The St. Lawrence River Estuary and Gulf: A stronghold for Barrow's Goldeneyes Wintering in Eastern North America

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Abstract.—From 1997 to 2005, the distribution, seasonal abundance, and age and sex ratios of wintering Barrow's Goldeneyes (*Bucephala islandica*) was documented in the St. Lawrence River Estuary and Gulf, Canada, with a combination of ground and helicopter surveys. Ground surveys showed that Baie-Comeau and Baie-des-Rochers were the most important localities, with monthly averages of 250 (max. = 1020) and 273 (604) individuals, respectively, from November through April. Helicopter surveys showed that four areas (Baie-Comeau, Baie-des-Rochers, Baie-Sainte-Catherine and La Malbaie/Cap-à-l'Aigle) harboured on average 74% of all Barrow's Goldeneyes in the estuary, that numbers of individuals were more stable at these sites, and that the distribution of Common Goldeneyes (*Bucephala clangula*) within the estuary differed from that of Barrow's Goldeneyes. Because of ice conditions, goldeneyes were not found on the south shore of the estuary during the coldest winter months, although they were quite numerous in spring and fall. In contrast, large numbers of goldeneyes used the north shore of the estuary all winter long and through the end of April. In January-February of 1999, 2002 and 2005, helicopter surveys (N = 8) yielded on average 2428 Barrow's Goldeneyes (CV = 8%), 2503 Common Goldeneyes (6%) and 1320 Red-breasted Mergansers (*Mergus serrator*; 70%) per year in the estuary. These species averaged 2087 (CV = 81%), 2214 (41%) and 2898 (34%) individuals/year, respectively, in the gulf in January-February of 2002 and 2005 (N = 3). Helicopter survey results indicated possible identification errors between these three species, stressing the need to survey them concurrently. The January-February ratio of adult males and 'brownheads' was greater in 1998 (57.0%) than in 1999 (51.8%), partly because there were more immatures in the population in 1999 (18.1%) than in 1998 (10.2%). Adult sex ratios were significantly different from 1/1 in January-February of 1998 ($P < 0.0001$) and 1999 ($P = 0.0072$), whereas immature sex ratios were not ($P \geq 0.27$). The monthly proportion of immatures increased between January and May of 1998 ($P < 0.0001$) and 1999 ($P < 0.0001$), because of adults departing for breeding areas. The eastern North American wintering population of Barrow's Goldeneyes may include a maximum of 6187 individuals, of which > 90% would winter along the St. Lawrence Estuary and Gulf. Thus, the St. Lawrence corridor should undoubtedly be considered as the winter stronghold for Barrow's Goldeneyes in eastern North America. *Received 21 June 2006, accepted 9 August 2006.*

Key words.—*Bucephala islandica*, Barrow's Goldeneye, St. Lawrence River, winter surveys, Common Goldeneye, *Bucephala clangula*, Red-breasted Merganser, *Mergus serrator*, age ratio, sex ratio, hybrid.

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Barrow's Goldeneyes (*Bucephala islandica*) are distributed principally in western North America, where more than 90% of the world population breeds and winters. Besides a small (<2000 birds) resident population in Iceland, the only other population is located in eastern North America (Eadie *et al.* 2000; Robert *et al.* 2000a). In 2001, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed the eastern North American population as 'of Special Concern' because of its small size (<5000 individuals) and the threats it faces on its breeding and wintering grounds; these include logging, fish introductions in breeding lakes, and oil spills (Robert *et al.* 2000b; COSEWIC 2006). Little is known about this population as no research and few surveys had been conducted before it was designated by the COSEWIC. It was first suspected that many individuals were wintering along the St. Lawrence River in the middle of the 20th Century (Hasbrouck 1944), but it was not until the mid-1970s that the St. Lawrence River was found to be an important wintering area for Barrow's Goldeneyes in eastern North America (Reed and Bourget 1977). Yet detailed information on wintering Barrow's Goldeneye abundance and distribution along the St. Lawrence River was lacking in the mid-1990s, when concerns about the vulnerability of the eastern North American population were growing (Savard and Dupuis 1999).

From 1997 to 2005, we studied Barrow's Goldeneyes wintering along the St. Lawrence River with a combination of helicopter and

ground surveys. In this paper we present 1) the seasonal abundance and distribution of wintering Barrow's and Common (*Bucephala clangula*) Goldeneyes in the St. Lawrence River Estuary; 2) winter population estimates for Barrow's Goldeneyes, Common Goldeneyes and Red-breasted Mergansers (*Mergus serrator*) for the St. Lawrence Estuary and Gulf; 3) age and sex ratios estimates for Barrow's Goldeneyes; and 4) information on natural hybrids between Barrow's and Common Goldeneyes.

STUDY AREA AND METHODS

Winter surveys were conducted along the St. Lawrence River Estuary (Upper and Lower Estuaries), and the Gulf of St. Lawrence, in southern Québec, Canada, between December 1997 and February 2005 (Fig. 1). The St. Lawrence River spreads along 1600 km from the outlet of Lake Ontario, Ontario, to the Atlantic Ocean. Its Upper Estuary (3277 km^2) runs along 150 km, is on average 17 km wide, and harbours ca. 50 islands. Salinity increases from 2‰ to 20‰, semi-diurnal spring tidal range reaches 7 m, and high-intensity currents are common along the Upper Estuary. The St. Lawrence Lower Estuary (12 600 km^2) stretches along 230 km, averages 42 km wide, and has a 30-34‰ salinity level and a spring tidal range on the order of 5 m. The Gulf of St. Lawrence is an immense (195 000 km^2), semi-enclosed sea where spring tidal amplitudes are typically about 3 m (St. Lawrence Centre 1996).

Ground Surveys

Ground surveys were conducted on the south and north shores of the St. Lawrence Estuary, during which all open-water areas were checked with a telescope and binoculars for Barrow's and Common Goldeneyes. A total of 1080 surveys were carried out at 14 localities distributed along the north shore of the estuary: 502 from December 1997 through May 1998, 511 from October 1998 through May 1999, and 67 in October and November 2001. Localities surveyed were chosen because of their accessibility and because available information indicated they had harboured ≥25 Barrow's Goldeneyes before the beginning of this study (ÉPOQ database, unpubl. data). Most surveys (73.2%) were conducted at five localities already known (Savard 1990; Savard and Dupuis 1999) or suspected to be important Barrow's Goldeneyes wintering areas: Baie-Comeau, Franquelin, Baie-des-Rochers, Cap-à-l'Aigle and La Malbaie (Fig. 1). In addition, 28 ground surveys were conducted on the south shore of the St. Lawrence Estuary from October 1998 through May 1999, each one covering, in a single day from 62 distinct observation sites, all accessible coastal areas between Saint-Fabien-sur-Mer and Métis-sur-Mer (Fig. 1), a 78 km long area recognized as important for Barrow's Goldeneyes (Larivée 1993). Sixty five other ground surveys were done at five specific localities distributed in that same area in October and November 2001 to get additional information on Barrow's Goldeneyes fall arrival dates in the St. Lawrence Estuary. Ground surveys carried out at specific localities of the north and south shores of the estuary always covered the same area.

The mean number of Barrow's Goldeneyes observed at each locality was derived by calculating the total number of birds tallied at a given locality during a given month (including all years), and by dividing this figure

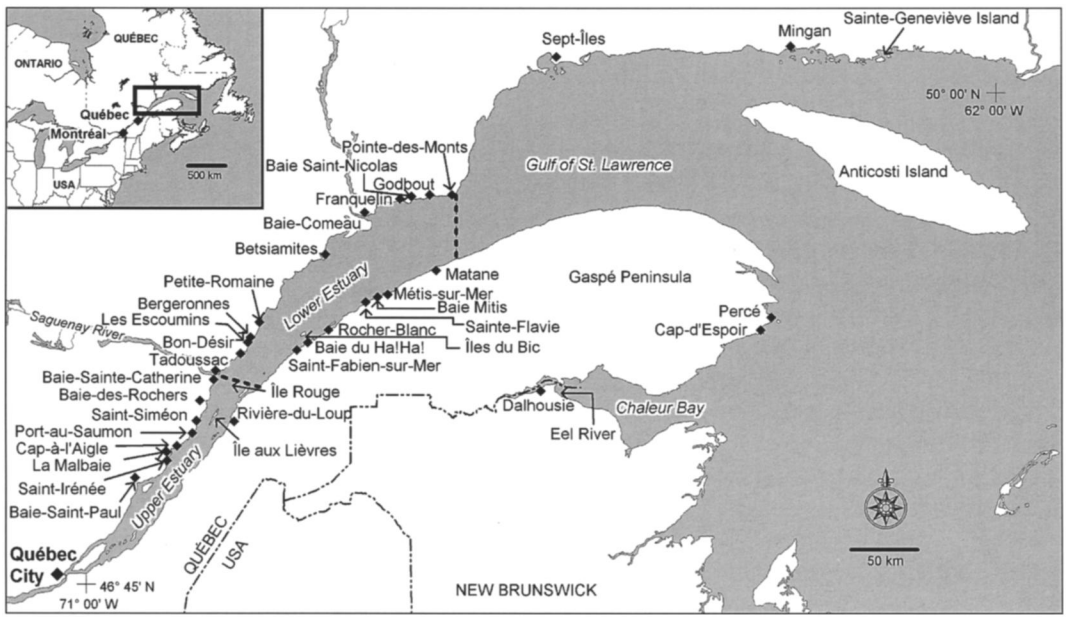

Figure 1. Location of the St. Lawrence River Upper and Lower Estuaries and the Gulf of St. Lawrence, Québec, Canada, where helicopter and ground surveys were conducted in 1997-2005 to document the distribution, numbers and age-sex ratios of wintering Barrow's Goldeneyes.

by the number of days during which there was at least one survey at this locality. The most productive survey was always selected when more than one survey were conducted during a given day. The same calculations were done for localities of the south shore of the St. Lawrence Estuary by grouping results from the 62 observation sites according to their belonging to a given locality. All means are presented with their standard errors, unless specified otherwise. The coefficient of variation (CV) was used to present the level of variability in various estimates.

Helicopter Surveys

Eight helicopter surveys were conducted in the St. Lawrence Estuary to locate Barrow's and Common Goldeneyes wintering concentrations and estimate their abundance: three in 1999 (26 January, 10 and 16 February), two in 2002 (28 January and 19 February), and three in 2005 (31 January, 17 and 18 February). The number of Red-breasted Mergansers was also recorded as they can be confused with goldeneyes during aerial surveys. Barrow's were separated from Common Goldeneyes by their distinctive, darker upperwing pattern or, occasionally, by the males' facial crescent or the females' bill color (Tobish 1986; Eadie *et al.* 2000). Flying Barrow's Goldeneyes were distinguished from Red-breasted Mergansers by their respective rump coloration, which is black in the goldeneye and grey in the merganser. Each survey covered the Upper and Lower St. Lawrence Estuaries, from Baie-Saint-Paul to Pointe-des-Monts on the north shore, and from Matane to Rivière-du-Loup on the south shore (Fig. 1). The littoral located upstream from this area was not surveyed because it is not considered potential for wintering Barrow's Goldeneyes (CWS, unpubl. data) and because it is almost entirely covered with ice in mid-winter (Canadian Ice Service 2006). Aerial surveys were conducted during the coldest and iciest winter period to facilitate goldeneye detection and obtain mid-winter population estimates. Each survey necessitated between 7.5 and 9 h of flying time from Québec City, was completed in a single day, and covered 781 km of coastline: 444 and 238 km on the north and south shores of the St. Lawrence Estuary, respectively, as well as 99 km around islands. The helicopter Bell 206 Long Ranger was equipped with bubble windows, and flew over the littoral at a speed and altitude varying from 75 to 150 km/h and 50 to 100 m, respectively, depending on visibility, atmospheric conditions, and topography. Three experienced observers participated in each survey (one in front, and two in the back, one on each side) and noted all waterfowl sightings on 1:50 000 topographic maps.

Three of these surveys were extended to the Gulf of St. Lawrence: from Pointe-des-Monts to Sainte-Geneviève Island in the Mingan Archipelago on the North Shore, around Anticosti Island, and around Gaspé Peninsula, i.e., from Matane to Percé as well as along the Chaleur Bay, south to the mouth of Eel River, near Dalhousie, New Brunswick (Fig. 1); a stretch of New Brunswick coast was surveyed specifically to include the Dalhousie area, which is suspected to be the most important Barrow's Goldeneye wintering area in Atlantic Canada (Daury and Bateman 1996). These surveys necessitated between 18.2 and 22.4 h of additional flying time, and were carried out between 29 January and 1 February 2002, 12-15 February 2002, and 31 January-3 February 2005. They covered 1782 km of coastline: 450 km on the North Shore, 442 km from Matane to Percé, 307 km along the Chaleur Bay (including 38 km in New Brunswick), 583 km around Anticosti Island, and 254 km around other islands, mostly in the Mingan and Sept-Îles archipelagos (Fig. 1).

Because identification of Barrow's Goldeneyes, Common Goldeneyes and Red-breasted Mergansers is sometimes difficult, the helicopter survey results of all three species combined, as well as individually are presented.

Sex and Age Ratios

Additional ground surveys were conducted at La Malbaie, Cap-à-l'Aigle, Saint-Siméon and Baie-des-Rochers (Fig. 1) to determine sex and age composition of Barrow's Goldeneyes wintering in the St. Lawrence River Estuary. Two wintering seasons were covered: from 1 December 1997 to 22 May 1998 and from 12 November 1998 to 13 May 1999. Observations were made at different dates, times and locations, resulting in 67 flocks of ≥5 individuals in 1997-98 (N = 2973 individuals) and 59 in 1998-99 (N = 2565 individuals). Flocks were carefully examined and all individuals were aged and sexed. Because of the difficulty of aging and sexing immatures and adult females, all surveys were performed by one experienced observer, and all were conducted under good observation conditions. Various criteria (e.g., head, bill, iris, and breast color, head shape) were used for aging and sexing Barrow's Goldeneyes, and identifying possible Common Goldeneyes among them (cf. Palmer 1976; Tobish 1986; Di Labio *et al.* 1997; Eadie *et al.* 2000).

Flocks observed in January and February (N = 1116 and 1269 individuals in 1998 and 1999, respectively) were modelled to estimate mid-winter sex and age proportions in the population. The GENMOD procedure (using the Repeated-Statement) of SAS statistical package (SAS Institute 2001) was used for fitting binomial data (being a male and being an adult or not) of each bird in the flock, considering flocks as repeated measurements of the proportions estimated. Considering that adults migrate to breeding areas in spring before immatures (Eadie *et al.* 2000; Robert *et al.* 2002), logistic regression (LOGISTIC procedure; SAS Institute 2001) was used to verify if there was an increase in the proportion of immatures between January and May. The January-February proportion of adult males versus 'brownheads' (i.e., immatures + adult females) was also calculated using data from general ground surveys conducted at La Malbaie, Cap-à-l'Aigle, Saint-Siméon and Baie-des-Rochers (rather than surveys conducted specifically for sex and age ratios), because of the larger sample size (N = 6013 and 12 714 individuals for 1998 and 1999, respectively).

RESULTS

Seasonal Abundance and Distribution within the St. Lawrence Estuary

Ground surveys.—Barrow's Goldeneyes were first observed in early October on the south shore of the St. Lawrence Estuary (20 individuals near Saint-Fabien-sur-Mer on 7 October 1998). They were observed on the north shore of the estuary from 18 October

onwards i.e., when several individuals were already present on the south shore (Fig. 2). The highest numbers of Barrow's Goldeneyes at a given locality of the south shore were observed in fall (N = 500 on 6 November 2001 at Baie du Ha! Ha!), as well as in spring (N = 284 on 8 April 1999 at Baie Mitis), but few individuals were found on the south shore in winter, i.e., between the end of December and mid-March. The maximum number of Barrow's Goldeneyes counted during a given survey covering all accessible coastal areas between Saint-Fabien-sur-Mer and Métis-sur-Mer was 827, on 3 April 1999. Numerous Barrow's Goldeneyes were surveyed on the north shore of the estuary all winter long, and through the end of April (Fig. 2). Surveys conducted in May (N = 135) yielded 134 Barrow's Goldeneyes (17 ASY and 46 SY males; 1 ASY and 70 SY females) still at Saint-Siméon on 13 May 1999, 50 (all 'brownheads') at Métis-sur-Mer on 11 May 1999, and 9 (2 ASY males and 7 'brownheads') at Franquelin on 29 May 1999.

Baie-Comeau and Baie-des-Rochers were the most important localities for wintering Barrow's Goldeneyes, as they supported a monthly average of 250 (max. = 1020) and 273 (max. = 604) individuals, respectively, from November through April (Table 1). La Malbaie and Cap-à-l'Aigle were also important, and harboured on average 80 (max. = 473) and 74 (max. = 302) individuals during the same period. Barrow's Goldeneyes were more common at some localities of the north shore during certain months, as in January ($\bar{x}$ = 652) and February ($\bar{x}$ = 490) at Baie-Comeau, February ($\bar{x}$ = 138) and March ($\bar{x}$ = 138) at La Malbaie, and March ($\bar{x}$ = 148) and April ($\bar{x}$ = 116) at Franquelin (Table 1). Coefficients of variation of average monthly estimates of abundance ranged from 41% to 152% among localities, indicating quite strong fluctuation in Barrow's Goldeneye abundance between November and April at some sites. Only 11 Barrow's Goldeneyes (N = 5 complete surveys) were found on the south shore of the estuary during January and February, but hundreds were present there during fall and spring (Table 1). The most important areas of the south shore were Saint-Fabien-sur-Mer ($\bar{x}$ = 162 in November; 73 in March) and Baie du Ha! Ha! ($\bar{x}$ = 142 in November; 59 in April). Numerous Barrow's Goldeneyes were also surveyed in spring at Baie Mitis ($\bar{x}$ = 131 in March; 187 in April) and Rocher-Blanc ($\bar{x}$ = 68 in March; 84 in April; Table 1).

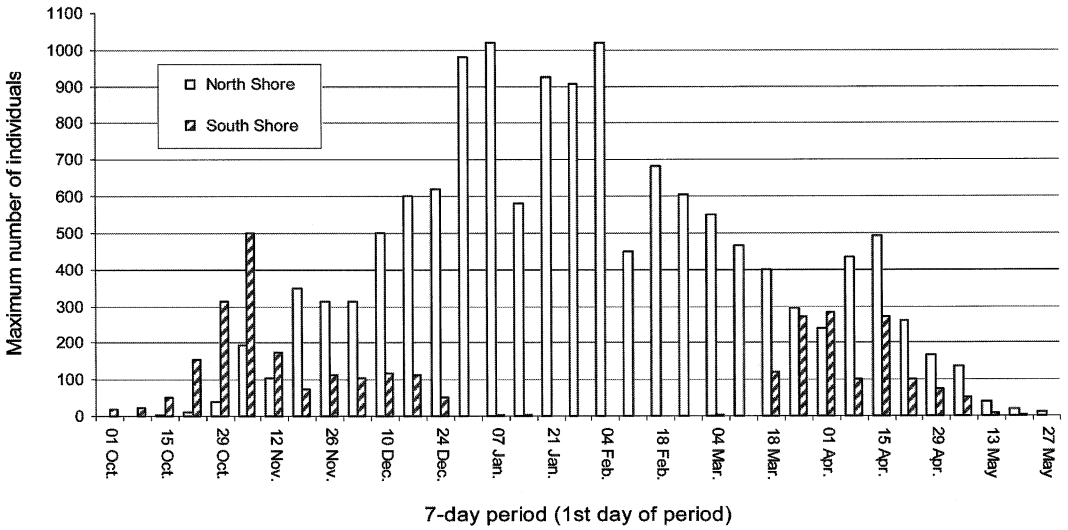

Figure 2. Maximum number of Barrow's Goldeneyes found at any locality of the north and south shores of the St. Lawrence River Estuary during ground surveys conducted between December 1997 and 2001. This figure shows that numerous Barrow's Goldeneyes are found on the north shore of the estuary during the entire wintering period, but that very few are found on the south shore of the estuary in mid-winter.

Table 1. Monthly mean number of Barrow's Goldeneyes found at specific localities of the north and south shores of the St. Lawrence River Estuary, Québec, Canada, during ground surveys conducted during the 1997-1998 and 1998-1999 wintering periods, and the fall of 2001.

Localities	Mean number of individuals per survey (N)						Mean ± SE	CV (%)
	November	December	January	February	March	April		
North Shore[1]								
Saint-Irénée	65.8 (5)	—	5.2 (5)	14.0 (5)	48.5 (8)	29.1 (7)	32.5 ± 11.1	76
La Malbaie	15.1 (9)	41.1 (9)	92.2 (13)	138.2 (13)	138.4 (16)	54.4 (12)	79.9 ± 21.1	65
Cap-à-l'Aigle	76.6 (9)	95.1 (12)	31.7 (15)	64.6 (12)	128.9 (16)	43.8 (12)	73.5 ± 14.4	48
Saint-Siméon	5.0 (9)	10.7 (9)	5.3 (9)	21.7 (12)	58.7 (10)	39.6 (8)	23.5 ± 8.8	92
Baie-des-Rochers	62.0 (10)	298.5 (10)	288.1 (7)	368.4 (8)	363.6 (8)	257.7 (7)	273.1 ± 45.8	41
Baie-Sainte-Catherine	10.0 (1)	6.0 (1)	62.0 (3)	1.0 (2)	5.0 (1)	—	16.8 ± 11.4	152
Bergeronnes	0.0 (2)	0.8 (5)	13.0 (4)	41.6 (5)	10.4 (5)	0.0 (4)	11.0 ± 6.5	146
Petite-Romaine	—	—	—	—	140.0 (1)	6.5 (2)	73.3 ± 66.8	129
Baie-Comeau	99.3 (4)	242.2 (11)	652.2 (16)	490.2 (13)	10.7 (17)	6.4 (14)	250.2 ± 109.4	107
Franquelin	4.5 (4)	9.5 (8)	2.7 (9)	36.4 (7)	147.8 (12)	115.7 (13)	52.8 ± 25.8	120
Godbout	—	—	159.0 (2)	19.0 (2)	16.3 (4)	13.9 (9)	52.1 ± 35.7	137
South Shore[1]								
Saint-Fabien-sur-Mer	162.4 (8)	69.0 (4)	0.0 (4)	0.0 (1)	73.0 (3)	59.0 (4)	60.6 ± 24.5	99
Baie du Ha! Ha!	141.8 (8)	38.0 (4)	0.0 (4)	0.0 (1)	1.3 (3)	58.7 (3)	40.0 ± 22.7	139
Rocher-Blanc	6.8 (4)	0.3 (4)	0.0 (4)	0.0 (1)	68.0 (3)	83.5 (4)	26.4 ± 15.8	146
Sainte-Flavie	15.8 (4)	3.0 (4)	0.0 (4)	0.0 (1)	30.3 (3)	21.0 (3)	11.7 ± 5.2	108
Baie Mitis	37.2 (6)	44.0 (4)	0.0 (4)	0.0 (1)	130.7 (3)	187.0 (3)	66.5 ± 31.0	114

[1]Localities (Fig. 1) are listed from upstream to downstream, and results are presented only for localities where at least 10 Barrow's Goldeneyes were on average surveyed during all surveys.

Helicopter surveys.—Helicopter surveys confirmed Baie-Comeau as the most important locality for wintering Barrow's Goldeneyes in January-February, with on average 752 (max. = 1201, CV = 44%) individuals (Table 2). These surveys provided a better coverage of Baie-Sainte-Catherine than ground surveys and revealed high numbers of Barrow's Goldeneyes ($\bar{x}$ = 395, max. = 1350, CV = 105%). The number of individuals wintering at Baie-des-Rochers ($\bar{x}$ = 340, max. = 700, CV = 65%) and La Malbaie/Cap-à-l'Aigle ($\bar{x}$ = 262, max. = 466, CV = 69%) were similar to those found during ground surveys (Table 1), confirming the importance of these localities. Overall these four areas harboured on average 74% of all Barrow's Goldeneyes located along the St. Lawrence Estuary. Numbers of Barrow's Goldeneyes were also more stable at these sites than at the others (Table 2). The wintering distribution of Common Goldeneyes within the estuary differed from that of Barrow's Goldeneyes (Table 2). On average, 80% of all Common Goldeneyes were surveyed at Baie-Sainte-Catherine ($\bar{x}$ = 929, max. = 1270, CV = 31%), Bon-Désir/Bergeronnes ($\bar{x}$ = 619, max. = 1308, CV = 52%), Tadoussac ($\bar{x}$ = 209, max. = 426, CV = 52%) and Baie-Comeau ($\bar{x}$ = 201, max. = 428, CV = 70%); apart from Baie-Comeau, all these localities are located near the mouth of the Saguenay River (Fig. 1). Although both species of goldeneyes wintered at Baie-Comeau and Baie-Sainte-Catherine, Barrow's Goldeneyes were more numerous at Baie-Comeau and Common Goldeneyes at Baie-Sainte-Catherine. Interestingly, the Barrow's Goldeneye was nearly the only goldeneye species found at Baie-des-Rochers and is much more abundant than the Common Goldeneye at La Malbaie/Cap-à-l'Aigle (Table 2). The only island with substantial numbers of goldeneyes was Île aux Lièvres where we found on average 70 Barrow's (max. = 235, CV = 135%) and 71 Common Goldeneyes (max. = 124; CV = 59%; Table 2).

Helicopter surveys confirmed the concentration of goldeneyes on the north shore of the estuary in January and February. In all years, nearly all (≥92.6%) goldeneyes were found on the north shore of estuary, and

Table 2. Number of Barrow's Goldeneyes and Common Goldeneyes found along the St. Lawrence River Estuary, Québec, Canada, during eight helicopter surveys conducted in January and February 1999, 2002, and 2005.

	Barrow's Goldeneye				Common Goldeneye			
Localities[1]	Mean	Max.	Min.	CV (%)	Mean	Max.	Min.	CV (%)
Saint-Irénée	38	145	0	147	11	40	0	158
La Malbaie/Cap-à-l'Aigle	262	466	0	69	34	53	0	53
Port-au-Saumon	19	80	0	186	2	11	0	257
Saint-Siméon	44	107	0	99	1	6	0	190
Baie-des-Rochers	340	700	60	65	2	5	0	116
Île aux Lièvres	70	235	0	135	71	124	0	59
Baie-Sainte-Catherine	395	1350	30	105	929	1270	418	31
Tadoussac	99	745	0	264	209	426	86	52
Île Rouge	6	50	0	283	37	130	0	147
Bon-Désir/Bergeronnes	33	120	0	164	619	1308	280	52
Les Escoumins	19	53	0	110	72	248	0	118
Petite-Romaine	96	241	0	105	84	195	2	72
Îles du Bic	7	30	0	165	5	15	0	116
Betsiamites	48	160	0	149	3	14	0	175
Baie-Comeau	752	1201	242	44	201	428	45	70
Franquelin	16	60	0	163	2	16	0	264
Baie Saint-Nicolas	11	60	0	198	34	100	0	116
Godbout	123	490	0	132	91	253	0	101
Pointe-des-Monts	0	0	0	0	25	170	0	241

[1]Localities (Fig. 1) are listed from upstream to downstream. A few Barrow's (N = 145) and Common (N = 796) Goldeneyes were located in areas others than the ones listed here.

very few (max. = 54 individuals or 1.2%) were located on the south shore. We found between 3.0% and 7.3% (max. = 430) of them around islands.

Population Estimates

St. Lawrence Estuary.—During the eight helicopter surveys conducted between 1999 and 2005 along the estuary, an average of 2395 (CV = 19%) Barrow's Goldeneyes per survey, 2530 (CV = 18%) Common Goldeneyes, and 1248 (75%) Red-breasted Mergansers were observed (Table 3). In all three years, estimates of Red-breasted Mergansers were more variable (CV = 40%, 104%, 34%) than either those of Barrow's Goldeneyes (22%, 26%, 13%) or Common Goldeneyes (15%, 6%, 13%). Estimates of all three species combined (*Mergini*) averaged 6479 in 1999, 6882 in 2002, and 5394 in 2005; they were equally variable among years (CV = 16%, 17%, 15%) and often less variable than individual species estimates (Table 3), suggesting identification errors and/or important fluctuations in Red-breasted Merganser abundance and distribution. For example, Red-breasted Mergansers and Barrow's Goldeneyes were probably confused on 28 January 2002 in the Godbout area (Fig. 1) when 258 mergansers and 520 goldeneyes were estimated as compared to 1819 mergansers and 84 goldeneyes estimated on 19 February 2002.

In 1999, 2002 and 2005, Barrow's Goldeneyes averaged 2428 individuals/year (CV = 8%) with a maximum count of 3181 birds on 28 January 2002, Common Goldeneyes averaged 2503 individuals/year (CV = 6%) with a maximum of 3325 on 26 January 1999, and Red-breasted Mergansers averaged 1320 individuals/year (CV = 70%) with a maximum count of 3295 on 19 February 2002 (Table 3).

Gulf of St. Lawrence.—Estimates of *Mergini* and individual species varied greatly between 2002 (N = 2) and 2005 (N = 1) surveys (Table 3), and much more than in the estuary, suggesting greater change in distribution between years and/or greater identification errors. Results from 2002 indicate possible identification errors between Barrow's Goldeneyes and Red-breasted Mergansers in that year. More Barrow's Goldeneye and Red-breasted Mergansers but fewer Com-

Table 3. Number of Barrow's Goldeneyes, Common Goldeneyes and Red-breasted Mergansers found along the St. Lawrence River Estuary and the Gulf of St. Lawrence, Québec, Canada, during helicopter surveys conducted in January and February 1999, 2002, and 2005.

	Number of individuals			
	Barrow's Goldeneye	Common Goldeneye	Red-breasted Merganser	Total
St. Lawrence Estuary				
26 January 1999	2437	3325	758	6380
10 February 1999	1702	2463	1278	5443
16 February 1999	2634	3049	1790	7558
Mean ± SE (CV)	2258 ± 284 (22)	2946 ± 254 (15)	1275 ± 298 (40)	6479 ± 586 (16)
28 January 2002	3181	2390	502	6073
19 February 2002	2204	2191	3295	7690
Mean ± SE (CV)	2693 ± 489 (26)	2291 ± 100 (6)	1899 ± 1397 (104)	6882 ± 809 (17)
31 January 2005	2406	2493	1051	5950
17 February 2005	2001	1943	521	4465
18 February 2005	2596	2385	785	5766
Mean ± SE (CV)	2334 ± 175 (13)	2274 ± 168 (13)	786 ±153 (34)	5394 ± 467 (15)
Gulf of St. Lawrence				
28 Jan-1 Feb 2002	546	2840	2938	6309
12-15 Feb 2002	1238	2869	1450	5557
Mean ± SE (CV)	892 ± 346 (55)	2855 ± 15 (1)	2194 ± 744 (48)	5941 ± 384 (9)
31 Jan-3 Feb 2005	3281	1573	3601	8455

mon Goldeneyes were counted in 2005 than in 2002. Over the two years of surveys, *Mergini*, Barrow's Goldeneye, Common Goldeneye and Red-breasted Merganser estimates averaged 7198 (CV = 25%), 2087 (81%), 2214 (41%) and 2898 (34%), respectively.

Sex and Age Ratios

Adult sex ratios were significantly different from 1 male/1 female in January-February 1998 and 1999 (Table 4; 1998: $\chi^2 = 31.37$, $P < 0.0001$; 1999: $\chi^2 = 7.22$, $P = 0.0072$). Sex ratios of immatures did not differ from 1/1 (Table 4; 1998: $\chi^2 = 1.24$, $P = 0.2657$; 1999: $\chi^2 = 0.12$, $P = 0.7303$). There were proportionally more males among adults in 1998 than in 1999 (Table 4), and the overall ratio of adult males and 'brownheads' found during general ground surveys also yielded a higher proportion of adult males in January-February 1998 (57.0 ± 2.8%) than in January-February 1999 (51.8 ± 1.6%, $\chi^2 = 9.94$, $P = 0.0016$). There was a significant difference (0.10 level) in the immature/adult ratios between January-February 1998 and 1999 (Table 4). The monthly proportion of immatures increased between January and May of both winters (Fig. 3; 1998: $\chi^2 = 44.46$, $P < 0.0001$; 1999: $\chi^2 = 108.31$, $P < 0.0001$). To estimate the number of adult females in the population, ratios from 1998 and 1999 (x = 31.2%; Table 4) were averaged and applied to our aerial survey results.

Hybrids

Barrow's × Common Goldeneyes hybrids were observed on 60 occasions, and all were adult males. Hybrids were found at 13 localities distributed along both shores of the St. Lawrence Estuary, but 70% of observations were done at Baie-Comeau, Baie-des-Rochers, La Malbaie, and Cap-à-l'Aigle. Never more than two hybrids were observed during any given ground survey. Yet, two were regularly observed at La Malbaie between November 1998 and March 1999, and two at Baie-Comeau i.e., 228 km downstream from La Malbaie, between October 1998 and April 1999. In March 1998, a hybrid and two adult male Barrow's Goldeneyes displaying near an adult female Barrow's Goldeneye were observed at Baie-Comeau, whereas a hybrid observed at Baie-Comeau in April 1998 was this time accompanied by an adult female Common Goldeneye.

DISCUSSION

Seasonal Abundance and Distribution within the St. Lawrence Estuary

During the coldest parts of winter, Barrow's Goldeneyes were mostly restricted to intertidal zones that remained free of ice. Along the north shore of the St. Lawrence Upper Estuary, they congregated in Baie-Sainte-Catherine, Baie-des-Rochers, and La

Table 4. Sex and age ratios of Barrow's Goldeneyes surveyed in January-February 1998 and 1999 along the St. Lawrence River Estuary, Québec, Canada. LCL and UCL indicate 95% lower and upper confidence limits, respectively.

	January-February 1998			January-February 1999			1998-1999 comparison	
	Estimate	LCL	UCL	Estimate	LCL	UCL	χ^2	P
Male proportion[1]								
Adults	68.5%	62.4%	74.0%	58.3%	52.3%	64.0%	5.68	0.0171
Immatures	54.6%	46.5%	62.6%	51.1%	45.1%	57.0%	0.48	0.4883
Immature proportion	10.2%	7.2%	14.1%	18.1%	10.4%	29.7%	3.09	0.0788
Male/Female ratio								
Adults	2.17	1.66	2.85	1.40	1.09	1.78	5.68	0.0171
Immatures	1.20	0.87	1.67	1.04	0.82	1.33	0.48	0.4883
Immature/Adult ratio	0.11	0.08	0.16	0.22	0.12	0.42	3.09	0.0788

[1]The proportion of adult males in the population in 1998 (61.5%) can be calculated by multiplying the adult proportion in the population (100%-10.2%) by the male proportion in adults (68.5%).

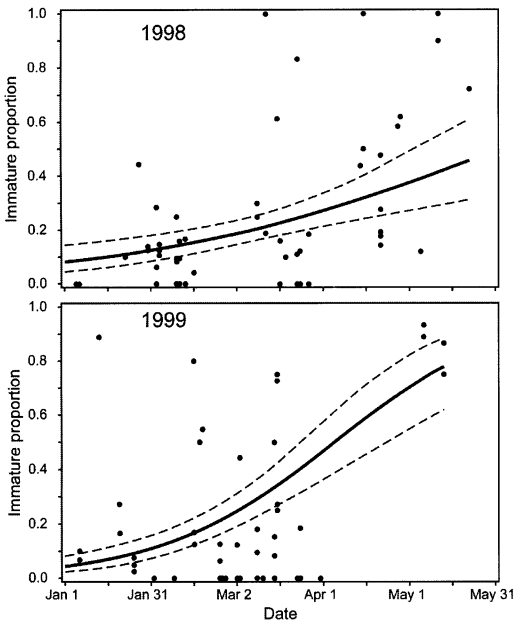

Figure 3. Proportion of immature Barrow's Goldeneyes found during ground surveys conducted of the north shore of the St. Lawrence River Estuary between January and May of 1998 and 1999, showing an increase in the proportion of immatures as spring progresses. Dashed lines represent the upper and lower 95% confidence intervals of the fitted curves.

Malbaie/Cap-à-l'Aigle, where are located most (4394/4723 ha; 93%) intertidal zones of the area. The same is true for the St. Lawrence Lower Estuary, where they were found principally over the very large (6531 ha) intertidal zone near Baie-Comeau. These intertidal zones usually remain free of ice all winter long (Canadian Ice Service 2006), mainly because of currents and prevailing west, northwest or southwest winds (Environment Canada 1994, Bourget 1997). For the same reason, intertidal zones of the south shore of the St. Lawrence Estuary are covered by ice during winter (Canadian Ice Service 2006), limiting feeding opportunities and explaining why no goldeneyes were observed there between the end of December and mid-March. Bourget (2004) found that Barrow's Goldeneyes collected in fall along the south shore of the St. Lawrence Estuary fed mostly on intertidal amphipods and gastropods. Using satellite telemetry, Robert *et al.* (2002) documented movements of Barrow's Goldeneyes between the south and north shores of the St. Lawrence Estuary in relation to ice conditions and seasons, notably their return on the south shore in spring. Our results also demonstrate that numerous Barrow's Goldeneyes move to the south shore of the St. Lawrence Estuary in spring, even though their breeding areas are located north of the St. Lawrence corridor (Robert *et al.* 2000a), which suggests good feeding opportunities and possibly some prey depletion at certain wintering sites of the north shore. Guillemette *et al.* (1996) showed that mussels beds depletion by Common Eiders (*Somateria mollissima*) wintering in the Gulf of St. Lawrence affect the birds' distribution.

Eggeman (1986) showed that the winter distribution of Common Goldeneyes was influenced by habitat and climatic variables including wind speed and direction, and tide conditions. Similarly, Esler *et al.* (2000) found that the distribution of Barrow's Goldeneyes in Alaska was positively correlated with the occurrence of a stream within 200 m and the lack of exposure to wind. The large variability we found in the number of goldeneyes at a given site throughout winter may be due in part to movements associated to tide cycles, ice conditions, and wind exposure. Several other studies have shown the great influence of climate and food resources on Common Goldeneye distribution and movements (Nilsson 1970, 1972; Perhsson 1975, 1976; Sayler and Afton 1981). For example, the upstream limit of Barrow's Goldeneye occurrence along the St. Lawrence Estuary (Saint-Irénée) corresponds to the limits (Bourget 1997) of their main preys, amphipods, gastropods and pelecypods (Eadie *et al.* 2000; Bourget 2004).

This study revealed, contrary to previous belief (Savard 1990), that Barrow's Goldeneyes are about as numerous as Common Goldeneyes in the St. Lawrence Estuary in winter. However, both species have different distribution along the estuary north shore, Common Goldeneyes being mostly distributed along a 30-km stretch of coast between Baie-Sainte-Catherine and Bon-Désir, on both sides of Saguenay River outlet, whereas Barrow's Goldeneyes occurred elsewhere as in Baie-Comeau, Baie-des-Rochers, and La

Malbaie/Cap-à-l'Aigle. Some areas, like Baie-des-Rochers for the Barrow's Goldeneye, are also inhabited almost exclusively by one species. We do not know why both species of goldeneyes were often found in specific areas of the St. Lawrence Estuary, although their food habits may partly be in cause: both species consume mostly amphipods but the Common Goldeneye specializes on *Nereis* spp. and the Barrow's Goldeneye on gastropods (Bourget 2004).

Population Estimates

The eastern population of Barrow's Goldeneyes had been estimated at no more than 4500 birds by Savard and Dupuis (1999) and Robert *et al.* (2000b). Our study confirms that the St. Lawrence River corridor is a key wintering area for that population and the survey we conducted in 2005 suggests that it may be somewhat more numerous than previously thought, as we then estimated 5687 individuals along the St. Lawrence Estuary and Gulf. However this estimate, as the one obtained on 28 January-1 February 2002 (3727 individuals), have to be interpreted with caution considering possible identification errors with Red-breasted Mergansers and Common Goldeneyes, as indicated by the lower variability of total counts than individual species counts. Being fish feeders, Red-breasted Mergansers likely use greater wintering areas than Barrow's or Common Goldeneyes, which feed on invertebrates, and their local distribution may be more affected by tide and ice conditions than that of goldeneyes (Eadie *et al.* 1995, 2000; Titman 1999). Whereas goldeneyes always occur in shallow waters usually fairly close to shore (Esler *et al.* 2000; Bourget 2004), Red-breasted Mergansers also occur further offshore (Richner 1988; Titman 1999) and are more likely to be overlooked on surveys targeted towards goldeneyes. This may explain in part the greater variability of merganser numbers between our surveys. In addition, conditions (ice, tide, and clouds) differed between surveys increasing the risk of differences in the accuracy of aerial estimates. This was especially true for our 2005 survey in the Gulf of St. Lawrence, during which ice conditions were extreme and birds concentrated at a few sites. The numbers of goldeneyes observed at Anticosti Island and in the Chaleur Bay (including Dalhousie) in 2005 were the highest ever recorded there, so we suspect it may have included birds from other areas of the Maritime Provinces. Clearly additional surveys will be necessary to get a better estimate of the number of Barrow's Goldeneyes wintering in the St. Lawrence corridor, especially in the gulf. Nevertheless, according to available data and knowing that very few (≤400) individuals apparently winter elsewhere in eastern Canada and United States (Daury and Bateman 1996; Robert *et al.* 2000b; D. Amirault and P. Thomas, CWS-Atlantic, pers. comm.), the St. Lawrence Estuary and Gulf should undoubtedly be considered as the winter stronghold for Barrow's Goldeneyes in eastern North America.

A few winter surveys had been conducted along the St. Lawrence River before this study. Reed and Bourget (1977) estimated 2542 Barrow's Goldeneyes i.e., 1394 individuals in the estuary and 1148 in the gulf (excluding the Dalhousie area); however this estimate is certainly less reliable than ours because it was obtained from an airplane, from which it is nearly impossible to properly separate Barrow's Goldeneyes from Common Goldeneyes and Red-breasted Mergansers, and because it yielded only 286 Red-breasted Mergansers. A helicopter survey conducted on 12-15 February 1996 (P. Dupuis, CWS-Québec, unpubl. data; see Robert *et al.* 2000b) yielded 5907 Barrow's Goldeneyes along the St. Lawrence, i.e., 4214 in the estuary and 1693 in the gulf, including the Dalhousie area. Again, this survey yielded very few mergansers (89 individuals) and much more goldeneyes (10,646 individuals, both species included) in the estuary, as compared to the eight helicopter surveys conducted during our study, suggesting that many birds identified as goldeneyes in February 1996 were probably mergansers. Ground surveys have corroborated the presence of large numbers of wintering Red-breasted Mergansers along the St. Lawrence

Estuary as we found, for example, 2000 individuals at Godbout on 29 January 1998.

Our results illustrate the limitations of helicopter surveys for monitoring the winter population of Barrow's Goldeneyes. In our opinion, coefficients of variations associated with *Mergini* estimates (9-17%) likely approximate counting and detection errors, whereas additional variation may be brought in by identification errors. Greater understanding of goldeneyes and mergansers distribution in the St. Lawrence corridor in relation to ice conditions would help improve surveys. Coefficients of variation were lower in the St. Lawrence Estuary than in the Gulf of St. Lawrence, which suggests that adequate monitoring could still be achieved in the estuary. It is also likely that the variability of aerial estimates could be reduced in the gulf as only three surveys were done there, under quite different ice conditions. Yet a large part of the Barrow's Goldeneyes wintering in the St. Lawrence Estuary are concentrated in a few areas only, as Baie-Sainte-Catherine and Baie-Comeau, where lie huge intertidal zones difficult to survey and where large flocks of goldeneyes and mergansers are often difficult to tally precisely.

Sex and Age Ratios

Einarsson (1997) estimated that the 2000 individual Icelandic population included 60% males, a ratio similar to the 60% adult males in the Barrow's Goldeneyes wintering near Vancouver, British Columbia (Savard 1989), and the ones we calculated in 1998 (57.0%) and 1999 (51.8%) from the general surveys or from the sex and age ratios surveys (61.5% in 1998; 47.7% in 1999). Sayler and Afton (1981) reported proportions of 54.8% to 66% of adult males in a wintering population of Common Goldeneyes on the Mississippi River. The above ratios include immature birds, thus dominance of males is stronger if one considers adult birds only, as we found (68.5% in 1998 and 58.3% in 1999). Sex-ratios in sea ducks are typically in favour of males, basically because females are subject to greater mortality than males during the nesting and brooding periods (Bellrose 1980; Baldasarre and Bolen 1994). Our results indicate that sex ratios in immatures were not different from 1:1 in 1998 as in 1999, which supports the above assumption that there may be a differential mortality between adult males and females. The annual difference we found between the male proportion in adults is not surprising because sex-ratios may vary greatly not only from one year to the next, but also from one band of birds to another and from one time of year to the next, as European studies on Common Goldeneyes have shown (Nilsson 1970; Pounder 1976; Campbell 1977; Duncan and Marquiss 1993). Mid-winter sex-ratios may also vary at the regional scale, adult males predominating in colder climates and females and immatures elsewhere (Nilsson 1969, 1970; see also Cramp and Simmons 1977).

Age-ratios among goldeneye populations are almost unknown, probably because it is usually difficult to distinguish adult females from immature females and immature males. The ratios of immatures we obtained (10.2% in 1998 and 18.1% in 1999) were comparable to the ones measured by Gardarsson (1978) for Icelandic Barrow's Goldeneyes in January i.e., 4.3% (1976) and 16.4% (1977). Similar proportions of immatures were also measured by Smith *et al.* (2001) during a five-year study on Harlequin Ducks (*Histrionicus histrionicus*) wintering in British Columbia. As nest and brood rearing success can vary greatly between years (Savard *et al.* 1991; Eadie *et al.* 2000), often because of weather conditions and/or predator abundance, we should expect annual variation in the proportion of immatures in the population.

We observed a greater proportion of immatures in spring when adults leave the St. Lawrence corridor for their breeding grounds. Using satellite telemetry, Robert *et al.* (2002) documented that adult male Barrow's Goldeneyes wintering along the St. Lawrence Estuary remained on their wintering area on average until 3 May (20 April-21 May), and arrived on their breeding areas on average on 9 May (27 April-22 May). Immatures, which do not breed before two years of age, and unpaired males are also known to stay on wintering grounds later

than breeding adults (Eadie *et al.* 2000), which explains why we found only one adult female among the 134 Barrow's Goldeneyes surveyed at Saint-Siméon on 13 May 1999.

Hybrids

Ground surveys were not designed to detect goldeneye hybrids, so they are probably more common than our results indicate. A Common × Barrow's Goldeneyes hybrid was first reported by Snyder (1953), and Martin and Di Labio (1994) provided information on 20 additional records worldwide, half of them originating from eastern North America, among which one from the St. Lawrence Estuary (Baie-Comeau). As nearly all records reported to date, all hybrids located during our study were alternate-plumaged males exhibiting intermediate characteristics between the two parent species. Hybrids are also reported every one or two years in the Montreal area (P. Bannon, pers. comm.).

Conclusions and Recommendations

This study clearly indicates that the St. Lawrence Estuary and Gulf represent key areas for wintering Barrow's Goldeneyes in eastern North America. Most birds congregate in a few specific areas, so we consider that shipping along the St. Lawrence corridor and associated polluting spills may represent a serious threat to this small population. The St. Lawrence is one of North America's most important waterways for shipping, linking the entire Atlantic seaboard to Québec Province and Great Lakes ports. According to Robert *et al.* (2000b), about 7000 vessels pass yearly through a maritime station located near the mouth of the Saguenay River (Fig. 1), among which 900 tankers travelling in winter as during the rest of the year. Sea ducks are particularly vulnerable to spills because they are gregarious in winter and always rest on water. In other respects, we found large numbers of Barrow's Goldeneyes at Baie-Comeau and Dalhousie, two areas recognized as contaminated by PCB and PAH, and by mercury and cadmium, respectively (Robert *et al.* 2000b), so toxic contaminants may also be an issue.

This study provided a general overview of the Barrow's Goldeneye population wintering in the St. Lawrence River corridor, but more detailed studies are needed to identify factors (e.g., habitat physical attributes, prey biomass) controlling its distribution in this key wintering area. The two years with surveys covering the entire St. Lawrence Estuary and Gulf yielded 3727 Barrow's Goldeneyes in 2002 and 5687 in 2005. If we take that last estimate and add 400 birds for the Atlantic Provinces (apart from Dalhousie) and 100 for Maine we get 6187 birds, which corresponds to 1930 adult females. Considering the threats listed by Robert *et al.* (2000b) and the new COSEWIC criteria and guidelines for the status assessment of species (COSEWIC 2006), we believe that the status of the eastern North American population of Barrow's Goldeneyes should be reassessed.

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Literature Cited

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, PA.

Baldasarre, G. A. and E. G. Bolen. 1994. Waterfowl ecology and management. John Wiley & Sons, Inc., Toronto.

Bourget, E. 1997. Les animaux littoraux du Saint-Laurent: guide d'identification. Les Presses de l'Université Laval, Québec.

Bourget, D. 2004. Répartition et écologie alimentaire du Garrot d'Islande (*Bucephala islandica*) et du Garrot à oeil d'or (*Bucephala clangula*) en période d'hivernage sur la rive sud de l'estuaire maritime du fleuve Saint-Laurent. MS Thesis, Université du Québec à Rimouski, Rimouski, Québec.

Campbell, L. H. 1977. Local variations in the proportion of adult males in flocks of Goldeneye wintering in the Firth of Forth. Wildfowl 28: 77-80.

Canadian Ice Service 2006. Climatic Ice Atlas, East Coast. Median of Ice Concentration (online). Available from http://ice-glaces.ec.gc.ca.

COSEWIC 2006. Canadian species at risk, 25 April 2006. Committee on the status of endangered wildlife in Canada, Ottawa.

Cramp, S. and K. E. L. Simmons. 1977. Handbook of the birds of Europe, the Middle East and North Africa. The birds of Western Palearctic. Volume 1. Oxford University Press, London.

Daury, R. W. and M. C. Bateman. 1996. The Barrow's Goldeneye (*Bucephala islandica*) in the Atlantic Provinces and Maine. Regional report. Canadian Wildlife Service, Atlantic Region, Sackville, New Brunswick.

Di Labio, B., R. Pittaway and P. Burke. 1997. Bill color and identification of female Barrow's Goldeneye. Ontario Birds 15: 81-85.

Duncan, K. and M. Marquiss. 1993. The sex/age ratio, diving behaviour and habitat use of Goldeneye *Bucephala clangula* wintering in northeast Scotland. Wildfowl 44: 111-120.

Eadie, J. McA., M. L. Mallory and H. G. Lumsden. 1995. Common Goldeneye (*Bucephala clangula*). *In* The Birds of North America, No 170 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

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

Eggeman, D. R. 1986. Influence of environmental conditions on distribution and behavior of common Goldeneyes wintering in Maine. MS Thesis, University of Maine, Orono.

Einarsson, A. 1997 Barrow's Goldeneye (*Bucephala islandica*). *In* The EBCC atlas of European breeding birds: their distribution and abundance (W. J. M. Hagemeijer and M. J. Blair, Eds.). T. & A. D. Poyser, London.

Environment Canada. 1994. Climatological charts of the St. Lawrence River and Gulf for the months of January to December. Environment Canada, Ville-St.-Laurent, Québec.

Esler, D., T. D. Bowman, C. E. O'Clair, T. A. Dean and L. L. McDonald. 2000. Densities of Barrow's Goldeneyes during winter in Prince William Sound, Alaska in relation to habitat, food and history of oil contamination. Waterbirds 23: 423-429.

Gardarsson, A. 1978. Distribution and numbers of the Barrow's Goldeneye (*Bucephala islandica*) in Iceland. Natturu Fraedin Gurinnn 48: 162-191.

Guillemette, M., A. Reed and J. H. Himmelman. 1996. Availability and consumption of food by Common Eiders wintering in the Gulf of St. Lawrence: evidence of prey depletion. Canadian Journal of Zoology 74: 32-38.

Hasbrouck, E. M. 1944. The status of Barrow's Goldeneye in the eastern United States. Auk 61: 544-554.

Larivée, J. 1993. Chronobiologie des oiseaux du Bas-Saint-Laurent. Club des ornithologues du Bas-Saint-Laurent, Pointe-au-Père, Québec.

Martin, P. R. and B. M. Di Labio. 1994. Natural hybrids between the Common Goldeneye, *Bucephala clangula*, and Barrow's Goldeneye, *B. islandica*. Canadian Field-Naturalist 108: 195-198.

Nilsson, L. 1969. The migration of the Goldeneye in north-west Europe. Wildfowl 20: 112-118.

Nilsson, L. 1970. Local and seasonal variation in sex-ratios of diving ducks in South Sweden during the non-breeding season. Ornis Scandinavica 1: 115-128.

Nilsson, L. 1972. Habitat selection, food choice, and feeding habits of diving ducks in coastal waters of south Sweden during the breeding season. Ornis Scandinavica 3: 55-78.

Palmer, R. S. 1976. Handbook of North American birds. Volume 3. Yale University Press, New Haven, CT.

Perhsson, O. 1975. Regional, seasonal, and annual fluctuations of the goldeneye, *Bucephala clangula* (L.), on the Swedish west coast. Viltrevy 6: 241-302.

Perhsson, O. 1976. Food and feeding ground of the Goldeneye *Bucephala clangula* (L.) on the Swedish west coast. Ornis Scandinavica 7: 91-112.

Pounder, B. 1976. Wintering flocks of Goldeneyes at sewage outfalls in the Tay estuary. Bird Study 23: 121-131.

Reed, A. and A. Bourget. 1977. Distribution and abundance of waterfowl wintering in southern Quebec. Canadian Field-Naturalist 91: 1-7.

Richner, H. 1988. Temporal and spatial patterns in the abundance of wintering Red-breasted Mergansers *Mergus serrator* in an estuary. Ibis 130: 73-78.

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

Robert, M., R. Benoit and J.-P. L. Savard. 2000b. COSEWIC status report on the eastern population of the Barrow's Goldeneye (*Bucephala islandica*) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa.

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

SAS Institute, Inc. 2001. The SAS System for Windows, release 8.2, SAS Institute, Inc., Cary, NC.

Savard, J.-P. L. 1989. Birds of rocky coastlines and pelagic waters in the Strait of Georgia. *In* The ecology and status of marine and shoreline birds in the Strait of Georgia, British Columbia (K. Vermeer and R. W. Butler, Eds.). Spec. Publ. Can. Wildl. Service, Ottawa, Ontario.

Savard, J.-P. L. 1990. Population de sauvagine hivernant dans l'estuaire du Saint-Laurent: distribution, abondance et comportement. Canadian Wildlife Service Technical Report Series No 89.

Savard, J.-P. L., G. E. J. Smith and J. N. M. Smith. 1991. Duckling mortality in Barrow's Goldeneye and Bufflehead broods. Auk 108: 568-577.

Savard, J.-P. L. and P. Dupuis. 1999. A case for concern: the eastern population of Barrow's Goldeneye. *In* Behaviour and ecology of seaducks (R. I. Goudie, M. R. Petersen and G. J. Robertson, Eds.). Occasional Paper No 100, Canadian Wildlife Service, Ottawa.

Sayler, R. D. and A. D. Afton. 1981. Ecological aspects of Common Goldeneyes *Bucephala clangula* wintering on the upper Mississippi River. Ornis Scandinavica 12: 99-108.

Smith, C. M., R. I. Goudie and F. Cooke. 2001. Winter age ratios and the assessment of recruitment of Harlequin Ducks. Waterbirds 24: 39-44.

Snyder, L. L. 1953. An apparently hybrid golden-eye. Wilson Bulletin 65: 199.

St. Lawrence Centre. 1996. State of the environment report on the St. Lawrence River. Volume 1. The St. Lawrence ecosystem. Environment Canada, Quebec Region, and Éditions MultiMondes, Montréal, Québec.

Titman, R. 1999. Red-breasted Merganser (*Mergus serrator*). *In* The Birds of North America, No 443 (A. Poole and F. Gill, Eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, D.C.

Tobish, T. 1986. Separation of Barrow's and Common Goldeneyes in all plumages. Birding 18: 17-27.