Harlequin Duck Winter Ecology Study White Rock, BC

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Summary

Harlequin Ducks (*Histrionicus histrionicus*) are small sea ducks that are endangered on the eastern coast of Canada and yellow-listed in British Columbia (BC). Both Atlantic and Pacific populations have felt the effects of excessive hunting, oil pollution, recreational activities, and loss of nesting habitat to hydroelectric projects, road construction, logging, mining and degradation of riparian areas.

Our study focused on a five-kilometre section of coastline between White Rock and Crescent Beach, BC that supports a wintering population of approximately one hundred Harlequins, which have been studied over the past five years. Behavioural observations of this population were made on a weekly basis from October 1, 1999 to March 9, 2000. Data were collected by observing and recording the behaviour of banded pairs and single banded males and females. Only banded birds were studied so the Canadian Wildlife Service can keep a constant record and monitor behavioural patterns of the same birds year after year. The data recorded included behaviour and event occurrences and times, sex, location, band and/or nasal disk identification, group size, pair status and distance between paired males and females. The objectives of this study were:

- To examine Harlequin Duck pair bond strength and how it changes seasonally, by looking at distances between individuals within a pair.
- To describe the temporal budgets of single or paired Harlequin Ducks by examining foraging and interaction behaviours.

Behavioural observations revealed:

- Foraging was the predominant behaviour throughout the survey months for both single and paired Harlequins of both sexes.
- Both single and paired Harlequins of both sexes showed peaks in foraging times in mid January, but only paired Harlequins showed foraging peaks in March.
- Distances between pairs did not significantly differ between seasons suggesting that pair bonds remain established throughout the winter months.
- Interactions of paired Harlequins peaked in February and March, while single male interactions were high in mid November and single female interactions on November 1 and January 26.
- Paired and single males demonstrated more average time interacting than paired and single females.

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Acknowledgements

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1.0 Introduction

Harlequin Ducks (*Histrionicus histrionicus*) are small colourful sea ducks that are endangered on the Atlantic coast of Canada (COSEWIC, 2000) and yellow-listed in British Columbia (BC) (MOELP, 2000). Both Atlantic and Pacific populations have felt the effects of over hunting, oil pollution, recreational activities (e.g. river rafting), and loss of nesting habitat to hydroelectric projects, road construction, logging, mining, and degradation of riparian areas. The Pacific group winter and moult in rocky coastal habitats from the Aleutian Islands in Alaska, along British Columbia and to as far south as northern California (Environment Canada,1999). In late spring, they migrate inland mainly to the coastal mountains, or as far inland as the Yukon and eastern slopes of the Rockies in Alberta (Chadwick, 1993), where they nest along rushing mountain streams (Figure 1).

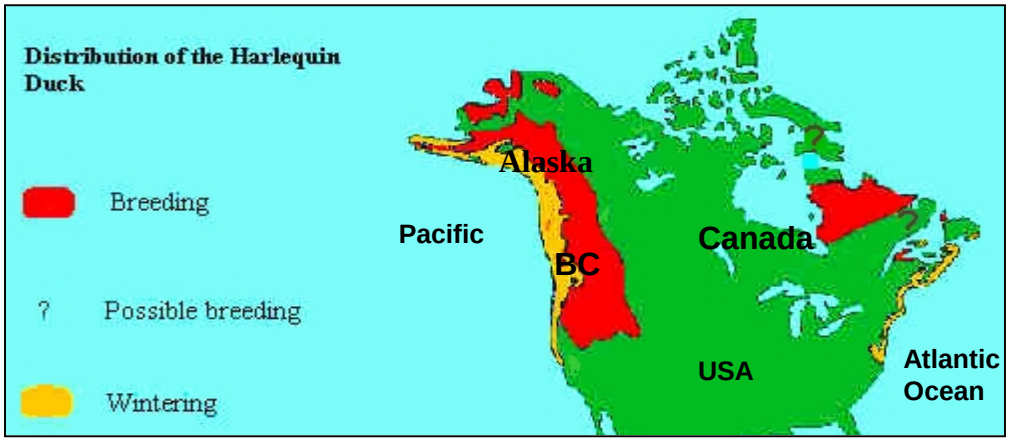


Figure 1 Distribution map of the Harlequin Duck in North America. (Source: Environment Canada web page).

There are an estimated 4,000 to 8,000 breeding pairs of Harlequins in British Columbia and wintering populations may range in the 10,000's (Breault and Savard, 1991). The eastern population of Harlequin Ducks was estimated at 5,000-10,000 individuals in 1991(Breault and Savard, 1991), but the population is now under 2,000 individuals (Mason, 2000). In BC, populations of wintering Harlequins are concentrated in White Rock, on the east coast of Vancouver Island, in the Georgia Strait, and in the Queen Charlotte Islands (Breault and Savard, 1991).

Our study focuses on a 5-kilometre stretch of coastline between White Rock and Crescent Beach, BC. This area supports a wintering population of approximately one hundred Harlequins that have been studied over the past five years (1995 – 1999) (Boyd et al. 2000).

Long-term pair bonds have been well documented in sea ducks and there is evidence of strong winter philopatry in this group (Boyd et al. 2000). In waterfowl, pair formation often occurs away from the breeding area, often during the winter months (Boyd et al. 2000). This behaviour facilitates the development of long-term pair bonds. Throughout the early winter months, the male (drake) guards his mate intensively, but observations have suggested that these pair bonds may break down in the middle of winter and then re-establish in the spring (Boyd, 1999).

During the winter ecology study at White Rock from October 1999 to March 2000, efforts were concentrated on gathering data on behavioural interactions and pair bonds between conspecific animals. The objectives of this study were:

- To examine Harlequin Duck pair bond strength and how it changes seasonally, by looking at distances between individuals within a pair.
- To describe the temporal budgets of single or paired Harlequin Ducks through foraging and interaction time budget analysis.

These objectives were based on the following hypothesis: Pair bonds establish in the fall and re-establish in spring but break down in mid-winter because it is too costly for males to meet their energy requirements (low number of daylight hours, low air-water temperatures, possibly low food abundance, or other reasons). Little has been documented on this topic so the data collected will contribute to baseline data on Harlequin Duck behaviour while on their wintering grounds.

Proposed strategies to protect the endangered eastern population of Harlequins include protection of important breeding and wintering habitat, and obtaining a better understanding of reproductive and wintering ecology (Breault and Savard, 1991). Any information on the ecology of Pacific Harlequin Ducks may aid in developing management prescriptions and recovery efforts in eastern Canada and may help avoid further declines in the western population.

2.0 Study Area

The study area is in White Rock, BC along 5 kilometres of coastline between White Rock and Crescent Beach along Boundary Bay (Figure 2).

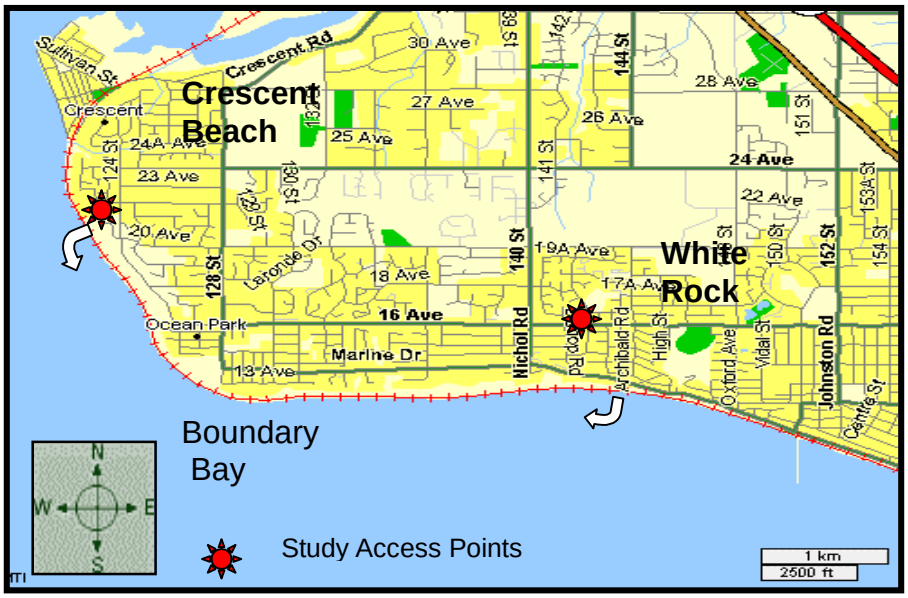


Figure 2 Location of the Harlequin Duck study area (1999-2000) along Boundary Bay, White Rock, BC (Source: Map Quest web page).

2.1 Survey Route

The route starts at the bottom of the unmarked stairs at the 14000 block of Marine Drive in White Rock. The opposite end of the survey route is at the bottom of the unmarked stairs located at the west end of 24 th Avenue in Surrey. The Burlington Northern Railway (BNR) parallels the coastline and provides a good vantage point for walking and completing the surveys. The BNR mile marker at the start of the survey route is 123.0 and 126.4 at the end of the route. There are multiple mile markers along the survey route that serve as reference points during the survey. The tracks run east west and average 40 meters away from the waters edge at the high tide mark.

2.2 Site Description

The shoreline is mainly rocky with intermittent patches of sand and gravel. The northern side of the track is vegetated primarily with deciduous trees and shrubs. The Harlequins, during survey times, are usually either found on the water within 100 meters from shore or hauled out on rocks near the shoreline. Exposed coastal shorelines such as this are preferred winter habitat for Harlequin Ducks (Breault and Savard, 1991) because of the abundance of rocks and ledges (for hauling out onto) and a strong surge. Submerged rocks in shallow waters (3-4 meters) harbour molluscs and crustaceans, which are the Harlequin Duck's main winter food source (Gooders and Boyer, 1986).

3.0 Materials and Methods

3.1 Harlequin Duck Identification

Harlequins are small ducks with rounded heads, stubby bills, and short stocky bodies. The drakes (males) are brightly coloured with striking plumage of slate blue, chestnut, and bold white stripes and spots on head, neck and scapulars (Figure 3). The hens (females) are much more discrete; their subtle black brown colour camouflages them for nesting and their breasts and upper bellies are mottled grey (Figure 4). Hens can be distinguished from other female ducks by three white patches on each side of their face. The dot behind their eye is the most distinct of the patches. The female Surf Scoters have similar plumage, but can be distinguished by their larger size and longer, broad bills. Juvenile Harlequins look very similar to adult females, but have discreet physical differences including:

- Fine vermiculated plumage on chest
- Mottled straw-yellow and grey feet
- Notched tail feathers
- Overall polished, smooth look (Boyd et al, 2000).)

Juvenile Harlequins have a vermiculated plumage on the breast similar to that of the adult females except they have more vermiculations and their feathers are shinier. Juvenile Harlequins can be identified by their distinct plumage when they first arrive on the coast (about mid-August), but soon after arrival they undergo a partial body moult into their first alternate plumage (as early as late September) (Boyd et al, 2000). At that time immature males still look different than adult males, but immature females and adult females look almost identical (Boyd et al, 2000). Consequently, age identification may not be possible at this time. The juveniles may also exhibit distinct behaviours including erratic diving and mimicking adults.

Figure 3 Adult Harlequin drake in full plumage. (Source: Chadwick, 1993).

Figure 4 Adult Harlequin hen and chick in river habitat. (Source: Chadwick, 1993).

3.2 Leg Bands and Nasal Tags

To allow positive identification of individuals, birds are tagged with leg bands, nasal tags, or both. Unique alphanumeric leg bands were applied annually from 1994 to 1998 during the wing moult in early July and early August (males) and September (females) (Boyd et al. 2000). Plastic nasal disks were applied in 1997 and 1998 (Boyd et al. 2000). Moulting Harlequins are caught by herding the ducks into nets with kayaks. Once captured, a nasal tag (Figure 5) is attached through the lateral nostrils with a short length of monofilament or a leg band is clamped on either leg (Figure 6). Nasal disks have also been applied while the Harlequins are on their breeding grounds in BC and Alberta. To capture a Harlequin on breeding grounds, a mist net is strung across the adjacent river of these sites.

Because the Harlequins that winter at White Rock breed and moult at a number of different locations, an influx of unbanded birds to our study area has resulted (Boyd et al. 2000) and these birds have not been included in the surveys unless paired with a banded mate.

Figure 5 Square nasal tags applied to a Montana Harlequin. (Source: Chadwick, 1993).

Figure 6 Leg band with alphanumeric code. (Source: Banff and Jasper National Parks web page).

3.2.1 Reading Nasal Tags and Leg Bands

The use of nasal tags is a valuable tool for identifying individual birds, tracking their migration patterns and locating an individual's winter and summer habitats. Nasal tag identification is especially useful when weather or high tidal conditions prevent Harlequins from hauling out onto rocks and exposing their leg bands. The nasal tags are small plastic shapes of different colours and are read *first from the left side of the bird's bill, then to the right side.* The small alphanumeric coloured leg bands are read *up the bird's leg.* Colour of the band and leg on which the band was placed, and nasal tag colour, shape, and nostril combination (Table 1) were all recorded.

Table 1 Nasal tag and leg band colours, shapes and codes used to record observed tags in the White Rock Harlequin Duck study 1999-2000.

Nasal Tags		**Leg Bands**	
Colour	Y (yellow)	Colour	wh (white)
	W (white)		aq (aqua)
	G (green)		re (red)
	B (blue)		gr (green)
	O (orange)		ye (yellow)
			bk (black)
Shape	R (rectangle)		
	T (triangle)		
	C (circle)		

3.3 Materials

To conduct the study efficiently, ground survey data were obtained with the use of 7-10X binoculars and 20-60X spotting scopes mounted on tripods. Binoculars were required to scan habitat and count visible birds within the defined route. A scope was required to scan more distant areas, count groups of birds, read nasal tags and leg bands and to determine the age and sex of birds. Data were recorded and logged using data forms in waterproof notebooks. Equipment used included:

- Three pairs (Nikon and Bushnell) 7-10X binoculars
- Two Bushnell 20-60X spotting scopes
- Two tripods for spotting scopes
- Waterproof notebooks and pencils
- Raingear
- Canon AE-1 camera
- Colour slide film (Kodak Ektachrome 200 ASA)
- Camera tripod.

3.4 Behavioural Observation Methodology

Behavioural surveys were completed on Wednesdays from October 6, 1999 to March 8, 2000. Surveys started at 0900 and were completed between 1400 and 1530, depending on the number of birds encountered along the study route. The team of four crew members was divided in half and each group of two started at opposite ends of the survey route and then later met in the middle of the route. The five-kilometre section was travelled on foot and when a bird or group of birds was spotted, scopes, binoculars, and bird guides were used to positively identify them. If a Harlequin Duck was identified, the team would determine if it was banded and then begin a survey. Surveys were only performed on banded birds and the presence of non-banded birds was noted. Thirty minutes of behavioural data was collected for each surveyed bird, as long as feasible. During a weekly survey, both survey groups would attempt to collect behavioural data on at least two pairs and two single birds (one single banded male and one single banded female). During observations, both behaviours and events (Table 2) were recorded. Behaviours and events differ in that behaviours last more than several seconds (a 30 second minimum was used for this study), while events are activities of a quick nature. For example, swimming is a behaviour while a bill poke is an event.

Table 2 Codes used for recording behavioural observations during the White Rock 1999-2000 Harlequin Duck study.

Behaviour and Code	Event and Code
Foraging	**Foraging**
Diving (D)	Up (U)
Surface Feeding (SF)	Down (D)
Handling (H)	Tip (TIP)
Dabbling (DAB)	
Interaction	**Interaction**
Chase (C) if over 30 seconds	Chase (C)
Flee (FL) if over 30 seconds	Flee (F)
Guard (G)	Head-nod (HN)
Copulation (COP)	Bill Gape (BG)
Follow (FOL)	Bill Poke (BP)
Locomotion (Other)	**Locomotion**
Swimming (S)	Haul Out (HO)
Walking (W)	Haul In (HI)
Flying (F)	Looking (L)
Maintenance (Other)	**Maintenance**
Preening (P)	Defecate (DEF)
Bathing (B)	Wing Flap (WF)
Rest-Head Up (RU)	
Rest-Head Tucked (RT)	

One technician would perform the observations with the aid of a spotting scope or binoculars, if needed, while the other would record the activities and corresponding time duration. Data collected for each behavioural survey also included:

- Distance between male and female (if paired)
- Sex of focal bird
- Location in reference to mile markers
- Band &/or nasal disk readings
- Distance from shore (visual estimate)
- Group size (number of Harlequins together with focal bird(s))
- Pair status (paired or single)
- Weather conditions (cloud cover, precipitation, wind).

When performing behavioural observations, we tried to observe ducks at distances that didn't influence behaviour. However, we could not control events such as trains or pedestrians walking their dogs that sometimes influenced or disrupted behaviours. When this occurred, corresponding field notes were made and the survey was completed if still possible.

3.5 Data Analysis Methodology

Unpaired and paired birds from each sex were selected for data analysis. The amount of data collected varied from month to month and also varied between sexes and paired or single birds. Less data were able to be collected on single birds as this population of Harlequins has a higher ratio of paired birds. There was also less data collected during the winter when weather or tidal conditions occasionally prevented us from performing surveys. Only complete 30-minute surveys were used for analysis. The data analysed includes the surveys performed on Wednesdays for the purpose of this project. It also includes additional data collected solely by Brian Arquilla, a Harlequin Duck researcher that accompanied us on Wednesday surveys and collected data throughout the week.

The ducks analysed all had nasal tags or leg bands (or one partner within a pair did) and were positively identified for each survey. The majority of the birds surveyed had nasal tags as they could be positively identified even when swimming where leg bands are not visible. Consequently, more behavioural data were collected on these individuals than on non-nasal tagged individuals.

On request of the CWS, two categories of behaviour, foraging and interactions, were examined and graphed. Surface feeding, diving, handling and dabbling were classified as foraging behaviour while fleeing, following, guarding, chasing, head nodding, bill poking, vocalising and bill gaping were classified as interactions. Refer to Appendix 1 for definitions of these behaviours. Behaviours associated with locomotion and maintenance activities (e.g. swimming, resting, and preening) were combined under an "Other" category.

Pair bond strength and how it changed seasonally was analysed by evaluating the distances between individuals within a pair throughout the survey duration. The surveys were divided into two sub-samples, Oct. 26, 1999 – Dec. 9, 1999 (sample 1, 9 surveys) and Jan. 5, 2000 - March 8, 2000 (sample 2, 10 surveys). The first Oct. 26 survey was eliminated from the data analysis because the distance between the pair was unusually large. The data may have been an anomaly and would have skewed the final results. The weighted mean of the distances apart of individuals within a pair was calculated for each 30-minute survey. A statistical hypothesis test (see formula in Appendix 2) was then applied to prove or disprove the null hypothesis at 95% confidence. The null hypothesis stated "the mean distance between sample 1 and sample 2 is equal".

4.0 Results & Discussion

4.1 Limitations of Survey Techniques

Limitations in data collection methods sometimes originated from incomplete observations due to bird behaviour. Large groups of Harlequins or frequent diving behaviour sometimes reduced the observer's ability to identify their focal bird during a survey. Other events that influenced Harlequin behaviour during surveys included trains, people and dogs passing close by and disturbing the ducks.

Weather (wind and waves) and high tides during November, December and the start of January influenced behaviour by making it difficult or impossible for the ducks to find available rocks for hauling out. The significance of this occurrence is decreased observer ability to positively identify an individual duck for survey purposes. Ducks that possessed leg bands could not be identified unless they were hauled out of the water. There was a greater number of ducks that possessed leg bands than nasal tags. Therefore finding marked ducks during these months was difficult and limited surveys to a restricted number of Harlequins with nasal tags. The resulting data reflects gaps in winter surveys, especially for single males and females whose occurrence in the study area is already less than pairs.

High precipitation during the study occasionally limited the number of surveys performed. The spotting scopes used for this study were not waterproof, as a result some field days had to be cancelled or terminated early.

Survey locations were sometimes difficult to reference. The BNR mile markers used as survey reference points are sporadically distributed and were not always within the observer's visibility when performing a survey. Location estimates were made as accurately as possible by referencing to the nearest marker.

4.2 Time Budgets of Single Harlequin Ducks

Time budgets of single females showed that foraging was the dominant activity during the months surveyed (Figure 7). Foraging behaviour was lowest in the first two surveys in November 1999, but generally increased throughout the winter and spring with peaks in both mid January and mid February. January 26, 2000 was also a low foraging day. Interactions were generally minimal and were highest in the November 1, 1999 survey. Many of the single females may not have been of breeding age; therefore single males would have spent nominal time trying to secure one of these females as their mate. This would result in minimal interaction behaviour as reflected in the data.

Time budgets of single males also showed that foraging was the dominant activity during the months surveyed (Figure 8). Foraging behaviour was lowest in the first two surveys in October 1999, but showed a general increase throughout the winter and spring with peaks in both mid January and mid February. Single males exhibited on average, more time interacting than single females. These interactions were primarily with other single males and paired males as the single males competed for a mate.

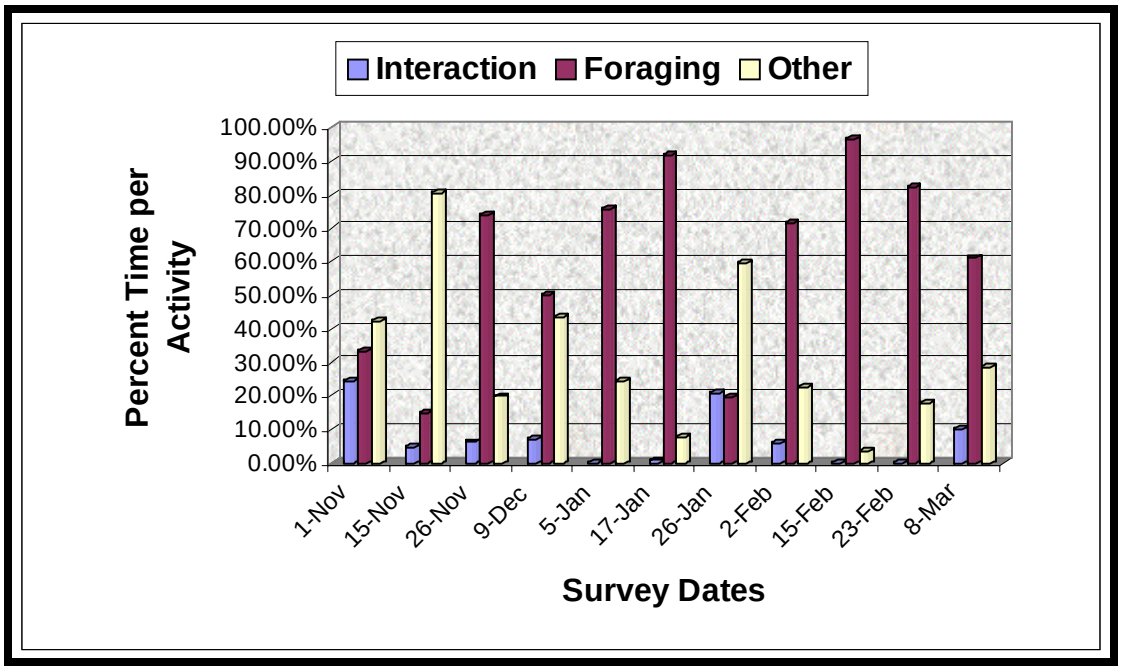


Figure 7 Time budgets of single female Harlequin Ducks per 30 minute survey from Nov. 1, 1999 –March 8, 2000.

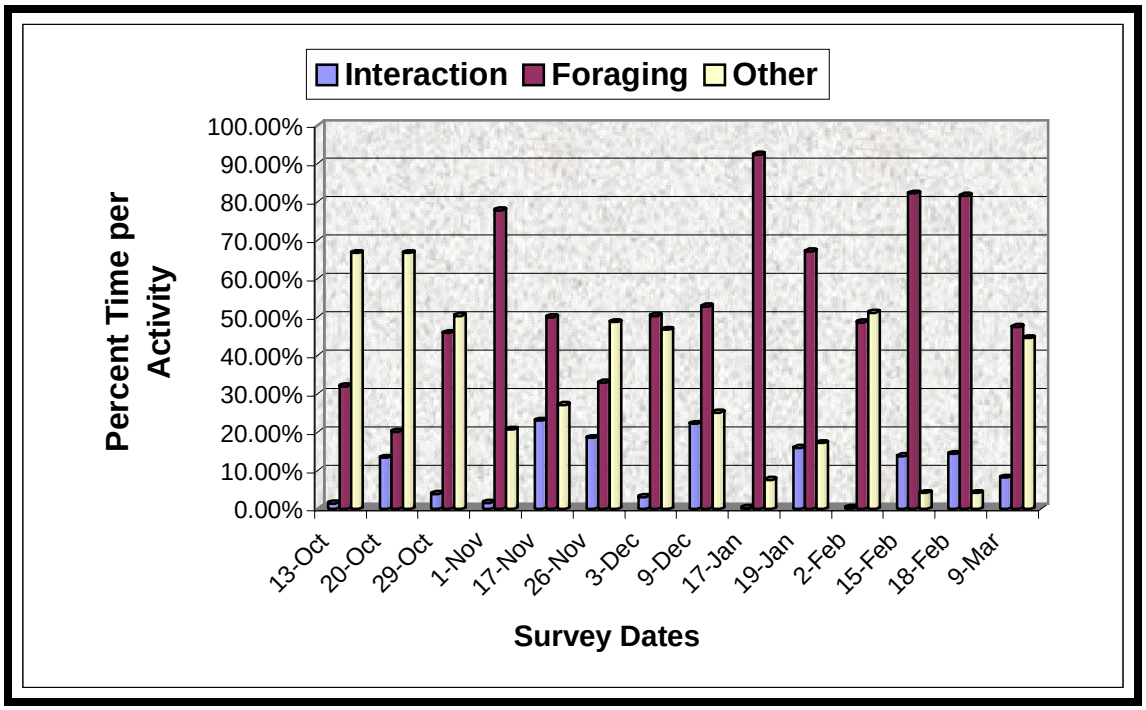


Figure 8 Time budgets of single male Harlequin Ducks per 30 minute survey from Oct. 13, 1999 – March 9, 2000.

4.3 Time Budgets of Paired Harlequin Ducks

Figure 9 shows that foraging was on average the dominant behaviour throughout the study period for paired male Harlequins. Foraging behaviour was low for paired males in the first three surveys of October 1999, but generally increased throughout the winter and spring with peaks in mid January and mid March.

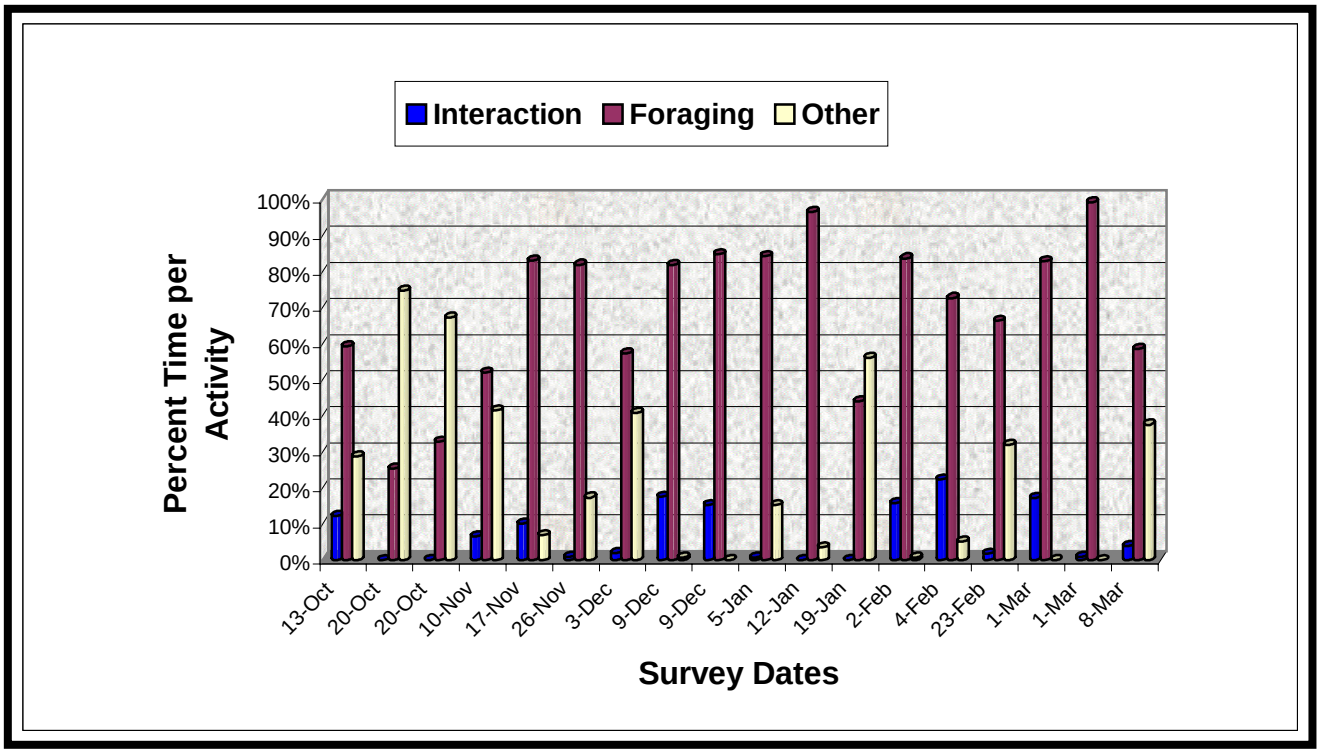


Figure 9 Time budgets of paired male Harlequin Ducks per 30 minute survey from Oct. 13, 1999 – March 8, 2000.

Time budgets of paired females also showed that foraging was the dominant activity during the months surveyed (Figure 10). Foraging behaviour for paired females was lowest in the first four surveys of October and November 1999, but generally increased throughout the winter and spring with peaks in mid January and mid March. The March peak in foraging was unique to paired Harlequins and is likely to maximize their body condition for breeding success.

Paired males and females appeared to spend almost equal amounts of time foraging (Figures 9 and 10). This is reflective of pair bond strength where males and females mimic their mate's behaviour and exhibit simultaneous activities.

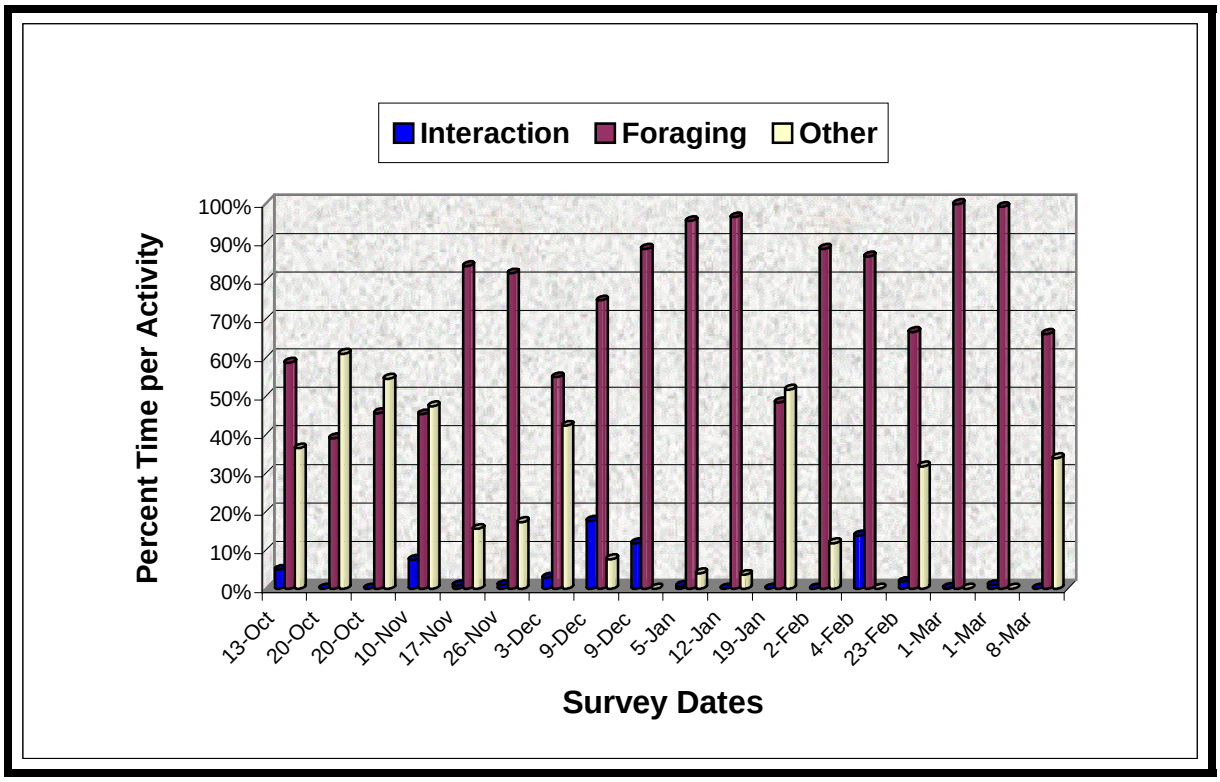


Figure 10 Time budgets of paired female Harlequin ducks per 30 minute survey from Oct. 13, 1999 – March 8, 2000.

Paired males and females showed little or no interaction throughout the January surveys (Figures 9, 10 and 11) and paired females also showed little interaction throughout the March surveys (Figures 10 and 11). The lack of interaction behaviour throughout January was likely because the ducks maximize their foraging times to meet their increased energy requirements during this time. Both single and paired Harlequins of both sexes showed peak foraging times during mid January (Figures 7, 8, 9 and 10). Peaks in interaction behaviour of pairs occurred in February and March when competition between ducks increased prior to breeding (Figure 11). The paired Harlequins also showed a peak in interactions in mid October when they were still securing their pair formations and then another peak in December. Paired males exhibited on average, more time interacting than the paired females. These interactions were primarily towards single male Harlequin Ducks that showed interest in the paired male's mate. The paired males were usually vigilant in defending their mate; therefore single males had little opportunity to interact with the paired females and the paired females demonstrated less interaction behaviour than paired males.

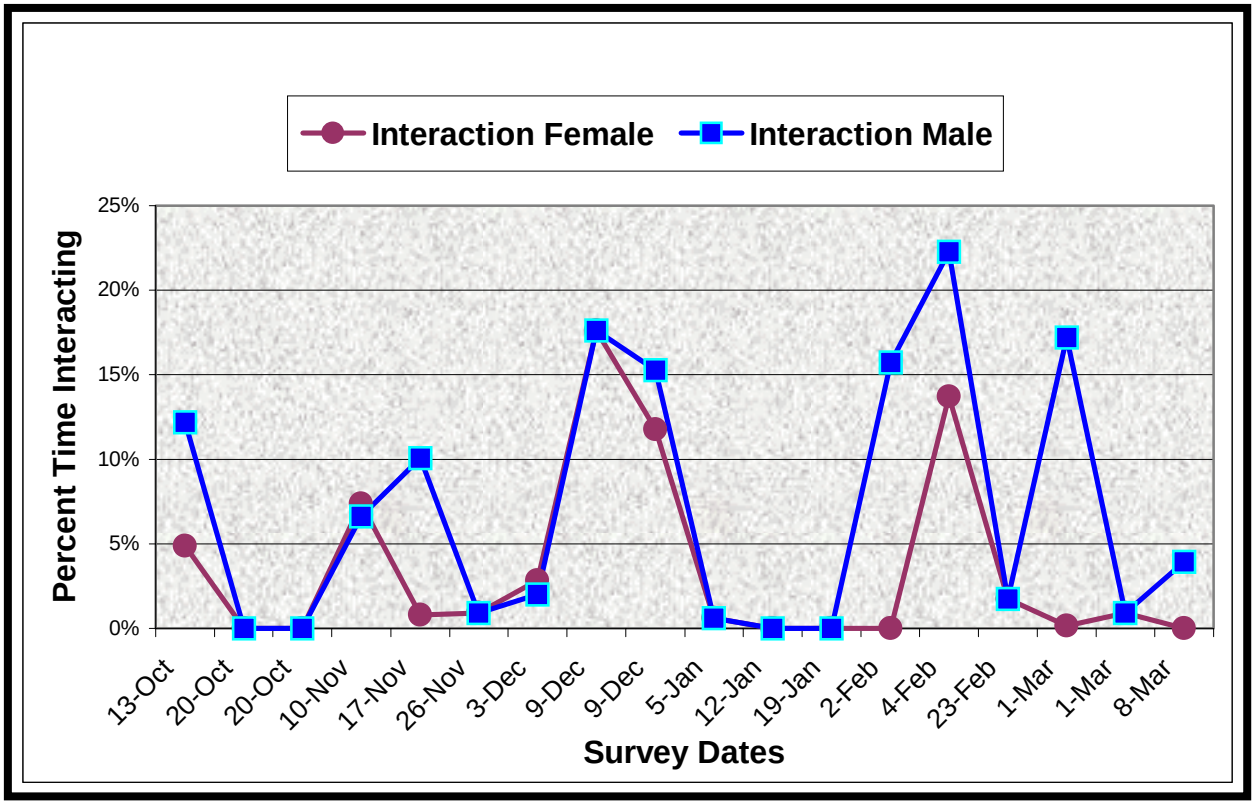


Figure 11 Interaction time comparison per 30 minute survey between paired male and female Harlequin Ducks from Oct. 13, 1999 to March 8, 2000.

4.4 Pair Bonds

Figure 12 shows a small increase in distances apart between individuals of a pair starting at the January 5, 2000 survey and peaking on February 2, 2000. The hypothesis test revealed that the distances apart in the survey time frame from October 26, 1999 – December 5, 1999 could not be proven at 95% confidence to be different from the January 5, 2000 – March 8, 2000 time frame. In other words, the null hypothesis "the mean distance between sample 1 and sample 2 is equal" was proved. At this sample size, it can be derived that pair bonds remained established throughout the fall, winter and spring despite the small increase in distances apart apparent on the graph.

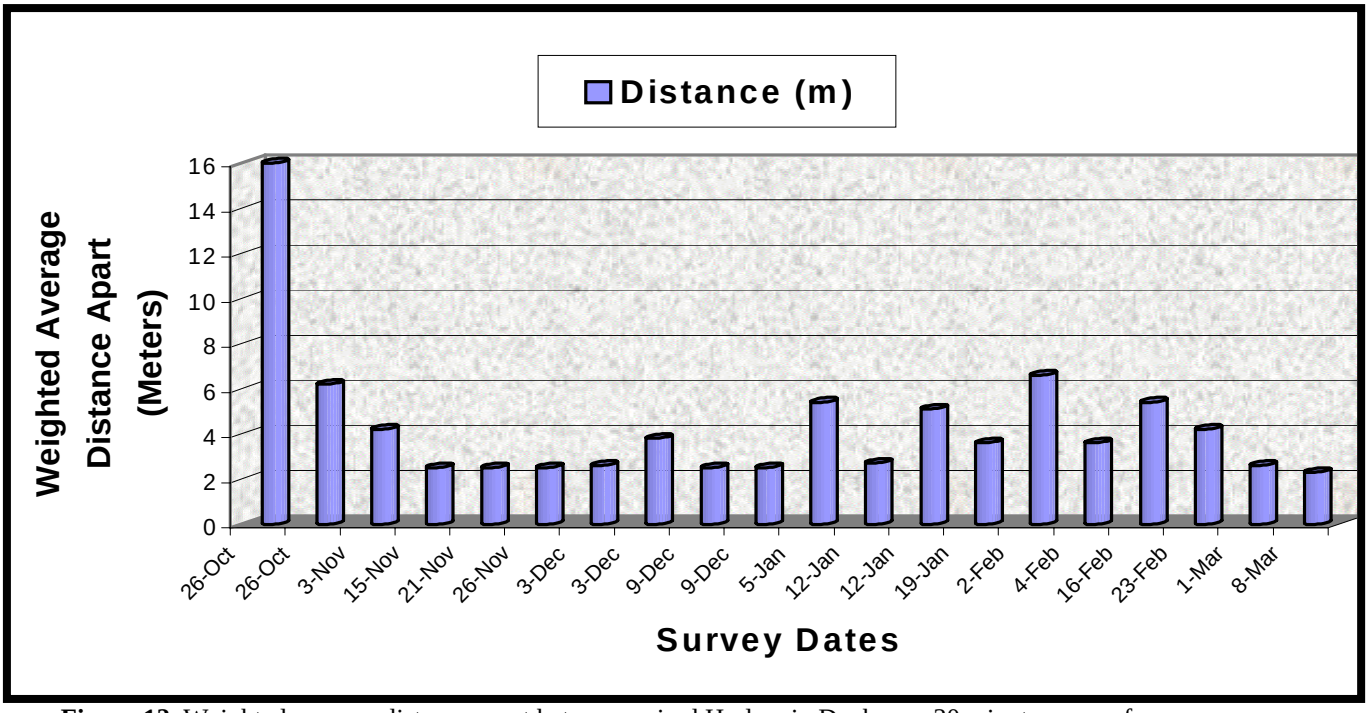


Figure 12. Weighted average distance apart between paired Harlequin Ducks per 30 minute survey from October 26, 1999 – March 8, 2000.

5.0 Conclusions

The Harlequin Duck Winter Ecology Survey has been successful in collecting behavioural data of Harlequin Duck's along the White Rock coastline. Data collected on the surveyed Harlequin Ducks revealed the following:

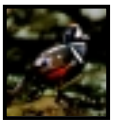
- Foraging was the predominant behaviour throughout the survey months for both single and paired Harlequins of both sexes.

- Both single and paired Harlequins of both sexes showed peaks in foraging times in mid January, but only paired Harlequins showed foraging peaks in March.

- Distances between pairs did not significantly differ between seasons suggesting that pair bonds remain established throughout the winter months.

- Interactions of paired Harlequins peaked in February and March, while single male interactions were high in mid November and single females on November 1 and January 26.

- Paired and single males demonstrated more average time interacting than paired and single females.



6.0 Recommendations

This study was successfully completed and there are few alterations needed for future studies of this sort. A few recommendations that would improve data collection techniques and efficiency are:

- Continued nasal tagging efforts throughout future summers. This would provide more marked birds for consistent data collection data over the winter months when few leg bands are visible.

- Conducting surveys with waterproof scopes. This would aid in consistent data collection in incidences of high precipitation.

- Erecting more location markers along the survey route to serve as more consistent reference points when conducting a survey.

Literature Cited

Banff and Jasper National Parks. *Harlequin Ducks-Whitewater Specialists* [Web Page] http://www.worldweb.com/ParksCanada-Banff/harlequi.html [Accessed 12 November, 1999]

British Columbia Ministry of Environment, Lands & Parks. *2000 Provincial Vertebrate Animal Tracking List* [Web Page] http://www.elp.gov.bc.ca/rib/wis/cdc/vertebrates.htm Accessed 17 March, 2000]

Boyd, S. 1999. Canadian Wildlife Service. Personal Communication

Boyd, S., F. Cooke, G.J. Robertson, C. Smith, and I. Goudie. 2000. *Survival, Emigration and Winter Population Structure of Harlequin Ducks.* The Condor. 102: 137-144

Breault, A.M. and J-P. L. Savard. 1991. *Status report on the distribution and ecology of Harlequin Ducks in British Columbia*. Technical Report Series No. 119, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Chadwick, D H. 1993. *Bird of White Waters.* National Geographic. 184:116-132

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). [Web Page] http://www.cosewic.gc.ca [Accessed 14, March 2000]

Environment Canada. Harlequin Duck (Eastern population). [Web Page] www.cws-scf.ec.gc.ca/es/renew/RENEW97_98/eng/species/haduck.html [Accessed 14, January 2000]

Gooders, J. and T. Boyer. 1986. *Ducks of North America and the Northern Hemisphere*. New York. Facts on File: 176p.

Map Quest.com, Inc. *Mapquest.* [Web Page] http://www.mapquest.com [Accessed 12 November, 1999]

Mason, A. 2000. *Harlequins-BC's Whitewater-Surfing Sea Ducks*. Beautiful British Columbia. 42: 16-21

Ministry of Environment, Lands and Parks (MoELP). *Selected Red, Blue, and Yellow Species.* [Web Page] www.elp.gov.bc.ca/kor/wld/species/distribu.html [Accessed 14, January 2000]

Additional References

Canadian Wildlife Service. *Hinterland Who's Who.* [Web Page] http://www.cws-scf.ec.gc.ca/hww-fap/harlduck/harlequin.html [Accessed 13 December, 1999]

Appendix 1. Glossary of Terms for Behaviour and Event Codes

Behavioural Observation Definitions

Feeding Behaviour (Lasts thirty seconds or longer)

Diving (D): Repeated diving consisting of diving down and subsequently surfacing.

Surface Feeding (SF): Lowering head and picking prey from water surface.

Handling (H): Handling prey at surface following a dive.

Dabbling (DAB): Feeding along shore with head submerged and bottom tipped up.

Feeding Event (Lasts less than thirty seconds)

Up (U): Up at the surface following a dive.

Down (D): Completely submerged during diving behaviour.

Tip (TIP): Head submerged and bottom tipped up.

Locomotion Behaviour (Lasts thirty seconds or longer)

Swimming (S): Swimming

Walking (W): Walking over rocks.

Flying (F): Flying

Locomotion Event (Lasts less than thirty seconds)

Haul Out (HO): Hauls out from water onto rock or log.

Haul In (HI): Hauls into water from rock or log.

Looking (L): Swimming with bill and eyes immersed in water perhaps looking for prey.

Interaction Behaviour (Lasts thirty seconds or longer)

Chase (C): Focal Harlequin chases another bird.

(Also recorded sex of bird being chased and whether or not it was the focal birds mate).

Flee (F): Focal Harlequin flees from another bird.

(Also recorded sex of bird executing chase and whether or not it was the focal bird's mate).

Guard (G): Focal male is guarding female (male moves between mate and intruder).

Copulation (COP): Focal bird copulates with mate; if copulation was not with mate (or if focal bird has no mate) sex and age of other bird was recorded.

Follow (FOL): Focal bird is followed or follows another bird (specify).

Interaction Event (Lasts less than thirty seconds)

Chase (C): Focal Harlequin chases another bird.

(Also recorded sex of bird being chased and whether or not it was the focal birds mate).

Flee (F): Focal Harlequin flees from another bird.

(Also recorded sex of bird executing chase and whether or not it was the focal bird's mate).

Head-nod (HN): Focal bird nods head at another bird; (if not directed at mate, or if focal bird had no mate, the bird the behaviour was directed at was recorded).

Bill Gape (BG): Focal bird opens bill and hisses at another bird; (if not directed at mate, or if focal bird had no mate, the bird the behaviour was directed at was recorded).

Bill Poke (BP): Focal bird jabs bill at other bird; (if not directed at mate, or if focal bird had no mate, the bird the behaviour was directed at was recorded).

Vocalisation: Focal bird squeaks, etc. (if not directed at mate, or if focal bird had no mate, the bird the behaviour was directed at was recorded).

Maintenance Behaviour (Lasts thirty seconds or longer)

Preening (P): Cleaning feathers.

Bathing (B): Bathing in water.

Rest-Head Up (RU): Resting with head up.

Rest-Head Tucked (RT): Resting with head tucked on back.

Maintenance Event (Lasts less than thirty seconds)

Defecate (DEF): Defecates.

Wing Flap (WF): Flaps wings.

Appendix 2. Hypothesis Formula

Statistical Hypothesis Formula

$$t_{n_1+n_2} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}} \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$\overline{x}$ = mean

n = sample size

s = standard deviation

Appendix 3. Selected examples of Data Entry Tables