Inventory Methods for Riverine Birds:

Harlequin Duck, Belted Kingfisher and American Dipper

Standards for Components of British Columbia's Biodiversity No. 12

Prepared by
Ministry of Environment, Lands and Parks
Resources Inventory Branch
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Preface

This manual presents standard methods for inventory of Riverine Birds in British Columbia at three levels of inventory intensity: presence/not detected (possible), relative abundance, and absolute abundance. The manual was compiled by the Elements Working Group of the Terrestrial Ecosystems Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methods that will lead to the collection of comparable, defensible, and useful inventory and monitoring data for the species component of biodiversity.

This manual is one of the Standards for Components of British Columbia's Biodiversity (CBCB) series which present standard protocols designed specifically for group of species with similar inventory requirements. The series includes an introductory manual (Species Inventory Fundamentals No. 1) which describes the history and objectives of RIC, and outlines the general process of conducting a wildlife inventory according to RIC standards, including selection of inventory intensity, sampling design, sampling techniques, and statistical analysis. The Species Inventory Fundamentals manual provides important background information and should be thoroughly reviewed before commencing with a RIC wildlife inventory. RIC standards are also available for vertebrate taxonomy (No. 2), animal capture and handling (No. 3), and radio-telemetry (No. 5). Field personnel should be thoroughly familiar with these standards before engaging in inventories which involve either of these activities.

Standard data forms are required for all RIC wildlife inventory. Survey-specific data forms accompany most manuals while general wildlife inventory forms are available in the Species Inventory Fundamentals No. 1 [Forms] (previously referred to as the Dataform Appendix). This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem (SPI). For more information about SPI and data forms, visit the Species Inventory Homepage at:
http://www.env.gov.bc.ca/wld/spi/ric_manuals/

It is recognized that development of standard methods is necessarily an ongoing process. The CBCB manuals are expected to evolve and improve very quickly over their initial years of use. Field testing is a vital component of this process and feedback is essential. Comments and suggestions can be forwarded to the Elements Working Group by contacting:

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests".

For further information about the Resources Inventory Committee and its various Task Forces, please contact:

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Terrestrial Ecosystems Task Force

All decisions regarding protocols are the responsibility of the Resources Inventory Committee. Background information and protocols presented in this document are based on the unpublished draft manual, *Manual of Inventory Methods for Riverine Birds in British Columbia* prepared for the Resources Inventory Committee by John M. Cooper and Kenneth G. Wright. Ian Goudie and Francis Cassirer provided considerable comment on Harlequin Duck survey techniques and access to their libraries. Ian Goudie, Holly Hogan, Trudy Chatwin, Francis Cassirer, and Steve Wilson provided extensive reviews which greatly improved this document.

The Standards for Components of British Columbia's Biodiversity series is currently edited by James Quayle with data form development by Leah Westereng.

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1. INTRODUCTION

Three species of birds are found mainly along rivers during the breeding season in British Columbia. These are the Harlequin Duck (*Histrionicus histrionicus*), the Belted Kingfisher (*Ceryle alcyon*), and the American Dipper (*Cinclus mexicanus*). They have been collectively grouped as riverine birds for purposes of this manual.

Riverine birds comprise a distinctive component of the avifauna of British Columbia. They are familiar to anyone who spends time along our mountain streams or valley-bottom rivers. Populations are widespread in the province because of its vast area of mountainous regions with their abundant river systems.

The Harlequin Duck (hereafter harlequin) is a small "sea duck" that occurs on rivers only during the breeding season. At other times it occurs on the coast where it frequents rocky islets and reefs. Populations in British Columbia are relatively large, but may be declining (I. Goudie pers. comm.), and there are considerable potential threats from oil spills, logging of riparian habitat, and disturbance from commercial river rafting (I. Goudie pers. comm.; Cassirer *et al*. 1993; Hunt 1993).

The Belted Kingfisher (hereafter kingfisher) is widespread along rivers from spring through autumn, but many interior birds move to marine coasts or coastal rivers for the winter. Some populations also breed along marine coasts or along lake shores, so it is not strictly a riverine species. There are no significant management or conservation concerns for kingfisher at present in British Columbia.

The American Dipper (hereafter dipper) is truly a riverine species, found almost exclusively along fast-flowing rivers and streams during all seasons. Populations are limited mainly by stream productivity and nesting site availability (Price and Bock 1983). The few threats to habitat include the down slope effects (e.g., siltation) from logging of watersheds and general pollution of waterways. Because of their sensitivity to stream pollution, dippers are good indicators of stream quality (Tyler and Ormerod 1994).

The purpose of this manual is to recommend methodologies and provide protocols for the inventory of riverine birds at three levels of survey intensity - presence/not detected (possible), relative abundance, and absolute abundance.

2. INVENTORY GROUP

This section summarizes the distribution and ecology of riverine birds. This background information is important to consider when developing inventory programs. Excellent summaries of the biology, distribution and location of major populations of riverine birds in British Columbia are contained in Campbell *et al*. (1990a, 1990b, 1997). Other major references include Cannings *et al*. (1987), Palmer (1976), Cramp and Simmons (1977) for harlequin; Price and Bock (1983), Kingery (1996) for dipper; and Hamas (1994) for kingfisher.

2.1 Harlequin Duck

2.1.1 Description

A medium-sized duck weighing about 450-750 g with sexually dimorphic plumage. Females are brownish with a bright white spot behind the eye, and white below the eye and between the eye and forehead. Males in breeding plumage are brightly coloured with chestnut sides and white streaks scattered over a slate blue background. Males do not reach their full breeding plumage until their third year, and have distinctive juvenile (1st year) and subadult (2nd year) plumages. Moulting males look similar to females when in full eclipse plumage.

2.1.2 Distribution

Harlequins have a disjunct holarctic distribution (Bengtson 1972; Palmer 1976). Breeding occurs in eastern Siberia, northwestern North America, eastern Canada, Greenland, and Iceland. Wintering distribution is mainly confined to coastal areas. Harlequins in British Columbia have a widespread breeding range despite the paucity of breeding records (Campbell *et al*. 1990a). Although their breeding range is confined to regions with fast-flowing rivers and streams; in British Columbia this includes the Rocky Mountains, Cassiar Mountains, Coast Mountains, Vancouver and Queen Charlotte Islands. Harlequins may also occasionally breed on coastal islets with dense cover. Breeding densities vary markedly according to habitat quality and presence of spring staging areas. The Queen Charlotte Islands probably support a resident, insular population (I. Goudie pers. comm.).

2.1.3 Migration/Seasonal Movements

The harlequin is a short-distance migrant that moves to breeding streams from Pacific coastal areas. Arrival on breeding streams is dependent on timing of spring break-up, which varies with latitude and altitude. Males spend only 4-10 weeks on breeding streams, depart during the onset of incubation and fly to coastal moulting sites, where they join nonbreeders (Palmer 1976). Breeding females move to the coast later depending on breeding success and whether or not females abandon young. Nonbreeding females also remain on rivers through the incubation period. Successful females and juveniles arrive on the coast in mid to late September. Some coastal breeding populations are probably nonmigratory.

Very large aggregations of harlequins have been reported during early spring associated with Pacific herring spawn (Campbell *et al*. 1990a). For example, up to 4,500 birds were reported to be off Hornby Island in March, 1995 (Goudie and Wright in prep.).

2.1.4 Ecology

Spring migrants arrive to swiftly-flowing breeding streams, with relatively little insect prey available, shortly after ice-out although snow is usually still on the ground. Their arrival, in the southern Canadian Rocky Mountains at least, coincides with the spawning of the Long-nosed Sucker (*Catostomus catostomus*), which provide pre-nesting birds with an important food source (Van Tighem 1994). Later, they feed on insect larvae and crustaceans. Elsewhere, harlequins feed primarily on aquatic insect larvae during the breeding season (Cassirer and Groves 1994) while on the coast they eats mainly molluscs and crustaceans.

Harlequins nest on the ground, under roots along banks, on cliffs among boulders, and in large tree cavities. Clutch and brood sizes range from 3-10 eggs or young. The incubation period is about one month and young fledge after about two months (Bengtson 1972; Campbell *et al*. 1990a).

During nonbreeding seasons, harlequins are gregarious, almost always occurring in conspecific flocks. In British Columbia, they do not usually associate with other duck species. On breeding streams, pairs tend to avoid other pairs but are not considered territorial (Palmer 1976).

2.2 Belted Kingfisher

2.2.1 Description

The kingfisher is a familiar bird to most people in British Columbia. Its bluish and white plumage, raucous call, crested head, and habit of plunging into water to catch prey, are distinctive. The females differs from the male in the chestnut band across her chest, just below the blue band which both sexes share. Juveniles tend to look like males.

2.2.2 Distribution

The kingfisher is one of the most widely distributed "landbirds" in North America (American Ornithologists' Union 1983). In British Columbia, it breeds throughout the province wherever fish-bearing streams or lakes and banks suitable for burrowing exist. It winters mainly along the coast, but small numbers winter in southern interior valleys (Campbell *et al*. 1990b).

2.2.3 Migration/Seasonal Movements

Spring migration occurs in March and April, and into May in the north. Migrants follow river valleys and lake shores. Autumn migrants leave the northern interior in August and early September, and the southern interior in October (Campbell *et al*. 1990b). Winter populations occur most frequently along coastal rivers with plentiful small fish populations, in estuaries and harbours, and in the vicinity of fish hatcheries.

2.2.4 Ecology

Kingfishers excavate burrows in soft, sedimentary material in vertical banks along rivers, lake shores, gravel pits, or roads. They occasionally nest in piles of sawdust or buildings (Campbell *et al*. 1990b). Clutches of 5-8 eggs are laid mainly in late May. The incubation period is about three weeks while fledging requires about four weeks. Young stay with parents about three weeks after leaving the nest. The kingfisher is solitary outside the breeding season (Hamas 1994).

Kingfishers feed mainly on small fish and require clear waters for visual detection of prey and a supply of perches (dead branches, sticks, snags) along the water's edge.

2.3 American Dipper

2.3.1 Description

The dipper is a plump, thrush-sized bird, with longish legs. Its plumage is a dark slate grey all over, except for thin white marks on the upper and lower eyelids. Both sexes appear similar. Dippers are usually seen perched on a rock at the water's edge where they can be seen bobbing up and down in a distinctive manner. Males have a melodious song, mainly heard in late winter and spring, that beautifully compliments the sounds of their riverine habitat.

2.3.2 Distribution

The dipper is resident in western North America from Alaska south through British Columbia, Alberta and Montana to Mexico (American Ornithologists' Union 1983). In British Columbia, it breeds throughout most of the province along fast-flowing rivers with exposed cobble beaches, boulder-strewn rapids and riffles, and canyons. In winter, it leaves frozen rivers and migrates to river reaches near the coast or to milder climates in the interior. Some birds will remain as far north as open water allows (Campbell *et al*. 1997).

2.3.3 Migration/Seasonal Movements

Spring migration occurs in February and March and migrants follow coastlines and major river valleys. After breeding, birds disperse along breeding rivers. Autumn migrants leave as waters begin to freeze up. Large numbers move to coastal streams to take advantage of salmon spawn in the autumn and hatching fry in late winter.

2.3.4 Ecology

The dipper builds a large domed nest out of moss and mud, with an opening on the side. The nest is usually tucked away in a rock crevice in a cliff, behind a waterfall, under a bridge, or in a cutbank. A clutch of 4 to 6 eggs is laid. Incubation lasts about 15 days and young fledge after about three weeks. Young are vulnerable to disturbance and may leave the nest prematurely (Kingery 1996; Campbell *et al*. 1997).

Dippers feed mainly on aquatic insects, crustaceans, fish spawn and fish fry. They are unique among "songbirds" in that they walk and swim underwater to capture prey. Dippers are essentially restricted to rivers, occurring occasionally along lake shores during migration,

and along marine shorelines when nesting on streams that cascade down steep mountainsides to the sea.

3. PROTOCOL

This section reviews the recommended survey methods and provides protocols for the inventory of harlequins, kingfishers, and dippers. Recommendations for the use of the survey, a discussion of the method including a list of advantages and disadvantages, and specific protocols are included in each section. Survey techniques for dippers and kingfishers are similar for most seasons. For harlequins there are significant differences between breeding season and nonbreeding season survey methods. The following methods are intended for various census intensities and geographical and seasonal coverage.

Table 1. Recommended survey types for riverine birds in the breeding and nonbreeding seasons and the level of survey intensity.

	Survey Type	**Species**	**Level of Intensity**
Breeding Season			
	Aerial (Helicopter)	Harlequin Duck	PN, RA, AA
	River Shoreline	Harlequin Duck Belted Kingfisher American Dipper	PN, RA
	Mark/recapture	Harlequin Duck Belted Kingfisher American Dipper	AA
	Territory length	American Dipper	AA, (RA)
Nonbreeding Seasons			
	Aerial (Fixed-wing)	Harlequin Duck	PN
	Marine Boat Offshore Island	Harlequin Duck	PN, RA, AA
	Land-based shoreline	Harlequin Duck	PN, RA
	Mark/recapture	Harlequin Duck American Dipper	AA
	River Shoreline	American Dipper	PN
	Territory length	American Dipper	AA, (RA)

* PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance

3.1 Sampling Standards

The goal of any survey design is to obtain precise and accurate estimates. An estimate with a relatively low standard error is said to be precise. In some cases, precision can be improved by increasing sample size, standardizing methods and maintaining constant observers. An estimate that is free of systemic errors is said to be accurate. Unlike random errors, systemic errors tend to bias results in one direction i.e., either under-estimate or over-estimate. These errors are usually intrinsic to the method and are not reduced by increasing sample size. For example, aerial surveys constantly underestimate numbers. It is important to be aware of the source of errors and biases in any method so that they can be addressed and kept to a minimum.

3.1.1 Scheduling of the Survey

Scheduling of surveys is the most critical component of inventory planning. Unfortunately, because of different breeding chronologies and behaviours, riverine birds may not be efficiently surveyed at the same time. For example, Cassirer and Groves (1994) suggest that surveys must be conducted specifically for harlequins. In addition, the methods used to census breeding, wintering, and migrant populations may differ substantially.

3.1.2 Time of Year

Appropriate dates for surveys of breeding and wintering populations must be considered during the planning phase. Because the chronology of the annual cycle for riverine birds varies between species it may not be possible to efficiently survey all three species during the same time periods.

Surveys for harlequins on rivers should focus on the window around pre and/or post-laying and incubation periods, which varies with latitude and elevation, but is roughly May and August. Male dippers sing most intensively during April, so are most detectable then, but nests can be found most easily later in the spring, during the nestling period, when both parents are making regular feeding trips to the nest.

3.1.3 Time of Day

Variation in activity levels and behaviour throughout the day often causes changes in the detectability of birds, which may result in a time-of-day effect that biases the results of counts (Shields 1977; Rollfinke and Yahner 1990). Dippers are most active in mornings and late afternoons, but males sing all day long (Kingery 1996). Coastal wintering harlequins swim offshore and spend the night in rafted flocks, and may feed more actively during early morning and early evening. Kingfishers are active during daylight hours but feeding activity is least during mid day (Hamas 1994).

3.1.4 Tidal Cycle

The timing of counts of moulting and wintering harlequins in relation to the tidal cycle can cause wide variation in the numbers reported. During low tide, more reef habitat is available and birds can be more difficult to count as they are sparsely distributed in contrast to high

tide when harlequins will be concentrated in less habitat and are easier to detect and count. Alpha-numeric colour bands are often easier to see during higher tidal amplitudes.

3.1.5 Weather

During wet, cold or windy weather, birds may be less active and less detectable. Observers also have trouble concentrating because of the uncomfortable conditions and are more prone to make errors. Weather can cause severe safety hazards when traversing river banks (slippery rocks) or during at-sea boat surveys for harlequins. Certain types of surveys (notably aerial) must be limited to specific weather conditions; for example aerial surveys should occur when winds are less than 10 knots.

3.1.6 Effort and Speed

Errors in an estimate are generally inversely related to effort and directly related to speed for any given method. It is important that these factors are standardized between observers and between sites and years to be able to produce comparable results for certain types of surveys such as aerial or boat-based surveys.

3.1.7 Personnel

All survey methods need trained personnel capable of identification and age/sex determination of the various species. Dippers and kingfishers, and harlequins on breeding streams are unmistakable. However, workers may require training in harlequin identification at other times of year. Moulting harlequins can be confused with other sea ducks and misidentifications are possible. Also moulting male harlequins are frequently misidentified as females or young of the year. Harlequins are particularly difficult to see during moult when they spend considerable time hauled-out on rocks, standing amongst brown algae.

Variability always exists among observers in experience, ability to identify and count birds at various distances, and in visual acuity. Training may be required to ensure that observers are of comparable ability and understand the methodology to be used.

3.1.8 Habitat Data Standards

A minimum amount of habitat data must be collected for each survey type. The type and amount of data collected will depend on the scale of the survey, the nature of the focal species, and the objectives of the inventory. As most, provincially-funded wildlife inventory projects deal with terrestrially-based wildlife, the terrestrial Ecosystem Field Form developed jointly by MOF and MELP (1995) will be used. However, under certain circumstances, this may be inappropriate and other RIC-approved standards for ecosystem description may be used. For dippers, harlequin ducks, and kingfishers it may be appropriate to describe riverine habitats using a portions of the Stream Survey site card, available from MELP Fisheries Branch. For a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult the manual, *Species Inventory Fundamentals (No. 1)*.

3.1.9 Survey Design Hierarchy

Riverine bird surveys follow a survey design hierarchy which is structured similarly to all RIC standards for species inventory. Figure 1 clarifies certain terminology used within this manual (also found in the glossary), and illustrates the appropriate conceptual framework for a river shoreline survey. A survey set up following this design will lend itself well to standard methods and RIC data forms.

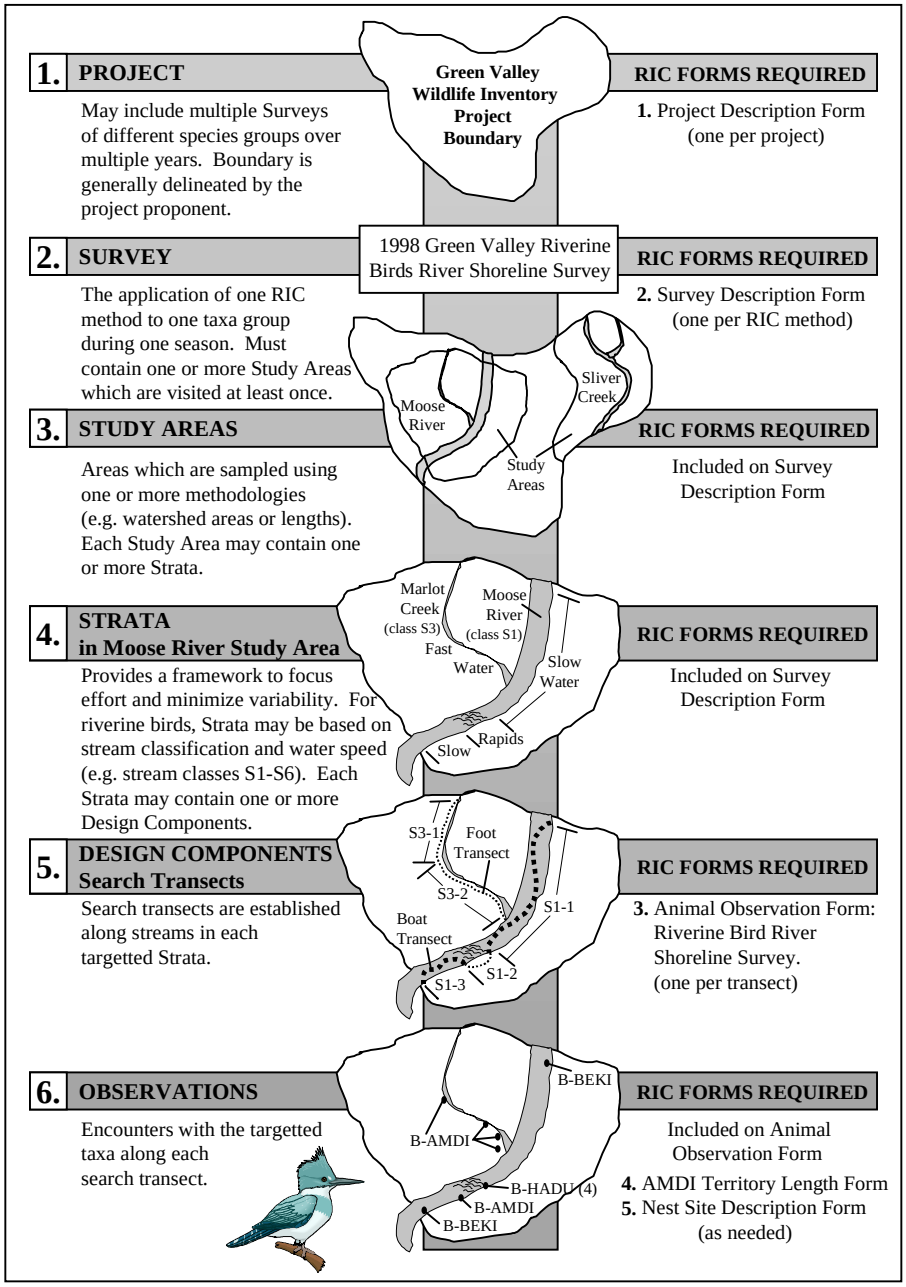

Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Inventory Surveys

The table below outlines the type of surveys that are used for inventorying riverine birds for the various survey intensities. These survey methods have been recommended by wildlife biologists and approved by the Resources Inventory Committee.

Table 2. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Note: See Table 1 to ensure surveys are conducted in the appropriate season for the target species and the level of intensity desired.

Survey Type	Forms Needed	*Intensity
Aerial	Wildlife Inventory Project Description Form	PN
	Wildlife Inventory Survey Description Form - General	RA
(Harlequin Duck)	Animal Observations Form- Harlequin Duck Aerial & Marine Offshore Island Survey	AA
Marine Boat Offshore Island	Wildlife Inventory Project Description Form	PN
	Wildlife Inventory Survey Description Form - General	RA
(Harlequin Duck)	Animal Observation Form - Harlequin Duck- Aerial & Marine Offshore Island Survey	AA
Land-based Marine Shoreline	Wildlife Inventory Project Description Form	PN
	Wildlife Inventory Survey Description Form - General	RA
(Harlequin Duck)	Animal Observation Form- Harlequin Duck- Land-based Marine Shoreline Survey	
River Shoreline	Wildlife Inventory Project Description Form	PN
	Wildlife Inventory Survey Description Form - General	RA
(all spp depending on season)	Animal Observation Form- Riverine Bird- River Shoreline Survey	
Territory Length	Wildlife Inventory Project Description Form	AA
	Wildlife Inventory Survey Description Form - General	(RA)
(American Dipper)	Animal Observation Form- American Dipper- Territory Length	
Mark/ recapture	Wildlife Inventory Project Description Form	AA
	Wildlife Inventory Survey Description Form - General	
(all spp depending on season)	Capture (Stations) Form - Riverine Bird	
	Animal Observation Form- Riverine Bird- Capture	

*PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance

3.3 Aerial Surveys (Harlequin Ducks)

Recommendations: Fixed-wing aerial surveys are recommended to determine presence over large scale marine areas or census wintering and moulting populations of harlequin ducks over large geographic areas in conjunction with surveys for other waterbirds. Helicopter aerial surveys are recommended for inventory of breeding pairs and broods on rivers with good visibility. Helicopter aerial surveys can be used to determine presence and to provide relative abundance estimates. On streams with good visibility, and using a helicopter, estimates of absolute abundance can be made.

Fixed-wing aerial surveys have been used extensively for censusing general waterbird populations at sea, in estuaries, and on breeding wetlands in British Columbia (e.g., Savard 1979, 1982), but few attempts have been made to survey streams. In coastal British Columbia, few attempts have been made to census moulting or wintering harlequin populations by air (Savard 1988). Aerial surveys of harlequins on the coast are hampered by the cryptic plumage of moulting males, females and juveniles, and by their behaviour of hauling out on rocky islets or swimming among rocks, which makes them difficult to spot at high speeds (Savard 1988). They can not be adequately detected by flying transects but require passes over suitable islets or along shorelines.

In Labrador and Quebec, helicopter aerial surveys have been conducted specifically, and successfully, for breeding harlequins along rivers (Goudie 1988; Goudie *et al*. 1994b; Morneau *et al*. in prep.). Similar surveys have been used successfully in Alaska where 750 km where surveyed by helicopter (McCaffery 1996; McCaffery and Harwood 1996). However, in high density areas ground truthing indicated that up to 50 % of the birds were missed. On breeding streams, aerial surveys are hampered by tree cover, terrain, vegetation, observer bias, and water hydraulics which all can reduce visibility of harlequins. Helicopter surveys can be especially effective in subalpine areas because of better visibility (I. Goudie pers. comm.).

Two breeding season helicopter aerial surveys have been conducted in British Columbia. The first was a survey of Carbon Creek in May 1977, which was successful in finding breeding pairs (10 pairs over 19.5 km; Breault and Savard 1991). This method was tested in June 1996 on the Nahatlatch River (Boston Bar) and proved to be ineffective due to high tree height which forced the helicopter to fly above the optimal height, and riparian vegetation which obscured birds. Detection was estimated to be 30% (n=4) of ground-detected birds.

Clearly, surveys by fixed-wing aircraft for wintering or moulting harlequins present a few difficulties, notably low detection rates associated with higher speeds and heights. Helicopter surveys have several advantages such as they permit low level flying (15-20 m if tree cover permits), slower speeds, and high maneuverability, but are relatively expensive. On wintering and moulting grounds, helicopter surveys of rocky islets and shorelines are also feasible for the same reasons. Although no estimates of the reliability of aerial surveys for harlequins have been made, it seems apparent that helicopter surveys provide satisfactory data.

Aerial surveys often have a consistent bias, the underestimation of population densities (Pollock and Kendall 1987). Comparisons of aerial surveys with ground-truthing or boat surveys are recommended to calibrate abundance estimates. Furthermore, for species such as

coastal sea ducks, errors may be random and cannot be adjusted by standardized correction factors (see Savard 1982).

Video cameras and aerial photography are sometimes used in conjunction with aerial surveys. Aerial photography could improve estimates of wintering or moulting flocks of harlequins, as well as provide valuable information about habitat, though this technique has not be attempted.

Advantages

- Helicopter surveys are effective in marine areas and along streams that are safe to fly and have good visibility.
- Large areas can be covered in a short period of time.
- Useful for reconnaissance of potential breeding areas, moulting areas, or wintering areas.
- Remote areas can be easily accessed (i.e., alpine areas, headwaters of rivers, unnavigable sections of rivers, offshore islets, remote coastlines), especially if surveys have to be repeated at regular intervals.
- Since counts are relatively instantaneous, biases caused by movement of harlequins between areas can be avoided.

Disadvantages

- Suitable only for harlequins.
- Costly method that is feasible only when considering high priority species.
- Very difficult and thus inappropriate to survey forested streams because of reduced visibility and safety considerations.
- Requires low-level flying especially on breeding streams (possibly hazardous).
- Wintering and moulting harlequins are difficult to detect from the air.
- Aerial surveys invariably underestimate populations because birds will be inevitably missed. Harlequins prefer to stay close to shore or haul-out on rocks and are difficult to detect. Ground-truthing is likely necessary to correct for these biases but must be co-ordinated with aerial surveys.
- Variables such as light conditions, different observers, altitude, and precise route flown tend to affect the estimate of bird numbers. In some cases these difficulties lead to random error which cannot be adjusted by a standard correction factor (Stott and Olson 1972). Higher quality personnel will, hopefully, minimize error.
- The sight and sound of the aircraft may disturb birds and cause some birds to flush ahead of flights and consequently be missed in counts or, if detected, be double counted at another site.

Aerial surveys are, essentially, encounter transects that follow the contours of shorelines and inland water courses.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the *Species Inventory Fundamentals (No. 1).*
- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).

- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and study areas from maps.
- Select study areas from 1:20,000 and 1:50,000 maps on the basis of personal experience and existing data.
- Survey routes must be chosen to maximize the coverage of suitable habitat.
- The survey route should follow a transect along coastal shoreline or stream courses and should be drawn on maps used for navigation. The survey route is traced lightly on a 1:5 000 map.
- Contract a suitable aircraft and pilot with previous experience in wildlife surveys.
- The desired survey altitude and flight speed are discussed in advance with the pilot. These will vary with the type of aircraft and weather conditions and determine, in part, the detail at which the data are collected.
- Along the coast, tidal cycles must be calculated for the area to be surveyed and coordinated with the flight plan. High tides are usually best.
- Authority to fly over sensitive areas (Ecological Reserves, Wildlife Management Areas), must be obtained in advance of the survey.
- Maps, recording equipment, and recording forms should be assembled and double checked at least a week prior to the survey date. This will allow for equipment checking, repair, replacement, and photocopying of forms.
- Prior to the survey, personnel should meet to standardize recording and spotting estimates. Team members should review maps of the area.
- Data are recorded on cassette tape during the flight if observations are frequent and transcribed to data sheets as soon as possible after the flights. Tape transcription time should be scheduled for the survey team shortly after the flight. This will reduce errors and allow changes in procedures for more efficient recording on following flights. If observations are infrequent, data may be recorded directly on maps and accompanying data sheets. Harlequin breeding densities rarely exceed 1 pair/km of river.

Sampling Design

- Systematic. Transects follow the shoreline along the coast or stream courses. The entire survey route may be broken up into smaller segments to facilitate counting.

Sampling Effort

- If only one survey is to be scheduled, it should coincide with the peak in moulting or winter abundances, as determined from existing data. However, in most cases, surveys should be repeated several times during peak abundances.
- The time required for a survey depends on: (a) distance covered, (b) level of intensity of the survey and detail of information to be collected, (c) travel time to and from the survey location, (d) number of times the survey is to be repeated, and (e) fuel limitations.

Personnel

- A pilot with previous wildlife aerial survey experience is preferred.
- In addition to the pilot, it is recommended that the crew should consist of a navigator, in the co-pilot seat, and two spotters in the left- and right-hand-side passenger seats (Goudie *et al*. 1994b). The navigator usually doubles as an observer for surveys of harlequins.

- All personnel must have a high tolerance for motion sickness. *Gravol* or other preventative medications may be taken prior to take-off if there is a chance of motion sickness, but these may affect an observers' attention span. New observers should be instructed on ways to avoid air motion sickness, e.g., concentration on the horizon line and relaxation of the body during aerial maneuvers.

Equipment

- Overhead fixed-winged aircraft are recommended for marine surveys (e.g., Cessna 182, 206, Beaver). For harlequin breeding pair counts use Bell Jet Ranger 206 or Astar 350 helicopters or equivalent. The same type of aircraft should be used each time to standardize noise disturbance and speed. Helicopters with extended fuel capacity are best to extend time and potential survey coverage.
- It is recommended that the aircraft be fitted with bubble windows to allow for better spotter visibility.
- It is very important the plane or helicopter has a good airphone-intercom system to allow dialogue between pilot, navigator, and observers.
- The navigator should be equipped with a Global Positioning System (usually available with the aircraft), detailed maps (preferably 1:20,000 TRIM maps) of routes, pencils to trace flight route, a precision watch for noting time, and a tape recorder to record data.
- Each observer should have 7-8X, wide-angle binoculars, a tape recorder, extra blank tapes, maps of routes, a precision watch, extra batteries, and pencils and field note book in case of tape recorder failure.
- Provincial standard data forms will be required to transcribe information from tapes.
- Video cameras and still cameras may also be used to supplement the data. Again extra film and batteries should be on board.

Field Procedures

- Breeding pair counts should be conducted during late May and early June in British Columbia (Goudie *et al*. 1994a).
- A certain amount of flexibility has to be planned into scheduling to accommodate delays caused by bad weather or mechanical problems.
- Survey routes must be chosen to maximize efficiency and coverage of suitable habitat. The survey route is traced lightly on maps and discussed with the pilot such that the slowest speeds and lowest heights possible can be chosen for the given aircraft, weather and terrain conditions. Flights altitudes between 20-60 m, preferably 20-30 m, above water level are recommended (20 m for harlequin river surveys if forest cover permits).
- The entire survey route is a long transect which may be broken up into smaller segments to facilitate counting. Each of the segments must be clearly labelled on the maps so that the navigator and spotters can name each segment as it is counted.
- To avoid low sun angles and glare during spring, summer, and fall, surveys should be scheduled on clear or overcast days. It is best to survey harlequins during the first 3-4 hours of daylight, but approach plots from the appropriate direction to avoid glare on sunny days. Surveys should not be conducted in winds greater than 30 km/hr, or during periods of rain or fog. On sunny days, flight paths should be oriented to avoid glare.
- To avoid observer fatigue, which will bias the accuracy of data collected, total daily air time should not exceed 6 hours. Each session should last no more than 2 to 3 hours with half hour breaks.

- The navigator and the two spotters meet prior to commencing surveys to synchronize watches, double check all equipment, and ensure all crew members are familiar with the flight route and clearly know their responsibilities. Contingency plans in case of problems should also be discussed at this time.
- On marine surveys, search all islets, reefs, and exposed "mainland" points for harlequins. In rivers, check all boulders and gravel bars.

The navigator sits in the co-pilot seat and helps the pilot with navigation and is responsible for:

1. Tracing the exact route flown on the maps;
2. Recording time at which counting on each segment is commenced and stopped, GPS coordinates, flight altitude, ground speed, airspeed, weather conditions, tide level for coastal surveys, details of habitat, distance of flight line from the edge of the water, and if spotting was done from both, or one, sides of the aircraft (see accompanying dataforms);
3. Marks locations of birds/flocks on the map;
4. Records details such as deviations from planned flight lines or repeated flights over any segment.

The two rear observers record data directly into tape recorders. At the start of each segment, the spotter clearly dictates:

1. The name/number of the segment, the GPS co-ordinates, time of commencing of count;
2. Numbers of harlequins spotted;
3. At the end of each segment, they record again the name/number of segment, GPS co-ordinates and time. The segment can then be marked off on the map so that they can keep track of their flight path. It is recommended that the navigator announce the beginning/end of each segment so that the two counters and the navigator are synchronized.
4. Sightings should be discussed as they occur to prevent multiple counting of the same individuals.

- Accuracy of data from aerial surveys can be improved by ground-truthing of subsets of the survey data. Ground-based or boat surveys are assumed to be more accurate, and may be used to adjust aerial counts for bias or error. These ground-truthing surveys should be made at approximately the same time.
- Personal comfort note: Toilet facilities are not available in-flight. The survey team should restrict beverage intake, especially those with caffeine, during the hour prior to take off. However, during the flight, energy snacks (chocolate bars, fruit, etc.) are recommended to reduce observer fatigue.

Data Analysis

- The navigator and spotters transcribe data on to the accompanying data forms using permanent black ink. If replicate counts were made by the counters, this has to be clearly marked on the data form so that the counts are not summed. Convention is to use the higher figure in replicate counts. Additional notes made during the flight should be transcribed as well.

- Data can then entered into a computerized file for inclusion in the provincial data base.
- Relative and absolute abundance: These can be expressed either as (1) total counts of birds/breeding pairs for a particular location, (2) as density of birds per square kilometre (winter and moulting only) or (3) as the number of birds/breeding pairs per kilometre of shoreline, survey route, or stream.

1. Total counts: The total number of birds in all the segments within a certain location are summed together to give the absolute abundance of birds in an area at a given time. Data on numbers at different locations can be visually presented on maps using variable circles for different population classes.

2. Density (for wintering populations) of birds in an area:

$D = B/A$

where D = density of birds (Birds/km^2)

B = No. of birds observed

A = area surveyed (calculated by measuring the area surveyed from a map)

3. Birds/kilometre (for breeding populations):

$K = B/Z$

where K = birds/pairs per kilometre of survey route (Birds/km)

B = No. of birds observed

Z = Length of survey route measured from maps

3.4 Marine Boat Offshore Islands Surveys (Harlequin Ducks)

Recommendations: Marine boat surveys of offshore islands are recommended at the local and management unit scales: to determine presence and estimate relative and absolute abundance of harlequins during the moulting and wintering periods. Since birds will likely be missed, absolute estimates will likely be underestimated.

Boat surveys are relatively inexpensive and are an effective means of surveying harlequins on marine coasts. Small boats can circle rocky islets and follow coastlines close to shore. Observers count birds as they are encountered. If appropriate distance is maintained then accurate identification, sexing, aging and counts are possible with little disturbance to the birds. Zweifelhofer (1994) surveyed nearly 1,000 km of shoreline on Kodiak Island, Alaska by this method and found that sex/age ratios can be determined during the wintering period. This method is suitable for relative and absolute abundance estimates, although it tends to underestimate true population size (see Mittelhauser 1994).

Advantages

- Allows careful searching of potential habitat because of maneuverability of boats.
- Allows accurate observation, counting, and identification of cryptic species like harlequins.
- Can determine sex ratios in flocks.
- Can monitor productivity based on age/sex determination from plumages.
- Can survey remote sites not accessible by land.
- Relatively cost-effective compared to aerial surveys.
- Colour-banded birds are detectable.
- Can cover large geographic areas in relatively short periods of time.

Disadvantages

- Suitable only for harlequins.
- Probably results in underestimates of populations.
- Need more specialized equipment than for land-based surveys.
- Need trained personnel capable of handling boats and working in remote coastal settings.
- Very dependent on sea and weather conditions.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals (No. 1).*
- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and study areas from maps.
- Select study areas from 1:20,000 or 1:50,000 maps using marine charts, personal experience and existing data.
- Plan the survey route to maximize efficiency in travelling and covering all habitat.

- Survey lines are transects which follow the shoreline along the coast and are drawn on maps used for navigation.
- Organize rental of boats and availability of personnel.
- Provide training for personnel on boating safety, and survey techniques.
- Prior to the survey, personnel should meet to standardize recording. Team members should review maps of the area.

Sampling Design

- Systematic. Islands are circled by boat. Island shorelines are considered to be circular transects which may be further broken into segments.

Sampling Effort

- The time required varies with the area to be surveyed, the travel time to and from the survey area, and the speed of the watercraft.

Personnel

- The survey crews (2-4 people) should be led by a Registered Professional Biologist, or experienced waterfowl biologist, with experience in marine bird surveys.
- All crew members should have a high tolerance for motion sickness.

Equipment

- A suitable boat for surveying near shore marine waters. A smaller boat or inflatable is preferred to enable maneuvering between small offshore islets.
- Marine charts and Global Positioning System for noting location of survey sites.
- Waterproof notebooks, data forms and mechanical pencils.
- Each observer should have 7-8X wide-angle binoculars.
- Appropriate safety equipment (life jackets or survival suits, flares, HF radio, spare fuel, emergency rations, etc.).

Field Procedures

- Surveys should be scheduled for fair weather days with wind speeds less than 25 km/hr.
- Surveys should be scheduled to coincide with peaks in moulting and wintering abundance.
- Survey routes should be marked on maps. Individual islets within island groups have to be clearly numbered on the maps.
- Islands are circled by boat, at a speed that allows observers to detect any birds present. The observers scan the shorelines for birds. The boat may be stopped to enable better identification and counting.
- All harlequins present should be detected. Age and sex classes of the birds should be noted, and behaviour if time permits.
- Hauled out harlequins should be checked for tarsal coloured bands if time permits.
- The data should be recorded in waterproof note books/data forms with pencils. Note: if note books are used, data must later be transcribed onto the provincial standard data forms.

Data Analysis

- Data may be displayed and analyzed as in Aerial Surveys.

3.5 Land-based Marine Shoreline Surveys (Harlequin Ducks)

Recommendations: Land-based surveys are recommended for determining presence and relative abundance of local wintering and moulting flocks of harlequins. These surveys are recommended for shorelines that can be accessed or viewed easily through a spotting scope. Land-based marine shoreline surveys are effective and recommended at the local and management unit scales.

Land-based surveys are commonly used to survey migrating and wintering waterfowl, shorebirds, and gulls along marine shorelines (e.g., Butler and Cannings 1989; Bradley and Bradley 1993). This survey method involves counting all birds visible from preselected land-based points and/or by walking the shoreline and observing. Ground survey data can be used to determine presence/not detected (possible) and relative abundance at a given time. For this inventory group it is useful for harlequins in local areas where they frequent coastlines accessible by land.

This method is currently being used to study harlequin winter site fidelity and moulting chronology near White Rock, British Columbia (Savard 1988; G. Robertson pers. comm.). It is not useful for dippers or kingfishers because they do not occur along marine shorelines frequently enough to warrant surveys, although small numbers of kingfishers may winter along estuary shorelines.

Advantages

- Methodologically simple and requires very little specialized equipment.
- Since methodology is simple, a large number of experienced amateur bird watchers can be trained quickly and used to survey many study areas.
- Inexpensive.
- Thorough coverage of visible shorelines is possible.
- Multiple counts are easily feasible and improve the accuracy of estimates.
- Notes on habitat use and other environmental factors can be easily documented at the same time as the counts.
- Facilitates band reading of harlequins.

Disadvantages

- Misidentification at a distance can be a problem, so counts may be inflated.
- Labour intensive.
- Only land-accessible areas can be censused. Impractical to census remote regions.
- Ground-based counts are not instantaneous. This increases the potential error due to movement of birds (e.g., the same birds may be counted twice or some birds not counted at all because they have moved).
- Suitable for harlequins only.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals (No. 1).*

- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and study areas from maps.
- Select study areas from 1:20,000 maps using personal experience and, existing data.
- Plan the survey route (transect) and observation points (stations) to maximize efficiency in travelling and covering all habitat.
- Plan timing of surveys to coincide with tides and seasons that will show peak numbers, unless surveys are year round.
- Prepare and gather equipment and supplies.
- Organize availability of personnel.
- Prior to the survey, personnel should meet to standardize recording. Team members should review maps of the area.

Sampling Design

- Survey observation points should cover all habitat in a study area.
- Time surveys to coincide with tides and seasons that will show peak numbers, unless surveys are year round.
- Several study areas should be covered each day or part day.

Sampling Effort

- Time requirements dependent mainly on travel time to observation stations. Several study areas should be covered each day or part day.
- Multiple counts are easily feasible and improve the accuracy of estimates.

Personnel

- Observers should be experienced in identifying, aging, and sexing harlequins and keeping records.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Waterproof notebooks, data forms and mechanical pencils.
- 20-60X spotting scope.
- 7-10X binoculars.

Field Procedures

- Scan habitat with binoculars and count visible birds from preselected land-based observation stations or while walking the shoreline (a transect).
- Use the scope to scan more distant areas, to count clusters of birds, and to age and sex birds where possible.
- If birds are flying, note their direction and the time of detection, to avoid double counting. This is especially imprint if counts are occurring simultaneously at other observation stations.
- Check for alpha-numeric coloured leg bands on legs of harlequins that are out of water.
- Record data as birds are observed.

Data Analysis

- Same as for Section 3.4 - Marine Boat Offshore Islands Surveys.

3.6 River Shoreline Surveys (Breeding Pairs/Broods for All Species)

Recommendations: Walking alongside the river may be the most practical method to inventory breeding pairs and find nests and broods, for short rivers or sections of rivers. Walking surveys are recommended at the watershed level scale. For larger and longer rivers, surveys from a watercraft (raft, kayak, etc.) are recommended where navigation is not difficult. Walking and watercraft river surveys are recommended for all species during the breeding season to determine presence/not detected (possible) and relative abundance. Driving on roads that are beside rivers, watching for birds, and stopping to scan at convenient lookouts may also be used if roadside visibility is good. This technique can be used to determine presence for all three riverine species, but can only be used to determine relative abundance for harlequins and kingfishers. Roadside surveys along rivers are recommended at the watershed level scale.

3.6.1 Walking Rivers

Breeding pairs, individuals, or broods of riverine birds can be detected by walking along the shores of rivers. This method has essentially the same assumptions as the line transect method (Emlen 1977). Birds are relatively easily detectable on smaller systems because of the close range of the observer, although they can fly or swim past unnoticed if observers are not constantly watching the river. Riverine birds are constantly moving up and down the river so observers need to note the direction and numbers of birds moving past. Dippers and kingfishers can often be heard before they are seen which increases detection rates. Some rivers are easily walked but many, especially those in rugged terrain, are not. Marked birds can enhance population estimates.

Harlequins are relatively stationary during the pre-laying period and tend to not move very far, or to other rivers (Bengtson 1972). They are still difficult to detect because of their secretive behaviour and Cassirer and Groves (1994) noted that walking surveys under-estimate the number of breeding pairs by 25-35%. Both kingfishers and dippers are territorial, move actively up and down rivers within their territories, and are relatively easily detected.

Walking along rivers is the best method of censusing dippers (Price and Bock 1983). Price and Bock suggest that one person wade if possible, to help locate hiding birds. They also suggest throwing rocks into dense bushes during high waters and pounding ice ledges with poles, as most hiding birds would flush and be detected (Bakus 1959). Note that dippers are polygamous, males may have one or two mates, which confounds estimates of breeding populations.

Kingfishers may nest away from the river if nest sites are limited, so surveyors may miss birds if they are not foraging or resting along the river. During incubation, they are relatively secretive and less detectable. Kingfishers may be most detectable when adults are making frequent trips to the nest to feed nestlings (M.J. Hamas pers. comm.).

Family groups of riverine birds are visible along the river for various lengths of time. Brood counts are feasible for all species but different breeding chronologies mean it will be difficult

to time surveys when all three species will have broods. Brood counts for harlequins have been routinely conducted in many areas (Bengtson 1971; Hunt 1993; Cassirer and Groves 1994). Timing of counts is important if only one survey is to be conducted: brood counts should be conducted when most harlequin females are likely to have broods. Broods have been found in British Columbia between 16 June and early September, with most found from 10 July to 13 August (Campbell *et al*. 1990a).

Local knowledge of rivers and the birds present there is necessary before embarking on labour-intensive walking surveys (R. Ydenberg pers. comm.). Dippers occur in most fast streams with whitewater. Kingfishers prefer slower streams with cutbanks for nesting. Harlequins are patchily distributed in different geographic regions. Helicopter transport to survey areas can greatly increase efficiency when surveying remote locations.

This method is useful for all three riverine species for determining presence, and relative and absolute abundance on short rivers or sections of rivers. If surveys are repeated, then estimates of breeding success and brood survival may be possible.

Advantages

- Counts of breeding pairs/birds may be relatively accurate early in the breeding season.
- Best method of detecting riverine birds on rivers and estimating relative abundance for limited areas, except for harlequins where boat surveys are equally as good (F. Cassirer pers. comm.).
- Can detect, age, and count broods when found.
- Streams not visible from the air or from roads can be surveyed.

Disadvantages

- Timing of surveys is critical. Pairs are most detectable during the early breeding season before egg-laying occurs and, for kingfishers and dippers, after eggs hatch when adults make frequent trips to the nest to feed young, so only a limited time frame is available. Note that the three riverine species have different nesting chronologies, and there are differences with latitude and altitude. Early surveys may contain a significant proportion of transients.
- Labour and time intensive. Can only cover short distances at a time.
- Some streams will not be easily walked, be dangerous to walk, or maybe impossible to walk.

3.6.2 Floating Rivers in Rafts or Kayaks for Breeding Pairs/Broods

Virtually the same technique as above but observers are in boats rather than walking. Breeding pairs can be detected relatively easily, but observations in difficult sections of the river can be impaired by attention being concentrated on getting downstream safely, rather than looking for birds. This method is most feasible in medium-sized rivers where navigation is not difficult. Long distances can be covered, much more rapidly than on foot (D. Genter pers. comm.). Rafting with one person rowing, and one person looking for birds is best.

Advantages

- Can cover long distances quickly.

- Can probably detect most individuals along a river, unless it is very wide, or is difficult to navigate.
- Is an exciting way to conduct a survey, so personnel will be alert.

Disadvantages

- May not be as accurate for kingfishers and dippers as walking.
- Has obvious safety risks.
- Personnel require additional skills like paddling or rowing experience.
- May not be able to stop when needed to check on a sighting, possible nest site, etc.
- Only a small proportion of rivers are suitable.

3.6.3 Roadside Travel Along Rivers

This method involves driving along roads beside rivers, watching for birds, and stopping to scan at convenient lookouts. It is a useful method in situations where sections of river are visible from roads and the route is frequently travelled (i.e., high number of samples). Harlequins, kingfishers, and dippers can all be detected by this method, in that order of efficiency. At normal driving speeds harlequins will stand out more easily than kingfishers, which will be more visible than dippers. Even though all sections of a river may not be visible, an index of relative abundance and/or presence can be determined.

Four potential biases in this method include: 1) river flow rates (which depend on rate of melting and size of snow pack) which may affect distribution of birds on the river, 2) seasonal or temporal effects related to presence and activity of males and females, 3) habitat used for loafing or foraging (i.e., when birds may be most visible) may not occur along sections visible from roads, and 4) timing will affect visibility depending on the extent of deciduous foliage that has emerged. For example, harlequin males may move to mouths of rivers during the incubation period, and may be joined by females in early evening (I. Goudie pers. comm.). Dippers and kingfishers, however, tend to stay within their territories until young fledge.

Assuming that the quality of habitat does not change, then changes in numbers detected can be assumed to indicate changes in population sizes, rather than movements of birds to areas of the river that are not observed. This method is currently being used, in Jasper National Park, for monitoring the number of harlequin breeding pairs along streams that have roads beside them (B. Hunt pers. comm.).

Advantages

- Efficient because data are collected during work for other purposes.
- Cost-effective.
- Useful for long term population trend studies if the entire stream reach used by the birds is visible from the road. Can be combined with walking surveys to cover lengthy rivers.

Disadvantages

- Habitat near roads may have relatively low densities of birds because of disturbance or negative habitat alterations.

- Kingfishers may be more visible along roads with utility lines than elsewhere because they often perch on wires when available.

3.6.4 Procedures

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals (No. 1).*
- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and study areas from maps.
- Select study areas from 1:20,000 or 1:50,000 maps, personal experience and existing data.
- Select streams with relatively high densities of birds.
- Plan the survey route to maximize efficiency in travelling and covering all habitat.
- Survey lines are transects which follow river shorelines and are drawn on maps used for navigation.
- Organize rental of boats if required. Provide training for personnel on boating safety.
- Organize availability of personnel provide training on survey techniques.
- Prior to the survey, personnel should meet to standardize recording. Team members should review maps of the area.
- Prepare maps and data forms/notebooks.

Sampling Design

- Systematic. Follow transect along river shorelines.

Sampling Effort

- Surveys can be conducted once per breeding season. However, if surveys are repeated, more accurate brood counts are obtained and estimates of breeding success and brood survival maybe possible.

Personnel

- Two observers are recommended, mainly for reasons of efficiency and safety.
- Personnel should be familiar with riverine bird identification and behaviour.
- Local knowledge of rivers is necessary before embarking on labour-intensive walking surveys (R. Ydenberg pers. comm.).

Equipment

- Binoculars
- Waterproof notebooks, data forms and mechanical pencils.
- Hiking boots
- Waders with felt soles if wading
- Pack with extra food and survival gear
- For Watercraft surveys: rafts, kayaks and safety gear (Don’t forget your PFD)

- For Driving surveys: vehicle

Field Procedures

Walking Surveys

- Use of helicopters to ferry observers to headwaters or remote streams can increase efficiency for surveys.
- Walk along stream shoreline so that the entire stream and both banks are visible.
- Record numbers and species of birds seen, noting if they fly ahead or behind you so that they are not double-counted later, broods (age young Harlequins according to standard waterfowl criteria (Gollop and Marshall 1954), and nest sites. Mark locations on maps.
- Observers should walk upstream rather than downstream, because harlequin hens with broods are more easily detected this way (D. Genter, B. Hunt pers. comm.).

Avoid disturbing broods.

Watercraft Surveys

- Use of helicopters to ferry observers to headwaters or remote streams can increase efficiency for surveys.
- On rivers, drift downstream and count birds seen, noting the direction they fly off so as not to double count them downstream. Record numbers and species of birds seen, broods (age young Harlequins according to standard waterfowl criteria (Gollop and Marshall 1954), and nest sites. Mark locations on maps.
- Stop when necessary to record data or observe birds.

Roadside Surveys

- Can be combined with walking surveys to cover lengthy rivers.
- Drive on roads that are beside rivers, watching for birds, and stopping to scan at convenient lookouts.
- Record numbers and species of birds seen, noting if they fly ahead or behind you so that they are not double-counted later, broods (age young Harlequins according to standard waterfowl criteria (Gollop and Marshall 1954), and nest sites. Mark locations on maps.

Data Analysis

- For harlequins and kingfishers relative abundance or absolute abundance can be estimated as the number of birds/pairs/broods (N) divided by the length of the stream surveyed (km).
- For dippers, which are polygamous, Price and Bock (1983) developed a formula for estimating density of breeding populations based on adult birds counted in predefined 400 m segments of streams:

$D_i = \Sigma_{j=1,2} (T_j/A_j)P_{ij}$ where

D_i = estimated density in segment *i*;

T_j = the total number of segments occupied by the territory of female $_j$ whose territory included segment $_i$;

A_j = the number of adults in the territory of female $_j$ (2.0 for monogamous and 1.5 for polygamous territories); and

P_{ij} = the proportion of segment $_i$ occupied by the territory of female $_j$

Assumptions for this formula include 1) polygamous males divided their time equally between the territories of the two females and 2) that all parts of a territory were used equally.

3.7 Territory Length Method (American Dipper)

Recommendations: The territory length method is recommended at the watershed level scale for relative abundance and estimating absolute abundance of breeding and, in some cases, wintering dippers (a territorial bird). This technique is best used during walking surveys. Works well on rivers with moderate or high densities of dippers.

Similar to the consecutive flush method for grassland passerines (Wiens 1969), this method involves walking along a river and flushing birds in one direction until they turn around, then flushing them in that direction until they turn around again. This method thus determines the upstream and downstream boundaries of the linear territories of dippers and kingfishers and can be used to estimate densities of territorial birds during the breeding season.

This method has been used successfully with kingfishers (Davis 1982), and dippers (Bakus 1959; Sunquist 1976; Vickery 1990). In British Columbia, however, it offers little benefit for purposes of kingfisher inventory because of the relatively low densities of kingfishers in the province compared to those found by Davis (1982). It may be most useful for estimating absolute abundance of dippers on streams with relatively high densities and where individuals have not been marked. This method is not feasible for harlequins.

Bakus (1959) and Price and Bock (1983) noted that dippers were not always consistent in turning at the edges of their territories. Price and Bock (1983) found that dipper territorial encounters were better indicators, and they chased birds from different directions to induce encounters. Dipper territories range from 400 m to 4 km (Kingery 1996). However, territories of isolated pairs were not easily determined and non-territorial floaters were not accounted for.

Dippers are also territorial on their wintering streams, but their territories are smaller and densities greater than during the breeding season, so this method may also be used in winter. For example, high counts on the Okanagan River included 35 dippers in 1 km or 13 dippers along 100 m of shoreline (Cannings *et al*. 1987). However, there is potential for confusion when flushed birds fly up and down stream.

Advantages

- Provides data on territorial limits which can be used to refine density estimates of breeding populations.
- Especially useful for dippers.

Disadvantages

- Not useful for harlequins as there is no fixed territory, and of little use for kingfishers.
- Possible confusion with floaters or neighbouring birds, unless birds are marked.
- Labour and time intensive.
- Intrusive because birds are flushed repeatedly.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals (No. 1).*
- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and study areas from maps.
- Select study areas from 1:20,000 or 1:50,000 maps, personal experience and existing data.
- Select streams with high densities of dippers.
- Plan the survey route to maximize efficiency in travelling and covering all habitat.
- Survey lines are transects which follow river shorelines and are drawn on maps used for navigation.
- Organize availability of personnel and provide training on survey techniques.
- Prior to the survey, personnel should meet to standardize recording. Team members should review maps of the area.
- Prepare maps and data forms/notebooks.

Sampling Design

- Systematic. Walk transect along river shorelines to encounter birds.

Sampling Effort

- Continue along river until the territory length for each bird encountered has been determined.

Personnel

- Two observers are recommended, mainly for reasons of efficiency and safety.
- Personnel should be familiar with riverine bird identification and behaviour.
- Local knowledge of rivers is necessary before embarking on labour-intensive walking surveys (R. Ydenberg pers. comm.).

Equipment

- Binoculars
- Waterproof notebooks, data forms and mechanical pencils.
- Hiking boots
- Waders with felt soles if wading
- Pack with extra food and survival gear

Field Procedures

- Approach birds encountered and flush up or down stream. Repeat until the bird changes course and flies in the opposite direction.
- Note location it turned around on small scale map.
- Follow bird and flush in opposite direction. Repeat until the bird changes course.

- Note that location on map, and measure distance between the two points. This is the length of the territory.
- Continue along river and determine territory length for each bird encountered.

Data Analysis

- Relative abundance or absolute abundance can be estimated as territorial birds or pairs/kilometre of stream.
- Visual presentation can include maps of territories along the stream.

3.8 Mark/Recapture (All Species)

Recommendations: Mark/recapture studies are recommended for all three riverine species if the objectives are to obtain data on absolute abundance, survival rates, demography, ecology, or behaviour of individuals. Recommended for kingfishers during the breeding season, and for dippers and harlequins for breeding and wintering populations. Mark/recapture is recommended at the local and management unit scales.

Mark-recapture methods have traditionally been used to help estimate population sizes, to determine migratory routes, to study individuals of breeding populations, and to determine individual fidelity to specific sites for many wildlife species (Verner 1985; Bibby *et al*. 1992). This technique has the inherent advantage of allowing population estimates with reasonable confidence limits without having to use expensive and time consumptive traditional census methods. Populations are estimated by using ratios of banded/unbanded birds and estimated annual mortality.

More recently, the estimation of survival rates for different age and sex classes has been feasible with a level of precision (Lebreton 1992). These data are crucial for management purposes, and can only be obtained from marked birds. For example, recent work by I. Goudie in British Columbia, has been linking breeding harlequins from streams in the Coast Range, southern interior, and Rocky Mountains with wintering sites in the Strait of Georgia.

In general, birds are captured in traps, then routinely aged, sexed, measured, and banded. Birds are marked using relatively permanent metal (usually aluminium) bands. Coloured tarsal bands, patagial tags, nasal saddles, and/or radio transmitters are also used to allow individual identification. Birds are "recaptured" by physically recapturing them, or by identifying them at a distance by their colour bands or other markers, or by detecting a radio signal. Statistical analyses are needed to process the data collected on "recaptures" in order to determine the probabilities of detection of a banded bird. These methods are now available through standard computer software. For discussions on statistics appropriate for mark-recapture studies consult Pollock *et al*. (1990) and Lebreton *et al*. (1992).

It is practical for harlequins, dippers, and kingfishers to be trapped and banded. During the past few years, there has been an extensive banding program for harlequins in the Pacific Northwest (I. Goudie pers. comm.). Alpha-numeric coded, colour tarsal bands have proven effective in allowing identification of individual harlequins at moulting and winter haulout sites and on breeding streams. Currently, there are a significant number of known-aged birds present on wintering and breeding areas and there are good opportunities for estimating survival rates and population trends. Regional wintering populations can now be estimated by comparing ratios of banded and unbanded harlequins at winter haul-out sites, especially where large numbers have been banded (e.g., Strait of Georgia).

It is practical to use mark/recapture techniques to inventory breeding populations at the watershed level, but is impractical at larger scales unless a massive banding effort is undertaken.

Little inventory or research has been conducted on dippers or kingfishers in British Columbia. Banding programs would be useful for surveys of breeding populations of both species, and wintering populations of dippers. Dippers do use traditional roost sites at night

(Ormerod and Tyler 1990), and there is considerable potential for mark-recapture studies because they can be easily trapped and are a highly visible species. Dippers are usually banded with colour, alpha-numeric tarsal bands, as the legs of dippers are usually very visible to observers, especially when dippers perch on rocks or logs.

Kingfishers can be tempted to attack taxidermy mounts of kingfishers with playback calls during the breeding season (Davis 1980), which would facilitate capture in mist nets. Marking generally includes "painting" of wing feathers with various unique combinations of colour to identify individuals (Davis 1980). The legs of kingfishers are rarely visible, even when perched, so marking of the wings is the most appropriate technique.

Advantages

- This is the only method suitable for determining survival rates, juvenile recruitment, and fidelity to breeding and wintering areas.
- Is a superior technique for estimating absolute abundance.
- Once the birds are captured, considerable additional data can be collected: morphometrics, moult, age, sex, body fat, blood samples, etc.
- Dippers can be captured with mist nets while trapping breeding harlequins.

Disadvantages

- The capture of birds requires trained personnel and is time and labour intensive.
- A large number of birds have to be banded and resighted before statistically useful data on recaptures can be obtained.
- Capture is stressful to the birds, and potentially dangerous if done by inexperienced personnel.
- Data analyses are complex and require 2-3 years of data.
- Capturing of harlequins at sea from small boats and kayaks, and weather changes pose safety risks to personnel.
- May be too intensive for needs of inventory studies.

Before conducting a mark/recapture survey ensure that mark/recapture data are necessary to meet the objectives of the inventory program, and justify the effort required to obtain necessary permits.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals (No. 1).* Be sure you are also familiar with the manual, Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians, and Reptiles.
- Obtain relevant maps for project area (e.g. Nautical charts, 1:50 000 air photo maps, 1:20 000 forest cover maps, 1:20 000 TRIM maps, 1:50 000 NTS topographic maps).
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for project and survey areas from maps.
- Select survey study areas, from 1:20,000 or 1:50,000 maps, personal experience and existing data.
- Plan the survey route to maximize efficiency in travelling and covering all habitat.

- Organize availability of personnel and provide training on survey techniques.
- Prior to the survey, personnel should meet to standardize recording. Team members should review maps of the area.
- Obtain necessary capture, mist netting, and banding permits from Canadian Wildlife Service (CWS).
- Acquire mist nets, banding supplies, bands, and traps as necessary.
    - Mist nets, poles, and measurement tools can be ordered from:
        - Avinet, Inc. PO Box 1103, Dryden, New York, USA, 13053-1103. and
        - AFO Mist Net Sales, Manomet Bird Observatory, PO Box 936, Manomet, MA, USA 02345.

          Ask the suppliers for appropriate sizes of nets, poles, bands, and tools.
    - For information on banding protocol contact the Bird Banding Office, Canadian Wildlife Service, Hull, Quebec, K1A 0H3.
    - To order coloured bands for dippers and kingfishers contact:
        - A.C. Hughes, 1 High St., Hampton Hill, Middlesex, England, TW12 1NA or
        - Avinet Inc.
    - For alpha-numeric bands for harlequins contact:
        - Harlequin Duck Working Group (Ian Goudie, CWS-Delta, B.C.), or
        - Protouch Engraving, Saskatoon, SK.
- Prepare banding data forms or notebooks as required.
- Plan survey times and areas well in advance. Male Harlequins are best trapped from late July through early August; females and young of the year on rivers in August through early September; moulting females in mid to late September on the coast; breeding pairs on rivers in late April to early May.
- Obtain permission to access private or restricted areas if necessary.
- It is extremely important to inform local residents of plans to trap birds when these areas are near human settlements, to avoid negative publicity.

Sampling Design

- Set up nets perpendicular to expected flight paths, preferably around a corner to reduce the chance of birds detecting the net.

Sampling Effort

- A large number of birds have to be banded and resighted before statistically meaningful conclusions can be obtained from recaptures.

Personnel

- Personnel required depend on the scale of the survey and numbers of birds to be captured. Six people are recommended.
- All personnel should be thoroughly familiar with the Live Animal Capture and Handling Guidelines manual (although it is worth adding that literary review is no substitute for experience).

- The team should be led by a Registered Professional Biologist, or experienced waterfowl biologist, with extensive experience in banding, trapping, and mist net procedures. All others must be supervised and trained in handling of birds, techniques to extract badly entrapped birds from mist nets, banding techniques, and record-keeping.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Mist nets, net poles, string, pole anchors, drive traps (for moulting harlequins),and other traps as required
- Holding bags or sacks
- Small scissors
- Measuring implements (Pesola scale, calipers)
- USFWS leg bands, alpha-numeric colour leg bands, banding pliers, specialized markers if needed
- Waterproof notebooks, data forms and mechanical pencils.
- Special equipment for moulting and wintering harlequins include ocean kayaks (usually for 5 crew members), 1 small motor-driven craft, wetsuits, and a spotting scope to read bands.

Field Procedures

Note: For capture techniques, refer to Section 5.0.

Sites where nets/traps are placed are referred to as Capture Stations.

Riverine areas

- Set up nets perpendicular to expected flight paths, preferably around a corner to reduce the chance of birds detecting the net.
- Station a hidden observer near the net.
- Retrieve captured birds as soon as possible after they enter the net.
- Put birds in holding bags, one bird per bag, until all captured birds are removed from nets. Have one person watch the bags.
- Process birds in order of capture.
- Record species, sex, age, measurements, band number, and colour band combinations on data forms. Band the bird and record band number before measurements are taken in case it escapes. Standard measurements include weight, wing chord, tarsus, and culmen.
- Band with aluminium band first, then colour bands.
- Seal plastic bands with the appropriate solvent.
- Release birds as they are processed, except release pairs together, and hen and brood together.

Harlequins at sea

- Reconnaissance of study areas to see if birds are present is required before setting up traps (minimum of 30 birds is suggested).
- Trap should be positioned near concentrations so that flocks can be driven en masse into the trap.
- Orientation of the trap is important: when the birds are being driven into the "wings" they should see a background of water rather of land.
- Beaches with small to medium-sized boulders are useful for erecting drive traps for harlequins.
- Use the same handling, banding, and measurement procedures as listed for riverine areas. For large captures, birds can be released in groups of 4-6.

Data Analysis

- See Lebreton *et al*. (1992) for SURGE analysis of survival rates of marked populations. Obtain software from the Canadian Wildlife Service (CWS) or Simon Fraser University (SFU) website (http://www.biol.sfu.ca/cmr/).
- A simple and coarse estimate of populations of wintering harlequins (n) at specific sites can be made using the following formula, based on resightings of banded birds:

$$N = \frac{n \times N'}{n'}$$

where N = population

n = number initially marked and released

n' = number of marked birds resighted

N' = number observed in the sample

- For a more advanced analysis and measure of variance:

$$N \text{ (population estimate)} = \frac{(N_1 + 1)(N_2 + 1)}{(M_2 + 1)} - 1$$

where N_1 = initial number of marked birds

N2 = number of marked and unmarked birds in subsequent sample

M_2 = number of marked birds in the subsequent sample

4. HOW TO DETERMINE BREEDING STATUS OF RIVERINE BIRDS

Data on breeding populations can be collected either indirectly (behaviour of adults) or directly (nests, eggs, or young).

4.1 Harlequin Duck

Harlequins form pairs on winter grounds and arrive in spring on the nesting rivers. All pairs detected should be considered to be potential breeding pairs. Harlequin populations have a sex ratio significantly skewed to males. Unpaired males are often present in proximity to pairs. Nests can be found by watching from a blind as females go to the nest to lay eggs, by systematic searches of river banks, tree cavities, and canyons, by using pointing hunting dogs to detect incubating females, or by radio-telemetry tracking of females. However, nests are very difficult to find and generally should not be searched for because of the danger of abandonment and the very high cost/benefit ratio related to inventory.

Broods are reasonably visible after they leave the nest. Brood counts are useful in estimating populations but significant proportions of pairs defer breeding in any given year (e.g., mean = 0.44 in Iceland, Bengtson 1972). In some years young survival during the first week is very poor, so broods may not be found if surveys occur after mortalities. Females are not known to renest (Goudie *et al*. 1994a).

4.2 American Dipper

Dipper nests can be found, but many may be in inaccessible places. Searches for nests should be concentrated along canyon walls, rock bluffs, bridges, log jams, boulder piles, and high cut gravel banks of nesting streams. Nests are most easily found during the construction phase (late March through mid April depending on region) and when parents are feeding young in the nest. Watch for birds flying back and forth and follow them to their origin. Observers may need to hide when close to the nest because dippers can be wary of going to the nest when being observed.

4.3 Belted Kingfisher

Kingfishers nest in excavated cavities in river banks or lake banks, where they burrow into soft sedimentary material. Nest burrows are usually easily spotted but, at times, the entrance hole may be partially obscured by overhanging roots or located a considerable distance from water. Active burrows are best identified by the presence of adults and the presence of fresh markings around the entrance hole: the shuffling feet of the kingfisher leaves a distinctive set of two grooves along the bottom of the burrow. Unused or old burrows will likely have had the grooves sloughed away by rain or wind. Kingfisher entrance holes are several times larger than bank-nesting swallow burrows, but natural holes may be confusing at times. Some burrows are used for roosting. Although one or more burrows may be present in a territory, only one will be used for nesting in a given year.

5. CAPTURE TECHNIQUES

Birds are usually captured so that they can be banded and/or marked, and to gather information on physiological condition and morphometrics. Banded birds then allow biologists to gather more detailed information on population sizes and demographics than is possible with other methods. Capturing of birds for inventory purposes must be carefully rationalized, as capture can be stressful or injurious to individual birds and the value of marking individuals should be high.

Special banding permits must be obtained from federal (Canadian Wildlife Service) and/or provincial (Ministry of Environment, Lands and Parks) agencies, and workplans must undergo a peer and veterinary review or obtain the approval of an animal care committee. It is very important that efforts to explain capture activities to the public are made to reduce negative reaction. It is equally important to obtain permission to enter private property, ecological reserves, and other restricted areas.

5.1 Capture of Moulting Harlequin Ducks at Sea

Capture of harlequins must be supervised by trained professional biologists who have been issued capture and banding permits from the Canadian Wildlife Service (CWS). Harlequins use traditional sites for moulting and can be most easily trapped at this time in late summer when they are flightless. Birds are best captured by drive-trapping: several kayaks and a motor-driven canoe (6 boats are ideal) "drive" swimming birds into a double-winged drive trap with one-way access (Figure 2). This method has been used to trap hundreds of birds in the Strait of Georgia (I. Goudie pers. comm.).

Important points to consider include: proximity to access for boat launching, local weather conditions and exposure, strength of tidal currents, shoreline topography, wave action, other human disturbance factors, and safety for trapped birds.

Mortality of trapped birds must be minimized. This can be best accomplished by watching for birds getting caught in a net and possibly drowning and trapping only as many birds as can be handled promptly by the crew. Avoid trapping during adverse conditions. Capture mortality for harlequins is <1% in the Strait of Georgia (I. Goudie pers. comm.).

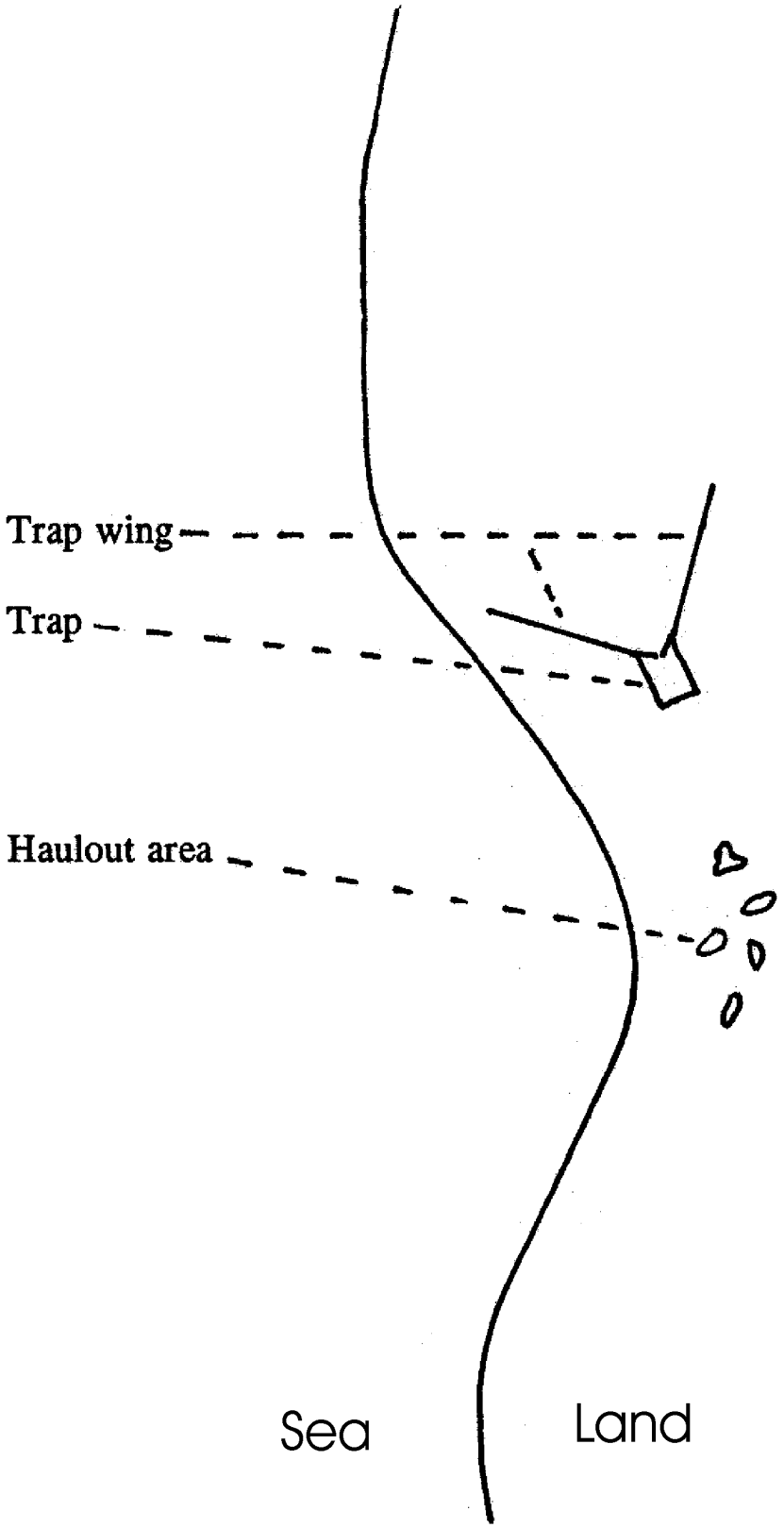

Figure 2. Possible position for a drive trap to capture harlequin ducks at sea.

5.2 Capture of Breeding Riverine Birds

Riverine birds can be trapped on nesting streams by stringing mist nets across streams or shorelines. Note that an additional permit from Canadian Wildlife Service is required for mist-netting birds. This method is most feasible on smaller streams, or larger streams that are shallow and not too turbulent, because birds must be immediately retrieved from nets to avoid drowning. Dippers and kingfishers can be captured with nets with 40-50 mm mesh. Larger (100 mm); heavier gauge mesh is required for harlequins, but will also catch the other species.

For harlequins, mist-netting must occur before males abandon their mates and return to the coast (after incubation begins). Harlequins are not easily trapped when swimming, although they can be flushed into traps, so traps should be set where birds are most likely to be flying. Mist nets should be set-up downstream of observed birds. Ideally, a passive setup is best which intercepts birds as they ascend the watershed in spring. Localized hen and brood captures is possible in late summer.

For dippers, nets can be strung perpendicular to the shorelines that they use for foraging, or on their approach routes to their nest sites. Dippers can also be captured at night at roost sites. There, when using a flashlight, they can be picked up by hand (Ormerod and Tyler 1990). Although they do not often roost communally, this method is an alternative to netting, especially where they roost under bridges. Young dippers in nests should not be handled because of their tendency to abandon the nest prematurely when disturbed (Price and Bock 1983). Young dippers can be captured in mist nets after they fledge.

For kingfishers, mist nets can be strung perpendicular to shorelines where they tend to fly, near hunting perches, or on approaches to their nesting burrows. Several traps have been designed to capture cavity-nesting birds like woodpeckers and swallows and some of those traps can be used to capture kingfishers at their burrows (Rendell *et al*. 1990; Jackson and Parris 1991). For a review of mist-netting techniques see Keyes and Grue (1982) and Bleitz (no date, distributed by Avinet, Inc.).

Glossary

ABSOLUTE ABUNDANCE: The total number of organisms in an area. Usually reported as absolute density: the number of organisms per unit area or volume.

ACCURACY: A measure of how close a measurement is to the true value.

ALPHA-NUMERIC BANDS: Plastic bands that have visible numbers and letters embedded so that individual birds can be identified when bands are placed on them.

BIODIVERSITY: Jargon for biological diversity: the variety of life forms, the ecological roles they perform, and the genetic diversity they contain (Wilcox 1984 cited in Murphy 1988).

BLUE LIST: Includes any indigenous species or subspecies (taxa) considered to be Vulnerable in British Columbia. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not extirpated, endangered or threatened.

CRYPTIC: Difficult to distinguish from the surroundings.

DISJUNCT: Populations that are geographically separated, with no intermixing, are said to be disjunct.

FIDELITY: Site fidelity is the tendency to return to the same place.

FLEDGING: The maturation of a young bird until it becomes independent of its parents.

HAUL-OUT SITE: Rocky islets where moulting and resting harlequins roost on land.

HOLARCTIC: Distributed in both North America and Eurasia.

LINE TRANSECT: Census method where an observer walks a predetermined route and counts all the birds in view. Population index is calculated as birds/kilometre.

MIGRANT: A species that passes through British Columbia during spring and/or autumn migration.

MORPHOMETRICS: Body measurements such as weight, length, wing chord, etc.

POLYGAMOUS: A mating system where males may have more than one mate.

PRECISION: A measurement of how close repeated measures are to one another.

PRESENCE/NOT DETECTED (POSSIBLE): A survey intensity that verifies that a species is present in an area or states that it was not detected (thus not likely to be in the area, but still a possibility).

PROJECT AREA: An area, usually politically or economically determined, for which an inventory project is initiated. A project boundary may be shared by multiple types of resource and/or species inventory. Sampling generally takes place within smaller study areas within this project area.

RADIO-TELEMETRY TRACKING: Monitoring movements of individuals that have been fitted with radio transmitters.

RANDOM SAMPLE: A sample that has been selected by a random process, generally by reference to a table of random numbers.

RELATIVE ABUNDANCE: The number of organisms at one location or time relative to the number of organisms at another location or time. Generally reported as an index of abundance.

RED LIST: Includes any indigenous species or subspecies (taxa) considered to be Extirpated, Endangered, or Threatened in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. Red-listed taxa include those that have been, or are being, evaluated for these designations.

REACH: A section of river.

RECRUITMENT: The proportion of young that survive to breed.

RELATIVE ABUNDANCE: This level of survey intensity requires inventory techniques to provide indices of population sizes that are comparable between similar sites and species or within species over time.

SEA DUCK: Duck species that spend most of their annual cycle at sea, such as scoters, eiders, oldsquaw, and harlequin duck.

SEX RATIO: The proportion of males to females in a flock or population.

STRATIFICATION: The separation of a sample population into non-overlapping groups based on a habitat or population characteristic that can be divided into multiple levels. Groups are homogeneous within, but distinct from, other strata.

STUDY AREA: A discrete area within a project boundary in which sampling actually takes place. Study areas should be delineated to logically group samples together, generally based on habitat or population stratification and/or logistical concerns.

SURVEY: The application of one RIC method to one taxanomic group for one season.

SYSTEMATIC SAMPLE: a sample obtained by randomly selecting a point to start, and then repeating sampling at a set distance or time thereafter.

TRANSIENTS: Migrants or birds that are passing by.

YELLOW-LISTED SPECIES: Any native species which is not red- or blue-listed.

WINTER: Typically December to February. Species that have been recorded in British Columbia during this period are said to winter in the province.

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