Inventory Methods for Colonial-Nesting Freshwater Birds:

Eared Grebe, Red-Necked Grebe, Western Grebe, American White Pelican, and Great Blue Heron

Standards for Components of British Columbia's Biodiversity No. 8

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Preface

This manual presents standard methods for inventory of Colonial-Nesting Freshwater 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:

Species Inventory Unit
Wildlife Inventory Section, Resource Inventory Branch
Ministry of Environment, Lands & Parks
P.O. Box 9344, Station Prov Govt
Victoria, BC V8W 9M1
Tel: (250) 387 9765

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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:

The Executive Secretariat

Resources Inventory Committee

840 Cormorant Street

Victoria, BC V8W 1R1

Tel: (250) 920-0661

Fax: (250) 384-1841

http://www.for.gov.bc.ca/ric

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, *Standardized Inventory Methods for Components of Biodiversity in British Columbia: Colonial-nesting freshwater birds*, prepared for the Resources Inventory Committee by Michael G. Shepard and John M. Cooper, with reviews by Tom Ethier and James Clowater, technical assistance from Wayne Campbell, logistical support from Cynthia Shepard, and Dianne Cooper, and editorial assistance by Ann Eriksson. Personal communications were kindly provided by Rob. W. Butler, R. Wayne Campbell, and James Clowater.

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

In British Columbia, colonial-nesting freshwater birds are familiar and important parts of our avifauna. Five species of colonial-nesting birds are discussed in this manual: Red-necked Grebe (B-RNGR, *Podiceps grisegena*), Eared Grebe (B-EAGR, *Podiceps nigricollis*), Western Grebe (B-WEGR, *Aechmophorus occidentalis*), American White Pelican (B-AWPE, *Pelecanus erythrorhynchos*), and Great Blue Heron (B-GBHE, *Ardea herodias*).

Red-necked Grebes are widespread breeders in the interior and common along the coast during winter. Eared Grebes are relatively inconspicuous birds that breed in shallow interior marshes, in very large colonies at some sites, and winter mainly in the United States. Western Grebes breed at four sites in British Columbia, but are very abundant in the southern Strait of Georgia during winter. The American White Pelican, a highly recognizable species, is seldom seen in British Columbia, except in the Chilcotin where it breeds. The Great Blue Heron nests in trees and forages mainly along intertidal areas, edges of freshwater marshes, ditches, and grassy fields. It is a highly recognizable species and most populations exist in areas with high levels of human development (*e.g.*, in valley bottoms and along lake, river, and marine shorelines).

Disturbance by human activities poses a significant threat to these species, especially during the breeding season. Because of the concentration of nests at one site, a single event can affect an entire population at one time. Untimely visits to colonies can allow predation of eggs or young by gulls and corvids, or chilling or overheating of eggs which reduces hatching success. Severe disturbances can result in complete reproductive failure.

In addition, habitats of colonial nesters are threatened by development, disturbance, and pollution. Wetlands near cities and towns continue to be drained for residential, industrial, or agricultural expansion. Other wetlands can be so heavily used for recreational purposes as to discourage use by these species. Stands of mature trees used for nesting by Great Blue Herons are often as attractive to loggers and developers as they are to herons.

The species in this manual are all at, or near, the top of the food chain, and can suffer from concentration of organochlorines and heavy metals, which may reduce reproductive success. All three grebes, especially the Western Grebe, and the Great Blue Heron are vulnerable to marine oil spills. Because of threats to their habitat, their vulnerability due to seasonal concentration, and their sensitivity to disturbance, American White Pelican and Western Grebe are listed on the British Columbia Red List as Endangered and Threatened, respectively, and Great Blue Heron is listed on the Blue List as Vulnerable (B.C. Wildlife Branch 1993).

The inventory and monitoring of these species is important because of the fragile nature of their habitat and populations. This inventory manual is one of many manuals being developed for all wildlife and plant taxa in British Columbia by the Resource Inventory Committee. These manuals are intended to provide standard methods for the collection of data on populations. The purpose of this manual is to provide protocols for inventory at three levels of survey intensity: presence/not detected (possible), relative abundance, and absolute abundance.

2. INVENTORY GROUP

This section includes a brief overview of the biology and distribution of each member of the inventory group. This information is taken primarily from Campbell *et al*. (1990). Table 1 lists the location and size of major British Columbia colonies of each species. Also included in this section is a discussion of species-specific factors to consider when developing survey programs.

2.1 Red-necked Grebe *Podiceps grisegena*

Biology

The Red-necked Grebe is a widely distributed and fairly common breeder in marshes and lakes in the interior of British Columbia. Breeding populations are highest in the Central Interior, Southern Interior, and Peace Lowland. In winter, it is widely and sparsely distributed along most of the coast and on open waters of the Southern Interior and Southern Interior Mountains. It is most abundant during migration and in winter in shallow bays and estuaries along the coast (Campbell *et al.* 1990).

Red-necked Grebes breed in shallow marshes or in areas of emergent vegetation along the edges of lakes. They are loosely colonial, with nests usually well spaced along the edges of emergent vegetation. Nests are soggy, floating platforms constructed of aquatic vegetation, and attached to stems of bulrush or cattail. Clutch sizes range from 3-6 eggs, but only 1 or 2 young are usually produced each year (Campbell *et al.* 1990).

Factors to consider for inventory of Red-necked Grebes

- In the breeding season, this species is widely distributed, with most nesting wetlands having only a few pairs. Unlike Western and Eared Grebes, monitoring all or a majority of populations is not feasible.
- The tendency of grebes to dive at the close approach of aircraft and boats may increase the difficulty in making accurate counts.
- Red-necked Grebes are so widespread along the coast in winter that there is great potential to make use of high-use areas, currently surveyed for other waterbirds, for long-term monitoring programs, with occasional coast-wide surveys to monitor general usage of the province's coastline. Although this grebe does not occur in large flocks, areas with large numbers of scattered individuals include the Gulf Islands, Boundary Bay, Sidney shoreline, and various bays and sounds on the mainland and Vancouver Island.
- During migration, this species may have coastal staging areas (locations where it gathers for short periods, either before or during migration) that are different from primary winter areas. Some of these locations remain to be identified. Coastal surveys conducted over the migration and wintering period (mid-August to mid-May) would be useful to detect areas of concentration.
- Direct censusing of nest and nest contents during visits to colonies should be restricted to the period before hatching takes place, so that most pairs are represented by nests.

2.2 Eared Grebe *Podiceps nigricollis*

Biology

The Eared Grebe is a widely distributed bird in the interior of British Columbia from spring through fall, with numerous, but discrete, breeding areas. Breeding populations are highest in the Central Interior and the Peace Lowland. Most Eared Grebes winter south of British Columbia, although a few remain in the south interior and along the southern coast, particularly in the Gulf Islands (American Ornithologists' Union 1983; Breault *et al.* 1988; Campbell *et al.* 1990).

Eared Grebes nest mainly in tight, compact colonies on sheltered freshwater marshes, lakes, ponds, and sewage lagoons. Nests are usually platforms placed in stands of bulrushes, sedges, cattails, and other emergent vegetation. Clutch sizes range from 3-8 eggs. Data on success rates are confounded by mixing of broods from different nests (Campbell *et al.* 1990).

Factors to consider for inventory of Eared Grebes

- At breeding colonies, disturbance caused by human visitors may negatively affect breeding success if incubating birds are put off their nests frequently.
- Direct censusing of nests and contents during visits to colonies should be restricted to the period before hatching takes place, so that most pairs are represented by nests with eggs. Detailed counts are probably not necessary each year - major colonies can be surveyed intensively every 3-5 years to monitor population sizes.
- In winter, Eared Grebes are very localized in distribution, occurring mainly in the Gulf Islands, particularly Ganges Harbour (Campbell *et al*. 1990). They can only be identified by careful examination through binoculars or spotting scope, because of the similarity of their winter plumage to Horned Grebes.

2.3 Western Grebe *Aechmophorus occidentalis*

Biology

The Western Grebe is widely distributed in the southern half of British Columbia. As a breeding bird, it is currently restricted to four colonies (Table 1). From fall through spring, concentrations of this species can be found on nearshore marine waters in the southern Strait of Georgia, and on large lakes in the southern interior. Western Grebes winter commonly on the south coast with concentrations at Boundary Bay, Burrard Inlet, Iona Island, Mill Bay, Saltspring Island, Deep Bay, Comox, and Campbell River. Very large concentrations occur in areas in March where Pacific Herring spawn (*e.g.*, Barkley Sound, Nanoose Harbour, Qualicum Beach). Little is known of their migration routes (Campbell *et al*. 1990).

Western Grebes usually nest in stands of bulrushes or cattails, in water deeper than that used by Red-necked and Eared Grebes. Nests are soggy, floating platforms of aquatic vegetation and sticks. Clutch sizes range from 3-7 eggs. Most pairs probably raise two young (Campbell *et al*. 1990; Storer and Neuchterlein 1992).

Factors to consider for inventory of Western Grebes

- At breeding colonies, human disturbance can be detrimental to Western Grebe breeding success. In direct censusing of nests and contents, colony visits should be restricted to the period before hatching takes place, so that most pairs will be accounted for by nests with eggs. Some pairs will not be accounted for because nests have been lost through weather or predation. Counts of adults present will help determine the total number of birds that are probably breeding. Detailed counts are probably not necessary each year, but it is recommended that colonies be carefully surveyed every three years because of declining numbers of colonies in British Columbia (Burger 1991). Annual estimates of populations should be made (from a distance) of the number of pairs using the major colonies.
- Unlike for Red-necked and Eared grebes, wintering Western Grebes can be easily surveyed from aircraft.
- Western Grebes return to favoured wintering areas each year. Annual monitoring of these areas is recommended.
- Winter flocks tend to disperse during the late afternoon and reform the next morning. Counts are best made between about 1030-1400 hours (J. Clowater pers. comm.).

2.4 American White Pelican *Pelecanus erythrorhynchos*

Biology

The American White Pelican is a summer visitant in British Columbia. In this province, it is very local in distribution and breeds at only one site, Stum Lake about 25 km northeast of Alexis Creek. In summer, it forages over a wide area in the Chilcotin Plateau. Migration occurs mainly in a narrow interior corridor including parts of the Nicola and Okanagan valleys. Elsewhere in the province, it is only rarely recorded (Dunbar 1984; Campbell *et al*. 1990).

American White Pelicans nest on bare, rocky outcropping islands at Stum Lake. Nests are untidy mounds of dirt, sticks, reeds, and debris, or are mere depressions in sand or gravel. Most clutches contain 2 eggs and 1-2 young fledge. However, nest success is extremely variable (Dunbar 1984; Campbell *et al.* 1990).

Factors to consider for inventory of American White Pelicans

- Inappropriate timing of visits to the colony at Stum Lake may result in breeding failure.
- The species is sufficiently rare in the province that annual monitoring is recommended (see Table 1).

2.5 Great Blue Heron *Ardea herodias*

Biology

The Great Blue Heron is resident along much of the coast. Although widespread in British Columbia, the Great Blue Heron occurs as a nesting species primarily in the Southern Interior and Georgia Depression (Forbes *et al.* 1985; Breault 1988; Campbell *et al*. 1990). In winter, it is rare to uncommon except in the Georgia Depression where it is common.

Great Blue Herons are arboreal nesters and colonies are typically situated in mature forests that are relatively free from disturbance by human activities and near suitable foraging areas (Butler 1991, 1992). Nests are large stick platforms, mostly 15 to 30 m above ground. Clutch sizes range from 3-8 eggs. In successful nests, 2-3 young usually fledge (Campbell *et al.* 1990; Butler 1992).

Factors to consider for inventory of Great Blue Herons

- Colonies can be difficult to census as they are often high up in trees, dispersed in a few or many trees, and obscured by vegetation. To accurately count active nests, it may be necessary to climb trees; however this should only be done by a professional arborist.
- For surveys of intertidal foraging areas, tidal cycles need to be considered when choosing survey times, and analyzing data. Herons tend to use intertidal areas at low to medium tides and are rarely present on the foreshore at high tides.

Table 1. Location and maximum counts of nesting colonies (data from Campbell *et al.* 1990)

Species	Locality	Maximum # pairs or nests
Red-necked Grebe	Stump Lake	64
	Charlie Lake	62
	Swan Lake (Vernon)	55
	Duck Lake (Creston)	55
Eared Grebe	Cecil Lake	1000
	Little White Lake	590
	Boundary Lake	500
	Westwick Lake	469
	McMurray Lake	440
	Elkhorn Lake	205
	Boudreau Lake	185
	Rock Lake (Riske Creek)	173
	Lake 6 (Williams Lake)	81
	Meadow Lake	79
	Lake 8432 N (Williams Lake)	72
	Stump Lake	61
	Sorensen Lake	50
	Dry Lake (Hanceville)	50

Western Grebe	Duck Lake (Creston)	90
	Okanagan Lake, north arm	83
	Shuswap Lake (Salmon Arm)	65
Great Blue Heron	University of British Columbia	183
	Port Coquitlam Indian Reserve	169
	Gabriola Island	138
	Salwein (Chilliwack)	130
	Duck Lake (Creston)	122
	Central Saanich	87
	Denman Island	70
	North Alouette River	65
	Parson	60
	Shoal Islands	60
	Edgewater Bar	59
	Prevost Island	59
	Stanley Park	44
	Brisco	40
	Beacon Hill Park	40
	Fairmont	35
	Sechelt	35
	Goat River (Creston)	33
	Otter Lake (Vernon)	25
	St. Mary's River	25
American White Pelican	Stum Lake	152

3. PROTOCOLS

The recommended methods and sampling designs for inventory of colonial-nesting freshwater birds in British Columbia are summarized in Table 2. A protocol for each of the recommended methods is provided in this section.

Table 2. Summary of recommended methods for inventory of colonial-nesting freshwater birds in British Columbia at three levels of intensity.

	Recommended Method(s) Note: where more than 1 method is given, methods are listed in order of economy and logistical ease.		
Species	**Presence / Not Detected**	**Relative Abundance**	**Absolute Abundance**
Red-necked Grebe	Breeding - Aerial surveys or ground-based surveys	Breeding - Ground-based surveys Wintering - Ground-based surveys or boat transects	Breeding - Direct counts of nests combined with ground-based surveys in adjacent marsh Wintering - Ground-based surveys or boat transects
Eared Grebe	Breeding - Aerial surveys or ground-based surveys	Breeding/wintering - Ground-based surveys	Breeding - Direct counts of nests combined with ground-based surveys in adjacent marsh Wintering - Ground-based surveys or boat transects
Western Grebe	Breeding/wintering- Aerial surveys or ground-based surveys	Breeding - Ground-based surveys Wintering - Ground-based surveys or boat transects or aerial surveys	Breeding - Direct counts of nests combined with ground-based surveys in adjacent marsh. Wintering - Ground-based surveys or boat transects or aerial surveys
American White Pelican	Breeding: Aerial surveys for lakes in Chilcotin	N/A	Breeding - Boat transects on Stum Lake and aerial surveys for foraging on adjacent lakes
Great Blue Heron	Non-breeding - Aerial surveys in open areas or ground-based surveys	Breeding/non-breeding - Ground-based surveys or aerial surveys	Breeding - Direct counts of nests Intertidal foraging - Ground-based surveys Open areas - Aerial surveys

3.1 Sampling Standards

The following standards are recommended to ensure comparison of data between surveys, and to mitigate several sources of common bias. Individual protocols include standards which are applicable to a specific method.

3.1.1 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 a generic but useful description of approaches to habitat data collection in association with wildlife inventory, consult the introductory manual, *Species Inventory Fundamentals* (*No.1).*

3.1.2 Common errors and biases

The goal of most survey designs is to obtain precise and accurate estimates of numbers. An estimate that is free of random errors is said to be precise. This can be improved by increasing sample size, standardizing methods and having censusers of similar experience and training. 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. 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.

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 this reason, be sure to record ground speed as well as the time started and finished for each survey (as indicated on the RIC dataforms).

Time of day

Variation in activity levels and behaviour throughout the day often causes change in the detectability of bird species, which may result in a time-of-day effect that biases the results of counts (Shields 1977; Rollfinke and Yahner 1990). For this reason, it is important to relate sampling to time of day as indicated on the RIC dataforms.

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.

Bird density

Accurate counts of birds may be possible when the numbers of birds are not large. However, when numbers increase, estimation techniques have to be used and these have much larger errors than direct counts.

Observability/visibility bias

Not all birds have the same observability. Factors that contribute to variability include:

- size of the bird (small grebes);
- behaviour (*e.g.,* tendency to dive (grebes) or fly away (B-AWPE and B-GBHE) from observer, whether or not the species flocks, tendency to hide in vegetation);
- colouration of bird - many species blend well into their surroundings, making them difficult to detect; and
- atmospheric and light conditions affect the ability of the observer to detect birds: factors such as heat haze, glare, precipitation, cloud cover, wind direction and wind speed can all contribute to bias.

3.1.3 Disturbance of birds during surveys

Colonial-nesting birds, especially American White Pelicans, Great Blue Herons, and Western Grebes are vulnerable to disturbance at colonies. Some colonies of Great Blue Herons are acclimatized to routine human activities (*e.g*., Stanley Park, Vancouver and Beacon Hill Park, Victoria), but others are not. For example, at Quamichan Lake (Duncan), in the most sensitive of nine heronries studied, adult herons flew from their nests, when a human observer approached within: a) 200 m before eggs had been laid; b) 100 m after eggs had been laid; and c) 10 m after chicks were present (Butler 1991). Butler (1991) recommended a 300 m buffer zone around heronries with no human activity during the breeding season.

American White Pelicans are extremely sensitive to overflights of aircraft at their nesting colonies (Bunnell *et al.* 1981). Direct counts of nest contents are also not recommended. Pelicans tend to flush excitedly into the water and then fly off. Such disturbance can cause delays in egg-laying or loss of eggs and/or young through chilling or overheating. This effect can also occur if the nesting islands are approached by humans in boats. Pelicans incubate eggs with the bottoms of their feet (Johnsgard 1993), so eggs maybe broken if incubating birds are flushed suddenly (Dunbar 1984). If people land on the nesting islands during the incubation period, or if incubating pelicans are put off their nests repeatedly by human visitors *(e.g.,* fishermen) then abandonment of nests can occur (Campbell *et al*. 1990). For example, human disturbance caused abandonment of all 130 American White Pelican nests at Stum Lake during 1986 (Campbell *et al.* 1990). Visits to the colony should be restricted to times when young pelicans are to be banded. Banding programs should be carefully rationalized and planned to maximize data gathering potential and minimize negative impacts on survival of young. Pelicans are also sensitive to aircraft, especially helicopters, on foraging lakes and may take flight upon approach within 1 km (J. Cooper unpubl. data).

Grebes are less susceptible to casual disturbances, because they cover their eggs with vegetation before leaving the nest, and tend to return quickly after humans leave the area (J. Cooper pers. observation). However, continuous and increasing human activities (water-skiing, floatplanes, fishing) have been implicated in the permanent abandonment of Western

Grebe colonies at Williams Lake, Swan Lake, and Vernon (Cannings *et al.* 1987; Campbell *et al.* 1990; Burger 1991). In addition, predation by Ring-billed Gulls on Western Grebe (and probably other grebes) is a problem at Salmon Arm and possibly at other locations (R.W. Campbell, pers. comm.). Putting adults off the nest may, therefore, contribute to loss of eggs by increasing exposure of nests to predators. Increasing the risk of lower reproductive success should be a serious concern to biologists working on species with small populations, like Western Grebe and American White Pelican.

Wildlife managers should consider if the benefits of the survey will offset potential damage to colony success.

3.1.4 Chronology of population patterns

Birds may spend varying amounts of time in wintering, staging, migration, and breeding areas. Surveys must cover the period (extreme early and late dates) when populations might peak. Surveys to determine population trends must be conducted over a number of years to account for short term fluctuations.

Factors such as weather, water level, tidal cycle, and disturbance can affect daily, seasonal, and annual use patterns. For example, Great Blue Heron colonies may move *en masse* to a new site (R.W. Butler pers. comm.), Eared Grebes may not breed in traditional marshes during years of low water level (unpubl. data in B.C. Nest Record Scheme), and storms may temporarily disperse local winter concentrations of Western Grebes (J.M. Cooper pers. obs.). Because of possible bird population shifts, surveys may need to be repeated to accurately assess normal bird use of the study areas.

3.1.5 Observer variability

Variability always exists among observers in experience, ability to identify and count birds at various distances, visual and auditory acuity, *etc*. (Verner 1985). When more than one person is involved in surveys, the members of the team should be of equal ability. If not, training is required. Data will not be comparable between observers of different quality. One method of minimizing bias is to rotate observers between or among surveys so that bias is distributed equally.

3.1.6 Estimating numbers in large flocks

Every individual in a flock can be counted directly if flocks number no more than a few hundred birds. Direct counting is easy with large birds at close range, but becomes progressively more difficult with larger numbers, smaller species and greater distances (Bibby *et al*. 1992). Problems in counting waterbirds will occur during aerial surveys of large flocks of Western Grebes, Eared Grebes, and Great Blue Herons, and during ground or water-based surveys of large flocks of grebes that are diving or swimming, or herons that are actively feeding.

When the number of birds is greater than a few hundred birds, estimation procedures have to be used. The birds in a large flock may be estimated by counting a block of 10, 20, 50 or 100 birds and then estimating how many similar-sized groups make up the entire flock (*e.g.*, Butler *et al.* 1992).

3.1.7 Survey Design Hierarchy

Colonial-nesting freshwater 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 ground-based survey for grebes. A survey set up following this design will lend itself well to standard methods and RIC data forms.

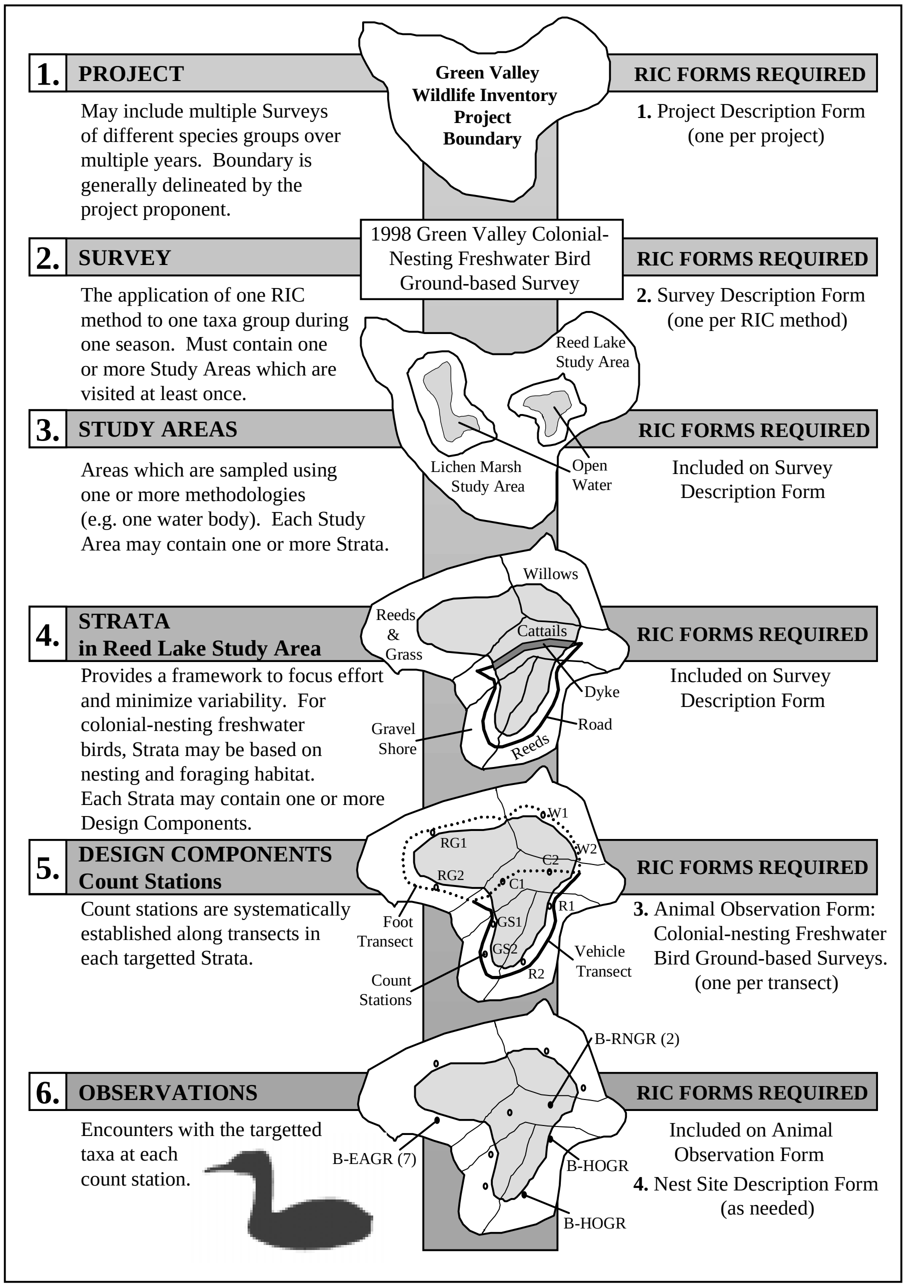

Figure 1. RIC species inventory survey design hierarchy with examples.

3.2 Inventory Surveys

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

Table 3. Types of inventory surveys, the data forms needed, and the level of intensity of the survey.

Survey Type	Forms Needed	*Intensity
Aerial Survey	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form- Colonial-Nesting Freshwater Birds Aerial Survey	• PN • RA • AA
Ground-based Surveys	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form- Colonial-Nesting Freshwater Birds Ground-based Surveys • Ecosystem Field Form	• PA • RA • AA
Boat Transect	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form- Colonial-Nesting Freshwater Birds Boat Transect	• RA • AA
Direct Nest Counts	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - General • Animal Observations Form- Colonial-Nesting Freshwater Birds Direct Nest Counts • Ecosystem Field Form	• AA

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

3.3 Aerial Surveys

Recommended Use: This method is used at all 3 levels of inventory intensity depending on species and season. See Table 2 for species-specific recommendations.

Presence/Not detected

Aerial surveys provide an excellent means for detecting conspicuous birds. Species that are large, or occur in large flocks are appropriate targets for this method. Aerial surveys are particularly effective for determining the presence/ absence of:

- American White Pelicans in foraging areas;
- Great Blue Herons foraging on tidal flats, lakeshores and open fields;
- Western Grebe wintering or staging concentrations on lakes and at sea; and
- concentrations of nesting Red-necked and Eared grebes.

Relative Abundance

Data from aerial surveys can be effectively used to produce relative abundance indices for comparing waterbird populations temporally and geographically, especially for nonbreeding populations of Western Grebes and breeding and nonbreeding populations of Great Blue Herons along the British Columbia coast.

Absolute Abundance

For locations where the entire study area is exposed, estimates of total numbers of birds can be made. This is applicable to Great Blue Herons on tidal flats from spring through autumn, American White Pelicans on breeding and foraging lakes in spring and summer, and wintering concentrations of Western Grebes.

Aerial surveys have been used since the late 1940's to census wildlife populations (Caughley 1979). Waterbirds (mainly waterfowl) are regularly surveyed by fixed-wing aircraft in British Columbia, and this method is the most effective technique for acquiring data on waterbirds over large geographic areas, or where the birds are difficult to census by other methods due to problems such as ground access restrictions, heat haze, or angle of observation (*e.g.,* Savard 1982, 1985; Butler *et al.* 1986; Butler and Campbell 1987; Butler 1989). Since counts are relatively instantaneous, biases caused by movement of birds between areas may be avoided.

Surveys are usually conducted using high-wing single or twin engine fixed-wing aircraft. Helicopters are not suitable, because of the high degree of disturbance caused by low-level flights. Flight altitudes usually range from 25-100 m above ground level at airspeeds that are as slow as feasible (110-240 km/hr) (*e.g.,* Morrison *et al*. 1989).

Video cameras and aerial photography are sometimes used in conjunction with aerial surveys. Aerial photography can be used to obtain accurate estimates of flocks in limited areas, as well as provide valuable information about the habitat. Photographs can also be used to improve estimates made during flights and as training for estimation of numbers in flocks.

Factors to consider in the use of aerial surveys

Sources of Bias

- Savard (1982) and Pollock and Kendall (1987) cautioned against use of aerial surveys because of the difficulty in observing cryptic species (*i.e.*, small grebes) and other observability biases such as the difficulty in identifying birds viewed at oblique angles, observer fatigue, missing birds that dive, and weather factors. Because of these biases, aerial surveys can often underestimate populations, compared to ground-based surveys, because birds are more often missed (Pollock and Kendall 1987).
- Bird behaviour and detectability will vary with weather, as will the ability of observers to detect birds under different conditions. It is generally recommended that surveys should not be conducted during periods of heavy rain, fog, snow, strong winds, or extreme temperatures. For example, grebes are difficult to count on water when winds create waves or swells.
- Other important sources of bias include:
    - birds may flush (B-AWPE, B-GBHE) or dive (grebes) ahead of aircraft, which may reduce the accuracy of counts;
    - variables such as light conditions, different observers, altitude flown, and precise route flown are difficult to control; and
    - observer fatigue is inevitable in all but the shortest of surveys, affecting consistency of results.
- Briggs *et al*. (1985a) compared aerial surveys with ship surveys and found that aerial surveys recorded higher densities of waterbirds, but had lower rates of species-specific identification (77-96% vs 95-97%). Therefore, although total birds were more accurately estimated, identification of those birds was more difficult. Grebes are the only species in this inventory group that might be confused with other species during aerial surveys.
- Data from aerial surveys can be improved by ground-truthing subsets of the survey area and correcting for differences. Ground-based counts are presumed to be more accurate than aerial counts, because there is more time to observe birds at specific locations and repeat counts can be made. For Western Grebes and Great Blue Herons, count concentrations from land at the same time as aerial surveys are done.
- Aerial surveys of Red-necked and Eared Grebes on the coast during nonbreeding seasons are not feasible because of probable confusion with other waterbirds. Western Grebes in winter, American White Pelicans, and Great Blue Herons in open foraging habitats are distinctive and easily viewed from the air. It is not feasible to survey breeding colonies, for any of these species, for numbers of active nests. Surveys for breeding pairs of grebes are feasible, although confusion with ducks will cause biases.

Logistics and Cost

- Large areas can be effectively covered in a short period of time. Remote areas can be easily accessed, especially if surveys have to be repeated at regular intervals. Few trained personnel are required which greatly reduces inter-observer variability and improves the comparability of counts. Procedures can be more easily standardized between study areas and between years if fewer personnel are involved.

- Although aerial surveys appear relatively costly, they are usually the most cost effective method for censusing large and remote geographic areas. However, aerial surveys designed solely to count species included in this manual would not be a wise use of funds. Censusing all available birds in the survey area is more cost-effective.
- One additional factor to consider is that aerial surveys are probably relatively dangerous for personnel, compared to ground surveys.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual *Species Inventory Fundamentals (No. 1).*
- Obtain any necessary permissions for over flying survey areas (*e.g.*, restricted airspace near airports or military bases (contact Airport Operations); Ecological Reserves (contact local Ministry of Environment office). Contact landowners, for reasons of courtesy, if privately-owned wetlands are going to be overflown at low altitude.
- Select areas to be surveyed from 1:20 000 or 1:50 000 maps, making use of existing data, and experience with the study area.
- Obtain 1:50 000 air photo maps and plan flight lines according to available habitat. Plan survey route to minimize travel time between beginning and end points.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for census areas from maps.
- Choose the appropriate flying altitude. Fly for American White Pelicans at about 500 m, for Great Blue Herons at about 50-100 m, and for grebes between 30-60 m.

Sampling Design

- Stratify habitat based on expected densities (low, medium, high) for the species under study.
- For large-scale studies, randomly select sample blocks from the three strata. For intensive studies of smaller areas, fly the entire area. Note: if the whole area within a stratum is being flown, label the stratum as one sample block.
- Survey lines (transects) should be flown to cover all habitat where birds are expected within predefined survey areas. Transect lines can be straight lines across broad expanses of water/mudflats/fields, or can follow contours of coastlines, lakeshores, or rivers. Count birds along survey lines from both sides of the aircraft out to a predetermined distance (25-200 m); include all available habitat by conducting several passes, while ensuring that areas are not counted twice. Narrower transect strips generally allow greater observation accuracy than broader strips (Briggs *et al.* 1985b), but narrow transects may increase biases when counting grebes because birds at close detection distance may dive more readily.
- When surveying wetlands, small lakes, or discretely bounded marine waters the entire body of water can be surveyed, even if several passes are required. This method provides estimates of total numbers per wetland. Survey bird concentrations by circling around several times and making several estimates.

Sampling Effort

- Approximately 600-1,000 kms of transects can be flown per day.
- Surveys should be repeated several times during the breeding or wintering season.

- Western Grebes - Annual monitoring is recommended for breeding and wintering populations.
- Red-necked/Eared Grebes - Major colonies should be surveyed every 3-5 years.
- American White Pelican - Annual monitoring is recommended.
- Great Blue Heron- Annual monitoring is recommended.

Sampling Standards

Time of day

- To avoid low sun angles and glare during spring, summer, and fall, schedule surveys on clear or overcast days, between three hours after dawn and three hours before dusk.
- Survey times along the coast should also take into account tidal cycles. Plan timing of coastal surveys to coincide with low to mid tide levels (B-GBHE) or between 1030-1400 hours (wintering B-WEGR)

Weather

- Surveys should not be conducted in winds greater than 30 km/hr, or during periods of rain or fog. On sunny days, orient flight paths to avoid glare.
- A certain amount of flexibility has to be planned into scheduling to accommodate delays caused by bad weather or mechanical problems.

Personnel

- 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.
- 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 spotter fatigue.

Personnel

- A pilot with previous 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.
- The survey crew members need to be trained in standard methods of flock size estimation and identification.
- Consistent biases in estimation can be improved with training. Spotters should practice making estimations of flock sizes and species composition from aerial photographs and video tapes. With discussion between the observers, this procedure can greatly reduce the error factor of inter-observer variability.
- Members of the survey crew must know exactly the specific data that they are responsible for collecting (see data forms). This will avoid oversights and duplication. Each crew member should be familiar with the flight route and be responsible for all the equipment that they will be using during the flight.

- All personnel must have a high tolerance for motions associated with flying. *Gravol* or other preventative medications should be taken prior to take-off if there is the slightest chance of motion sickness.

Equipment

- Overhead fixed-winged aircraft are recommended (*e.g.*, Cessna 182 or 206; Beaver). The same type of aircraft should be used throughout a survey to standardize noise disturbance and speed.
- It is recommended that the aircraft be fitted with bubble windows to allow for better spotter visibility.
- The navigator should be equipped with a chronometer, Global Positioning System (usually available with the aircraft), detailed maps of routes, pencils to trace flight route, precision watch for noting time, and a tape recorder to record data.
- Each counter should have 7-10X 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.
- Video and/or still cameras may also be used to supplement the data. Again, carry spare film and batteries on board.

Field Procedures

- Survey routes (transects) must be chosen to maximize the coverage of suitable habitat. The survey route is traced lightly on a 1:50 000 map and discussed with the pilot such that the slowest speeds and lowest heights feasible can be chosen (given limitations of aircraft, weather, terrain, and potential for disturbance to birds).
- Air speeds between 110-200 km/hr are recommended.
- The recommended heights above water are 50 m for grebes, 100 m for herons, and 500 m for pelicans.
- The entire survey route (transect) may be broken up into smaller segments to facilitate counting. Each segment should be clearly labelled on a map so that the navigator and spotters can reference each one as it is counted.
- The navigator and the two spotters should meet prior to commencing surveys to ensure that are comfortable with their roles for the survey and are familiar with the flight route. Contingency plans in case of problems should also be discussed during this time.
- The navigator sits in the co-pilot seat and helps the pilot with navigation and is responsible for:
    - tracing the exact route (transect) flown during the survey onto the maps;
    - recording time at which counting on each segment 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;
    - marking location of large flocks on the map; and
    - recording details such as deviations from planned flight lines or repeated flights over any segment.
- The two spotters record data directly into tape recorders. At the start of each segment the spotter clearly dictates:

  - the name/number of the segment, the GPS co-ordinates if known, time of commencing of count;
  - each waterbird species spotted;
  - number of each species; and
  - direction of flight of flocks (if flushed) until the end of that segment is reached.
- At the end of each segment, record the GPS co-ordinates and time. The segment can then be marked on the map as a record of the flight path. It is recommended that the navigator announce the beginning/end of each segment to the counters so that all observers are synchronized.
- All waterbirds seen are counted. Individuals and small flocks are counted directly, but sizes of larger flocks may need to be estimated (B-WEGR-winter or staging flocks, B-EAGR-breeding concentrations, B-GBHE-foraging flocks are estimated) (see 3.1.6).
- Aerial 35 mm still photography can also be used when the density of waterbirds is high and spot estimates are difficult. A 35 mm SLR camera with a wide angle to medium telephoto lens (35-200 mm) and high speed 400 ASA film is recommended. If computers will be used extensively for analysis, consideration should be given to having the film images scanned to CD ROM. This allows for rapid scanning, image magnification, and far easier storage/retrieval than with slides.
- Many cameras have interchangeable data backs that allow the date, time, and code number (segment) to be permanently printed onto the negative. More expensive "professional" models of Canon and Nikon have interchangeable camera viewers which allow for using larger screen "sports" or "action finders". These make spotting and framing significantly more efficient and less prone to trigger motion sickness discomfort.
- Accuracy of data from aerial surveys can be improved by ground-truthing subsets of the survey data. These ground counts should be made at approximately the same time as flights.
- Transcribe data from recorders to data sheets after the aerial survey. To improve efficiency and accuracy, data should be transferred to paper data sheets, as soon as possible after the survey. Data can then be entered into computer databases when convenient.

Data Analysis

- The navigator and spotters transcribe data on to the 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. Species are noted as the tapes are transcribed using standard abbreviations (Cannings and Harcombe 1990). Additional notes made during the flight should be transcribed as well.
- Data should be entered into the Species Inventory Database.
- Presence/Not detected (possible): Data from aerial surveys can be presented in the form of tables which list the species present at each location. Since aerial surveys are usually used to cover large geographic areas, maps are recommended for presentation. The survey area can be divided into grids and the presence of a species in a given grid square can be denoted by a circle. Use different-sized circles for various abundances. Temporal variability in presence/not detected can be indicated by filling in different sections of the circle, each section indicating a season, month, week, or day.

- Relative and absolute abundance: These can be expressed either as (1) total counts of birds for a particular location, (2) as density of birds per square kilometer; or (3) as the number of birds per kilometer of survey route. To carry some meaning, data should be broken into meaningful classifications, such as habitat units or strata.

  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.

  2. Density of birds in an area: $D = B/A$

     where:

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

     B = No. of birds observed

     A = area surveyed (this is calculated by measuring the map of the area surveyed with a planimeter)

  3. Birds/kilometer: $K = B/Z$

     where

     K = birds per kilometer of survey route (Birds/km)

     B = No. of birds observed

     Z = Length of survey route measured from maps

3.4 Ground-based Surveys of Wetlands and Waterways

Recommended uses: This method is used at all 3 levels of inventory intensity depending on species and season. See Table 2 for species-specific recommendations.

Presence/Not detected

Recommended for presence/not detected studies in areas with land-based access because of low-cost and logistical ease.

Relative abundance

Recommended for relative abundance estimates on wetlands and marine waters where birds are visible through binoculars or spotting scopes.

Absolute abundance

Recommended for absolute abundance estimates of breeding colonies on ponds and small lakes without extensive emergent cover, and for nonbreeding populations on nearshore marine waters and staging populations on large inland lakes.

When used in support of nest counts, this method can improve estimates of breeding populations of grebes. It is very useful for inventory of herons at prime foraging sites, where they gather in large numbers (*e.g*., Roberts Bank).

Ground-based surveys have been widely used to inventory breeding and wintering grebes, populations of Great Blue Herons at foraging areas, and long-range inventory of breeding and foraging flocks of American White Pelicans (Ryder 1973; Breault *et al*. 1988; Butler 1989; Butler and Cannings 1989; Savard 1991; Searing and Cooper 1992). Birds are observed by spotting scope and/or binoculars from observation points. If the whole study area can be readily observed, a fairly accurate count of birds on individual wetlands and waterways can be obtained. However, surveys are restricted to areas with land-based access.

For grebes, during the early breeding season, counts of breeding pairs can be made. Although not useful for inventory of active nests of grebes and pelicans, it is a suitable method for counting broods of grebes after young have left the nest. Counting broods is a widely-used technique for assessing reproductive success in specific wetlands, and provides a minimum value for numbers of breeding pairs in specific locations (Savard 1991). Mixing of older broods can be extremely confusing, however, especially in marshes with large numbers of breeding pairs (*e.g*., Eared Grebes). Great Blue Herons can be counted from a distance as they fly to and from nests while feeding nestlings (Forbes 1986). Numbers of breeding pairs can be estimated, when nestlings are 5-8 weeks old and parents spend little time brooding, by counting birds as they leave to feed around dawn.

One major advantage of this method is that surveys can be conducted slowly, and repeat counts can be made to improve estimates of numbers. This is especially helpful for grebes which may be diving, or for large flocks of foraging Great Blue Herons that often move around in short up-and-down flights as they follow flooding or ebbing tide lines. Additional advantages are that survey "teams" can consist of one person, and trained amateur naturalists can easily participate, thus increasing cost-effectiveness.

Data can provide reliable estimates of presence/not detected and relative abundance. Estimates of absolute abundance may require repeated surveys to account for variability in presence or visibility of birds. For example, Great Blue Herons gather at key foraging sites during the breeding season, but only part of the adult population will be present during the incubation and early nestling periods. After nestlings require less brooding, both parents may leave the nest and higher counts will result.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual *Species Inventory Fundamentals (No. 1).*
- Obtain any necessary permissions for access to survey areas (private land-owners when private property must be crossed to reach a wetland or observation point).
- Select study areas from 1:20 000 or 1:50 000 maps based on personal experience, and existing data. Existing data are available to locate colonies or wintering concentration sites (see B.C. Nest Records Scheme, or Campbell *et al*. (1990). Check with regional Ministry of Environment biologists or local naturalists if current status of specific sites is in doubt.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for census areas from maps.

Sampling Design

- Systematic. Travel along selected wetlands and waterways, stopping at viewpoints (observation stations) where birds are easily visible. Ensure that all possible habitats are covered.

Sampling Effort

- A survey party can probably cover 0.5 to 1.5 kilometers per hour of wetland shoreline, depending on density and complexity of distribution and abundance of target species.
- Surveys should be repeated more than once during the season.
- Estimates of absolute abundance may require several repeated surveys to account for variability in presence or visibility of birds.
- Western Grebes - Annual monitoring is recommended for breeding and wintering populations.
- Red-necked/Eared Grebes - Major colonies should be surveyed every 3-5 years.
- Great Blue Heron - Annual monitoring is recommended.

Sampling Standards

Time of day

- The time of day and tidal cycle can affect bird distribution. For example, Great Blue Herons forage on open intertidal habitats during low and mid tidal cycles where they are very visible but disperse to upland roosting areas, or back to their colonies when the tide is in (Butler 1991). American White Pelicans leave for foraging lakes in mid-morning and, although some birds may stay away overnight, counts are best made in the early morning (Dunbar 1984).

Vantage point

- Emergent vegetation on breeding or staging wetlands can obscure birds from view, especially grebes. This problem intensifies as the season progresses and vegetation grows taller and thicker. Vantage points with clear views of the study area are critical to obtaining reliable estimates.

Distance

- Birds beyond the range of a spotting scope will be missed (large lakes and marine habitat). Variable 20-45X scopes are commonly used and 45X is a normal maximum power because of blurring caused by heat waves and/or wind. Distances at which birds are detectable vary with species. With bright light and low wind, herons and pelicans can be identified and counted up to about 1.5 km, Western Grebes to about 1 km, Red-necked Grebes to about 500 m, and Eared Grebes to about 300 m.

Weather

- Surveys should not be conducted if the wind speed is over 30 km/hr, during heavy or moderate rain, or during periods of snow or fog.

Personnel

- The survey crew can be as small as one person (although safety considerations may preclude this possibility). Additional personnel can increase the number or area of wetlands surveyed per day.
- All crew members should have excellent waterbird identification skills. The crew leader should be an experienced biologist.

Equipment

- A suitable vehicle is needed which provides good visibility to the surrounding countryside for roadside viewpoints. Ideally, the vehicle will ride high enough above the road surface so that vision will not be hindered by roadside bushes.
- In most cases, a 4WD vehicle may be advisable to access wetlands.
- Each observer must have a pair of 7-10X binoculars and each team should have a spotting scope ≥20X.

Field Procedures

- Travel to/along selected wetlands and waterways, and scan for target species from view points. Ensure that all possible habitats are searched. If certain areas are inaccessible or cannot be surveyed, note their locations and the extent of area not searched.
- Mark view points on maps and relate position of each bird recorded to view point.
- Complete enclosed dataforms.

Data Analysis

- Relative and absolute abundance estimates can be made by determining total counts for specific wetlands, by calculating numbers of birds per unit area, or numbers of birds per km of shoreline.
- Data can be displayed as:
  - distribution maps:
  - maps for each species, or combined for all species,
  - maps for relative abundance (*i.e.*, different sized circles for various group sizes),
  - maps showing occurrence in relationship to habitat, ecoprovince, biogeoclimatic zone, *etc*.,
  - tables comparing total counts of individual wetlands.
  - tables comparing presence/not detected in different surveys, temporally or in distribution.

3.5 Boat transects

Recommended use(s): Relative abundance and absolute abundance of wintering and breeding grebes. See Table 2 for species-specific recommendations

Relative abundance

Recommended for estimating relative abundance of wintering grebes in protected coastal waters. It is best used in conjunction with surveys of other waterbirds.

Absolute abundance

Recommended for surveys of concentrations of Western Grebes and Eared Grebes on breeding lakes where counts cannot be made effectively from land, where total nest counts cannot be made, and in marine habitats for nonbreeding grebe populations where land-based counts are not feasible.

Boat transects involve identifying all birds encountered along a transect line (straight or contours with shorelines), or by counting all birds in areas of concentrations from a boat. This technique is especially useful for waterbirds that are relatively small, and difficult to identify at a distance, or waterbirds that can occur at low densities and be easily missed from aircraft (wintering B-RNGR, B-EAGR). It is not useful for surveys of Great Blue Herons.

Surveys of waterbirds by boat have been used extensively in coastal marine areas in British Columbia and have been found to be a good technique for censusing grebes (*e.g.*, Vermeer 1983, 1989; Morgan 1989; Rodway 1989; Vermeer and Morgan 1992; Vermeer *et al.* 1994). Observers sit or stand, depending on size of boat and roughness of water, and count birds as they are encountered. Most surveys are done from small, fast boats, rather than large ships, and one observer spots from each side of the boat. Transects can be as wide as observers can see and accurately identify waterbirds. Maximum distances depends on sea and weather conditions. In calm waters, binoculars can be used to extend the width of the transect up to about 200 m. In rougher waters, it is difficult to use binoculars and small birds like grebes can disappear behind waves or swells. Under less than calm conditions, transect widths should be about 75 m. This method can also be used on large interior lakes to census grebes.

Boats can be used to survey areas not accessible from land-based viewpoints (remote marine coasts, large lakes, large rivers), and considerable distances can be quickly covered. The slow speeds of watercraft, compared to aircraft, allow observers sufficient time for accurate species identification and inventory, and boats can stop to allow observers to count concentrations. Surveys of known localized concentration areas may be cost-effective compared to aerial surveys.

Factors to consider in the use of surveys by watercraft

- Strong winds, rain, and tidal action can cause biases in counts, pose danger to personnel, or preclude surveys altogether. Extra gear such as survival suits and HF radios are recommended. Personnel must have a high tolerance to motion sickness.

- Grebes may dive if approached too closely, making accurate counting difficult. However, observers can easily determine if they are approaching too closely and should scan ahead to count birds that may dive.
- Large geographic areas cannot be covered quickly, as with aerial surveys (100s of km^2), but smaller areas (10s of km^2) can be efficiently covered.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the introductory manual *Species Inventory Fundamentals (No. 1).*
- Select study areas from 1:20 000 or 1:50 000 maps, marine charts based on personal experience with the study area, and existing data.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for census areas from maps.
- Select survey route and draw transect lines on maps.

Sampling Design

Stratified random sampling.

- Stratify habitat based on expected densities (low, medium, high) for the species under study and select survey routes.
- For large-scale studies, randomly select sample blocks from the three strata. For intensive studies, all areas will be traversed.
- When surveying "shoreline" transects, follow a contour 100-300 m from shore (distance to be determined onsite and depends on distance at which birds can be identified and counted).
- When surveying sample blocks in open waters navigate along straight lines within the sample block, ensuring that the entire sample block is covered but that transects do not overlap. Note that tidal currents can confound efforts to navigate.
- When surveying areas within discrete geographic boundaries, survey all available habitat.

Sampling Effort

- 50 to 100 kilometers of transects can usually be surveyed per day in small, fast boats.
- Repeat surveys several times during the season.
- Western Grebes - Annual monitoring is recommended for wintering and breeding population.
- Red-necked/Eared Grebes - Monitor colonies every 3-5 years. Monitor wintering populations annually?

Sampling Standards

Weather

- Surveys should not be conducted if the wind speed is over 25 km/hr, or during periods of rain, fog or snow.

Tides

- In estuaries, conduct surveys at mid to high tide, not at low tide.

Personnel

- An experienced boat operator is needed with knowledge of local waters and navigation techniques. Preferably they may also be able to act as navigator and backup observer.
- The survey crew (2-4 people) should be led by a biologist with excellent skills in identifying waterbirds. Other personnel must be experienced in identifying waterbirds. All personnel must have high tolerance for motion-sickness.

Equipment

- A suitable boat for local conditions (inflatables or small hard-hulled craft for surveys on lakes or nearshore marine waters; larger vessels for surveys in remote marine areas), with GPS or other positioning equipment on board (for surveys along marine coasts).
- Each observer must have 7-10x binoculars.
- Waterproof notebooks, data forms, mechanical pencils.
- Appropriate safety equipment (life-jackets or survival suits, flares, HF radio, spare fuel, emergency rations, etc.)

Field Procedures

- Survey routes should be traversed at speeds that allow complete identification and counting of birds within the transect width. Appropriate speeds will vary between 5-50 km/hr depending on numbers of birds present and water conditions. Choose a speed and navigate at that speed throughout the survey, but stop to count concentrations if necessary.
- One observer should count on each side of the boat out to a range of 50-300 m, depending on the survey design and visibility. Transect widths of 100 m is suggested for grebes, but concentrations of Western Grebes should be counted and recorded if they are beyond 100 m.
- Record observations on data forms or in notebooks or on tape recorder (to be transcribed onto data forms after the survey).
- Monitor observer fatigue and take breaks as necessary to maintain sharpness.
- Map areas of concentrations (>10 birds for wintering B-RNGR, >20 birds for B-GBHE, >100 birds for wintering B-WEGR).

Data Analysis

- Enter all data into the Species Inventory datasystem.
- Densities can be calculated as outlined in Aerial Surveys.
- Relative and absolute abundance estimates can be made by determining total counts for specific locations, by calculating numbers of birds per unit area (density), or numbers of birds per km of transect (see Aerial Surveys).
- Data can be displayed as:
    - mapped locations with relative abundance (*i.e.*, different sized circles for various group sizes);
    - tables comparing presence/not detected in different surveys, temporally or in geographic distribution; and
    - for relative abundance, a table can show indices in birds/km.

3.6 Direct Nest Counts

Recommended use: Absolute abundance; see Table 2 for species-specific recommendations.

Recommended for estimating total numbers of breeding birds in colonies. Estimates of the entire provincial breeding populations of Western Grebes and American White Pelicans can be made, but pelicans should not be routinely surveyed with this method.

This method is best for monitoring long-term population trends of specific colonies and for inventories involving analysis of reproductive success.

Counting nests requires visiting a colony and determining the status of each nest. Often, all or most potential habitat is searched and the contents of each nest is recorded (*e.g.,* Breault *et al.* 1988; Butler 1989). Direct counts of active nests provide the most accurate data on numbers of breeding pairs and can also provide data on clutch sizes, microhabitat use and other characteristics which may be useful for management purposes. Nest counts require personnel that can correctly identify eggs and nests of each species, and can conduct themselves in a manner which minimizes disturbance to incubating birds, nests, and nesting habitat.

Grebe colonies can be surveyed by wading through nesting marshes, or in combination with a small boat in deeper water. If sufficient effort is expended, virtually all nests can be found. Great Blue Heron colonies can be inventoried from the ground by assessing each nest for presence of adults or young (Butler 1989), or by climbing trees and looking into each nest. It is best to survey nests from neighbouring trees rather than climbing the nest tree itself. Although American White Pelicans can be surveyed by visiting nesting islands and counting active nests, this is not recommended.

Because of the few number of colonies of Western Grebes and American White Pelicans in British Columbia, the entire provincial breeding population can be inventoried by this method (*e.g.,* Dunbar (1984); Burger (1991); Table 1). Similarly, as the locations of the largest colonies of Eared Grebes (Breault *et al.* 1988; Campbell *et al.* 1990; Table 1) and Great Blue Herons (Mark 1976; Forbes *et al.* 1985; Breault 1988; Campbell *et al.* 1990; Butler 1991) have been documented, a large portion of the provincial breeding populations can also be surveyed this way. For Red-necked Grebes, representative colonies could likely be surveyed to provide data for comparisons over time.

Factors to consider in the use of direct nest counts

- If all nests can be found, an extremely accurate count of the number of nests and contents can be made, allowing for relatively accurate estimates of absolute abundance. However, counts of grebe nests must be made when eggs are present because young leave the nest about a day after hatching and nests found without eggs may or may not represent a breeding pair. Grebes may build a nest but not use it, or may build a second nest if catastrophe strikes the first one (for example eggs may be washed away by a storm). Remember that counts of nests do not account for nonbreeders, or for breeders that have not begun nesting at the time of the survey.
- Nesting chronology must be considered for grebes and Great Blue Heron. Local knowledge of timing of egg-laying is critical for planning of nest counts. In general,

coastal (B-GBHE only) and southern populations nest earlier than interior and northern populations, respectively. There may also be variation in timing of nesting from year to year. Repeat visits may be necessary if the first survey is done too early.

- If data on annual productivity (clutch sizes, hatching rate, fledging rate) are required, repeat visits to colonies will be necessary. Trained amateur naturalists can effectively participate in this type of survey and increase cost-effectiveness.

Office Procedures

- Review the section, Conducting a Wildlife Inventory, in the manual *Species Inventory Fundamentals(No. 1).*
- Select study areas from 1:20 000 maps based on existing data, and experience with the study area.
- Determine Biogeoclimatic zones and subzones, Ecoregion, Ecosection, and Broad Ecosystem Units for census areas from maps.
- Obtain any necessary permission for access to survey areas (private land-owners when private-property must be crossed to reach a colony; Ministry of Environment if colonies are on Ecological Reserves or Provincial Parks).
- Plan timing of visits to coincide with maximum numbers of active nests.
- Prepare notebooks, data forms and field maps.

Sampling Design

- Non-random. Count all nests at a colony.

Sampling Effort

- Most colonies in British Columbia can be surveyed in a single day. Exceptions include large colonies of Eared Grebes and, possibly, Great Blue Heron.
- Western Grebes: Annual monitoring is recommended.
- Red-necked/Eared Grebe: Monitor major colonies every 3-5 years.
- American White Pelicans: Direct counts of American White Pelican nests are not needed every year. Direct counts should not be made during the incubation period. Counts of young should be made only once every 5 years, in conjunction with banding of young.
- Great Blue Heron: Annual monitoring is recommended where colonies may be disrupted by human activities.

Sampling Standards

Sensitivity

- Direct counts of nests can be very intrusive, therefore, great care must be exercised to minimize impacts of disturbance (see 3.1.3).

Weather

- Surveys should **not** be conducted in the rain or during periods of cold (<10^{o}C) or hot temperatures (>30^{o}C).

Personnel

- Survey crews should be led by a biologist with extensive experience in surveying colonial waterbird nests.
- Other personnel must be experienced or trained to: 1) identify eggs and nests of various grebe species present, or 2) identify young and adult Great Blue Herons. Depending on the size of the colony, the number of personnel needed may vary from 1 - 6 people.
- For safety reasons, 2 persons should be a minimum crew size. Larger crews (4-6) should be used to minimize time spent in: Great Blue Heron colonies if trees are being climbed (because climbing trees is relatively intrusive it is advisable to minimize the time of disturbance); American White Pelican colonies (to minimize time that adults are off the colony); in large Eared Grebe colonies (100s of nests).
- For herons, professional climbers should be employed to climb tall trees, and be trained and equipped to avoid defensive behaviour of heron nestlings. Some heronries may be difficult to census because of visibility problems from the ground or unsafe climbing conditions (unsound trees). Nests in deciduous trees may be especially difficult to see after April because of fresh foliage. In addition, climbing trees to census herons may be hazardous to personnel and to nestling herons. Climbers should wear face protection.
- Finally, there may be health risks to personnel of bacterial or fungal infections as a result of visiting colonies (B-AWPE, B-GBHE). Personnel should carry first-aid equipment that includes disinfectants.

Equipment

- Waterproof field notebooks and data forms.
- Mechanical pencils.
- Depending on the location of the colony, various equipment may be required to reach the colony: *e.g.*, car/truck, 4WD vehicle, canoe, boat with outboard, aircraft.
- Chest waders are advisable for surveying grebe colonies to avoid contracting "swimmers itch".
- Tree-climbing gear (for heronries).
- Head and face protection (from bird attacks: B-GBHE, B-AWPE), such as hockey helmets with full clear plastic visors.

Field Procedures

- The timing of surveys can be determined from knowledge of when egg-laying occurs. Surveys for grebes should be conducted when the majority of clutches are complete and before hatching begins. Because of danger of egg predation and nest abandonment during early parts of the nesting season, surveys for herons and pelicans should be conducted when large young are present (if they are to be banded). Heron nests can be surveyed from the ground during the incubation or early nestling phases.
- Slowly approach the colony, allowing adults to leave without being unduly startled, then move slowly but efficiently through the colony.
- Minimize the length of stay at the colony. Time is dependent mainly on size of colony.
- At heronries, climbers should ascend trees beside nest trees so that the contents of nests can be determined. Climbing nest trees is only necessary if adjacent trees are not available or if young are to be banded. Mark each nest tree with painted numbers or numbered metal discs for later visits, and record status of each nest. Draw a map of nest

locations for trees with more than one nest so there is no confusion of which nest is which on the next visit.

- For grebes, recover eggs with wet vegetation after counting eggs, or cover eggs if adults did not do so before leaving nest.
- For pelicans, corral nestlings so that they do not escape into the water. Separate groups of nestlings based on size to reduce danger of injury to smaller nestlings.
- In large Eared Grebe colonies, surveyors should work relatively close to each other, to localize immediate impacts on the colony.

Data Analysis

- Data can be displayed as:
    - mapped locations with relative abundance of colonies (*i.e*., different sized circles for various colony sizes),
    - tables comparing changes of colony use/productivity over time,
    - with mapping of exact nest locations, subtle colony shifts can be noted which may have implications for conservation.
    - absolute abundance and productivity of breeding pairs in each colony can be estimated from counts of active nests.

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.

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).

BIOGEOCLIMATIC ZONE: An ecosystem classification based on differences in vegetation, soil, and climate.

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.

BREEDING CHRONOLOGY: Seasonal timing of nest-building, egg-laying, hatching, and fledging.

CRYPTIC: Naturally camouflaged by plumage colour or pattern.

ECOPROVINCE: Geographic region with broad similarities in climate and topography.

EMERGENT VEGETATION: Aquatic vegetation that grows above the surface of the water.

HERONRIES: Nesting colonies of Great Blue Herons.

HF RADIO: High frequency radio often carried for emergency communications.

OLDFIELD: An overgrown, unmowed, ungrazed field or pasture with tall grasses, herbs, and some shrubs.

ORGANOCHLORINES: Chlorine-based chemical such as DDT, DDE that have toxic effects.

PLANIMETER: A drafting tool that measures area from maps.

POPULATION: A group of organisms of the same species occupying a particular space at a particular time.

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.

RANDOM ERRORS: Errors based on natural variability in nature.

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

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.

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.

STAGING AREAS: Sites used by migrant birds before major migratory movements.

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.

SYSTEMIC ERROR: Errors based on built-in biases of methods or assumptions.

TRANSECT: A survey technique where observers count all birds observed within a predetermined radius of a "line" travelled by the observer.

UTM: Universal transverse mercator coordinates.

WETLAND: A freshwater marsh, slough, pond, or lake.

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

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