Species Status Summary and Information Needs

Sea Duck Joint Venture, August 2015

Note: Barrow's goldeneye populations in eastern and western North America are allopatric and thus are addressed separately in this document.

Barrow's Goldeneye, Western Population *(Bucephala islandica)*

Population Size and Trends: Population size and trends are uncertain at best. The western population has been crudely estimated at 250,000-300,000 birds (NAWMP 2012; Rothe et al. 2015). Waterfowl Breeding Population and Habitat Survey data show relatively stable numbers for goldeneye (both species combined) from 1957 to 1989, and then positive growth after the 1989 regime shift in oceanic conditions in the North Pacific (Flint 2013). Long-term surveys have been conducted in selected breeding areas of the British Columbia interior but this information has yet to be extrapolated into a breeding population estimate. The situation is similar for wintering populations, with only a handful of inconsistent surveys conducted at wintering sites (e.g., Baynes Sound and Stanley Park in British Columbia, Prince William Sound and southeast Alaska). The assessment of trends in the British Columbia breeding population is confounded by the fact that Riske Creek (one of the key survey areas supporting a relatively high density of birds) has been subjected to a variety of population manipulations (e.g., deployment of nest boxes and collection of adult females). The Waterfowl Breeding Population Survey produced an estimate of 22,848 individuals in the Central Interior Plateau of British Columbia in 2013, a 5% increase from the 2012 estimate (CWS Waterfowl Committee 2013). In the southern Yukon, there has been no apparent population trend over the past 5, 10, 15 or 21 years (CWS Waterfowl Committee 2013). It has been estimated that >165,000 Barrow's Goldeneye winter in Alaska, from the Gulf of Alaska westward through the Alaska Peninsula (Rothe et al. 2015). Audubon Christmas Bird Count data suggest stable or increasing numbers along the Pacific coast in winter, but this survey is not rigorous enough to detect relatively small changes, especially for sub-populations. In Prince William Sound, Alaska the wintering population was stable from 1997 to 2009 (Rosenberg et al. 2013). In the Strait of Georgia, British Columbia Coastal Waterbird Survey data indicated a significant decline of 4.3%/year from 1999-2011 (Crewe et al. 2012) while in Puget Sound, Washington there was a non-significant decline of 23.1% between1978-1980 and 2003-2005 (Bower 2009). However, there are no comprehensive, range-wide surveys to provide robust population estimates or long-term trend data.

Priority Information Needs:

1. Develop standardized surveys to estimate abundance levels and population trends across the breeding range.
2. Develop standardized surveys to estimate abundance levels and population trends across the wintering range.

Population Delineation: Breeding and wintering ranges of western Barrow's Goldeneyes are fairly well described, although the breeding range and relative densities in Alaska are less well

known. Recent efforts, led primarily by Environment Canada, have focused on using satellite telemetry to determine linkages among breeding, molting and wintering areas. Barrow's Goldeneye wintering on the south to central British Columbia coast migrate inland to breed in south-central interior British Columbia (roughly from Kamloops to Prince George); females tend to molt on or near their breeding areas (especially successful breeders) although some (usually failed breeders) migrate several hundred kilometers further north; and males migrate north and east to molt in Alberta and the Northwest Territories (from Slave Lake, Alberta to Great Bear Lake, Northwest Territories, but Cardinal Lake, Alberta supports up to 6,000 males). Individuals wintering in Douglas Channel near Kitimat (northern British Columbia) breed mainly in the interior of north/central British Columbia with males migrating to molt in northern British Columbia and Northwest Territories. From wintering grounds near Juneau in southeast Alaska, Barrow's Goldeneye migrate to breeding areas in northern British Columbia and the Yukon, with males molting mostly around Great Bear Lake but throughout an area reaching to Great Slave Lake, Northwest Territories. Birds wintering in Prince William Sound and Kachemak Bay, Alaska migrate to interior Alaska to breed, with females molting near breeding areas and most males migrating to Old Crow Flats, Yukon to molt. For these four wintering regions, there is little overlap of breeding areas but males from southern British Columbia, northern British Columbia and southeast Alaska share some common molting areas (S. Boyd et al., unpubl. data).

Priority Information Needs:

1. Evaluate dispersal patterns for sub-adult birds throughout range and determine age at first breeding

Population Dynamics: Little is known about reproductive and survival rates for local breeding or wintering populations, which limits any understanding of basic demographic properties underlying population dynamics. Dispersal patterns of different age and sex classes (especially HY birds) from breeding areas to the coast are not well understood. Studies of reproductive ecology and natal return rates have been conducted at Riske Creek, British Columbia, but similar work should be conducted at important breeding sites in northern British Columbia, Yukon, and Alaska for comparative purposes. At Riske Creek, annual apparent survival rates were 0.62 for AHY females, 0.58 for AHY males, 0.68 for HY females and 0.35 for HY males; however, true survival is likely higher for males than females and the low apparent survival for HY males was attributed primarily to their higher dispersal rates (Boyd et al. 2009). The probability of dispersal likely increases after individuals reach sexual maturity (at $\geq$ 2 years of age) and begin competing for breeding territories, indicating that density-dependent factors (e.g., access to limited resources such as nest cavities) may be important (Boyd et al. 2009). During remigial molt at Cardinal Lake, Alberta, radio-marked adult males had a daily survival rate (DSR) of 0.9987 (95% CI: 0.9967-1.000) and a 39-day period survival rate (PSR) of 0.95 (95% CI: 0.88-1.00); during fall staging DSR was 0.9938 (95% CI: 0.9898-0.9978) and the 62-day PSR was 0.68 (95% CI: 0.53-0.87) (Hogan et al. 2013a). In the Strait of Georgia, British Columbia male age ratio (first year males/adult males) ranged from 0.064 to 0.081; sex ratio (all males/all females) ranged from 1.307 to 1.615; and adult male proportion (adult males/total birds) was 0.533 to 0.571 (Rodway et al. 2015). The male age ratio (i.e., index of recruitment) was lower for Barrow's Goldeneye than other sea duck species in same study and the male age ratio differed substantially among regions (Rodway et al. 2015). Winter surveys in Puget Sound in 2010 indicated a 9.7% juvenile ratio (WDFW 2013).

Priority Information Needs:

1. Quantify reproductive, survival, and natal return rates for local breeding populations throughout the species range.
2. Quantify winter survival rates for all age and sex classes throughout the non-breeding range.
3. Measure annual recruitment rates using winter age ratio surveys over a large scale; this should be done at a variety of selected areas in British Columbia and Alaska.
4. Evaluate dispersal patterns for sub-adult birds throughout range and determine age at first breeding
5. Develop models describing population dynamics based on demographic data, as above.

Population Ecology: Breeding ecology has been studied extensively at Riske Creek, British Columbia with more recent studies of the post-breeding period at Cardinal Lake, Alberta. Stable isotope analysis indicated that Barrow's Goldeneye females used a mixed strategy of endogenous and exogenous nutrient allocation for egg production (Hobson et al. 2005). Female Barrow's Goldeneye likely compete for food with sympatrically nesting Bufflehead in central British Columbia (Thompson and Ankney 2002). Nest parasitism increased the likelihood that females would abandon their nests (i.e. nests with higher numbers of non-natal eggs were more likely to be abandoned) (Jaatinen et al. 2009a) and nest parasites were more likely to donate their eggs to related hosts (Jaatinen et al. 2009b). Furthermore, if host and donor were more closely related, the host female was more likely to reduce her own clutch size (Jaatinen et al. 2009b). Relative to dabbling ducks, Barrow's Goldeneye re-grow their remiges more slowly and are flightless for a longer period during molt; at a single location, initiation of molt was asynchronous within and among age and sex classes, indicating lack of pressures to complete molt quickly or during a narrow temporal window (Hogan et al. 2013b). All sex and age classes increased body mass during remigial molt at Cardinal and Leddy Lakes, Alberta; birds foraged diurnally on Cardinal Lake but foraged primarily nocturnally on the nearby but smaller Leddy Lake (Hogan et al. 2013c). Although the lakes were 25 km apart, birds on Leddy Lake were consistently heavier, in all sex and age classes and in both years of the study, indicating intraspecific variation in body-mass and foraging strategies during molt, perhaps influenced by environmental conditions (Hogan et al. 2013c). Conversely, at Old Crow Flats, Yukon, mean body mass of adult males decreased significantly during molt, and heavier birds exhibited greater mass loss and faster remigial growth (van de Wetering and Cooke 2000). Little is known about foraging ecology (e.g., prey selection) and how it differs by age, sex class, and season. Prey selection studies require intensive collections of birds and sampling of food items in their immediate environment.

Priority Information Needs:

1. Study the reproductive, wintering, and molt ecology of different age and sex classes across entire range.
2. Investigate seasonal movements and seasonal habitat affiliations of the different age and sex classes.
3. Investigate seasonal prey preferences of the different age and sex classes.

Habitat Requirements: Goldeneye nest in cavities primarily excavated by Pileated Woodpeckers in old, large-diameter trees adjacent to productive ponds. The physical

characteristics of these trees, ponds and surrounding habitat have been documented for the Riske Creek area to help develop logging guidelines and land-use plans for interior forests. However, these kinds of data should be collected for other types of forests throughout the breeding range, in particular the boreal forests in northern British Columbia, Alberta, and Alaska. In interior British Columbia, Barrow's Goldeneye nesting cavities were found in primarily quaking aspen with an average diameter at breast height of 48.2 cm, and were generally in live trees with visible signs of decay (Martin et al. 2004); nest cavities also occur in Douglas Fir trees (Evans et al. 2002). Barrow's Goldeneye nesting in nest boxes had larger clutch sizes, lower nesting success and different major predators than in natural cavities; these differences were attributed mainly to the greater visibility of nest boxes (Evans et al. 2002). During the reproductive period, female Barrow's Goldeneye fed primarily on aquatic insects (particularly larvae of damselflies, midges, and phantom midges), while plant foods formed <15% of their diet (Thompson and Ankney 2002). During 2004-2006, surveys in the Boreal Transition Zone of northern Alberta found molting goldeneyes on 40-45% of wetlands surveyed; 1.3-3.3% of wetlands had large aggregations (>100 birds) (Hogan et al. 2011). Two wetlands, Cardinal and Leddy Lakes, supported 5,000-7,000 Barrow's Goldeneye, mostly adult males, for remigial molt and fall staging (birds present for up to 5 months of the year) and Chip Lake, also in the Boreal Transition Zone, supports large numbers of molting Barrow's Goldeneye; all three of these highly productive lakes support large numbers of molting and staging waterfowl of several species, and are large, shallow wetlands with abundant submergent vegetation (Hogan et al. 2011). At Old Crow Flats, Yukon, molting Barrow's Goldeneye were more abundant on lakes with higher primary productivity, but lake size did not appear to influence habitat choice (van de Wetering 1997). In Malaspina Inlet, British Columbia, densities of wintering Barrow's Goldeneye were strongly positively associated with aquaculture facilities, mostly oyster longlines, presumably due to the abundance of mussels growing on the rafts (Žydelis et al. 2008). Mussels growing on floating aquaculture structures were at higher densities, were larger, with lower shell mass and weaker byssal attachments than mussels growing in nearby intertidal areas; these attributes likely make the shellfish farm mussels more profitable prey (Kirk et al. 2007). In southeast Alaska, habitat correlates with wintering distribution found that Barrow's Goldeneye were more likely to be closer to streams and less likely to be found along exposed shorelines (Gunn 2009). A similar analysis for British Columbia using British Columbia Coastal Waterbird Survey data is being undertaken by Ducks Unlimited Canada and the Canadian Wildlife Service (B. Harrison, DUC and K. Moore, CWS). Although some data are now available to characterize molting, staging and wintering sites, the limiting role of food and the importance of other habitat attributes are not clear.

Priority Information Needs:

1. Describe the characteristics of natural cavities used for nesting throughout breeding range.
2. Describe the biotic and abiotic characteristics of important breeding, staging, molting and wintering sites of all age and sex classes.

Harvest Assessment: Harvest statistics are for eastern and western populations combined, unless otherwise noted. From 1999-2008, the US sport harvest averaged 5,136 annually, with 96.2% in Pacific Flyway and 39.2% in Alaska; in Canada the average was 853/year, mostly in British Columbia, Québec and Alberta (Baldassare 2014). The index of percentage of population harvested was 2.2% for western Barrow's Goldeneye (Baldassare 2014). For the sport harvest,

the 2002-2011 average adult sex ratio (males:females) was 1.03 in Canada and 2.64 in the U.S.; the age ratio (immatures of both sexes:adult females) was 1.41 in Canada and 2.36 in the U.S. (Rothe et al. 2015). Harvest is difficult to assess, as small number of wing samples are submitted to national harvest surveys; since 1999 the Harvest Information Program (HIP) survey estimated an average of 700 Barrow's Goldeneye harvested per year in Washington State while state permit reports estimate ~110 in western Washington (Rothe et al. 2015). The HIP survey is a national effort, which uses state-based hunter licensing systems to collect harvest data while the western Washington estimate uses data gathered under a region-specific mandatory reporting system for sea duck hunters (Rothe et al. 2015). Several hundred are harvested annually in Idaho, Montana, Oregon and Utah, combined (Rothe et al. 2015). In Canada, harvest occurs in the Yukon, British Columbia and Alberta; prior to 1990, the combined harvest averaged 2,800/year, 85% in British Columbia; most recent 10-year average indicates annual harvest is <400/year, with 155 in British Columbia (Rothe et al. 2015). Bag limits were reduced in British Columbia in 1990 and in Washington in 2010; harvest of goldeneyes has been restricted to 2 daily in Washington since 2010-2011 and in Puget Sound, harvest subsequently declined to <400 (~60% Common, 40% Barrow's) (Rothe et al. 2015). During fall staging in Alberta, at least half of mortalities of radio-marked adult males were directly attributed to hunting, which indicated that localized hunting could be having a significant negative impact at an important staging area (Hogan et al. 2013a).

Alaskan subsistence harvest was estimated at 7,262 goldeneye/year (both species) (Rothe et al. 2015). The two species are often not distinguished by subsistence hunters, and the English names can cause confusion in areas where Barrow's Goldeneye are actually more abundant than Commons (Rothe et al. 2015). Forty-eight percent of subsistence harvest occurred in the Aleutian-Pribilof Islands, western Alaska and Interior Alaska (likely mostly Common Goldeneye) while 52% of the harvest was in Gulf of Alaska-Cook Inlet, Kodiak Archipelago and Upper Copper River (likely a mix of Common and Barrow's) (Rothe et al. 2015). The Canadian subsistence harvest was estimated at 950/year for the western population (SDJV 2007).

Priority Information Needs:

1. Accurately estimate annual harvest rates and trends in those rates for different parts of the range.

Parasites, Disease, Contaminants: In winter, these birds forage primarily on bivalves which are known to concentrate heavy metals and organochlorine pollutants. Contaminant levels in birds and their foods need to be determined, especially in areas adjacent to human and industrial development, to help predict what effect these may have on survival and reproduction rates. After the Exxon Valdez oil spill in Prince William Sound in 1989, evidence of hydrocarbon exposure (i.e. P4501A (CYP1A) gene induction/EROD activity) was detected in Barrow's Goldeneye (Esler et al. 2011). In 1996/97 and 2005, EROD activity was higher in birds captured in oiled versus unoiled areas and higher proportions of individuals exhibited elevated EROD activity. However, by 2009, there was no statistical difference in average EROD activity between birds from oiled and unoiled areas (Esler et al. 2011). Although oil was still present in the environment, and some individuals may have still encountered it, exposure had declined markedly by 16-20 years post-spill (Esler et al. 2011). A MSc. student at Simon Fraser University is currently studying exposure to polycyclic aromatic hydrocarbons in coastal British Columbia (Douglas Channel and Burrard Inlet), with consideration of the effects of individual

site fidelity and levels of PAHs in mussels at the study sites (M. Willie, pers. comm.). In northern Canada, hepatic mercury levels ranged from 0.12-0.8 mg/kg and selenium from 3.0-9.7 mg/kg in Barrow's Goldeneye (Braune and Malone 2006). In Prince William Sound, blood selenium concentration averaged 9.8 ppm wet weight (SD = 3.2, range = 3.1-17.0) in individuals that all appeared to be healthy (Heard et al. 2008).

Very little is known about parasite loads and diseases of goldeneye throughout the annual cycle. Avian influenza plasma antibodies were detected in 14% of Barrow's Goldeneye sampled in Prince William Sound but antibodies against adenovirus, reovirus and paramyxovirus 1 were not detected (Heard et al. 2008). Mortalities caused by duck plague (caused by duck herpesvirus 1) and avian botulism have been reported, as well as the occurrence of West Nile virus, *Sarcocystis* sp., and *Hemoproteus* sp. (Heard et al. 2008, Hollmen and Franson 2015).

Priority Information Needs:

1. Sample birds throughout the range and determine levels of known contaminants, parasites and disease.
2. Determine toxicity and sublethal effects of contaminants.

Barrow's Goldeneye, Eastern Population *(Bucephala islandica)*

Population Size and Trends: The eastern population of Barrow's Goldeneye was listed in Canada as a species of Special Concern in 2000 and has a global conservation rank of Vulnerable (NatureServe 2015). The population is provincially listed as endangered in New Brunswick and Nova Scotia, vulnerable in Québec and Newfoundland and Labrador and as state-threatened in Maine. Recent population estimates range from 6,800 (equivalent to 2,100 breeding pairs) (Robert 2013) to 7,500 (NAWMP 2012). However, 2011 survey results suggested that the wintering population was only 4,100 (F. Bolduc, unpubl. data in CWS Waterfowl Committee 2013). . It is imperative to closely monitor the population as it could easily be up-listed to Threatened in Canada. Wintering Barrow's Goldeneye in Québec and New Brunswick (St. Lawrence Estuary and Gulf) have been monitored roughly every three years, beginning in 1999); in 2009, most suitable areas in the Canadian Maritimes were surveyed as well (Lepage and Bordage 2013). However, results are considered imprecise and inadequate for monitoring trends (M. Robert, pers. comm. in Bowman et al. 2015).

Priority Information Needs:

1. Develop standardized census methodologies for monitoring breeding populations in order to obtain reliable estimates of population size, trends and density in the core breeding area.

Population Delineation: The winter range of the eastern population is fairly well known, with >95% wintering in the St. Lawrence Estuary and Gulf, ~500 individuals in the Atlantic Provinces and ~100 in Maine (Robert and Savard 2006, Environment Canada 2013). However, links to breeding areas have only been established for the birds wintering in the St. Lawrence estuary. Whether birds wintering in Québec, along the Gulf of St. Lawrence, the Maritimes and the eastern U.S. breed in the same area is unknown. Preliminary genetic studies are not conclusive and more detailed studies are needed. The general breeding area has been identified, but the exact boundaries, especially in the north and east, have yet to be determined (Robert and Savard 2008). Adult males and females have been observed during the breeding season, in suitable habitat, in the Chic-Choc Mountains on the Gaspé Peninsula in Québec; this is the first recorded evidence that Barrow's Goldeneye may breed on the south shore of the St. Lawrence Estuary (Ouellet et al. 2010). The 2010-2014 field campaign for the second Québec Breeding Bird Atlas has also brought some insights that pairs are probably breeding on the Gaspé Peninsula (Atlas of the breeding birds of Québec 2015).

Five females were captured and implanted with satellite transmitters on breeding grounds near Tadoussac, Québec and four molting sites were identified over two years of tracking – an inlet in Ungava Bay, a lake near Ungava Bay, a lake near Hudson Bay and the mouth of the Rivière aux Outardes in the St. Lawrence Estuary (range 156-1100 km from breeding area) (Savard and Robert 2013). All individuals wintered within the St. Lawrence Estuary and moved widely throughout the winter; individuals wintering in the St. Lawrence Estuary appear to belong to a single population but no movements were detected between the Estuary and the Gulf so birds wintering in the Gulf and Chaleur Bay should likely be considered separately from those in the Estuary (Savard and Robert 2013). Of four individuals with locations for consecutive years, three showed interannual fidelity to molt sites (within 5 km) and all returned to the breeding area

where they had been captured (Savard and Robert 2013). Adult male Barrow's Goldeneye molt at sites in coastal waters of Hudson, Ungava and Frobisher Bays and in a few inlets in northern Labrador (CWS Waterfowl Committee 2013).

Priority Information Needs:

1. Characterize the genetic and morphologic structure of the three major populations of Barrow's Goldeneye.
2. Determine the northern boundary of the Québec/Labrador breeding area.
3. Confirm the extent of the possible breeding area on the Gaspé Peninsula, Québec.
4. Determine affiliations among breeding, molting, and wintering areas for birds wintering along the Gulf of St. Lawrence (Québec), in the Maritimes and the U.S.

Population Dynamics: Little is known of the dynamics of the eastern population of Barrow's Goldeneye. The breeding area was just discovered in 1998 and breeding ecology has not been well-studied yet. In the Laurentian Highlands of Québec, nest success for goldeneyes (both species) was 67% for clutches of 6-9 eggs, and was lower for smaller and larger clutches (Savard and Robert 2007). In the St. Lawrence, the proportion of adult males varied from autumn to spring, ranging from 0-60% (Bourget et al. 2007). Also in the St. Lawrence, during January-February, the male:female ratio for adults was 2.17 in 1998 and 1.40 in 1999; for immatures the male:female ratio was 1.20 and 1.04, respectively (Robert and Savard 2006). Immature:adult ratio was 0.11 in 1998 and 0.22 in 1999; and the proportion of adult females in the population was estimated to be 31% (Robert and Savard 2006).

Priority Information Needs:

1. Determine the reproductive success of the population, both hatching and fledging success.
2. Determine the survival rate of various age-sex cohorts of the population.
3. Conduct regular winter surveys to provide information on age and sex ratios in the population.

Population Ecology: Little is known of the ecology of the eastern population of Barrow's Goldeneye. Recent work indicates that natural nest sites are located in large decaying snags, for which availability is probably greatly affected by substantial logging pressure in breeding habitats. Goldeneyes (both species) used 23-43% of nest boxes in the Laurentian Highlands in the boreal forest of Québec, and the number of breeding pairs in the area increased from 1999 to 2003, while the number of broods increased in 2000 but then stabilized (Savard and Robert 2007). Predation in the nest boxes was not a major cause of nest failure or mortality but nest desertion was the major cause of breeding failure and may have been caused by competition for nest cavities, high numbers of first year breeders, and/or human disturbance related to fishing activity (Savard and Robert 2007). Nest boxes may be useful to aid recovery of eastern Barrow's Goldeneye in areas where intensive forestry has limited availability of natural cavities but increases may be limited by productivity of brood-rearing habitat (Savard and Robert 2007). The feeding ecology of pairs and broods has not been documented on the breeding areas. Growth

rates of ducklings and the factors affecting them are unknown. Most wintering and staging areas for eastern Barrow's Goldeneye in Canada have been closed to hunting, and currently the major threats to population viability are thought to be forestry operations and introduction of fish to formerly fishless lakes in the breeding range (Robert et al. 2008).

Priority Information Needs:

1. Study the breeding ecology of the eastern population.
2. Study the molting ecology of adult males and females.
3. Study the ecology of sub-adults.

Habitat Requirements:

The core breeding area is located on the high plateaus north of the St. Lawrence, from the Saguenay River east to Blanc-Sablon, where breeding Barrow's Goldeneye use small fishless lakes in the boreal forest (Robert et al. 2000, Robert et al. 2008). Breeding lakes are small (< 15 ha), high-elevation (> 500 m), in rugged mountainous terrain in balsam fir-white birch and black spruce-moss forests (Robert 2013). Furthermore, Barrow's Goldeneye tended to select connected ponds and small islands and avoided isolated ponds, flooded swamps and nearshore and offshore areas of lakes; they were also more likely to use wetlands with area ≤ 8 ha (Lemelin et al. 2010). In the Sainte-Marguerite River watershed, Québec, Barrow's Goldeneye were found on lakes between 490-822 m elevation (90% were at ≥ 610 m); occurrence was higher on lakes with nest boxes, no fish (brook trout, *Salvelinus fontinalis*), none or few lakes upstream, many emergent rocks, none or few riparian wetlands; at high elevation (>610 m), in areas with low proportion of wetlands, high proportion of regeneration and high mean nearest-neighbor distances (Robert et al. 2008). The most important variables seemed to be nest boxes, fish occurrence, altitude and the interaction between altitude and slope; however R^2 value was <30% (Robert al. 2008). They appeared to be positively associated with highly productive aquatic ecosystems and the importance of fishless lakes was emphasized (Robert et al. 2008). Nest in cavities were found in very large dead or living trees (diameter at breast height ≥ 35 cm) (Robert 2013). Of 11 nest cavities, 10 were in dead, decaying trees and one in the dead part of a dying tree; 9 were in white birch (*Betula papyrifera*) trees; 5 had lateral entries and six were chimney type (top) entries; mean cavity height was 3.5 m; mean diameter at breast height was 37.8 cm and mean distance from water was 235 m (Robert et al. 2010). Natural cavities, rather than cavities excavated by other species, were used, as the breeding distribution in eastern Canada does not appear to overlap with large primary excavators such as Pileated Woodpecker (Robert et al. 2010). Of trees deemed large enough (i.e. diameter at breast height ≥20 cm and height ≥1 m), only 0.2% had cavities which were potentially suitable nesting cavities (7746 trees were sampled); all were in snags in advanced stages of decay; potential cavities were more abundant in unharvested forest than in cutblocks or remnant strips of forest (Vaillancourt et al. 2009). Forestry is considered an important threat to breeding habitat availability; nests are directly destroyed during logging, reducing availability of potential nest sites which can force females to nest further from ponds possibly increasing risk of predation on ducklings (Robert et al. 2000). Forestry activity (particularly road-building) also makes lakes more accessible, thereby increasing disturbance (Robert et al. 2000). From 1976-1996, logging caused loss of ≥4,172 km^2 of forests in core breeding area in Québec (Robert et al. 2000) and forests have been cut at 0.8% per year since 1995 (Robert et al. 2010).

Molting habitats have not been thoroughly described (Environment Canada 2013), but adult females marked with satellite transmitters have been located in estuarine areas as well as coastal and inland lakes during molt (Savard and Robert 2013). Males molt in northern areas of Québec, particularly the coasts of Hudson and Ungava Bays, and also the north coast of Labrador and south coast of Baffin Island (Robert 2013, Environment Canada 2013).

The St. Lawrence Estuary and Gulf form the main wintering area (>90% of the eastern population), particularly the north shore (Baie-Comeau, Baie-des-Rochers, La Malbaie, and Cap-à-l'Aigle) (Robert and Savard 2006), where they concentrate along wide tidal flats (Robert 2013). Barrow's Goldeneye were more frequently located in the intertidal zone than any other depth class, closer to medium-sized rivers, and in areas of lower ice concentration (Ouellet et al. 2010). At small spatial scales (1-2 km) there was a negative correlation between presence of Common and Barrow's Goldeneye although they were sympatric at larger scales (i.e. 25 km) (Ouellet et al. 2010). During autumn in the St. Lawrence Estuary, the main prey was crustaceans (mainly *Gammarus oceanicus* and *Calliopus laeviusculus*), followed by gastropods (*Littorina* sp.), mussels and polychaetes (Bourget et al. 2007). The south shore of the St. Lawrence is used during fall and spring, but birds moved to the north shore when intertidal areas on the south shore were covered by ice (Bourget et al. 2007). Important wintering areas have large intertidal zones which remain ice-free, due to currents and prevailing winds (Robert and Savard 2006). Large variability in numbers at a given site throughout the winter may be related to tide cycles, ice conditions and/or wind exposure (Robert and Savard 2006). Movement to the south shore in the spring (while breeding areas are north of the St. Lawrence) suggests good feeding opportunities there and/or prey depletion on north shore wintering areas (Robert and Savard 2006).

Priority Information Needs:

1. Locate and characterize molting sites of adult females.
2. Characterize molting sites of adult males.
3. Quantify winter habitat use in relation to tides, ice and other environmental variables.

Harvest Assessment: Important areas where wintering and staging birds concentrate have been partly closed to hunting in Canada, but some areas are still hunted and harvest continues to occur. The first harvest restrictions were imposed in Québec in 1995 and bag limits were reduced to 1 daily in Newfoundland and Labrador, New Brunswick, Nova Scotia, Ontario, Prince Edward Island and Québec in 2007-2008 (Rothe et al. 2015). A complete ban was considered, but rejected due to difficulty in distinguishing Barrow's from Common Goldeneye. Harvest has been closed in Maine since 2008 (Rothe et al. 2015). Because current levels of harvest are probably low and widely dispersed, waterfowl harvest surveys in Canada and the U. S. do not provide accurate estimates of the number taken annually. Harvest statistics are for eastern and western populations combined, unless otherwise noted. From 1999-2008, the U.S. sport harvest averaged 5,136 annually, with 96.2% in Pacific Flyway and 39.2% in Alaska; in Canada the average was 853/year, mostly in British Columbia, Québec and Alberta (Baldassare 2014). The index of percentage of population harvested was 8.2% for eastern Barrow's Goldeneye (Baldassare 2014). For the sport harvest, the 2002-2011 average adult sex ratio (males:females) was 1.03 in Canada

and 2.64 in the U.S.; the age ratio (immatures of both sexes:adult females) was 1.41 in Canada and 2.36 in the U.S. (Rothe et al. 2015). The Canadian subsistence harvest was estimated at 50/year for the eastern population (SDJV 2007), but data are lacking and subsistence hunting of sea ducks is popular in the Côte-Nord and Gaspé Peninsula regions of Québec. Although total harvest of the eastern population is likely low (100-400 individuals), if it continues at this rate there could be population-level impacts, particularly if adults are harvested (Robert et al. 2000). However, with new restrictions on bag and possession limits now in place, hunting is not expected to have a significant negative effect on the population (COSEWIC 2011).

Priority Information Needs:

1. Design a special survey to adequately estimate harvest levels for both western and eastern populations.
2. Determine if current restrictive measures are efficient in reducing harvest.

Parasites, Disease, Contaminants: Little is known about the level of contaminants in the population. However, an important portion of the population winters in heavily contaminated areas (Baie-Comeau, Québec [polychlorinated biphenyls and polycyclic aromatic hydrocarbons] and Dalhousie, New Brunswick [lead and mercury]). Individuals sampled from sites in the St. Lawrence Estuary and Gulf were tested for metals, trace elements, polychlorinated biphenyls (PCBs), organochlorine pesticides and brominated flame retardants (BFRs) (Ouellet et al. 2012). Levels of contaminants were generally low and not of toxicological concern; liver mercury levels were higher in Manicouagan (4.4 mg/kg) and Charlevoix (3.8 mg/kg) regions than in the Chaleur Bay (2.4 mg/kg) while selenium was higher in Chaleur Bay (36.9 mg/kg) than the other two sites (7.3 and 7.0 mg/kg); liver PCB levels were highest in Manicouagan (236 ng/g), DDT greatest in Chaleur Bay (66 ng/g), and the overall mean concentration of BFRs was low (4.02 ng/g) (Ouellet et al. 2012).

Very little is known about parasite loads and diseases of goldeneye throughout the annual cycle. Mortalities caused by duck plague (caused by duck herpesvirus 1) and avian botulism have been reported, as well as the occurrence of West Nile virus, *Sarcocystis* sp., and *Hemoproteus* sp. (Heard et al. 2008, Hollmen and Franson 2015).

Priority Information Needs:

1. Assess the nature and effects of disease and parasites.

Literature Cited

Atlas of the breeding birds of Québec (2015). Data obtained from the website of the Atlas of the breeding birds of Québec (www.atlas-oiseaux.qc.ca). Regroupement QuébecOiseaux, Environment Canada's Canadian Wildlife Service and Bird Studies Canada. Québec, Québec, Canada.

Baldassare, G. A. 2014. Ducks, Geese, and Swans of North America. John Hopkins University Press, Baltimore, MD. 1027 pp.

Bourget, D., J.-P. L. Savard, and M. Guillemette. 2007. Distribution, diet and dive behavior of Barrow's and Common goldeneyes during spring and autumn in the St. Lawrence estuary. Waterbirds 30(2): 230-240.

Bower, J. L. 2009. Changes in marine bird abundance in the Salish Sea: 1975 to 2007. Marine Ornithology 37: 9-17.

Bowman, T.D., E.D. Silverman, S.G. Gilliland, and J.B. Leirness. 2015. Status and trends of North American sea ducks: reinforcing the need for better monitoring. pp. 1-27 *in* J.-P.L. Savard, D.V. Derksen, D. Esler and J.M. Eadie (editors). Ecology and conservation of North American sea ducks. Studies in Avian Biology (in press), CRC Press, New York, NY.

Boyd, W. S., B. D. Smith, S. A. Iverson, M. R. Evans, J. E. Thompson, and S. Schneider. 2009. Apparent survival, natal philopatry, and recruitment of Barrow's Goldeneyes (*Bucephala islandica*) in the Cariboo-Chilcotin region of British Columbia, Canada. Canadian Journal of Zoology 87(4)3: 37-345.

Braune, B. M. and B. J. Malone. 2006. Organochlorines and mercury in waterfowl harvested in Canada. Environmental Monitoring and Assessment 114(1-3): 331-359.

Canadian Wildlife Service Waterfowl Committee. 2013. Population Status of Migratory Game Birds in Canada: November 2013. CWS Migratory Birds Regulatory Report Number 40.

COSEWIC. 2011. COSEWIC status appraisal summary on the Barrow's Goldeney *Bucephala islandica* Eastern Population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii pp. <www.sararegistry.gc.ca/status/status_e.cfm>

Crewe, T., K. Barry, P. Davidson, and D. Lepage. 2012. Coastal waterbird population trends in the Strait of Georgia 1999–2011: results from the first 12 years of the British Columbia Coastal Waterbird Survey. British Columbia Birds 22: 8-35.

Environment Canada. 2013. Management Plan for the Barrow's Goldeneye (*Bucephala islandica*), Eastern Population, in Canada. *Species at Risk Act* Management Plan Series. Environment Canada, Ottawa. iv + 16 pages.

Esler, D., B. E. Ballachey, K. A. Trust, S. A. Iverson, J. A. Reed, K. Miles, J. D. Henderson, B. R. Woodin, J. J. Stegeman, M. McAdie, D. M. Mulcahy, and B. W. Wilson. 2011. Cytochrome P4501A biomarker indication of the timeline of chronic exposure of Barrow's goldeneyes to residual *Exxon Valdez* oil. Marine Pollution Bulletin 62(3): 609-614.

Evans, M. R., D. B. Lank, W. S. Boyd, and F. Cooke. 2002. A comparison of the characteristics and fate of Barrow's Goldeneye and Bufflehead nests in nest boxes and natural cavities. Condor 104 (3); 610-619.

Flint, P. L. 2013. Changes in size and trends of North American sea duck populations associated with North Pacific oceanic regime shifts. Marine Biology 160(1): 59-65.

Gunn, T. 2009. Habitat correlates of wintering sea duck occurrence in southeast Alaska. MSc. Thesis, Simon Fraser University, Burnaby, BC. 44 pp.

Heard, D. J., D. M. Mulcahy, S. A. Iverson, D. J. Rizzolo, E. C. Greiner, J. Hall, H. Ip, and D. Esler. 2008. A blood survey of elements, viral antibodies, and hemoparasites in wintering Harlequin Ducks (*Histrionicus histrionicus*) and Barrow's Goldeneyes (*Bucephala islandica*). Journal of Wildlife Diseases 44(2): 486-493.

Hobson, K. A., J. E. Thompson, M. R. Evans, and W. S. Boyd. 2005. Tracing nutrient allocation to reproduction in Barrow's Goldeneye. Journal of Wildlife Management 69(3): 1221-1228.

Hogan, D., J. E. Thompson, 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(3): 261-388.

Hogan, D., J. E. Thompson, and D. Esler. 2013a. Survival of Barrow's Goldeneyes during remigial molt and fall staging. Journal of Wildlife Management 77(4): 701-706.

Hogan, D., D. Esler, and J. E. Thompson, J. E. 2013b. Duration and phenology of remigial molt of Barrow's Goldeneye. Condor 115(4): 762-768.

Hogan, D., D. Esler, and J. E. Thompson, J. E. 2013c. Variation in body mass and foraging effort of Barrow's Goldeneyes (*Bucephala islandica*) during remigial molt. Auk 130(2): 313-322.

Hollmen, T. E. and J. C. Franson. 2015. Infectious diseases, parasites, and biological toxins in sea ducks. *In* J.-P.L. Savard, D.V. Derksen, D. Esler and J.M. Eadie (editors). Ecology and conservation of North American sea ducks. Studies in Avian Biology (in press), CRC Press, New York, NY.

Jaatinen, K., M. Öst, P. Waldeck, and M. Andersson. 2009b. Clutch desertion in Barrow's goldeneyes (*Bucephala islandica*): effects of non-natal eggs, the environment and host female characteristics. Annales Zoologici Fennici 46(5): 350-360.

Jaatinen, K., S. Jaari, R. B. O'Hara, M. Öst, and J. Merilä. 2009b. Relatedness and spatial proximity as determinants of host–parasite interactions in the brood parasitic Barrow's goldeneye (*Bucephala islandica*). Molecular Ecology 18(12): 2713-2721.

Kirk, M., D. Esler, and W. S. Boyd. 2007. Morphology and density of mussels on natural and aquaculture structure habitats: implications for sea duck predators. Marine Ecology Progress Series 346: 179-187.

Lemelin, L.-V., M. Darveau, L. Imbeau and D. Bordage. 2010. Wetland Use and Selection by Breeding Waterbirds in the Boreal Forest of Québec, Canada. Wetlands 30(2): 321-332.

Lepage, C. and D. Bordage (Editors). 2013. Status of Québec Waterfowl Populations, 2009. Technical Report Series No. 525, Canadian Wildlife Service, Environment Canada, Québec Region, Québec City. xiii + 243 pages.

Martin, K., K. E. Aitken, and K. L. Wiebe. 2004. Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: nest characteristics and niche partitioning. Condor 106(1): 5-19.

NatureServe. 2015. Barrow's Goldeneye, *Bucephela islandica*. <http://explorer.natureserve.org/servlet/NatureServe?searchName=Bucephala+islandica>

NAWMP. 2012. North American Waterfowl Management Plan 2012: People Conserving Waterfowl and Wetlands. North American Waterfowl Management Plan Committee. xx + 48 pp. <http://www.nawmp.ca>

Ouellet, J. F., P. Fradette, and I. Blouin. 2010. Do Barrow's Goldeneyes, *Bucephala islandica*, breed south of the St. Lawrence Estuary in the Gaspé Peninsula, Eastern Canada? Canadian Field-Naturalist 124(2): 179-180.

Ouellet, J. F., L. Champoux, and M. Robert. 2012. Metals, trace elements, polychlorinated biphenyls, organochlorine pesticides, and brominated flame retardants in tissues of Barrow's Goldeneyes (*Bucephala islandica*) wintering in the St. Lawrence marine ecosystem, Eastern Canada. Archives of Environmental Contamination and Toxicology 63(3): 429-436.

Robert, M. 2013. Barrow's Goldeneye, pp. 190-194 in Lepage, C. and D. Bordage, eds. Status of Québec Waterfowl Populations, 2009. Technical Report Series No. 525, Canadian Wildlife Service, Environment Canada, Québec Region, Québec City. xiii + 243 pages.

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(4): 437-450.

Robert, M. and J.-P. L. Savard. 2008. Survey of Barrow's Goldeneyes in Southern Labrador and on the Québec North Shore (Spring 2008). Final report presented to the Institute for Environmental Monitoring and Research by Environment Canada, Québec Region, 14 pp.

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., B. Drolet, and J.-P. L. Savard. 2008. Habitat features associated with Barrow's Goldeneye breeding in eastern Canada. Wilson Journal of Ornithology 120(2): 320-330.

Robert, M., M. A. Vaillancourt, and P. Drapeau. 2010. Characteristics of nest cavities of Barrow's Goldeneyes in eastern Canada. Journal of Field Ornithology 81(3): 287-293.

Rodway, M. S., H. M. Regehr, W. S. Boyd, and S. A. Iverson. 2015. Age and sex ratios of sea ducks wintering in the Strait of Georgia, British Columbia: Implications for monitoring. Marine Ornithology: *In press*.

Rosenberg, D. H., M. J. Petrula, D. D. Hill, and A. M. Christ. 2013. Harlequin Duck population dynamics: measuring recovery from the *Exxon Valdez* oil spill. *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 040407). Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage, AK.

Rothe, T. C., P. I. Padding, L. C. Naves, and G. J. Robertson. 2015. Harvest of sea ducks in North America: A Contemporary Summary. *In* J.-P.L. Savard, D.V. Derksen, D. Esler and J.M. Eadie (editors). Ecology and conservation of North American sea ducks. Studies in Avian Biology (in press), CRC Press, New York, NY.

Savard, J.-P.L. 2008. Diversité, abondance et répartition des oiseaux aquatiques hivernant dans les eaux côtières du Parc marin Saguenay-Saint-Laurent. Revue des sciences de l'eau 21: 505-523.

Savard, J.-P. L. and M. Robert. 2007. Use of nest boxes by goldeneyes in eastern North America. Wilson Journal of Ornithology 119(1): 28-34.

Savard, J.-P. L. and M. Robert. 2013. Relationships among breeding, molting and wintering areas of adult female Barrow's Goldeneyes (*Bucephala islandica*) in eastern North America. Waterbirds 36(1): 34-42.

Sea Duck Joint Venture. 2007. Recommendations for Monitoring Distribution, Abundance, and Trends for North American Sea Ducks. December 2007. <http://seaduckjv.org/monitor.htm>

Thompson, J. E. and C. D. Ankney. 2002. Role of food in territoriality and egg production of Buffleheads (Bucephala albeola) and Barrow's Goldeneye (Bucephala islandica). Auk 119(4): 1075-1090.

Vaillancourt, M. A., P. Drapeau, M. Robert, and S. Gauthier. 2009. Origin and availability of large cavities for Barrow's Goldeneye (*Bucephala islandica*), a species at risk inhabiting the eastern Canadian boreal forest. Avian Conservation and Ecology 4(1): 6.

van de Wetering D. 1997. Moult characteristics and habitat selection of postbreeding male Barrow's Goldeneye (*Bucephala islandica*) in northern Yukon. MSc. thesis, Simon Fraser University, Burnaby, BC. 68 pp.

van de Wetering D. and F. Cooke. 2000. Body weight and feather growth of male Barrow's Goldeneye during wing molt. Condor 102(1): 228-231.

Washington Department of Fish and Wildlife. 2013. WDFW Sea Duck Management Strategies. Draft Report to the Washington Fish and Wildlife Commission. http://wdfw.wa.gov/publications/01007/

Žydelis, R., D. Esler, M. Kirk and W. S. Boyd. 2008. Effects of off-bottom shellfish aquaculture on winter habitat use by molluscivorous sea ducks. Aquatic Conservation: Marine and Freshwater Ecosystems 19: 34-42.