*
UNGU	Unidentified Gull species	*Larus spp.*
UNHA	Unidentified Hawk species (Buteo or Falcon)	
UNLO	Unidentified Loon species	*Gavia spp.*
UNME	Unidentified Merganser species	
UNMU	Unidentified Murre species	*Uria spp.*
UNOW	Unidentified Owl species	
UNPH	Unidentified Phalarope species	*Phalaropus spp.*
UNPT	Unidentified Ptarmigan species	*Lagopus spp.*
UNRA	Unidentified Raptor	
UNSB	Unidentified Seabird	
UNSE	Unidentified Seaduck species	
UNTE	Unidentified Teal species	
UNWH	Unidentified Whale species	
UNYE	Unidentified Yellowlegs species	*Tringa spp.*
USCA	Unidentified Scaup species	*Aythya spp.*
USCO	Unidentified Scoter species	*Melanitta spp.*
UTER	Unidentified Tern species	*Sterna spp.*
WHIM	Whimbrel	*Numenius phaeopus*
WIPT	Willow Ptarmigan	*Lagopus lagopus*
WWGU	White-winged Gull (Iceland and/or Glaucous)	
WWSC	White-winged Scoter	*Melanitta fusca*

[a] For birds fully identified to species, the species codes used are those found in the North American bird-banding manual. Species codes for mixed pairs were constructed by listing first the male, then the female.

Appendix 2. Rules for calculation of indicated pairs (IPs) for waterfowl

Sighting Combination[a]				Number of indicated pairs (IPs)					
M	F	U	T	Dabbler[b] (except Black Duck)	Black Duck	Diver[c] (except Ring-necked Duck)	Ring-necked Duck	Canada Goose	Loons
1	0	0	1	1	1	1	1	1	1
0	x	x	1	0	1	0	0	1	1
2	0	0	2	2	1.5	2	2	1	1
1	x	x	2	1	1.5	1	1	1	1
0	x	x	2	0	1.5	0	0	1	1
3	0	0	3	3	3	3	3	1	0
2	x	x	3	2	3	2	2	1	0
1	x	x	3	1	3	1	1	1	0
0	2	1	3	0	3	0	0	1	0
0	1	2	3	0	3	0	0	1	0
0	0	3	3	0	3	0	0	1	0
4	0	0	4	4	4	4	4	0	0
3	1	0	4	3	4	3	3	0	0
3	0	1	4	3	4	3	3	0	0
2	x	x	4	2	4	2	2	0	0
1	x	x	4	1	4	1	1	0	0
0	x	x	4	0	4	0	0	0	0
1	x	x	>4	0	0	0	1	0	0
2	x	x	>4	0	0	0	2	0	0
3	x	x	>4	0	0	0	3	0	0
4	x	x	>4	0	0	0	4	0	0
>4	x	x	>4	0	0	0	0	0	0

[a] M = male, F = female, U = unsexed, T = total; x = either female or unsexed.
[b] Dabbler : AGWT, AMWI, BWTE, GADW, MALL, NOPI, NOSH, WODU.
[c] Diver : BAGO, BLSC, BUFF, COGO, COME, GRSC, HARD, HOME, LESC, LTDU, RBME, SUSC, WWSC.

Appendix 3. Indicated pair counts and population estimates by species and plot for the western half of the low-level training area CYA-732, Labrador, 2009.

Plot	ABDU	AGWT	BLSC	BUFF	CAGO	COGO	COLO	COME	GRSC	HARD	HOME	LESC	LTDU	MALL	NOPI	RBME	RNDU	RTLO	SUSC	WWSC	Scoter	Scaup
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	10	6	3	0	3	0	0	0	1	0	1	3	0	0	0	6	0	0	11	0	14	4
6	1	3	0	0	3	0	0	3	0	0	0	0	1	0	2	8	0	0	1	0	1	0
7	0	8	3	0	3	0	0	0	0	0	0	1	0	0	3	2	0	0	10	1	14	1
8	2.5	14	4	0	6	0	1	0	2	0	0	3	1	0	7	6	0	3	1	0	5	6
9	4	1	0	0	2	0	1	0	0	0	0	2	0	0	0	2	0	0	6	0	6	2
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	5.5	1	1	0	7	0	1	0	0	0	0	2	0	0	0	13	0	0	5	0	6	2
12	0	4	2	0	3	0	1	0	3	0	0	2	0	0	0	5	0	0	0	0	2	5
13	5	6	9	0	13	0	0	0	2	0	0	3	6	1	2	8	0	0	3	5	17	5
14	2	5	6	0	2	0	0	0	1	0	0	0	0	0	0	6	0	0	1	0	7	1
15	8	11	7	0	9	1	1	0	2	0	0	13	0	0	3	1	0	0	17	1	25	16
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17	18.5	12	8	0	13	0	1	0	2	0	0	7	3	0	0	0	0	0	11	0	19	9
18	2	0	0	0	1	2	0	0	0	0	0	1	0	1	0	1	0	0	3	0	3	1
19	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
20	1.5	1	2	0	6	0	2	0	0	0	0	0	0	0	0	5	0	0	6	0	8	0
21	3	1	1	0	1	0	0	1	0	1	0	2	0	0	0	0	0	0	4	0	5	2
22	2.5	5	0	0	7	0	1	0	0	0	0	2	0	0	0	2	0	0	0	0	0	2
23	0	0	0	0	4	0	0	0	0	0	0	0	0	0	2	2	0	0	2	0	2	0
24	4.5	4	0	0	1	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
25	1	4	0	0	1	1	1	1	0	0	0	0	0	0	0	10	0	1	1	0	1	0
26	1	2	7	0	9	0	0	0	0	0	0	17	3	1	3	1	0	2	4	0	11	17
27	5	3	5	0	10	0	1	0	3	0	0	6	0	0	0	3	1	1	2	2	9	9
28	3	2	0	0	13	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0
29	4	0	0	0	2	0	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	1.5	0	0	0	0	0	1	0	0	0	0	1	0	0	1	5	0	0	0	0	0	1
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
33	7	2	0	0	10	1	4	0	0	0	0	4	0	1	0	24	0	0	7	0	7	4
34	3	7	0	0	3	0	7	1	0	0	0	3	0	0	0	6	0	0	6	0	6	3
35	0	0	0	0	5	0	2	0	0	0	0	0	0	0	0	6	0	0	1	0	1	0
36	3	0	2	0	2	0	1	1	0	0	0	0	0	0	0	5	0	0	0	0	2	0
37	1	2	0	0	1	0	1	0	1	0	0	1	0	0	0	3	0	1	8	0	8	2
Mean	3.2	3.4	1.9	0	4.6	0.16	1.0	0.23	0.55	0.03	0.03	2.4	0.45	0.13	0.74	4.4	0.03	0.29	3.5	0.32	5.8	3.0
SD	3.8	3.8	2.8	0	4.1	0.45	1.4	0.62	0.96	0.18	0.18	3.8	1.30	0.34	1.50	4.8	0.18	0.69	4.3	0.98	6.4	4.4
Nhat	3113	3308	1848	0	4475	156	973	224	535	29	29	2335	438	126	720	4280	29	282	3405	311	5642	2918
95%CI	1334	1334	983	0	1439	158	491	218	337	63	63	1334	456	119	526	1685	63	242	1509	344	2246	1544

Appendix 4. Total Individual and population estimates by species and plot for the western half of the low-level training area CYA-732, Labrador, 2009.

Plot	ABDU	AGWT	BLSC	BUFF	CAGO	COGO	COLO	COME	GRSC	HARD	HOME	LESC	LTDU	MALL	NOPI	RBME	RNDU	RTLO	Scoter	Scaup
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	11	7	5	0	6	0	0	0	1	0	2	6	0	0	0	11	0	0	27	7
6	1	4	0	0	4	0	0	5	0	0	0	0	3	0	2	13	0	0	1	0
7	0	9	6	0	4	0	0	0	0	0	0	2	0	0	3	4	0	0	27	2
8	3	14	5	0	24	0	2	0	4	0	0	5	1	0	10	10	0	4	7	11
9	4	1	0	0	5	0	2	0	0	0	0	4	0	0	0	3	0	0	12	4
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	6	6	1	0	17	0	2	0	0	0	0	4	0	0	0	19	0	0	6	4
12	0	4	3	0	3	0	2	0	4	0	0	4	0	0	0	29	0	0	3	8
13	6	7	16	0	25	0	0	0	2	0	0	4	6	1	2	24	0	0	32	6
14	2	7	11	0	3	0	0	0	1	0	0	0	0	0	0	9	0	0	13	1
15	9	12	14	0	14	1	2	0	3	0	0	17	0	0	5	2	0	0	51	22
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17	20	16	12	0	30	0	1	0	3	0	1	12	7	0	0	0	0	0	27	15
18	2	0	0	0	1	4	0	0	0	0	0	2	0	2	0	2	0	0	17	2
19	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
20	2	1	4	0	6	0	2	0	0	0	0	0	0	0	0	8	0	0	15	0
21	4	2	2	0	2	0	0	1	0	1	0	4	0	0	0	0	0	0	9	4
22	3	7	0	0	12	0	1	0	0	0	0	9	0	0	0	4	0	0	0	9
23	0	0	0	0	79	0	0	0	0	0	0	0	0	0	2	2	0	0	3	0
24	6	4	0	0	11	0	3	0	0	0	0	0	0	0	0	4	0	0	0	0
25	1	4	0	0	26	1	2	4	0	0	0	0	0	0	0	19	0	2	3	0
26	1	4	13	0	15	0	0	0	0	0	0	26	4	2	3	2	0	4	20	26
27	5	5	11	0	23	0	2	0	4	0	0	9	0	0	0	5	2	2	19	13
28	4	4	0	0	46	0	1	0	0	0	0	0	0	0	0	7	0	1	2	0
29	4	0	0	0	4	0	3	0	0	0	0	2	0	0	0	2	0	0	0	2
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	2	0	0	0	0	0	2	0	0	0	0	2	0	0	2	9	0	0	0	2
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
33	12	3	0	0	16	1	7	0	0	0	0	7	0	1	0	82	0	0	17	7
34	3	10	0	0	4	0	13	1	0	0	0	4	0	0	0	12	0	0	9	4
35	0	0	0	0	10	0	3	0	0	0	0	0	0	0	0	11	0	0	2	0
36	3	0	3	0	19	0	1	1	0	0	0	0	0	0	0	14	0	0	3	0
37	1	2	0	0	7	0	2	0	2	0	0	2	0	0	0	4	0	2	15	4
Mean	3.7	4.3	3.4	0	14	0.23	1.7	0.39	0.77	0.32	0.39	4	0.68	0.16	0.94	10	0.07	0.48	10.0	4.9
SD	4.4	4.4	5.1	0	16	0.76	2.6	1.1	1.4	0.18	0.40	5.8	1.8	0.54	2.10	15	0.36	1.1	12.0	6.6
Nhat	3689	4287	3390	0	13958	229	1695	389	768	319	389	3988	678	160	937	9970	70	479	9970	4885
95%CI	1544	1544	1790	0	5616	267	913	386	491	63	140	2036	632	190	737	5265	126	386	4212	2316

Appendix 11. Photos showing examples of species identification from the helicopter.

Photo 1. Two pairs of Lesser Scaup with a male Ring-necked Duck.

Photo 2. Two males with a female Surf Scoter.

Photo 3. Male Common Goldeneye.

Photo 4. Pair of Greater Scaup on the water.

Photo 5. Pair of Greater Scaup about to land on the water.

Photo 6. Pair of Red-breasted Mergansers.

Photo 7. Female Lesser Scaup taking off.

Photo 8. Pair of Black Scoters with a pair of Surf Scoters.

Photo 9. Pair of Black Scoters.

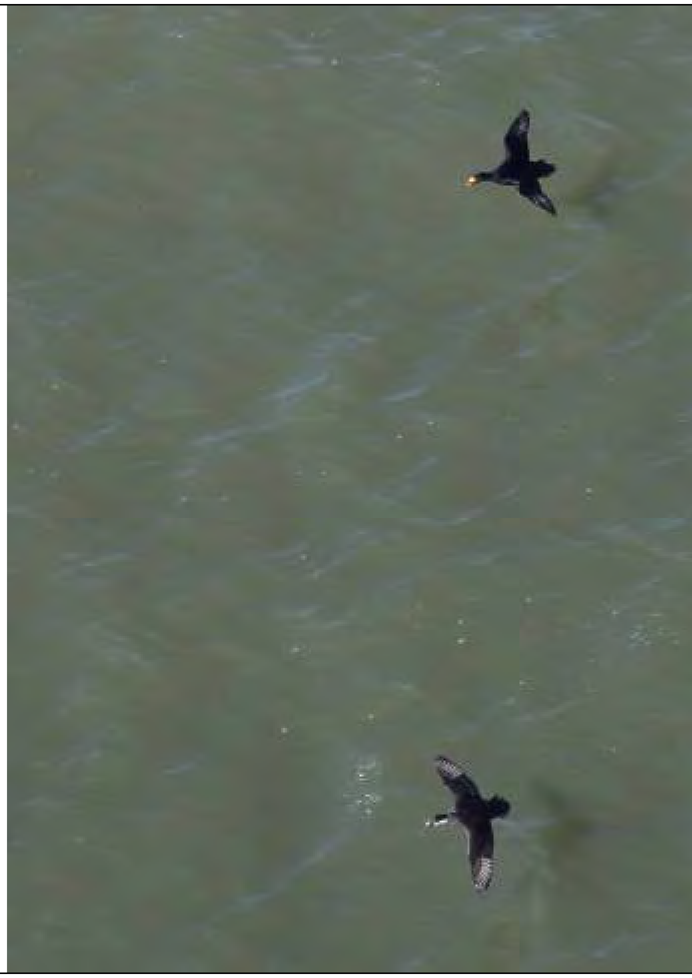


Photo 10. Three male and a female Ring-necked Ducks.

Photo 10. Two male, two female and a sub-adult male Harlequin Duck.