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Relationships among Breeding, Molting and Wintering Areas of Adult Female Barrow's Goldeneyes (*Bucephala islandica*) in Eastern North America

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Abstract.—While the breeding and wintering ranges of the eastern population of Barrow's Goldeneyes (*Bucephala islandica*) are generally described, molting locations and links among breeding, molting, and wintering areas are unclear, particularly for adult females. Incubating females from the same breeding location ($n = 5$) were equipped with satellite transmitters in June 2009. Four molting sites were identified over 2 years, spread broadly across Québec: an inlet in Ungava Bay 1,100 km from the breeding area, a lake 100 km south of Ungava Bay (880 km from breeding area), a lake near Hudson Bay (910 km from breeding area) and the mouth of the Rivière aux Outardes River in the St. Lawrence Estuary (165 km from breeding area). The distance between molting females averaged 755 km and two females molted in regions where males were known to molt. Of four birds with consecutive years of molt locations, three showed inter-annual fidelity to within 5 km of the previous molt sites and the fourth molted in sites that were 968 km apart. Females wintered in different locations within the St. Lawrence Estuary and moved widely throughout the area during winter. The south coast of the St. Lawrence Estuary was used during spring and fall staging, and the north coast during winter. There was not strong migratory connectivity among annual cycle stages in eastern adult female Barrow's Goldeneyes, indicating that they should be considered a single management unit that occurs over a broad range throughout the year. *Received 30 March 2012, accepted 17 October 2012.*

Key words.—Barrow's Goldeneye, *Bucephala islandica*, female, migration, molt population delineation, satellite telemetry, site fidelity.

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The eastern North American population of Barrow's Goldeneyes (*Bucephala islandica*) was designated to be 'of special concern' by the Committee on the Status of Endangered Wildlife in Canada in 2001 (Robert *et al.* 2000a) due to low numbers (estimated to be 4,000 individuals at the time) and anthropogenic threats (Savard 1996; Savard and Dupuis 1999). Lack of knowledge about basic ecology and distribution also contributed to conservation concerns; for example, breeding areas were not fully determined until 1998 (Robert *et al.* 2000b). In recent years, movements and migratory connectivity of adult males have been studied (Benoit *et al.* 2001; Robert *et al.* 2002), the wintering distribution and ecology have been well documented (Bourget *et al.* 2007; Ouellet *et al.* 2010), and numbers have been estimated to be approximately 5,200 birds (Robert and Savard 2006). Several molting sites for males were located, all north of the breeding areas, including Hudson Bay, Ungava Bay, southern Baffin Island, along the Labrador Coast, and on northern inland lakes (Robert *et al.* 2000c, 2002). The large number, diversity and wide distribution of molting sites were unexpected because of the small size of the population and because in Iceland most birds molted in a few areas (Einarsson and Gardarsson 2004). These studies provided insight into the relationships among breeding, molting and wintering locations of males, but whether females followed similar patterns was unknown. Data from British Columbia suggested that females molted closer to the breeding areas than males (Eadie *et al.* 2000; S. Boyd, unpubl. data). Males outnumber females (Robert and Savard 2006), pair on wintering areas (Rodway 2007), and follow their mate to her natal area (Savard and Eadie 1989). Females are thus important in structuring populations. As the number of adult females is small in the eastern population (~2,000 individuals; Robert and Savard 2006), their protection is essential and knowledge of their seasonal movements, molting areas, molting phenology and winter habitats is important to document. Also, it is important to determine whether there are subpopulations or management units within the eastern population as this would influence conservation strategies.

Our main objectives were to: (1) determine molting location(s) of adult female Barrow's Goldeneyes, (2) define migratory connectivity and population structure, and (3) determine whether females used the same molting location each year. Philopatry is important to assess as it may help define meaningful population subunits.

Methods

Five female Barrow's Goldeneyes were captured in nest boxes (Savard and Robert 2007) during incubation or laying on 9 and 10 June 2009 in the Martin-Valin and Chauvin Zecs located 60 km northeast of Tadoussac, Québec (48° 31' 40.59" N, 70° 14' 16.28" W; Fig. 1). Satellite transmitters were implanted in the abdominal cavities of females by experienced veterinarians (see

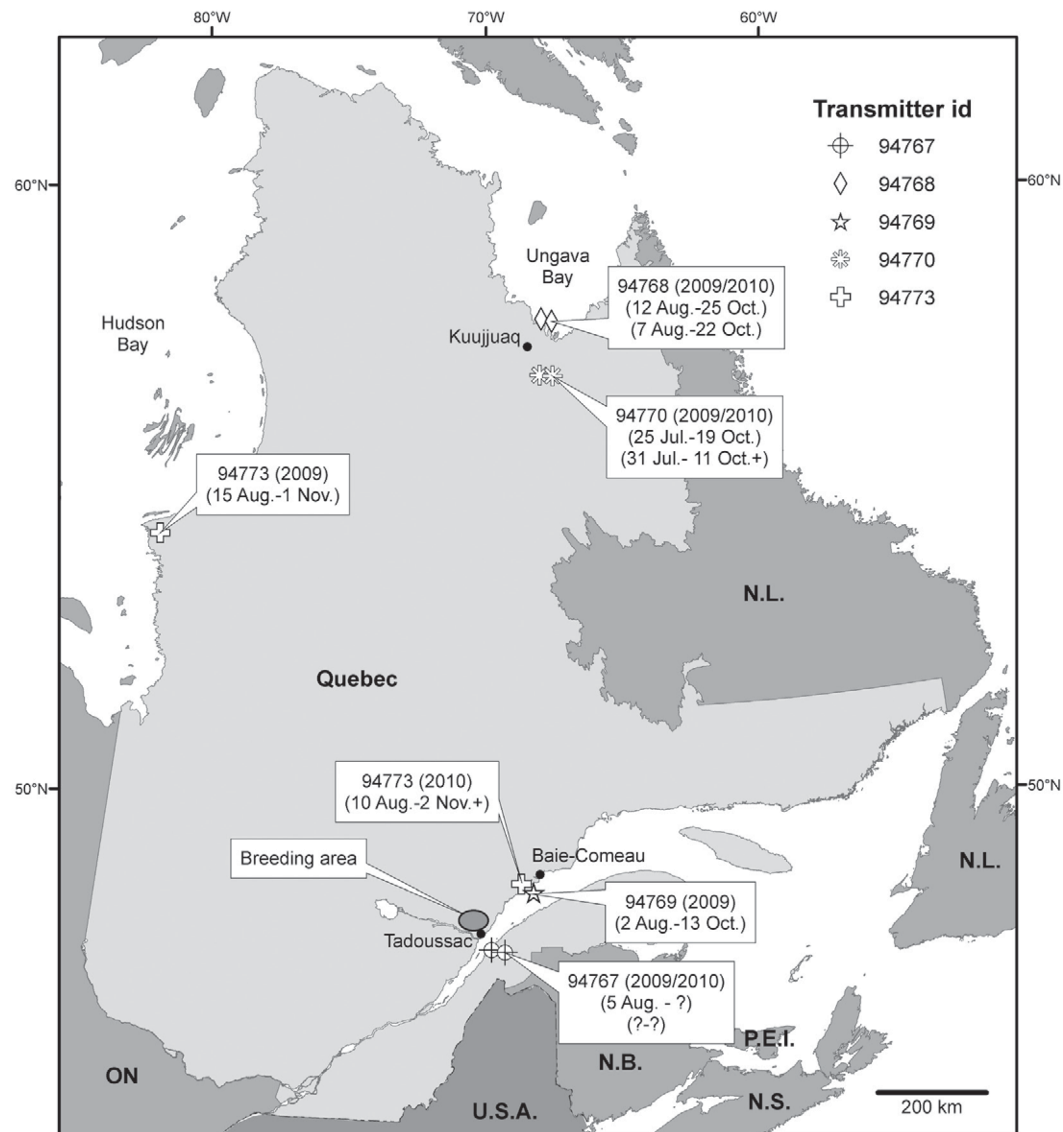

Figure 1. Molting locations of female Barrow's Goldeneyes breeding 60 km northwest of Tadoussac, Québec (nine molting occasions for five females; + indicates still present at molting site on this date).

Table 1. Detailed movement characteristics of adult female Barrow's Goldeneyes from the same breeding area.

Transmitter id	94767	94768	94769	94770	94773
Year 2009					
Capture date	09-Jun	09-Jun	10-Jun	10-Jun	09-Jun
Nest box content (eggs)	9 warm	14 warm	6 warm	9 warm	5 cold
Female weight (g)	718	748	693	706	690
Duration of an aesthesia (min)	54	93	68	57	89
Duration of surgery (min)	37	57	39	34	59
Last signal from breeding area	20-Jul	27-Jul	30-Jul	19-Jul	09-Aug
First signal from molting area	05-Aug	30-Jul	2-Aug	25-Jul	15-Aug
First signal from molting location	05-Aug	12-Aug	14-Aug	25-Jul	15-Aug
Length of stay at molt site (days)		75	61	87	79
Molting location	St. Lawrence	Ungava Bay	St. Lawrence	Inland (Ungava Bay)	Inland (Hudson Bay)
Distance molt-breeding areas (km)	97	1026	142	840	930
Last signal from molting area	?	25-Oct	13-Oct	19-Oct	01-Nov
First signal from fall staging area	03-Nov	29-Oct	04-Nov	25-Oct	08-Nov
Distance molt-fall staging areas (km)		1095	51	934	954
Distance fall staging-winter areas (km)		70	?	128	58
Year 2010					
Wintering location in the St. Lawrence	Petits Escoumins	Baie-Comeau	?	Franquelin	Petits Escoumins
Distance winter-spring staging areas (km)	32	35		128	38
Last signal from spring staging area	20-Apr	22-Apr		23-Apr	03-May
First signal from breeding area	20-May	25-Apr		26-Apr	06-May
Distance spring staging-breeding areas (km)	93	188		108	82
Last signal from breeding area	5-Aug	25-Jul		18-Jul	03-Aug
First signal from molting area	?	07-Aug		31-Jul	10-Aug
Molting location	St. Lawrence	Ungava Bay		Inland (Ungava Bay)	St. Lawrence
Distance from 2009 molt site (km)		0		5	965
Distance molt-breeding areas (km)	?	1044		844	132
Last signal from molting location		22-Oct		11-Oct++	02-Nov ++
Length of stay at molt site (days)		77		73++	
First signal from fall staging area		04-Nov			

++indicate that the radio stopped on this date.

Fitzgerald *et al.* 2001 for the detailed procedure). We used 26 g Argos PTT-100 implant transmitters (Microwave Telemetry) with external antennae. Transmitters were programmed to transmit for 5 hr every 3 days (5 hr on and 70 hr off) and constituted 3.5-3.8% of female mass. Females were released 1-2 hr post-surgery on the lake adjacent to their nest box. Bird movements were monitored using Argos (Harris *et al.* 1990; Service Argos 1996). The exact date on which an individual left or arrived at a given site could not be determined because locations were usually obtained at 2- to 3-day intervals. We assumed that a bird first arrived at a given site on the date of the first signal from that site and that it departed the site on the day following the last location at that site. We used a modified version of the Douglas-Argos Filter to remove implausible locations using minimum redundant distance and distance-angle-rate tests between consecutive location points (Douglas 2006). The distance between a location of quality 2-3 (< 350 m precision) and the next one of quality 2-3 (on a different day, usually 3 days later given our duty cycle) was measured to get an estimate or index (using the average) of the area used by a female when on the breeding, molting and wintering areas as well as on the fall and spring staging areas. Also, the coefficient of variation (CV) was calculated to portray individual variability.

RESULTS

Molting Areas

Females stayed on the breeding area (~600 m elevation) until mid to late July (Table 1). Arrival on molting areas ranged between 5 and 15 August in 2009 and 31 July and 10 August in 2010. Molting locations were quite dispersed, ranging from 97 to 1,044 km from the breeding area (Table 1) in a variety of directions (north, west and south; Fig. 1). In 2009, three females molted in three different estuarine habitats, two in the St. Lawrence Estuary (one at the mouth of the Rivière aux Outardes near Baie-Comeau and one near Kamouraska), and one in Ungava Bay. Two others molted on inland lakes: one about 100 km south of Ungava Bay (370 m elevation) and one near the southeastern shore of Hudson Bay (4 m elevation; Fig. 1).

In 2010, two females returned to the same area where they molted in 2009: female 94768 to the exact same estuary in Ungava Bay and female 94770 molted on a smaller lake, 4 km from the 2009 molting lake located about 100 km south of Ungava

Table 2. Comparison of the timing of migration and molt of female and male Barrow's Goldeneyes in eastern North America. Only for birds that molted outside the St. Lawrence Estuary. Males identified per Robert *et al.* 2002.

	Females		Males		
Action	Mean ± SD[2] (*n*)	Range	Mean ± SD[2] (*n*)	Range	Difference
Leaving breeding areas	25 Jul ± 8.8 (5)	18 Jul-9 Aug	9 Jun ± 6.5 (11)	29 May-20 Jun	46 days
Arrival at molting site[1]	06 Aug ± 8.0 (5)	25 Jul-15 Aug	29 Jun ± 12.9 (11)	14 Jun-06 Jul	39 days
Days on molting areas	80 ± 5.3 (4)	75 87	122 ± 9.2 (5)	109 135	43 days
Departure from molting areas	25 Oct ± 5.6 (4)	20 Oct-02 Nov	16 Oct ± 9.0 (4)	04 Oct-23 Oct	9 days
Arrival in the St. Lawrence Estuary	03 Nov ± 8.1 (4)	25 Oct-11 Nov	27 Oct ± 1.2 (3)	23 Oct-28 Oct	8 days

[1]The molting site is the location where the bird became flightless; the molting areas are the first coastal sites reached following breeding; some birds went directly to the molting site but others not.
[2]Days.

Bay (Fig. 1). One female (94773) molted on a lake near Hudson Bay in 2009 (930 km northwest of the breeding area) and in the St. Lawrence Estuary in 2010 (132 km southeast of the breeding area and 960 km from the 2009 molting site). Female 94767 molted both years in the St. Lawrence Estuary but the precise location was unclear. Duration of stay at molting areas outside the St. Lawrence Estuary averaged 79.5 ± 5.3 days (±SD; Range = 75-87; *n* = 4). The last signal from the molting areas outside the St. Lawrence Estuary averaged 25 October (±6 days; *n* = 4). Females departed on average 46 days later than males from the breeding areas and spent 42.5 fewer days at their molting site (Table 2). Females departed later than males from molting sites, but there were wide ranges in departure time of individuals (20 October-2 November; Table 2).

Wintering, Staging and Breeding Areas

All five females wintered in the St. Lawrence Estuary within the known wintering range. Arrival in the St. Lawrence Estuary for the females that molted north ranged between 25 October and 8 November (*n* = 4). One female staged for a few weeks during the fall on the north shore of the estuary and three staged along the south shore (Fig. 2). Female 94768 staged on the south shore of the St. Lawrence Estuary in 2009 and 2010 but at sites 38 km apart. All wintered on the north shore along a 220-km stretch of shoreline (Fig. 3). In the spring, two females returned to the south shore of the estuary where they staged before departing for their breeding area and two remained on the north shore. None of the females staged at the same location. The closest spring staging sites were 40 km apart and the farthest 160 km apart (Fig. 4). Last signals from the spring staging areas ranged between 20 April and 3 May. For three females, the next signal was 3 days later on the breeding area. The breeding area averaged 118 km (Range = 82-188) from the spring staging areas. All females for which we had data (*n* = 4) returned to the same breeding area in 2010.

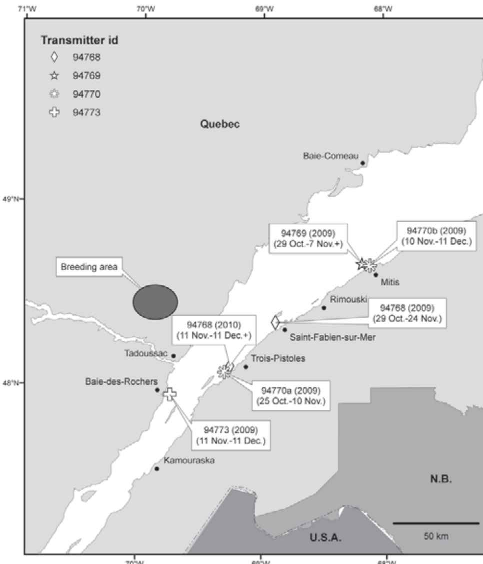

Figure 2. Fall staging areas used by female Barrow's Goldeneyes breeding 60 km northwest of Tadoussac, Québec (+ indicates still present at staging site on this date).

Migration

Both spring and fall migrations were quick with birds moving directly to breeding locations from their spring staging areas and from their northern molting locations

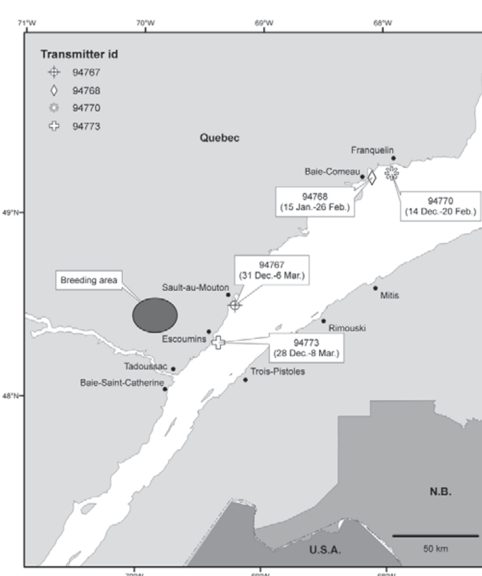

Figure 3. Wintering areas (2009-2010) used by four female Barrow's Goldeneyes breeding 60 km northwest of Tadoussac, Québec.

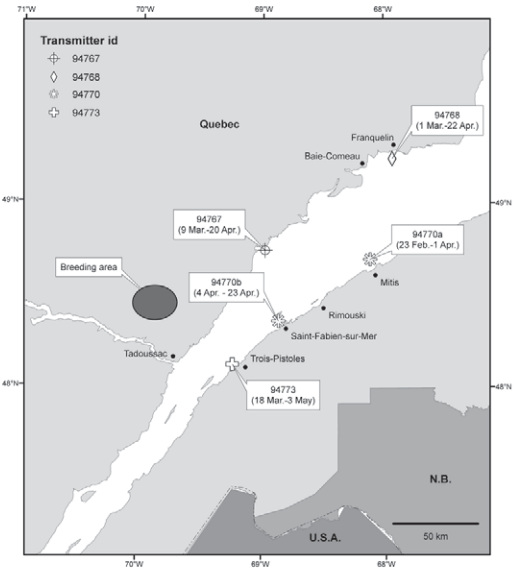

Figure 4. Spring staging areas (2010) used by female Barrow's Goldeneyes breeding 60 km northwest of Tadoussac, Québec.

to their fall staging sites. Our duty cycle did not permit a close monitoring of the migration, but birds spent < 5 days staging on lakes before returning quickly to the St. Lawrence Estuary. Two females (94770, 94773) spent < 5 days close to their breeding areas on their way back from their molting locations, but no inland stays > 4 days were detected during fall or spring migrations.

Within-Season Movements

Females stayed within the smallest area on the molting areas (females averaged 1.5 ± 0.6 km between successive high quality locations) and the largest on the wintering areas (20.4 ± 11.8 km; Table 3). Females were more mobile during fall (5.6 ± 2.5 km) than during spring staging (1.4 ± 0.7 km) or breeding (2.6 ± 0.9 km; Table 3). Females used the smallest area during molt and during spring staging. Movements of individual females were more variable during fall staging (CV = 84%) than wintering (CV = 49%) but not as extensive (5.6 km vs. 20.4 km).

DISCUSSION

Adult female Barrow's Goldeneyes from a single breeding area molted across a broad range of non-breeding sites. These findings indicate that there is little migratory connectivity among annual cycle stages, and thus there is little suggestion that subpopulation structure exists within the eastern North American population in relation to molting areas. A similar lack of relationship between breeding and molting locations has been found in Common Mergansers (*Mergus merganser*; Pearce *et al.* 2009) and in Steller's Eiders (*Polystica stelleri*; Dau *et al.* 2000). All females wintered within the St. Lawrence Estuary but not together. Thus, within the St. Lawrence Estuary (~250 km long and 60 km at its widest part), there is no direct connection between a wintering and a breeding site. Robert *et al.* (2002) did not find any relationship between the wintering and molting locations of male Barrow's Goldeneyes. However, there was a high degree of interannual site fidelity at both breeding and molting sites, indicating that perturbations at one of these stages might lead to effects on a population subunit. Unlike in western

Table 3. Average distance (km) ± SE (CV) between two Argos locations of quality 2 or 3 (distance between a location of quality > 2 and the next one of quality > 2 on a subsequent day) during different periods of the annual cycle. Breeding = while on the breeding area; Molting = while on the molting area; Fall = from arrival in St. Lawrence Estuary to settlement on wintering areas (for birds already in St. Lawrence Estuary, when moved >50 km from molt area); Wintering = mostly January and February; Spring = from first movement out of wintering area or in March and April. CV = coefficient of variation expressed in %; *n* = number of different female-seasons (number of different females involved).

Parameter	Breeding	Molting	Fall	Wintering	Spring
Mean of means	2.6 ± 0.9 (66)	1.5 ± 0.6 (28)	5.6 ± 2.5 (84)	20.4 ± 11.8 (49)	1.5 ± 0.7 (28)
Mean of maxima	7.3 ± 2.6 (63)	3.9 ± 1.5 (43)	21.7 ± 9.7 (132)	98.3 ± 56.7 (72)	3.2 ± 1.6 (40)
Range	1.1 - 15.3	0.9 - 6.46	1.8 - 71.42	13 - 178.72	1.0 - 4.84
n	8 (5)	7 (4)	5 (4)	3 (3)	4 (3)

North America where Barrow's Goldeneyes remain faithful to a wintering site in winter (Savard 1988; D. Esler, unpubl. data), female Barrow's Goldeneyes in the St. Lawrence Estuary move around, possibly in response to ice conditions.

In eastern North America, females, like males (Benoit *et al.* 2001; Robert *et al.* 2002), molt in estuarine settings as well as coastal and inland lakes, whereas in western North America they only molt on inland alkaline lakes (Van de Wetering 1997; Hogan *et al.* 2011). Three female Barrow's Goldeneyes were philopatric to their molting location and one was not. Hatton and Marquiss (2004) found similar patterns in female Common Mergansers with most females being philopatric to their molting location. Fidelity to molting locations has also been documented in Steller's Eiders (Flint *et al.* 2000) and Harlequin Ducks (*Histrionicus histrionicus*; Brodeur *et al.* 2002). Causes leading to the selection of a given molting site in a given year are unknown, but change of molting location between years has been documented in sea ducks but its frequency and causes are unknown (Hatton and Marquiss 2004; J.-P. L. Savard, unpubl. data).

Female Barrow's Goldeneyes likely abandoned their clutch following surgery as none remained on a single wetland for several weeks. As female sea ducks are known to remain on their breeding area even after nest failure (Eadie *et al.* 2000; Savard *et al.* 2007), it was impossible to clearly determine whether our females bred successfully or not. All females stayed within a few km during breeding suggesting that they do not prospect for nest cavities within a large area (Eadie and Gauthier 1985). Both female and male Barrow's Goldeneyes fly more or less directly to their molting site after leaving the breeding area (Robert *et al.* 2002). Male Barrow's Goldeneyes reach their molting location about a month before females (Robert *et al.* 2002).

Similar to males, females stay at their molting location until late fall, well after having regained their flying abilities. The molting area could be also considered as a first fall staging area as birds are flightless for about 4 weeks but remain there for over 10 weeks. Females left their northern molting areas and arrived in the St. Lawrence Estuary about a week after males but timing varied among individuals. Female King Eiders (*Somateria spectabilis*) also dispersed later from the molting areas than males (Phillips *et al.* 2006).

Females used the same fall staging areas as males. In the St. Lawrence Estuary, these sites are located mostly along the south shore. Birds are forced out of these areas by ice conditions (Bourget *et al.* 2007) as intertidal areas of the south shore of the St. Lawrence Estuary, unlike on the north shore, are ice-covered during winter (Robert *et al.* 2003). However, they return to the south shore in the spring as intertidal areas become ice-free. Food resources are likely greater there, as they are not exploited during winter. They used a very small area during spring staging, likely because females, likely already paired, focus on feeding at that time in preparation for the breeding season.

Female Barrow's Goldeneyes moved frequently during winter and each female used several sites throughout the winter. Also, all females did not winter in the same area. However, it seems that the estuary wintering population is a single one. We did not observe any movements between the St. Lawrence Estuary and the Gulf of St. Lawrence; neither did Robert *et al.* (2002) for males. Although sample sizes are relatively low, it may be prudent, from a conservation and habitat use perspective, to consider birds wintering in the Gulf of St. Lawrence and in Chaleur Bay (Robert and Savard 2006; Ouellet *et al.* 2010) distinct from those wintering in the estuary until shown otherwise. This should be kept in mind when planning and interpreting winter survey results.

The lack of a one-to-one relationship between breeding and molting locations implies that any disaster at a molting site will affect female Barrow's Goldeneyes from more than one breeding location as was found for males (Robert *et al.* 2002); inversely, any disaster at a breeding area would affect birds from several molting sites. Within the estuary (scale of 250 km long), females from the same breeding area did not winter together nor did they use the same spring or fall staging areas. Factors leading to the selection of wintering and staging areas are unknown in goldeneyes as is the case for most sea ducks. Possibly this selection occurs during the subadult years, which have been poorly studied in all sea ducks and could also have a genetic component (Berthold 1996). Philopatry to wintering areas has been documented in Barrow's Goldeneyes (Savard 1985) and other sea ducks (Iverson *et al.* 2004; Iverson and Esler 2006). Whether Barrow's Goldeneye pairs remain together for several years as was found for some pairs in western North America (Savard 1985) is unknown. Factors associated with winter movements are likely related to ice conditions and food resources but this remains to be confirmed.

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LITERATURE CITED

Benoit, R., M. Robert, C. Marcotte, G. Fitzgerald and J.-P. L. Savard. 2001. Étude des déplacements du Garrot d'Islande dans l'est du Canada à l'aide de la télémétrie satellitaire. Technical Report Series No. 360, Canadian Wildlife Service, Québec Region, Québec.

Berthold, P. 1996. Control of bird migration. Chapman and Hall, London, U.K.

Bourget, D., J.-P. L. Savard and M. Guillemette. 2007. Winter ecology of Barrow's and Common Goldeneyes in the St. Lawrence Estuary: distribution, abundance and diet. Waterbirds 30: 230-240.

Brodeur, S., J.-P. L. Savard, M. Robert, P. Laporte, P. Lamothe, R. D. Titman, S. Marchand, S. Gilliland and G. Fitzgerald. 2002. Harlequin Duck *Histrionicus histrionicus* population structure in eastern Nearctic. Journal of Avian Biology 33: 127-137.

Dau, C. P., P. L. Flint and M. R. Petersen. 2000. Distribution of recoveries of Steller's Eiders banded on the lower Alaska Peninsula, Alaska. Journal of Field Ornithology 71: 541-548.

Douglas, D. 2006. The Douglas Argos-Filter algorithm. U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska. http://alaska.usgs.gov/science/biology/spatial/douglas.html, accessed 16 October 2012.

Eadie, J. M. and G. Gauthier. 1985. Prospecting for nest sites by cavity-nesting ducks of the genus *Bucephala*. Condor 87: 528-534.

Eadie, J. M., J.-P. L. Savard and M. Malory. 2000. Barrow's Goldeneye (*Bucephala islandica*). No. 548 *in* The Birds of North America (A. Poole and F. Gill, Eds.). The Academy of Natural Sciences, Philadelphia and the American Ornithologist Union, Washington, D.C.

Einarsson, Á. and A. Gardarsson. 2004. Moulting diving ducks and their food supply. Aquatic Ecology 38: 297-307.

Fitzgerald, G., S. Brodeur and M. Robert. 2001. Implantation abdominale d'émetteurs sur l'Arlequin plongeur (*Histrionicus histrionicus*) et le Garrot d'Islande (*Bucephala islandica*). Le Médecin Vétérinaire du Québec 31: 39-43.

Flint, P. L., M. R. Petersen, C. P. Dau, J. E. Hines and J. D. Nichols. 2000. Annual survival and site fidelity of Steller's Eiders molting along the Alaska Peninsula. Journal of Wildlife Management 64: 261-268.

Harris, R. B., S. G. Fancy, D. C. Douglas, G. W. Garner, S. C. Amstrup, T. R. McCabe and L. F. Pank. 1990. Tracking wildlife by satellite: current systems and performance. U.S. Department of the Interior, Fish and Wildlife Service Technical Report 30, Washington, D.C.

Hatton, P. L. and M. Marquiss. 2004. The origins of moulting Goosanders on the Eden Estuary. Ringing and Migration 22: 70-74.

Hogan, D., J. E. Tompson, D. Esler and W. S. Boyd. 2011. Discovery of important postbreeding sites for Barrow's Goldeneye in the boreal transition zone of Alberta. Waterbirds 34: 261-388.

Iverson, S. A. and D. Esler. 2006. Site fidelity and the demographic implications of winter movements by a migratory bird, the Harlequin Duck. Journal of Avian Biology 37: 219-228.

Iverson, S. A., D. Esler and D. J. Rizzolo. 2004. Winter philopatry of Harlequin Ducks in Prince Williams Sound, Alaska. Condor 106: 711-715.

Ouellet, J.-F., M. Guillemette and M. Robert. 2010. Spatial distribution and habitat selection of Barrow's and Common goldeneyes wintering in the St. Lawrence marine system. Canadian Journal of Zoology 88: 306-314.

Pearce, J. M., D. Zwiefelhofer and N. Maryanski. 2009. Mechanisms of population heterogeneity among molting Common Mergansers on Kodiak Island: implications for genetic assessments of migratory connectivity. Condor 111: 283-393.

Phillips, L. M., A. N. Powell and E. A. Rexstad. 2006. Large-scale movements and habitat characteristics of King Eiders throughout the non breeding period. Condor 108: 887-900.

Robert, M. and J.-P. L. Savard. 2006. The St. Lawrence River Estuary and Gulf: a stronghold for Barrow's Goldeneyes wintering in eastern North America. Waterbirds 29: 437- 450.

Robert, M., J.-P. L. Savard and R. Benoit. 2000a. COSEWIC status report on the Barrow's Goldeneye (*Bucephala islandica)* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=2249, accessed 13 March 2012.

Robert, M., D. Bordage, J.-P. L. Savard, G. Fitzgerald and F. Morneau. 2000b. The breeding range of the Barrow's Goldeneye in eastern North America. Wilson Bulletin 112: 1-7.

Robert, M., J.-P. L. Savard, G. Fitzgerald and P. Laporte. 2000c. Satellite tracking of Barrow's Goldeneyes in eastern North America: location of breeding areas and molting sites. Pages 344-352 *in* Biotelemetry 15: Proceeding of the 15th International Symposium on Biotelemetry, Juno, Alaska, USA (J. H. Eiler, D. J. Alcorn and M. R. Neuman, Eds.). International Society on Biotelemetry. Wageningen, The Netherlands.

Robert, M., R. Benoit and J.-P. L. Savard. 2002. Relationship among breeding, molting, and wintering areas of male Barrow's Goldeneyes (*Bucephala islandica*) in eastern North America. Auk 119: 676-684.

Robert, M., R. Benoit, C. Marcotte, J.-P. L. Savard, D. Bordage and D. Bourget. 2003. Le Garrot d'Islande dans l'estuaire du Saint-Laurent: calendrier de présence annuelle, répartition, abondance, âge-ratio et sex-ratio. Technical Report Series No. 398, Canadian Wildlife Service, Québec Region, Québec.

Rodway, M. S. 2007. Timing of pairing in waterfowl II: testing the hypotheses with Harlequin Ducks. Waterbirds 30: 506-520.

Savard, J.-P. L. 1985. Evidence of long-term pair bonds in Barrow's Goldeneye (*Bucephala islandica*). Auk 102: 389-391.

Savard, J.-P. L. 1988. Winter, spring and summer territoriality in Barrow's Goldeneye: characteristics and benefits. Ornis Scandinavica 19: 119-128.

Savard, J.-P. L. 1996. The Barrow's Goldeneye. Pages 333-335 *in* The Breeding Birds of Québec: Atlas of the Breeding Birds of Southern Québec (J. Gauthier and Y. Aubry, Eds.). Association québécoise des groupes d'ornithologues (AQGO), The Province of Québec Society for the Protection of Birds (PQSPB), Canadian Wildlife Service (CWS), Québec Region, Environment Canada.

Savard, J.-P. L. and J. M. Eadie. 1989. Survival and breeding philopatry in Barrow's and Common goldeneyes. Condor 91: 198-203.

Savard, J.-P. L. and P. Dupuis. 1999. A case for concern? The eastern population of Barrow's Goldeneye (*Bucephala islandica*). Pages 66-76 *in* Behaviour and ecology of sea ducks (R. I. Goudie, M. R. Petersen and G. J. Robertson, Eds.). Occasional Paper No. 100, Canadian Wildlife Service, Ottawa, Ontario.

Savard, J.-P. L. and M. Robert. 2007. Use of nest boxes by goldeneyes in eastern North America. Wilson Journal of Ornithology 119: 28-34.

Savard, J.-P. L., A. Reed and L. Lesage. 2007. Chronology of breeding and molt migration in Surf Scoters (*Melanitta perspicillata*). Waterbirds 30: 223-229.

Service Argos. 1996. User's manual. Service Argos, Landover, Maryland.

Van de Wetering, D. E. 1997. Moult characteristics and habitat selection of postbreeding male Barrow's Goldeneye *Bucephala islandica* in northern Yukon. Canadian Wildlife Service, Technical Report Series No. 296. Pacific and Yukon Region, British Columbia.