# Species Status Summary and Information Needs

**Sea Duck Joint Venture, December 2015**

## Harlequin Duck, Western Population *(Histrionicus histrionicus)*

**Population Size and Trends**: There is no reliable index of population size or trend for Harlequin Ducks in western North America. Numbers of breeding birds have been estimated in some small portions of their range over the short term. Single or short-term winter indices are available for a few areas. Winter survey efforts have been most consistent in Prince William Sound, Alaska (since the 1989 *Exxon Valdez* oil spill [EVOS]), southern British Columbia, and Puget Sound, Washington.Estimate of Harlequins wintering in the Aleutian Islands, Alaska range from 147,000 to 1,000,000, which is likely the majority of the western population; however there are no reliable abundance or trend data for this region (Bellrose 1976, Bowman et al. 2015). In Prince William Sound, there was an increasing trend in wintering numbers from 1997 to 2009 and densities were perhaps slightly higher in 2007-2009 than in 1972-1973 (Rosenberg et al. 2013). The Strait of Georgia, British Columbia provides non-breeding habitat for >10,000 Harlequins (CWS Waterfowl Committee 2013) and a significant decline of 2.6% per year was observed from 1999-2011 (Crewe et al. 2012). In Puget Sound, there was an estimated non-significant increase of 19.8% between 1978-1980 and 2003-2005 (Bower 2009) and a decrease of 11% between 1999-2001 (3,425) and 2013-2015 (3,058) (Don Kraege, unpubl. data.). At White Rock BC, a 5km stretch of rocky shoreline that supports a small population of molting/wintering Harlequin Ducks, total numbers (especially the number of males) have declined by up to 50% between the early 1980s and 2015. Reasons for the decline are unknown but disturbance from recreationists and predation risk from increasing populations of Bald eagles (*Haliaeetus leucocephalus*) and river otters (*Lontra canadensis*) are suspected. Christmas Bird Count data show an increasing trend on the Pacific coast since 1974 (National Audubon Society 2015). Harlequin Duck has been designated a Species of Special Concern in Alberta because of specific breeding habitat requirements, relatively small breeding population size (2000-4000), and sensitivity to disturbance during breeding (ASRD 2010). Harlequin Duck is also a species of concern in some northern US States, including WY, ID, and MT.

**Priority Information Needs:**

1. Establish a comprehensive survey program to annually estimate the number of Harlequin Ducks on all major wintering areas in the west.
2. Establish monitoring surveys in selected key breeding areas to detect changes in bird densities at local or regional scales.
3. Investigate the interaction between certain populations of Harlequin Ducks in the Salish Sea and factors such as human recreation, eagles, and otters.

**Population Delineation**: Preliminary studies suggest some genetic differences between Eastern and Western populations and among breeding areas in western North America. Also, direct measures of movement (banding, telemetry) indicate low degrees of exchange at all stages of the annual cycle. Individuals wintering in southern British Columbia breed in the Coast Mountains and Rocky Mountains of southern British Columbia and Alberta while birds wintering in northern British Columbia (Douglas Channel) also breed mostly in the Coast and Rocky Mountains, but in northern British Columbia and southern Yukon (S. Boyd et al., unpubl. data). Migration tends to be east/west and individuals generally molt at or near wintering areas so there appears to be fairly strong latitudinal separation among subpopulations; however, one individual marked in Douglas Channel wintered in the San Juan Islands, Washington (S. Boyd et al., unpubl. data). Interestingly, one adult male Harlequin marked during winter in Prince William Sound, Alaska, molted in Russia; another male spent the summer in northwestern Alaska (D. Rosenberg, pers. comm.). Generally, there is strong fidelity to molting and wintering sites and local aggregations are thought to be largely demographically distinct (CWS Waterfowl Committee 2013). Recent satellite telemetry work indicates that male Harlequin ducks wintering in the Salish Sea (Hornby Island and White Rock) migrate to northern coastal latitudes to molt, from northern Vancouver Island to Prince Rupert BC, and some males tagged in Douglas Channel (near Kitimat BC) migrate north to SE Alaska to molt. However, all marked birds returned to their capture (winter) sites by late October, showing a high level of site fidelity.

Females marked with VHF transmitters in Prince William Sound had 95% kernel home range estimates that averaged 11.5 ± 2.2 $km^2$during the non-breeding season (Iverson and Esler 2006). Over six years of data collection, 75% of radioed females remained in the bay or coastline area where they were originally trapped, 94% remained on the same island or mainland region and 98% remained within the 4500 $km^2$ study area (Iverson and Esler 2006). Within the Strait of Georgia, each year 2-4% of adults and 7-11% of subadults moved among winter locations; adults were unlikely to move, regardless of sex and paired status (Regehr 2011). Furthermore, ≥95% of individuals winter in the same location as they molted, and between years, paired males had a100% return rate to molting sites while unpaired males and paired females had a 95% return rate (Regehr 2011). Although winter movement by subadults is low, it may be sufficient to prevent fine-scale genetic structuring (Regehr 2011).

**Priority Information Needs:**

1. More completely describe the degree of genetic similarity/difference between breeding birds from Rocky Mountain/Pacific Northwest component and the Alaska/Bering Sea component.
2. Expand marking studies (banding, satellite and VHF radios) to strengthen knowledge of connections between breeding birds and their molting and wintering grounds across the geographic range.
3. Investigate genetic relationships of breeding birds in northeastern Russia to those in North America.

**<u>Population Dynamics</u>**: There has been substantial progress in describing basic demographic parameters and population dynamics in western North America. Focused work in British Columbia and in Alaska (related to the EVOS) has accumulated much information on productivity, survival rates of young and adults, and age structure of the population. In other parts of the range, similar information is more limited. However, it appears that adult survival and production of young are sufficiently high to maintain a stable population (S. Boyd and D. Esler, pers. comm. in CWS Waterfowl Committee 2013). Cumulative survival probability (± SE) during the breeding season (100-day study period) for adult females was 0.75 ± 0.11 in the Rocky Mountains, Alberta;0.88 ± 0.08 in the Coast Mountains, British Columbia and 0.89 ±

0.08 in the Cascade Mountains, Oregon (Bond et al. 2009). Survival was lower during incubation than during nest-initiation or brood-rearing stages and mortality was higher on breeding grounds than at other locations and stages of the annual cycle (Bond et al. 2009). Based on measures of egg production (yolk precursors) and nesting behavior (determined by radio telemetry), breeding propensity of females that had migrated to breeding grounds was estimated at 92% (Bond et al. 2008).

For females molting in Prince William Sound, daily survival rate was 0.999 (95% CI: 0.994-1.000) and cumulative survival rate for the post-breeding period (20 August-15 October) was 0.99 (95% CI: 0.81-1.00) (Iverson and Esler 2010). For females wintering in Prince William Sound (11 to 14 years post-EVOS) the cumulative winter survival for after-hatch years was 0.837 (± 0.064) and 0.834 (± 0.065) in unoiled and oiled areas, respectively, and for hatch-year birds was 0.766 (± 0.138) and 0.758 (± 0.152) in unoiled and oiled areas (Esler and Iverson 2010). Neither area (unoiled versus oiled) nor exposure to residual oil (based on CYP1A induction) were strongly related to variation in survival rates (Esler and Iverson 2010). However, female survival was lower during mid-winter, suggesting this period may be a demographic bottleneck (Esler and Iverson 2010). In unoiled areas of Prince William Sound, the sex ratio was 41.9 females per 100 birds, the ratio of adult males to immature males was 14.0, and adult females to immatures of both sexes was 4.59 (Rosenberg et al. 2013). Winter survival rates for subadult birds may be underestimated because of movements among wintering locations (Regehr 2011). Age and sex ratio surveys in the Strait of Georgia (in 2003, 2004, 2014) found the male age ratio was 0.068-0.138, sex ratio (male/female) was 1.340-1.386, adult male proportion was 0.511-0.536, and female age ratio 0.094-0.202 (Rodway et al. 2015). Winter surveys in Puget Sound in 2010 indicated 9.7% juveniles (WDFW 2013). Environment Canada has a banding/resight data set for Harlequins in the Strait of Georgia and survival analysis is in progress (S. Boyd, unpubl. data). WDFW also has a banding/resight database for Harlequins using Puget Sound (Don Kraege, unpubl. data).

**Priority Information Needs:**

1. Expand studies of productivity factors in representative ecological regions across the breeding range (e.g. Rocky Mountain, interior subarctic, Pacific Coast, Bering Sea river basins).
2. Expand studies of seasonal and annual survival rates of juveniles, subadults and adults.
3. Initiate or expand studies of sex ratios and age ratios (productivity indices) for major wintering areas.
4. Expand studies of immigration, emigration, and dispersal rates among wintering areas.
5. Increase development of population models that integrate productivity, survival, and harvest components to assess the importance of factors affecting population growth.

**Population Ecology**: Breeding season ecology of western Harlequin Ducks has only been studies at a few areas and over relatively short periods of study. Little is known of the effects of regional climate, weather, food availability, and brood-rearing requirements. Stable isotope analyses indicated that females in the Coast Mountains, British Columbia used exogenous nutrients acquired on breeding streams for egg production, rather than endogenous reserves stored on marine wintering areas (Bond et al. 2007). Conversely, males acquired nutrient stores and increased mass on wintering grounds, prior to spring migration, and body mass decreased on breeding grounds, suggesting that male Harlequin Ducks used endogenous reserves during the breeding season (Esler and Bond 2010). During the breeding season in British Columbia, Alberta and Oregon, most female mortality was attributed to predation, mainly by mustelids (Bond et al. 2009). A very high proportion of pairs reunite in subsequent years (Rodway 2013).

Ecological requirements at traditional molting and wintering areas have been described most extensively in British Columbia and to a lesser degree in Prince William Sound. In other parts of the winter range, however, ecological data are scarce. During spring, Pacific Herring (*Clupeapallasi spp.*) spawn, and thousands of Harlequins congregate in the Strait of Georgia (CWS Waterfowl Committee 2013), which may foster demographic mixing and gene flow (Regehr 2011).

**Priority Information Needs:**

1. Determine physical, climatic, and trophic factors affecting breeding stream/nest site selection in representative ecoregions.
2. Determine brood-rearing ecology and factors that influence fledging success.
3. Continue studies of ecological characteristics that contribute to survival during molt and winter, especially in significant wintering areas where ecological work is lacking.

**Habitat Requirements**: Western Harlequin Ducks use a wide variety of riverine and coastal breeding habitats throughout their range, but few of these habitats have been adequately described. In coastal British Columbia, breeding Harlequin Ducks are less common on streams with more fish, presumably because fish compete for insect prey (LeBourdais et al. 2009). In recent years, substantial progress has been made in describing characteristics of major molting and wintering areas in British Columbia and south-central Alaska; work is needed in other parts of the winter range. Harlequins wintering near Dutch Harbor, Alaska had low daily foraging effort, suggesting high food availability (Reed and Flint 2007). However, home range sizes were not markedly smaller than otherwise documented for this species, and individuals may forage near shore (near seafood processing and municipal sewage effluent sources) but move further offshore to avoid predation by Bald Eagles (Reed and Flint 2007). The recent satellite telemetry study in the Salish Sea shows that birds are 2-4 km offshore at night, presumably because they are visual predators but also to avoid predators such as eagles and river otters (WS Boyd, unpubl. data). A study of sea duck habitat selection in southeast Alaska found that Harlequins were more likely to be present in areas with higher percentage of rocky shoreline and less likely with increasing intertidal width; there were also positive associations with number of islets and increased shoreline exposure (Gunn 2009). A study of sea duck abundance and habitat attributes 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).

**Priority Information Needs:**

1. Characterize features (biotic and abiotic) of river systems used by Harlequin Ducks in selected key breeding areas.
2. Expand identification and description of additional molting and wintering sites.

**Harvest Assessment**: Quantification of harvest and harvest composition is poorly known from local and national surveys. Sport harvest in the US was estimated to average 1,258/year from 1999-2008 with >90% taken in Alaska (Baldassare 2014). The abundant Alaskan population is managed separately from the Rocky Mountain-Northwest Coast population, and Harlequins make up 15% of the Alaska sea duck harvest (Rothe et al. 2015). Bag limits in British Columbia and Washington were reduced in the late 1990s and in 2004 were further limited to one per season in Washington (Rothe et al. 2015). National Harvest Information Program surveys estimated a harvest of 70 Harlequin/year in Washington while western Washington permit data indicated an average of 134/year during 2004-2014 (Rothe et al. 2015, Don Kraege, unpubl. data). Harvest was restricted in Prince William Sound after EVOS to facilitate recovery of the resident breeding population (Rothe et al. 2015). Harlequin Ducks are harvested at moderate to low levels during subsistence hunting (mostly fall-winter) in Alaska and Canada and the subsistence harvest in Alaska was estimated at 2,080 birds/year, mostly in Kodiak Archipelago and Aleutian-Pribilof Islands (Rothe et al. 2015). There were no reports of subsistence egg harvesting (Rothe et al. 2015).

**Priority Information Needs:**

1. Expand harvest surveys to accurately estimate subsistence harvests.
2. Improve regional and national harvest surveys to obtain adequate samples of sea duck hunters and estimate regional harvests of Harlequin Ducks.
3. Expand and improve parts collections surveys and explore other methods to reliably estimate sex and age composition of Harlequin Ducks in harvests.

**Parasites, Disease, Contaminants**: The recent expansion of work on Harlequin Ducks, including capture and handling of more birds, has modestly improved information on parasite loads, susceptibility to diseases, and risk of mortality from these factors. Low pathogenicity avian influenza was detected in Harlequin Duck sampled from St. Lawrence Island, Alaska (Ramey et al. 2010) and avian influenza plasma antibodies were detected in 42% of Harlequins sampled in Prince William Sound (Heard et al. 2008). However, antibodies against adenovirus, reovirus and paramyxovirus 1 were not detected in Prince William Sound birds (Heard et al. 2008). Harlequin Duck fecal samples collected from an industrialized area in Dutch Harbor, Unalaska Island, Alaska had 67% *E. coli* prevalence and 65% of the *E. coli* isolates were potentially avian pathogenic strains (Hollmen et al. 2011). Reoviruses, avian pox virus, and *Leucocytozoon* sp. have been detected in Harlequins (Hollmen and Franson 2015, Heard et al. 2008).

There is some local information on exposure of Harlequin Ducks to petroleum and metals contaminants, but little information on specific physiological impacts or health effects from these agents. The EVOS in Prince William Sound resulted in a 25% decrease in numbers in oiled areas in the short-term; survival rates were low in oiled areas 6-9 years after the spill and were not equal to rates in unoiled areas until 11-14 years after the spill (Iverson and Esler 2010). Total mortality from chronic exposure was greater than acute-phase mortality and the projected timeline to recovery was 24 years post-spill (range 16-32 years) (Iverson and Esler 2010). Hepatic EROD activity (an indicator to exposure to polycyclic aromatic hydrocarbons [PAHs]) was higher in individuals captured in oiled rather than unoiled areas of Prince William Sound up to 20 years post-spill. EROD activity did not vary in relation to age, sex, body mass or season

(Esler et al. 2010). Based on surveys from 1997-2009, the proportion of females in the population was slightly lower in oiled than unoiled areas of Prince William Sound and no increase in abundance was observed in oiled areas, which suggested that the population was perhaps still suppressed and hadn't returned to pre-spill levels (Rosenberg et al. 2013). Despite these studies, some authors claim that it is not plausible that Harlequins could continue to be exposed to environmentally significant levels of PAHs from EVOS 20 years post-spill (Harwell et al. 2012, Neff et al. 2011, Wiens et al. 2010, Wiens 2007). Harlequin Ducks captured in heavily oiled areas of Unalaska Island, Alaska, up to three years after the M/V *Selandang Ayu* oil spill had elevated EROD activity, indicating that individuals were still being exposed to residual oil (Flint et al. 2012). EROD activity was higher in Harlequins and PAH levels were higher in blue mussels (*Mytilus trossilus*) at industrialized sites rather than non-industrialized sites in the Aleutian Islands, Alaska (Miles et al. 2007). However, levels of organochlorine compounds were low in prey species and there was no relationship between polychlorinated biphenyl (PCB) levels and EROD activity (Miles et al. 2007). Levels of PCBs were low in Harlequin Ducks sampled from Prince William Sound and likely did not negatively affect population recovery post-EVOS (Ricca et al. 2010). Wintering Harlequins sampled in Prince William Sound had average blood selenium concentration of 5.5 ppm wet weight (SD = 3.0, range = 2.0-11.1) and all individuals appeared to be healthy (Heard et al. 2008). Blood mercury levels were higher at sites on Unalaska Island (mean > 0.3 ppm wet weight) than Kodiak Island (<0.1 ppm ww) (Savoy et al., unpubl. data).

**Priority Information Needs:**

1. Continue opportunistic assays of parasites, diseases, and contaminants in birds on major wintering areas.
2. Investigate cases of significant contaminant exposure (e.g. mine waste, oil spills) to document health effects.
3. Expand laboratory studies to determine effects of specific contaminants and exposure levels on physiological functions, reproduction and survival. Particular emphasis should be given to crude oil, heavy metals, and compounds that accumulate in invertebrate foods.

## **Harlequin Duck, Eastern Population** *(Histrionicus histrionicus)*

*(See also the Harlequin Duck Eastern Population Management Plan, produced by Canadian Wildlife Service at*: http://www.sararegistry.gc.ca/plans/showDocument_e.cfm?id=1276)

**Population Size and Trends**: In Canada, the eastern population of Harlequin Duck has been federally designated as a Species of Special Concern since 2001. It is listed as threatened in Maine and provincially designated as endangered in New Brunswick and Nova Scotia and vulnerable in Newfoundland and Labrador and Quebec. However, information on the size and trend of the eastern seaboard wintering component needs to be refined and little is known of the size and trends of the Greenland wintering component.

There are no range-wide breeding abundance estimates (Bowman et al. 2015) but the eastern population is probably around 6,800 individuals on the breeding grounds, with approximately 5,400 of those in Quebec (Robert 2013). However, these are rough estimates and there are no reliable breeding trend data for Quebec (Robert 2013, Savard et al. 2008). A partial survey of Hudson and James Bays regions of northwestern Quebec counted 420 individuals and it was estimated that thousands breed in this region (Morneau et al. 2008). In Labrador, the breeding population was estimated at 395 pairs, with stable or increasing numbers (Trimper et al. 2008). In insular Newfoundland, there are an estimated 284 birds present on the Northern Peninsula during the breeding season, but trend data are not available (Gilliland et al. 2008). Breeding occurs in Nunavut, particularly on Baffin Island, but abundance is unknown (Mallory et al. 2008).

During winter, about 3,000-3,500 Harlequins are found in eastern North America and 5,000-10,000 in Greenland. Only a few thousand pairs are estimated to breed in Greenland, so it is likely that a high percentage of the Greenland birds are eastern Canadian breeders (Boertmann 2008, Bowman et al. 2015). The most important wintering area in eastern North America is Maine, and about half of the North America wintering population (1,575-1,800; surveys from 1997-2002) is found from Maine to North Carolina (Mittelhauser 2008a). In the Isle au Haut region of Maine, numbers declined from 1989 to 1993, but subsequently increased while in eastern Maine, numbers have increased harlequins have expanded into new wintering areas (Mittelhauser 2008a). In areas south of Isle au Haut that have large wintering numbers (> 50 birds), significant increases have been reported since the 1980s (Mittelhauser 2008a). There were 150 birds wintering in Rhode Island in early 2000s which was higher than counts in 1980s and 1990s (Caron and Paton 2007). Winter surveys in eastern Canada have estimated 200-300 in New Brunswick/Bay of Fundy, 600 on the southern and eastern coasts of Nova Scotia, and 450 in Newfoundland (CWS Waterfowl Committee 2013, Boyne 2008). During the 2014 Eastern population Barrow's Goldeneye Winter Survey in Quebec, approximately 200 wintering Harlequin Ducks were reported between Port-Daniel and Newport, along the south coast of the Gaspé Peninsula (Canadian Wildlife Service Waterfowl Committee. 2015). Numbers wintering in eastern Canada appear to have increased since mid-1980s (CWS Waterfowl Committee 2013) and counts at wintering sites in Atlantic Canada indicated an increase of 8.6% per year from 2001 to 2013 (Bowman et al. 2015). However, there have been some problems with the data (i.e., non-random samples, counts not standardized) and the observed increase may be partially caused by refinement of survey effort or observer experience (Bowman et al. 2015).

The Eastern Harlequin Duck Management Plan (Environment Canada 2007) set a population target of at least 3,000 individuals for the eastern North American wintering population, with a minimum of 1,000 adult females in at least 3 of 5 consecutive years. This target can be revised based on future demographic studies (Environment Canada 2007).

**Priority Information Needs:**

1. Establish a monitoring program and determine the size and trend of the eastern seaboard wintering population, including Greenland birds.

**Population Delineation**: There seem to be two components of the population in eastern North America, a northern breeding component (northern Quebec, northern/central Labrador and Baffin Island) that molts and winters along the coast of southwestern Greenland and a southern breeding component (southern Labrador, parts of Labrador coast, Gaspe Peninsula, New Brunswick and insular Newfoundland) that molts along the southwestern Labrador coast and Gaspe Peninsula and winters in Quebec, the Atlantic Provinces and New England, particularly Maine (Thomas et al. 2008, Brodeur et al. 2002, 2008). Preliminary genetic studies support this division (Scribner et al. 2000), but better genetic studies are needed to establish the degree of genetic differentiation of the two components. Recent satellite telemetry and banding data have indicated some mixing between these two components. Males were implanted with satellite transmitters on a wintering area in Maine and two bred on the Gaspe Peninsula, two molted in northern Labrador and four migrated to southwestern Greenland (and likely molted there); one of the birds that migrated to Greenland first bred in Quebec; all returned to Maine the following winter (Robert et al. 2008). Males captured on breeding areas on central Labrador coast migrated to staging areas on the northern Labrador coast, and then to West Greenland to molt (Chubbs et al. 2008). More than 900 individuals were banded and color-marked in eastern North America and Greenland from 1996-2003 and 97 were resighted or recaptured with results similar to satellite telemetry data in Brodeur et al. (2002). There were links among southern breeding, molting and wintering areas (Gaspe Peninsula, Gannet Islands [Labrador], insular Newfoundland, and Maine) (Thomas et al. 2008). Birds banded in northern Labrador were not resighted at any North American wintering areas and south-central Labrador appeared to be an area of possible overlap, with birds breeding there wintering in both Greenland and eastern North America (Thomas et al. 2008). Chubbs et al. (2008) also suggest that there may be some overlap in breeding ranges in Labrador (around the Adlatok and Shipiskan Rivers). Thomas et al. (2008) recommended continued banding in central and southern Labrador and more extensive resighting efforts in coastal Newfoundland, Nova Scotia, New Brunswick and Maine to clarify the delineation of breeding populations. Little morphological variation has been found among birds in the northwest Atlantic, also suggesting links among subpopulations in this region (Robertson et al. 2008). However, Robert et al. (2008) mention that while there is possible overlap of breeding ranges of Greenlandic and North American wintering components, there is no evidence yet that they do and preliminary results from genetic analyses indicate they are separate populations (K. Scribner in Robert et al. 2008).

**Priority Information Needs:**

1. Determine the breeding boundaries between birds wintering in Greenland and along the eastern seaboard.

2. Complete a comprehensive genetic analysis of the various populations of Harlequin Ducks.
3. Determine affiliations of birds among breeding, molting and wintering areas; locate breeding areas of birds wintering in Nova Scotia and in Newfoundland.

**Population Dynamics**: Basic demographic parameters are needed for the two components of the eastern population. There are few reliable data on survival rates of young and adults. On breeding areas in northern Quebec, the sex ratio was not significantly different from 1:1 (Morneau et al. 2008). From 1993 to 2002, numbers of indicated breeding pairs on the Torrent River, Newfoundland increased ($\lambda = 1.14$) (Goudie and Gilliland 2008) and a similar population growth rate (20% annually) was observed for numbers wintering at Cape St. Mary's, Newfoundland during 1994-2008 (Thomas 2008). For Harlequins molting at the Gannet Islands, Labrador, the apparent survival rate was $0.466 \pm 0.118$ (95% PLI: 0.256 – 0.689) for second-year males and $0.744 \pm 0.045$ (95% PLI: 0.647 – 0.822) for adult males (Thomas and Robertson 2008). These survival rates are lower than reported in most studies, suggesting that although some individuals return to use the site in multiple years there is likely some emigration from the Gannet Islands molt site (Thomas and Robertson 2008).

The Wolves archipelago in the Bay of Fundy supports a small wintering population and during November-March, the ratio of adult males to females was 1.36 but when all age classes were included the ratio was slightly female biased (0.94) (Hicklin and Barrow 2008). The juvenile to adult ratios were 0.382 for males and 0.320 for females, higher than reported for other locations (Hicklin and Barrow 2008). In Maine, apparent survival rates were similar for adult males and females during winter, but were lower for females during summer (Mittelhauser 2008b). There was no evidence of difference in survival rates between young males and females but young males had slightly lower survival than adults during their first winter (Mittelhauser 2008b). Among birds wintering in Rhode Island, the male sex ratio was 1.6 and 13% of males were first-year birds (Caron and Paton 2007).

**Priority Information Needs:**

1. Estimate survival rates of adults and young.
2. Determine reproductive success on various rivers and across years.
3. Obtain more accurate sex and age ratios for various wintering areas (Quebec, Maine, Nova Scotia, Newfoundland and other peripheral wintering areas).

**Population Ecology**: Breeding ecology of the two components of the eastern population is poorly documented. Little is known of the effects of weather, food availability and spring runoff on reproductive success. Two of six radio-marked females on the Gaspé Peninsula were killed by raptors (Red-tailed Hawk and Great-Horned Owl) during the breeding season (Brodeur et al. 2008). In northern Labrador, different river canyons appeared to act as source-sink populations; source rivers had high density and abundance while sinks had low densities and variable numbers and population trajectories (Heath et al. 2006). Habitat characteristics and prey availability were similar between source and sink rivers but there was a strong negative relationship between Harlequin density and density of avian predators (Heath et al. 2006). Density, stability and inter-annual consistency in use were positively related (Heath et al. 2006).

In Iceland, annual production of young was positively correlated with black fly abundance, suggesting that productivity may be food-limited (Gardarsson and Einarsson 2008) but similar studies have not been done in eastern North America. During the wintering season in Maine, adult and first year males were more likely to disperse among areas than were adult females (insufficient data for first year females) (Mittelhauser 2008b). Wintering sites were clustered, with Harlequins more abundant at sites that were close to other wintering sites (McKinney et al. 2007).

**Priority Information Needs:**

1. Study factors affecting reproductive success.
2. Study dispersal behavior of young.

**Habitat Requirements**: Location and characterization of breeding rivers has begun in Quebec, Labrador and Newfoundland. In Quebec, Harlequin Duck breeds along rivers in the Gaspésie and Côte-Nord regions and around Hudson and Ungava Bays (Robert 2013). On the Gaspé Peninsula the most important rivers are the Port-Daniel and the Sainte-Anne Nord-Est Rivers; breeding densities appear to be quite low in the Quebec North Shore area, and high in parts of the Hudson Bay watershed (Savard et al. 2008). On the Gaspe Peninsula, three nests have been found and the two successful nests were on cliff ledges in river canyons (Brodeur et al. 2008). Broods used shallow rapids with cobble substrate and overhanging vegetation; stream/river width ranged from 4-30 m (Savard et al. 2008). In the Hudson and James Bays regions of Quebec, highest pair densities were observed on rivers in tundra and forested tundra areas (Morneau et al. 2008). In Labrador, on a river with high, stable densities and few avian predators, abundance of benthic invertebrates was a strong predictor of Harlequin Duck presence while on a river with high densities of avian predators, habitat variables such as vegetation cover and midstream boulders were more important in distinguishing used and unused areas (Heath and Montevecchi 2008). Birds of prey likely exclude Harlequins from otherwise suitable habitat and affect the relative importance of habitat variables such as food availability and protection (Heath and Montevecchi 2008). Torrent River, Newfoundland had the highest breeding density in the region; pairs selectively used riffles, runs and rapids, and avoided braided channels; and they were frequently associated with inlets and outlets of ponds (Goudie and Gilliland 2008). A brood observed on the Hudson Bay coast indicates that females and ducklings may move downriver and use coastal areas (Morneau et al. 2008).

Few staging areas have been identified and well characterized to date.Some may molt along the coast of Hudson Bay (Morneau et al. 2008) and some locations along the Gaspé Peninsula and Anticosti Island may be important during spring and post-breeding staging, as well as molt (Savard et al. 2008). The main wintering areas are in Atlantic Canada and Maine, particularly the Isle au Haut region, but also Cape Anne and Martha's Vineyard, Massachusetts and Sachuest Point, Rhode Island (Mittelhauser 2008a). In Rhode Island, wintering birds are mainly using rocky habitats, within 50 m of shore or offshore islands (Caron and Paton 2007). In New England, higher numbers were found at wintering sites south of Cape Cod, and these sites had higher prey densities and lower intertidal slopes than sites north of Cape Cod (McKinney et al. 2007). The presence of Harlequin Ducks at a site was negatively related to the proportion of developed land (residential, commercial or industrial) within a 100 m radius (McKinney et al. 2007).

**Priority Information Needs:**

1. Identify and characterize rivers that are heavily used by Harlequin Ducks and evaluate the impact of recreational activities on these streams, if any.
2. Identify and characterize spring staging areas.
3. Identify and characterize molting sites.
4. Identify and characterize important wintering sites.
5. Examine the possibility of establishing Marine Protected Areas at the most important molting and wintering areas.

**Harvest Assessment**: Hunting of Harlequin Ducks has been prohibited in eastern Canada since 1987-1990 (depending on province) and in the US Atlantic Flyway since 1989 (Rothe et al. 2015). There is likely still some take by hunters; the propensity for forming mixed-species flocks may contribute to accidental hunting mortality (Environment Canada 2007) but there is also high probability that illegal trophy hunting of adult males occurs (M. Robert, pers. comm. in Soulliere and Thomas 2009). Although the population has likely rebounded somewhat since hunting has been banned (Rothe et al. 2015) hunting mortality is still considered a threat to the eastern population (Environment Canada 2007). Subsistence harvest in Nunavut is incidental and probably insignificant (Mallory et al. 2008). Generally, the amount of illegal hunting and subsistence harvest is poorly documented but are thought to be a minor threat.

**Priority Information Needs:**

1. Estimate the level of illegal or accidental subsistence harvest in Canada and Greenland.
2. Educate local people living near major staging, molting and wintering areas about the status of the species to reduce accidental harvest.

**Parasites, Disease, Contaminants**: There is some information on body parasites, but no information on the levels of contaminants in the eastern populations. Reoviruses, avian poxvirus, and *Leucocytozoon* sp. have been detected in Harlequin Ducks (Hollmen and Franson 2015).

**Priority Information Needs:**

1. Determine the level of contaminants in birds at major wintering sites.
2. Determine the level of contaminants in birds from Greenland.
3. Compare contaminants levels in males and females.

**Literature Cited**


Alberta Sustainable Resource Development. 2010. Harlequin Duck Conservation Management Plan 2010-2015. Alberta Sustainable Resource Development. Species at Risk Conservation Management Plan No. 4. Edmonton, Alberta. 17 pp.

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

Bellrose, F. C. 1976. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Boertman, D. 2008. Harlequin Ducks in Greenland. Waterbirds 31(sp2): 4-7.

Bond, J.C., D. Esler, and K. A. Hobson. 2007. Isotopic evidence for sources of nutrients allocated to clutch formation by Harlequin Ducks. Condor 109(3): 698-704.

Bond, J. C., D. Esler, and T. D. Willisams. 2008. Breeding propensity of female Harlequin Ducks. Journal of Wildlife Management 72: 1388-1393.

Bond, J. C., S. A. Iverson, N. B. MacCallum, C. M. Smith, H. J. Bruner, and D. Esler. 2009. Variation in breeding season survival of female Harlequin Ducks. Journal of Wildlife Management 73: 965-972.

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, CRC Press, New York, NY.

Boyne, A. W. 2008. Harlequin Ducks in the Canadian Maritime Provinces. Waterbirds 31(sp2): 50-57.

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

Brodeur, S., J-P. L. Savard, M. Robert, A. Bourget, G. Fitzgerald, and R. D. Titman. 2008. Abundance and movements of Harlequin Ducks breeding on rivers of the Gaspé Peninsula, Québec.Waterbirds 31(sp2): 122-129.

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

Canadian Wildlife Service Waterfowl Committee. 2015. *Population Status of Migratory Game Birds in Canada: November 2015*. CWS Migratory Birds Regulatory Report Number 45.

Caron, C. M., and P. W. Paton. 2007. Population trends and habitat use of Harlequin Ducks in Rhode Island. Journal of Field Ornithology 78(3): 254-262.

Chubbs, T. E., P. G. Trimper, G. W. Humphries, P. W. Thomas, L. T. Elson, and D. K. Laing. 2008. Tracking seasonal movements of adult male Harlequin Ducks from central Labrador using satellite telemetry. Waterbirds 31(sp2): 173-182.

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 Birds22: 8-35.

Environment Canada. 2007. Management Plan for the Harlequin Duck (*Histrionicus histrionicus*) Eastern Population, in Atlantic Canada and Québec. *Species at Risk Act* Management Plan Series. Environment Canada. Ottawa. vii + 32 pp.

Esler, D., and J. C. Bond. 2010. Cross-seasonal dynamics in body mass of male Harlequin Ducks: a strategy for meeting costs of reproduction. Canadian Journal of Zoology 88(2): 224-230.

Esler, D., and S. A. Iverson. 2010. Female harlequin duck winter survival 11 to 14 years after the Exxon Valdez oil spill. Journal of Wildlife Management74(3): 471-478.

Esler, D., K. A. Trust, B. E. Ballachey, S. A. Iverson, T. L. Lewis, D. J. Rizzolo, D. M. Mulcahy, A. K. Miles, B. R. Woodin, J. J. Stegeman, J. D Henderson, and B. W. Wilson. 2010. Cytochrome P4501A biomarker indication of oil exposure in harlequin ducks up to 20 years after the Exxon Valdez oil spill.Environmental Toxicology and Chemistry 29(5): 1138-1145.

Flint, P. L., J. L. Schamber, K. A. Trust, A. K. Miles, J. D. Henderson, and B. W. Wilson. 2012. Chronic hydrocarbon exposure of harlequin ducks in areas affected by the Selendang Ayu oil spill at Unalaska Island, Alaska.Environmental Toxicology and Chemistry 31(12): 2828-2831.

Gardarsson, A., and A. Einarsson. 2008. Relationships among food, reproductive success and density of Harlequin Ducks on the River Laxá at Myvatn, Iceland (1975-2002). Waterbirds 31(sp2): 84-91.

Gilliland, S. G., G. J. Robertson, and G. S. Goodyear. 2008. Distribution and abundance of Harlequin Ducks breeding in northern Newfoundland. Waterbirds31(sp2): 104-109.

Goudie, R. I., and S. G. Gilliland. 2008. Aspects of distribution and ecology of Harlequin Ducks on the Torrent River, Newfoundland. Waterbirds 31(sp2): 92-103.

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

Harwell, M. A., J. H. Gentile, K. R. Parker, S. M. Murphy,R. H. Day , A. E.Bence, J. M. Neff, and J. A. Wiens. 2012. Quantitative assessmentof current risks to Harlequin Ducks in Prince William Sound, Alaska, from the Exxon Valdezc Oil Spill. Human and Ecological Risk Assessment18(2): 261-328.

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.

Heath, J. P., and W. A. Montevecchi. 2008. Differential use of similar habitat by Harlequin Ducks: trade-offs and implications for identifying critical habitat. Canadian Journal of Zoology 86(5): 419-426.

Heath, J. P., G. J. Robertson, and W. A. Montevecchi. 2006. Population structure of breeding Harlequin Ducks and the influence of predation risk.Canadian Journal of Zoology 84(6): 855-864.

Hicklin, P. W., and W. R. Barrow. 2008. Wintering Harlequin Ducks on the Wolves Archipelago, Bay of Fundy. Waterbirds 31(sp2): 130-132.

Hollmén, T. E., C. DebRoy, P. L. Flint, D. E. Safine, J. L. Schamber, A. E. Riddle, and K. A. Trust. 2011. Molecular typing of *Escherichia coli* strains associated with threatened sea ducks and near-shore marine habitats of south-west Alaska. Environmental Microbiology Reports 3(2): 262-269.

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, CRC Press, New York, NY.

Iverson, S. A., and D. Esler. 2010. Harlequin Duck population injury and recovery dynamics following the 1989 Exxon Valdez oil spill. Ecological Applications 20(7): 1993-2006.

Iverson, S. A. and D. Esler. 2006. Site fidelity and the demographic implication of winter movements by a migratory bird, the harlequin duck *Histrionicus histrionicus*. Journal of Avian Biology 37: 219-228.

LeBourdais, S. V., R. C. Ydenberg, and D.Esler. 2009. Fish and harlequin ducks compete on breeding streams. Canadian Journal of Zoology 87(1): 31-40.

Mallory, M. L., A. J. Fontaine, J. A. Akearok, and H. G. Gilchrist. 2008. Harlequin ducks in Nunavut. Waterbirds 31(sp2): 15-18.

McKinney, R. A., S. R. McWilliams, and M. A. Charpentier. 2007. Habitat characteristics associated with the distribution and abundance of *Histrionicus histrionicus* (Harlequin Ducks) wintering in southern New England. Northeastern Naturalist 14(2): 159-170.

Miles, A. K., P. L. Flint, K. A. Trust, M. A. Ricca, S. E. Spring, D. E. Arrieta, T. Hollmen, and B. W. Wilson. 2007. Polycyclic aromatic hydrocarbon exposure in Steller's eiders (*Polysticta stelleri*) and Harlequin ducks (*Histrionicus histrionicus*) in the eastern Aleutian Islands, Alaska, USA. Environmental Toxicology and Chemistry 26(12): 2694-2703.

Mittelhauser, G. H. 2008a. Harlequin Ducks in the Eastern United States. Waterbirds 31(sp2): 58-66.

Mittelhauser, G. H. 2008b. Apparent survival and local movements of Harlequin Ducks wintering at Isle au Haut, Maine. Waterbirds 31(sp2): 138-146.

Morneau, F., M. Robert, J-P. L. Savard, P. Lamothe, M. Laperle, N. D'Astous, S. Brodeur, and R. Décarie. 2008. Abundance and distribution of Harlequin Ducks in the Hudson and James Bay Area, Québec. Waterbirds 31(sp2): 110-121.

National Audubon Society. 2015. Christmas Bird Count Results. <http://netapp.audubon.org/cbcobservation/>

Neff, J. M., D. S. Page, and P. D. Boehm. 2011. Exposure of sea otters and harlequin ducks in Prince William Sound, Alaska, USA, to shoreline oil residues 20 years after the Exxon Valdez oil spill. Environmental Toxicology and Chemistry 30(3): 659-672.

Ramey, A. M., J. M. Pearce, C. R. Ely, L. M. S. Guy, D. B. Irons, D. V. Derksen and H. S. Ip. 2010. Transmission and reassortment of avian influenza viruses at the Asian–North American interface. Virology406(2): 352-359.

Reed, J. A., and P. L. Flint. 2007. Movements and foraging effort of Steller's Eiders and Harlequin Ducks wintering near Dutch Harbor, Alaska. Journal of Field Ornithology 78(2): 124-132.

Regehr, H. M. 2011. Movement rates and distances of wintering Harlequin Ducks: implications for population structure. Waterbirds 34(1): 19-31.

Ricca, M. A., A. K. Miles, B. E. Ballachey, J. L. Bodkin, D. Esler, and K. A. Trust. 2010. PCB exposure in sea otters and harlequin ducks in relation to history of contamination by the Exxon Valdez oil spill. Marine pollution bulletin60(6): 861-872.

Robert, M. 2013. Harlequin Duck, pp. 158-160 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., G. H. Mittelhauser, B. Jobin, G. Fitzgerald, and P. Lamothe. 2008. New insights on Harlequin Duck population structure in eastern North America as revealed by satellite telemetry. Waterbirds 31(sp2) 159-172.

Robertson, G. J., G. H. Mittelhauser, T. Chubbs, P. Trimper, R. I. Goudie, P. W. Thomas, S. Brodeur, M. Robert, S. G. Gilliland, and J-P. L. Savard. 2008. Morphological variation among Harlequin ducks in the Northwest Atlantic. Waterbirds 31(sp2): 194-203.

Rodway, M. S. (2013). Pair-bond defense relates to mate quality in Harlequin Ducks (*Histrionicus histrionicus*). Waterbirds 36(2): 189-198.

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, Alaska, USA.

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, CRC Press, New York, NY.

Savard, J-P.L., M. Robert, and S.Brodeur. 2008. Harlequin ducks in Quebec.Waterbirds 31(sp2): 19-31.

Scribner, K. T., S. Libants, R. Inman, S. Talbot, B. Pierson, and R. Lanctot. 2000. Genetic variation among eastern breeding populations of Harlequin Ducks (*Histrionicus histrionicus*). US Fish and Wildlife Service, unpublished report.

Soulliere, C. E. and P. W. Thomas. 2009. Harlequin Duck Threat Assessment, Eastern Population. Canadian Wildlife Service Technical Report, Series No. 491. St. John's, NL. vi+ 146 pp.

Thomas, P. W. 2008. Harlequin ducks in Newfoundland. Waterbirds 31(sp2): 44-49.

Thomas, P. W., and G. J. Robertson. 2008. Apparent survival of male Harlequin Ducks molting at the Gannet Islands, Labrador. Waterbirds 31(sp2): 147-151.

Thomas, P. W., G. H. Mittelhauser, T. E. Chubbs, P. G.Trimper, R. I. Goudie, G. J. Robertson, S. Brodeur, M. Robert, S. G. Gilliland, and J-P. L. Savard. 2008. Movements of Harlequin Ducks in eastern North America. Waterbirds 31(sp2): 188-193.

Trimper, P. G., P. W. Thomas, and T. E.Chubbs. 2008. Harlequin ducks inLabrador. Waterbirds 31(sp2): 32-43.

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/

Wiens, J. A. 2007. Applying ecological risk assessment to environmental accidents: Harlequin ducks and the Exxon Valdez oil spill. BioScience 57(9): 769-777.

Wiens, J. A., R. H. Day, S. M. Murphy, and M. A. Fraker. 2010. Assessing cause-effect relationships in environmental accidents: Harlequin ducks and the Exxon Valdez oil spill. Pp 131-189 *in* Current Ornithology Volume 17, Springer, New York.