VERSION 1.1

STANDARDIZED INVENTORY METHODOLOGIES FOR COMPONENTS OF BRITISH COLUMBIA'S BIODIVERSITY:

SHOREBIRDS

PLOVERS, OYSTERCATCHERS, STILTS, AVOCETS, SANDPIPERS, PHALAROPES AND ALLIES

Ministry of Environment, Lands and Parks
Resource Inventory Branch
Terrestrial Ecosystem Task Force
Victoria, British Columbia

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PREFACE

This manual presents standardized methodologies for inventory of Shorebirds 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 Ecosystem Task Force, under the auspices of the Resources Inventory Committee (RIC). The objectives of the working group are to develop inventory methodologies 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 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 (Introduction to RIC Wildlife Inventory) 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 Introduction to RIC Wildlife Inventory manual provides important background information and should be thoroughly reviewed before commencing with a RIC wildlife inventory. RIC standards are also available for animal capture and handling, and radio-telemetry. Field personnel should be thoroughly familiar with these standards before engaging in inventories which involve either of these activities.

Standardized data forms are required for all RIC wildlife inventory. This is important to ensure compatibility with provincial data systems, as all information must eventually be included in the Species Inventory Datasystem. The manuals and data forms are available from:

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It is recognized that development of standardized methodologies 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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ACKNOWLEDGMENTS

The background information and protocols presented in this document are base on the unpublished draft manual, *Manual of Inventory Methods for Shorebirds in British Columbia*, prepared for the Resources Inventory Committee by John M. Cooper, Purnima Price, and Stephen Price of Sirius Environmental Research. The draft manual was edited to its present form by Ann Eriksson, Leah Westereng, and James Quayle. All decisions regarding protocols are the responsibility of the Resources Inventory Committee. Data forms and coding instructions for this manual were developed by Naomi Pope and Leah Westereng in consultation with the Elements Working Group.

1. INTRODUCTION

Shorebirds comprise one of the major components of the Canadian and world avifauna. In general, populations are threatened by loss or degradation of habitat in breeding, wintering, and staging areas due to development, human disturbance, pesticide use, water pollution, and oil spills (Senner and Howe 1984; Myers 1988). As a consequence, some populations may have declined dramatically since the 1970's (Howe *et al.* 1989). Concern about these declines has led to the establishment of the International Shorebird Survey and the Western Hemisphere Shorebird Reserve Network (Morrison 1983a; Myers *et al.* 1987a, 1987b; Howe 1990). Attempts to analyze the data collected by these projects has highlighted the need to establish standard census procedures that are comparable between sites and years.

In British Columbia, 52 species of shorebirds in 4 families are known to occur: the Charadriidae (Plovers - 5 species), Haematopodidae (Oystercatchers - 1 species), Recurvirostridae (Stilts and Avocets - 2 species), and Scolopacidae (Sandpipers, Phalaropes and allies - 44 species). Most of these species are migrants or winter visitants, 18 species breed, and about 12 species are only casual visitors (Campbell *et al.* 1990). One species, the Upland Sandpiper, is on the Wildlife Branch Red List as a candidate for threatened or endangered status, and 7 others are on the Blue List and considered as sensitive or vulnerable (B.C. Wildlife Branch 1993).

Shorebirds occur in a wide variety of habitats in British Columbia. Some migrants like the Red Phalarope, are almost entirely pelagic, while some species migrate in spectacular numbers along the coast or travel through interior valleys. There are a few species that occur locally, in small numbers, and may pass through the province virtually unnoticed. Nesting habitats of the species that breed in British Columbia are equally varied, ranging from sub-alpine tundra and coastal sand dunes (Semipalmated Plover) to offshore rocky islets (Black Oystercatcher), spruce muskegs (yellowlegs and Solitary Sandpiper), and urban areas (Killdeer).

Most censusing studies of shorebirds in British Columbia have been conducted on the coast where millions of Western Sandpipers, Dunlins, Least Sandpipers, and other species migrate. Many of these surveys have focused on the rich mudflats of the Fraser River delta (e.g., Butler *et al.* 1987; Butler and Cannings 1989; Vermeer *et al.* 1991a,b; Butler 1992; Butler 1994). A few significant species-specific studies on breeding ecology have been done in the province [Least Sandpiper (Cooper 1993); Long-billed Curlew (Ohanjanian 1986; Hooper 1994, in press), Black Oystercatcher (Hartwick 1974; L'Hyver 1985; Purdy 1985)].

A comprehensive monitoring programme using standardized inventory methods is of particular value in British Columbia because most western species of shorebirds pass through this province on their way to and from wintering grounds in South and Central America, and breeding grounds in Alaska and the Yukon. Hence, long term monitoring of migratory populations in British Columbia will not only alert researchers to threats to local populations, but may also draw attention to problems in other regions and countries. The purpose of this manual is to recommend methodologies for the inventory of migrant, breeding and wintering populations of shorebirds; and to provide protocols for inventory at three levels of survey intensity: presence/not detected (possible), relative abundance, and absolute abundance.

2. INVENTORY GROUP

A brief description of the general abundance, status, habitats, and distribution of all species of shorebirds known to occur in British Columbia is given in Table 1. Excellent summaries of the biology, distribution, and location of major populations of shorebirds in British Columbia and the Pacific Northwest are contained in Campbell *et al.* (1990) and Paulson (1993).

Table 1. Summary of status, distribution, and habitat of shorebirds that occur in British Columbia.

Common name (Species code) Latin name	Abundance	Status	Habitat	Distribution	Size class
Charadriidae: Plovers					
Black-bellied Plover (B-BBPL) *Pluvialis squatarola*	Common	Migrant Winters	Mud flats, fields, pastures, airstrips, golf courses.	Mainly coastal	Medium
Lesser Golden-Plover (B-LGPL) *Pluvialis dominica*	Rare	Migrant Breeds Blue List	Grass fields, pastures, airstrips.	Coast / Interior	Medium
Snowy Plover (B-SNPL) *Charadrius alexandrinus*	Casual	Vagrant	Gravel beaches and mud flats.	Coast	Small
Semipalmated Plover (B-SEPL) *Charadrius semipalmatus*	Fairly Common	Migrant Breeds	Fallow fields, pastures, short grasslands.	NE Interior mainly	Small
Killdeer (B-KILL) *Charadrius vociferus*	Common	Migrant, Resident Breeds	Mud flats, sand spits, muddy or dried sloughs, stubble fields, flooded pastures.	Coast / Interior	Medium
Haematopodidae: Oystercatchers					
Black Oystercatcher (B-BLOY) *Haematopus bachmani*	Common	Resident Breeds	Rocky islets, reefs, spits, rocky beaches, sand bars and inlets.	Coast	Large

Common name (Species code) Latin name	Abundance	Status	Habitat	Distribution	Size class
Recurvirostridae: Stilts and Avocets					
Black-necked Stilt (B-BNST) *Himantopus mexicanus*	Very Rare	Vagrant	Muddy ponds, lakes, and lagoons.	Mainly interior	Large
American Avocet (B-AMAV) *Recurvirosta americana*	Rare	Migrant Breeds Blue List	Mud flats, estuaries, small ponds, spits and sparsely vegetated shorelines.	Mainly interior	Medium
Scolopacidae: Sandpipers, Phalaropes and allies					
Greater Yellowlegs (B-GRYE) *Tringa melanoleuca*	Uncommon	Migrant Breeds Winters	Mud flats, estuaries, flooded fields, sedge swamps, uplands. Roots on rocky shores.	Interior / Coast	Medium
Lesser Yellowlegs (B-LEYE) *Tringa flavipes*	Fairly Common	Migrant Breeds	Sheltered mudflats, muddy areas, sedge swamps, spruce muskeg, and sandy beaches. Roosts on near shore rocks.	Interior / Coast	Medium
Spotted Redshank (B-SPRE) *Tringa erythropus*	Accidental	Vagrant	Mudflats.	Coast	Medium
Solitary Sandpiper (B-SOSA) *Tringa solitaria*	Uncommon	Migrant Breeds	Secluded woodland ponds and pools, river edges, sewage lagoons and bogs.	Mainly interior	Small
Willet (B-WILL) *Catoptrophorus semipalmatus*	Very Rare	Vagrant	Mudflats, sand beaches, marshes, sloughs, grassy playing fields and sewage lagoons.	Interior / Coast	Large
Wandering Tattler (B-WATA) *Heteroscelus incanus*	Rare	Migrant Breeds Blue List	Surf-washed reefs, near shore rocks and beaches.	Mainly coastal / NW Interior	Medium

Common name (Species code) Latin name	Abundance	Status	Habitat	Distribution	Size class
Spotted Sandpiper (B-SDSA) *Actitis macularia*	Common	Migrant Breeds	Shorelines of rivers and lakes.	Coastal / Interior	Small
Terek Sandpiper (B-TESA) *Xenus cinereus*	Accidental	Vagrant		Coast	Medium
Upland Sandpiper (B-UPSA) *Bartramia longicauda*	Rare	Migrant Breeds Red List	Open grassy uplands, open bogs, wet pastures, golf courses, lawns, meadows, dirt roads and mudflats.	Mainly interior	Medium
Whimbrel (B-WHIM) *Numenius phaeopus*	Common	Migrant	Offshore islets and rocks, mudflats, wind swept sandy beaches, and spits.	Mainly coastal	Large
Bristle-thighed Curlew (B-BTCU) *Numenius tahitiensis*	Casual	Vagrant	Mudflats.	Coast	Large
Far Eastern Curlew (B-FECU) *Numenius madagascariensis*	Accidental	Vagrant	Mudflats.	Coast	Large
Long-billed Curlew (B-LBCU) *Numenius americanus*	Uncommon	Migrant Breeds Blue List	Mudflats, beaches and nearby fields.	Mainly interior	Large
Hudsonian Godwit (B-HUGO) *Limosa haemastica*	Very Rare	Migrant Breeds Blue List	Thawing areas at outflow streams and muddy shorelines, mudflats, sewage lagoons and sandy beaches.	Mainly interior	Large
Bar-tailed Godwit (B-BTGO) *Limosa lapponica*	Very Rare	Vagrant		South coast	Large

Common name (Species code) Latin name	Abundance	Status	Habitat	Distribution	Size class
Marbled Godwit (B-MAGO) *Limosa fedoa*	Very Rare	Transient	Sandy beaches, tidal mudflats, lagoons and near shore rocks.	Mainly coastal	Large
Ruddy Turnstone (B-RUTU) *Arenaria interpres*	Uncommon	Migrant	Offshore islets and reefs, pebble beaches, sand beaches and mudflats.	Mainly coastal	Medium
Black Turnstone (B-BLTU) *Arenaria melanocephala*	Common	Migrant Winters	Rocky beaches, reefs, jetties, and gravel bars at the mouths of rivers.	Coast	Medium
Surfbird (B-SURF) *Aphriza virgata*	Fairly Common	Migrant Winters	Rocky shorelines, reefs, beaches, headlands, jetties and breakwaters.	Coast	Medium
Red Knot (B-REKN) *Calidris canutus*	Uncommon	Migrant	Mudflats, hard packed sandy beaches, offshore rocks, sand dunes, and freshwater sloughs.	Coast	Medium
Sanderling (B-SAND) *Calidris alba*	Fairly Common	Migrant Winters	Hard packed sandy beaches, lake shores, sloughs and mudflats.	Coast / Interior	Small
Semipalmated Sandpiper (B-SESA) *Calidris pusilla*	Uncommon	Migrant	Mudflats, sewage lagoons, middy edges of sloughs and lakes.	Coast / Interior	Small
Western Sandpiper (B-WESA) *Calidris mauri*	Abundant	Migrant	Mudflats, muddy shores of lakes and marsh edges.	Mainly coastal	Small
Rufous-necked Stint (B-RNST) *Calidris ruficollis*	Casual	Vagrant	Mudflats.	Coast	Small
Little Stint (B-LIST) *Calidris minuta*	Accidental	Vagrant	Mudflats.	Coast	Small

Common name (Species code) Latin name	Abundance	Status	Habitat	Distribution	Size class
Temminck's Stint (B-TEST) *Calidris temminckii*	Accidental	Vagrant	Mudflats.	Coast	Small
Least Sandpiper (B-LESA) *Calidris minutilla*	Very Common	Migrant Breeds	Mudflats, estuaries, tidal pools, soft and muddy edges of lakes, sloughs, ditches, sewage ponds river banks and bogs.	Coast / Interior	Small
White-rumped Sandpiper (B-WRSA) *Calidris fuscicollis*	Rare	Migrant	Estuaries, tidal mudflats, lake edges, and sewage lagoons.	Mainly in the Peace Lowland	Small
Baird's Sandpiper (B-BASA) *Calidris bairdii*	Uncommon	Migrant	Beaches, mudflats, shallow water of lakes and ponds, alpine areas, lagoons and estuaries.	Coast / Interior	Small
Pectoral Sandpiper (B-PESA) *Calidris melanotos*	Common	Migrant	Drier areas of tidal mudflats and estuaries, grassy or flooded muddy fields, slough margins and sewage ponds.	Coast / Interior	Small
Sharp-tailed Sandpiper (B-SHSA) *Calidris acuminata*	Rare	Autumn Migrant	Short grassy uplands, lawns, tidal mudflats, estuaries, sewage lagoons, and river banks.	Mainly coastal	Small
Rock Sandpiper (B-ROSA) *Calidris ptilocnemis*	Uncommon	Migrant Winters	Rocky islets, rocky headlands, beaches and occasionally mudflats.	Coast	Small
Dunlin (B-DUNL) *Calidris alpina*	Abundant	Migrant Winters	Mudflats, spits, dykes, beached logs, log booms, sloughs, lakes, and flooded fields.	Mainly coastal	Small

Common name (Species code) Latin name	**Abundance**	**Status**	**Habitat**	**Distribution**	**Size class**
Curlew Sandpiper (B-CUSA) *Calidris ferruginea*	Very rare	Vagrant	Mudflats.	Coast	Small
Stilt Sandpiper (B-STSA) *Calidris himantopus*	Uncommon	Migrant	Shallow lakes of lakes, sloughs, ponds, and sewage lagoons.	Coast / Interior	Small
Spoonbill Sandpiper (B-SBSA) *Eurynorhynchus pygmeus*	Accidental	Vagrant	Mudflats.	Coast	Small
Buff-breasted Sandpiper (B-BBSA) *Tryngites subruficollis*	Rare	Migrant	Dry, short grass areas such as golf courses, airports, and residential lawns.	Coast / Interior	Small
Ruff (B-RUFF) *Philomachus pugnax*	Casual	Vagrant	Pools, shorelines, estuaries, sewage ponds, and flooded fields.	Coast / Interior	Medium
Short-billed Dowitcher (B-SBDO) *Limnodromus griseus*	Common	Migrant Breeds Blue List	Mudflats, farm ponds, muddy fields, golf courses, and offshore rocks.	Mainly coastal	Medium
Long-billed Dowitcher (B-LBDO) *Limnodromus scolopaceus*	Common	Migrant Winters	Mudflats, offshore rocks, islands, muddy shores of lowland lakes and sloughs, river banks and sewage ponds.	Coast / Interior	Medium
Common Snipe (B-COSN) *Gallinago gallinago*	Common	Migrant Winters Breeds	Bogs, fens, swamps, and muddy margins along rivers, lakes, and marshes.	Coast / Interior	Medium
Wilson's Phalarope (B-WIPH) *Phalaropus tricolor*	Fairly common	Migrant Breeds	Shallows of sloughs, lakes, flooded meadows and sewage ponds.	Mainly interior	Medium

Common name (Species code) Latin name	**Abundance**	**Status**	**Habitat**	**Distribution**	**Size class**
Red-necked Phalarope (B-RNPL) *Phalaropus lobatus*	Common	Migrant Breeds Blue List	Mainly offshore, edges of kelp beds, and rarely on sandy beaches, subalpine bogs.	Coast in spring; Coast / Interior in autumn.	Small
Red Phalarope (B-REPH) *Phalaropus fulicaria*	Uncommon	Migrant	Almost entirely pelagic.	Coast	Small

3. PROTOCOLS

3.1 Sampling Standards

The following standards are recommended to ensure comparison of data between surveys, and to mitigate several sources of bias common in surveys. Individual protocols provide more detailed standards applicable to the method(s) and design recommended.

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 manual, "Introduction to RIC Wildlife Inventory".

3.1.2 Personnel

All survey methods need trained personnel capable of identifying shorebirds. However, some methods such as aerial and boat surveys require only a few personnel with higher levels of training and experience, while methods like ground surveys may require many volunteers who need only expertise in identification and record-keeping, and who can often be easily trained. Variability always exists among observers in experience, in 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.

3.1.3 Difficulties in identification

Some shorebirds like the two species of yellowlegs and dowitchers, and the many small *Calidris* sandpipers are difficult to distinguish in the field. These may cause errors in both presence/not detected data and in actual counts of flocks. Observers need to be experienced or to have extensive training. See Paulson (1993) and Veit and Jonsson (1984) for tips on field identification.

3.1.4 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 produce comparable results.

3.1.5 Bird density

Accurate counts of birds may be possible when the number of birds in not large. However, when the numbers increase, estimation techniques have to be used and these have much larger errors than direct counts. Training of observers in estimation techniques is essential (Section 3.5).

3.1.6 Time of day

Variation in activity levels and behaviour throughout the day often causes changes 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). A methodology based on moving averages may be used to compensate for these effects in counts (Palmeirim and Rabaca 1994). However, standardization of time of counts will reduce the need for such correction factors.

3.1.7 Time of year

The analysis of ISS (International Shorebird Survey) data shows that most species exhibit fairly sharp annual local population peaks. If none of the sampling occurs during the peak period, the population for that site will be seriously underestimated (Howe 1990).

3.1.8 Tidal cycle

The timing of counts in relation to the tidal cycle can cause wide variation in the numbers noted (Burger 1984; Burger *et al.* 1977). Two solutions suggested to minimize this problem are to either count the birds when they are confined at roosts during the high tide period, or survey when the birds are actively feeding on intertidal flats. The latter is usually preferred because, although some traditional roosts are known, many roosts form unpredictably. During the rainy season birds may forage in agricultural fields and pastures when the tidal flats are inundated. Colwell and Cooper (1993) suggest that the best times to census are when tidal flats are just being inundated, and flocks are concentrated in a smaller area and forced to forage in habitats close to the observers.

In British Columbia, it is probably best to count shorebirds ±2 hours from peak high tides, when birds are concentrated along the edges of water. Falling, rather than rising, tides are probably best for most surveys. Counting of birds in roosts is feasible only during ground counts. Do not survey at low tides.

3.1.9 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 (Robbins 1981).

3.2 Inventory Surveys

Shorebirds in British Columbia occupy varied habitats depending on whether they are migrating, wintering or breeding. Most species form flocks during migration and winter, but are more dispersed when breeding. Therefore, the methods used to census these populations and to make population estimates differ between the seasons. In British Columbia, migratory and wintering shorebirds are found in very similar habitats. Hence, protocols for methods to census them during these periods of their annual chronology are discussed together in Section 3.3. However, the 18 species that breed regularly in British Columbia are found in diverse habitats and the protocols of the methods used to census these breeding populations are outlined separately in Section 3.4.

Migration

Most shorebirds found in British Columbia occur as migrants. Some species follow elliptical migratory routes and hence are more or less abundant in specific localities during different seasons. Some species migrate exclusively along the coast or through the interior. Some species are not easily censused during migration. For example, Solitary Sandpipers pass through singly, on a broad front, stopping at secluded bogs and ponds in interior forests; and Common Snipe can stopover in almost any damp, weedy spot they encounter and are best detected by flushing by close approach of humans or hunting dogs. However, many species can be effectively surveyed. Selection of survey methods, times, and population estimates may need to be modified depending on these species-specific characteristics.

Shorebirds move through stopover sites at varying rates determined by physiological and climatological factors. Major flights could be overlooked if the interval between samples is too long (Howe 1990).

Many species that prefer inland, freshwater sites, opportunistically select wetlands that have suitable water conditions at any given time (Howe 1990). However, a few studies have shown that at least some individuals of some species show fidelity to migration stopovers (Smith and Houghton 1984). Shorebirds migrating across the interior encounter temporally and spatially dynamic wetlands and use these opportunistically (Skagen and Knopf 1994a,b). Hence differences in relative abundance of shorebirds at any given site from one year to the next may not reflect the real population trends of the species.

Winter

Only a few species of shorebirds winter regularly in the province, mainly in southern coastal regions. Unlike migratory populations where there is immigration and emigration to a site, wintering populations are relatively closed. Hence, survey methods and calculation of relative abundance indices and absolute population estimates may differ for migratory and wintering populations of the same species.

Breeding

The variation in breeding strategies employed and habitats used by shorebirds in British Columbia confound the application of one, or even a few, methods of surveying breeding populations. Some species nest in loose aggregations in discrete habitats and are relatively easy to count, but others are widely dispersed in rugged terrain and are difficult to detect even under optimal conditions. The techniques used to census breeding shorebirds in British Columbia are generally species specific and may be costly and logistically difficult.

Table 2 summarizes recommended general survey methods for shorebirds in B.C. at the three levels of survey intensity, while Table 3 outlines species-specific survey methods during the migration, wintering, and breeding seasons. Where more than one technique is listed, they are listed in order of overall efficiency (quality of data balanced against cost of obtaining data). Where 'Transect' is listed as the recommended inventory technique, the most appropriate type of transect (Ground; Shoreline; Roadside) must be chosen depending on the type of habitat and species being surveyed. A transect type has already been recommended for some species. The survey methods chosen depend largely on the specific objectives of the researchers, and must be chosen accordingly. These survey methods have been recommended by biology specialists and approved by the Resources Inventory Committee.

In many cases, combinations of survey methods may be required to obtain accurate estimates. For example, estimates for populations spread over large areas (generally made from aerial surveys), or of mixed flocks of small sandpipers, can be improved by correcting with data on numbers and species composition from simultaneous ground surveys of subsets of the population.

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

Survey Type	Data Forms Needed	*Intensity
Migration and Winter Surveys:		
Aerial Encounter Transect	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Shorebirds • Animal Observations Form- Shorebird Aerial Encounter Transect	• PN • RA
Boat Offshore Island Encounter Transect	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Shorebirds • Animal Observations Form- Shorebird Boat Offshore Island Encounter Transect	• PN • RA
Ground Count	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Shorebirds • Animal Observations Form- Shorebird Ground Count	• PN • RA • AA

Survey Type	Data Forms Needed	*Intensity
At-Sea Transect (Red and Red-necked Phalaropes)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Shorebirds • Animal Observations Form- Shorebird At-Sea Transect	• PN • RA
Breeding Surveys:		•
Transect Survey (Ground; Roadside; Shoreline)	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form- Shorebirds • Animal Observations Form- Breeding Shorebird Transect	• PN • RA • AA
Call Playback for Common Snipe	• Wildlife Inventory Project Description Form • Wildlife Inventory Survey Description Form - Shorebirds • Animal Observations Form- Shorebird Call Playback • Ecosystem Field Form	• PN • RA • AA
Boat Offshore Island Encounter Transect and At-Sea Transect	• Used for Black Oystercathcers only. • Note: Use same forms as provided for migratory and winter surveys.	• PN • RA

* PN = presence/not detected (possible); RA = relative abundance; AA = absolute abundance
Note: See Table 3 for appropriate species for each survey type.

Table 3. Summary of recommended survey techniques for regularly occurring shorebirds in British Columbia.

Common Name	Recommended survey technique		
	Migration	**Winter**	**Breeding**
Family Charadriidae: Plovers			
Black-bellied Plover	• Aerial Encounter Transect • Ground Count	• Aerial Encounter Transect • Ground Count	
Lesser Golden-Plover	• Ground Count		• Transect: Ground
Semipalmated Plover	• Ground Count		• Transect: Ground
Killdeer	• Ground Count	• Ground Count	• Transect: Ground
Family Haematopodidae: Oystercatchers			
Black Oystercatcher	• Boat Offshore Island Encounter Transect	• Offshore Island Encounter Transect	• Boat Offshore Island Encounter Transect • At-Sea Transect
Family Recurvirostridae: Stilts and Avocets			
Black-necked Stilt	• Ground Count		
American Avocet	• Ground Count		
Family Scolopacidae: Sandpipers, Phalaropes and Allies			
Greater Yellowlegs	• Ground Count	• Ground Count	• Transect
Lesser Yellowlegs	• Ground Count		• Transect: Roadside
Solitary Sandpiper	• Ground Count		• Transect: Roadside
Wandering Tattler	• Boat Offshore Island Encounter Transect		
Spotted Sandpiper	• Transect: Shoreline		• Transect: Shoreline
Upland Sandpiper	• Transect: Roadside		• Transect: Roadside
Whimbrel	• Boat Offshore Island Encounter Transect • Ground Count		
Long-billed Curlew	• Transect: Roadside		• Transect: Roadside

Common Name	Recommended survey technique		
	Migration	**Winter**	**Breeding**
Hudsonian Godwit	• Ground Count		
Marbled Godwit	• Ground Count		
Ruddy Turnstone	• Boat Offshore Island Encounter Transect		
Black Turnstone	• Boat Offshore Island Encounter Transect • Ground Count	• Boat Offshore Island Encounter Transect • Ground Count	
Surfbird	• Boat Offshore Island Encounter Transect	• Boat Offshore Island Encounter Transect	
Red Knot	• Boat Offshore Island Encounter Transect		
Sanderling	• Ground Count • Aerial Encounter Transect	• Ground Count • Aerial Encounter Transect	
Semipalmated Sandpiper	• Ground Count • Aerial Encounter Transect		
Western Sandpiper	• Aerial Encounter Transect • Ground Count		
Least Sandpiper	• Aerial Encounter Transect • Ground Count		• Transect: Shoreline
White-rumped Sandpiper	• Ground Count		
Baird's Sandpiper	• Ground Count • Aerial Encounter Transect		
Pectoral Sandpiper	• Ground Count		
Sharp-tailed Sandpiper	• Ground Count		
Rock Sandpiper	• Boat Offshore Island Encounter Transect	• Boat Offshore Island Encounter Transect	
Dunlin	• Aerial Encounter Transect • Ground Count	• Aerial Encounter Transect • Ground Count	
Stilt Sandpiper	• Ground Count		

Common Name	Recommended survey technique		
	Migration	**Winter**	**Breeding**
Buff-breasted Sandpiper	• Ground Count		
Short-billed Dowitcher	• Ground Count		• Transect
Long-billed Dowitcher	• Ground Count		
Common Snipe	• Ground Count (flush)	• Ground Count (flush)	• Call Playback • Transect: Ground; Roadside
Wilson's Phalarope	• Ground Count		• Transect: Shoreline
Red-necked Phalarope	• At-sea Transect • (Boat Offshore Island Encounter Transect)		• Transect
Red Pharlarope	• At-sea Transect		

3.3 Protocols for Migratory and Wintering Shorebirds

Many shorebird species concentrate during migration with a large proportion of populations occurring at only a few sites (e.g., Morrison and Ross 1989; Morrison 1991). Because most shorebird species nest and winter at remote sites, it is often most feasible to monitor populations at migratory staging areas (Howe *et al.* 1989). The vast majority of migrant shorebirds in British Columbia pass through the Fraser River estuary, with smaller numbers in other large coastal estuaries, along a few major interior river valleys and at local sites in the northeast (Butler and Campbell 1987; Campbell *et al.* 1990). Thus, the spring and fall migration provide an opportune time to census populations of many species.

3.3.1 Aerial Encounter Transect

Recommended use: Aerial survey is the most cost effective technique for obtaining data on presence/not detected and relative abundance for shorebirds over large geographic areas and in remote regions.

1. To estimate relative abundance of migratory and wintering populations along the coast.
2. To monitor large-scale population trends of migratory shorebirds over time.
3. Comparison of distributions between habitats over relatively large areas.

Aerial survey has been widely used to inventory migrant shorebirds over large areas (e.g., Dunne *et al.* 1982; Morrison 1983b; Hicklin 1987; Stenzel and Page 1988; Clark *et al.* 1993) and to monitor wintering populations (Morrison and Ross 1989). This survey technique is most effectively used along coastal and estuarine areas where large flocks of shorebirds occur.

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 range from 25-100 m above ground level at airspeeds of 110-240 km/hr (Morrison and Ross 1989; Morrison *et al.* 1991; Clark *et al.* 1993; R.W. Butler pers. comm.).

Numbers of shorebirds are obtained either by direct counting of individuals in smaller flocks or by estimation of larger flocks. Data on bird numbers and habitat are recorded on cassette tape recorders and are later transcribed onto data sheets and/or maps. Ground truthing of aerial surveys have shown varying degrees of accuracy, ranging from very close correlation in some cases (e.g., Hicklin 1987), to only minimal correlation in other cases (e.g., Morrison and Ross 1989). Edwards and Parish (1988) attributed underestimates produced by aerial surveys to difficulties in counting birds when observers had to fly at higher speeds or at higher altitudes.

Many species of shorebirds cannot be identified to species during aerial surveys. The small sandpipers of the genus *Calidris* are usually grouped together as "peeps" (Morrison and Ross 1989). The two species each of yellowlegs and dowitchers are also usually grouped together due to difficulties in identification. Under some conditions, shorebirds are grouped into size categories (small, medium, and large: Table 1) for aerial surveys but this greatly reduces the utility of the information (Morrison and Ross 1989; Morrison *et al.* 1991).

Video cameras and aerial photography are sometimes used in conjunction with aerial surveys. Aerial photography can give accurate estimates of flocks in limited areas, as well as provide valuable information about the habitat. The Canadian Wildlife Service has found good results from photographing flocks of Western Sandpipers and Dunlins with a 300 mm lens at a survey altitude of 300 feet (R.W. Butler pers. comm.). Photography can also be used to calibrate visual estimates.

<u>Advantages</u>

- Large areas can be covered in a short period of time, i.e. there is a low chance of double-counting individuals.
- 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 sites and between years.
- Logistically simpler compared to coordinating personnel required for ground counts of similar geographic scale.
- Since counts are relatively instantaneous, biases caused by movement of birds between areas may be avoided.
- Can be effectively used for reconnaissance of different inland staging areas where changing environmental conditions may cause migratory flocks to move between sites.
- Aerial surveys are usually the most cost effective method for censusing large and remote geographic areas.

<u>Disadvantages</u>

- Large errors in estimates may occur if observers are not properly trained. Regular verification by comparing estimates of observers and that recorded by aerial photographs taken at the same time can help personnel improve their accuracy. Aerial surveys tend to either under or over estimate flock sizes. Photographs or ground surveys can be used to correct for these biases (Pollock and Kendall 1987).
- Errors in identification are inevitable given the large number of species, the mixing of flocks, and similarities between some species.
- Errors in estimating species composition of large, mixed flocks is probably high.
- Rare species within flocks and cryptic species are usually missed.
- Marked or colour-banded birds can not be spotted from the air.
- Aerial surveys are suitable only for wide open habitats. Vegetation usually reduces the effectiveness of aerial surveys.
- Variables such as light conditions, different observers, altitude, and precise route flown tend to affect the estimate of bird numbers.

- The sight and sound of the aircraft may cause some birds to flush ahead of flights and consequently, these birds are missed in the counts or, if counted, may be double-counted at another site.

Office procedures

- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- Survey lines usually follow the shoreline along the coast and are drawn on maps used for navigation.
- The length of flight paths will vary depending on the width of the survey area, the density of the flocks counted and the intensity of the level of the survey. This has to be estimated as accurately as possible and the flight path clearly traced onto a 1:5000 map.
- Survey routes must be chosen to maximize the coverage of suitable habitat. The survey route is traced lightly on a 1:5 000 map 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.
- Along the coast, tidal cycles must be calculated for the area to be surveyed and coordinated with the flight plan. Falling tides are usually best because most birds will be feeding on open mudflats.
- Authority to fly over sensitive areas (e.g., airports, 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 procedures and spotting estimates. Team members should review maps of the area.
- Data is recorded on cassette tape during the flight 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.

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 by 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 field procedures). This will avoid oversights and duplication. Each crew member should also be made responsible for rechecking all equipment they will be using during the flight and be familiar with the flight route. Each member should have their responsibilities detailed in written form, with copies given to other crew members.
- All personnel must have a high tolerance for motion sickness. *Gravol* or other preventative medications should be taken prior to take-off if there is the slightest chance of motion sickness.
- 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.

Sampling design

- Systematic or stratified random sampling.
- Air speeds between 110-240 km/hr and flights altitudes between 25-100 m above ground level are recommended.
- Survey lines for each sector may be modified to suit the terrain. Along narrow mudflats, the aircraft flies approximately 30-50 m offshore and all birds are counted from one side of the aircraft. In broad intertidal zones, flights are run approximately 100 m offshore and observers count birds within a 50-100 m transect zone, from both sides of the aircraft; these counts are later summed. On very broad mudflats, the entire area can be surveyed by conducting several passes, while ensuring that areas are not counted twice.
- Survey lines for each sector may be modified to suit the terrain. Along coastlines with narrow tidal zones, the survey lines should be run 25-50 m offshore, and one spotter and the navigator count from the same side of the aircraft. Along broad intertidal zones, survey lines may be run further offshore and the spotters count from opposite sides of the aircraft.
- For estimates of relative abundance, all habitat with potential to hold birds must be surveyed, meaning a more comprehensive, stratified sampling strategy must be employed. For relative abundance, a single standardized route may be sufficient.
- The entire survey route may be broken up into smaller sectors to facilitate counting. Each of the sectors have to be clearly labelled, and marked on the maps so that the navigator and spotters can name each sector as it is counted (Figure 1).

Sampling effort

- In most cases, surveys should be repeated several times during times of peak abundance, on opposite sides of the aircraft.
- For estimates of relative abundance, all habitat with potential to hold birds must be surveyed.

Time of Survey

- The time required for a survey depends on; (a) area 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) tide window available.
- Time of day: To avoid low sun angles and glare during spring, summer, and fall, surveys should be scheduled on clear or overcast days, between three hours after dawn and three hours before dusk (@ 0800 to 1600 hrs).
- Tidal cycle: Survey times along the coast should take into account tide levels. Survey flights may be conducted either during high tide when all the birds can be counted in roosting flocks above the high tide line (Hicklin 1987; Morrison and Ross 1989), or on the falling tide when shorebirds feed on exposed mudflats (Clark *et al.* 1993).
- Weather: 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.
- If only one survey is to be scheduled during the migratory period, it should be scheduled to coincide with the average peak in migration as determined from existing data (peaks always vary between years). For winter surveys, the surveys should be scheduled mid-winter to avoid biases from early and late migrants.
- A certain amount of flexibility has to be incorporated into scheduling to accommodate delays caused by bad weather or mechanical problems.
- 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.

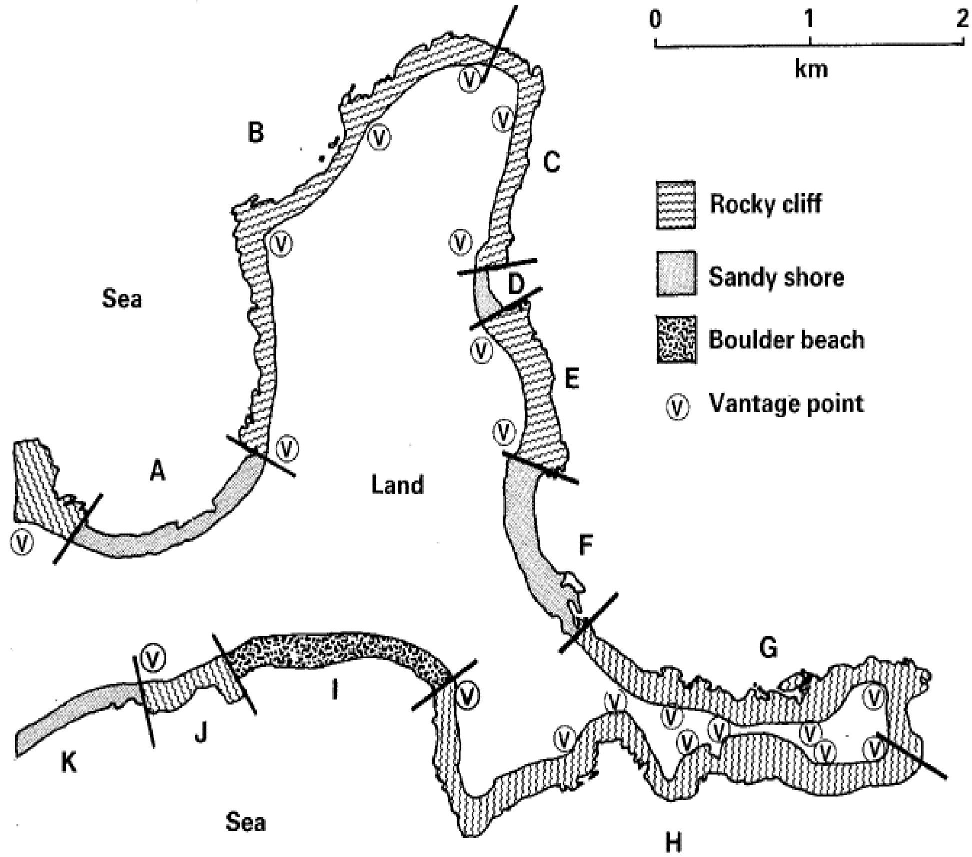

Figure 1. Division of Habitat into survey sectors (Modified from Bibby *et al.* 1992).

When flocks of migrating or wintering shorebirds are distributed along extensive beaches, tidal mudflats, or sandy beaches, the shore should be divided into sectors. Each sector should be easily surveyed by a team of observers within two hours. It is important that all sectors and vantage points are marked on a base map of the study area. Care must be taken to ensure the results correspond to each sector.

Equipment

- Overhead fixed winged aircraft are recommended (e.g., Cessna 182, 206). The same type of aircraft should be used each time 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 tape recorder to record data.
- Each counter should have 7-10X binoculars, a tape recorder plus one backup, extra blank tapes, maps of routes, a precision watch, extra batteries, and pencils and field data forms/note book in case of tape recorder failure.
- Video cameras and still cameras may also be used to supplement the data. Again spare film and batteries should be on board.

Field Procedures

- The navigator and the two spotters meet prior to commencing surveys to ensure that all methodologies are standardized, all crew members are familiar with the flight route, each clearly knows the data that they are responsible for recording, double check each others equipment and spares, and synchronize watches. 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:
  (a) tracing the exact route flown during the survey on the maps;
  (b) recording time at which counting on each sector 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;
  (c) marks location of large flocks on the map; and
  (d) records details such as deviations from planned flight lines or repeated flights over any sector.
- The two spotters record data directly in to tape recorders. At the start of each sector the spotter clearly dictates:
  (a) the name/number of the sector, the GPS co-ordinates if known, time of commencing of count;
  (b) each shorebird species spotted;
  (c) number of each species, including group sizes (mixed and single species flocks);
  (d) direction of flight of flocks until the end of that sector is reached; and
  (e) at the end of each sector they again record name/number of sector, GPS co-ordinates and time at the end of the sector. The sector can then be marked off on the map so that they can keep track of their flight path. It is recommended that the navigator call out the beginning/end of each sector to the counters so that the two counters and the navigator are synchronized.
- All shorebirds seen are counted or estimated. Small flocks are counted directly, but sizes of larger flocks are estimated (see Section 3.5). Shorebirds should be identified to species level if possible. However, in cases where specific identification is not possible due to large mixed flocks, or birds are seen at a distance in poor light, then they are assigned to one of three size categories - small, medium or large (Table 1). These unclassified species may then be assigned to specific categories if concomitant ground surveys provide estimation of species proportions.

- If estimates of abundance are needed, then photographic techniques can be used to increase the accuracy of data. If video cameras are used, the date and time counter functions should be turned on, such that they are recorded directly on the film. The time function of the video camera must be synchronized with the watches of the observers so that information from the observers can be easily correlated to that on video. Oral notes of birds and habitats can also be recorded on the audio tracks. A Hi-8 1-12 zoom palmcorder is recommended. Extra features such as image stabilizer and a large screen colour monitor are highly recommended to quickly lock in on a subject, and the large screen also reduces the tendency towards motion sickness. Short 30 minute tapes are recommended over long tapes to ease editing.
- Aerial 35 mm still photography can also be used when the density of shorebirds 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 are 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 using slides.
- Many cameras have interchangeable data backs that allow the date, time, and code number (sector) 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 viewers make spotting and framing significantly more efficient and less prone to trigger motion sickness discomfort.
- If estimates of abundance are needed, data from aerial surveys can be improved by ground-truthing of subsets of the survey data. Ground-based counts are assumed to be more accurate, and by comparisons of estimates of the same area the aerial counts may be adjusted for bias or error. These ground counts should be made at the same time.

Data Analysis

- The navigator and spotters transcribe data onto 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 (ensure correct date and time fields are filled out). Convention is to use the higher figure in replicate counts. The species column can be filled out in advance or species noted as the tapes are transcribed. Standard species codes should be used (Table 1). Additional notes made during the flight should be transcribed as well.
- Data can then entered into a computerized data base with mapping capabilities.

- <u>Presence/not detected:</u> 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 surveys can be indicated by filling in different quarters of the circle, each quarter indicating a season, month, week, or day (e.g., Campbell et. al. 1990).

- Relative abundance: This can be expressed as: (1) total counts of birds for a particular location, (2) birds per square kilometre or (3) number of birds per kilometre of survey route.
  1. Total estimated counts:
     The total number of birds in all the sectors within a certain location are summed together to give the relative abundance of birds in an area at a given time.

  2. 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/kilometre: $K = B/Z$
     where K = birds per kilometre of survey route (Birds/km)
     B = No. of birds observed
     Z = Length of survey route measured from maps

3.3.2 Boat Offshore Island Encounter Transects

Recommended use: Presence/not detected and relative abundance of migrating and/or wintering turnstones, Surfbirds, Wandering Tattlers, and Rock Sandpipers that forage on rocky shorelines and nesting Black Oystercatchers. Although this method will detect species that forage on open mudflats, but roost on rocky islets, those species are best surveyed on mudflats.

Some species of shorebirds such as the resident Black Oystercatcher, and migrating and/or wintering turnstones, Surfbird, Wandering Tattler and Rock Sandpiper are found primarily on rocky off-shore islands or points. Migrating Red-necked Phalaropes are also often found among kelp beds along outer coastal areas. These species are best surveyed from small boats that 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 and counts are possible with little disturbance to the birds.

Boat surveys that follow shorelines have been used to census shorebirds in British Columbia, mainly in protected coastal waters such as in the Strait of Georgia, in estuaries of large rivers, in fjords, or in large sounds and bays (e.g., Butler *et al.* 1991).

Black Oystercatchers have been inventoried by this method throughout the coast, although mainly as part of more intensive breeding surveys (e.g., Vermeer *et al.* 1992. One or more pairs may occur on each island and effort to verify the numbers of breeding pairs varies accordingly. The breeding density may be expressed as number of breeding pairs per km of shoreline surveyed (e.g., Vermeer *et al.* 1991a,b). Nonbreeding birds which, when present, may bias estimates of breeding pairs, tend to occur in flocks and to not exhibit behaviours associated with nesting. Care must be taken, however, to avoid including nonbreeders in estimates of breeding pairs when birds are present but nests are not found.

The other species have not been specifically surveyed often, but work by M.G. Shepard in Oak Bay has proven that this method is useful.

Butler *et al.* (1991) also used a combination of boat and ground surveys to document seasonal abundance of birds on mudflats in Browning Passage. More than half the birds documented there were Western Sandpipers.

Advantages

- The only practical method for surveying small offshore islands, islet groups, rocky spits and reefs.
- Least disruptive of the survey methods.
- Allows accurate observation and identification of cryptic species.

Disadvantages

- Specialized method applicable only to a few species that are found on rocky shorelines and offshore islands.
- More expensive than ground surveys.
- Very dependant on sea and weather conditions.
- Need trained personnel capable of handling boats and spending time on the water.

- A limited time frame for movement of migrants and relatively small numbers have discouraged any significant amount of inventory of migrant shorebirds on offshore islets.

Office Procedures

- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- Select survey sites from 1:20 000 or 1:50 000 maps, marine charts, personal experience and existing data.
- Plan the survey route to maximize efficiency in travelling and covering all habitat.
- Survey routes should be marked on maps. Individual islets within island groups have to be clearly numbered on the maps.

Sampling design

- Systematic sampling.
- This technique is a essentially a simple transect that follows the contours of a shoreline as close as possible and counts all birds encountered (Buchanan 1988; Edwards and Parish 1988).
- Black Oystercatchers nest on offshore rocky islets and require one additional technique. The perimeter of islands are surveyed using small boats and when an oystercatcher is observed, the island is checked thoroughly on foot to verify breeding.

Sampling effort

Time of Survey

- 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.
- 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 migration or, for breeding oystercatchers, during the nesting period.
- Since migrant shorebirds that use offshore islands pass through the province during a brief period, ensure that the survey coincides with this period (Table 1).

Personnel

- An experienced boat operator with knowledge of local waters and navigational techniques. The boat operator can also act as a backup observer.

- A survey crew of (2-4 people) should be led by a biologist experienced in shorebird census.
- All crew members should have a high tolerance for motion sickness.

Equipment

- A suitable boat for surveying nearshore marine waters. A smaller boat or inflatable is preferred for moving 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 a 7-10X binoculars.
- Appropriate safety equipment (life jackets or survival suits, flares, HF radio, spare fuel, emergency rations, etc.).

Field Procedures

- 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 shorebirds encountered should be recorded along with the age and behaviour of the birds.
- For censusing breeding oystercatchers, observers should search the islands where birds are observed for evidence of nesting, such as presence of nests or young or, in the absence of these, determine if the birds' behaviour indicates nesting (see Section 3.4).
- The data should be recorded in waterproof note books with pencils.

Data Analysis

- The data from field note books and data forms should be transferred to a data base with mapping capabilities.
- A database of 1:20 000 maps of the survey sites, survey routes and areas observed should also be maintained.
- Data may be displayed as:

  - <u>Presence/not detected:</u> This data may be displayed as for aerial surveys.

  - <u>Relative abundance:</u> For migratory shorebirds that occur on offshore islands, the index of bird abundance should be calculated as:

  1. Birds/kilometre of shoreline: $K = B/Z$
     where K = No. of birds per kilometre of shoreline surveyed
     B = No. of birds observed
     Z = Length of shoreline surveyed (km)

2. Birds in an area: $D = B/A$
   where D = density of birds (Birds/km^2)
   B = No. of birds observed
   A = area of islands (The area of the islands/islets surveyed is calculated from maps using a planimeter)

3. For breeding oystercatchers which nest on rocky shorelines, the index of nesting abundance is calculated as:

   Breeding pairs/kilometre of shoreline: $K = B/Z$
   where K = Breeding pairs or nests per kilometre of survey route
   B = No. of nests or breeding pairs observed
   Z = Length of shoreline of islands measured from maps

3.3.3 Ground Counts

Recommended use:

1. To inventory significant migratory staging and wintering sites along the coast and in the interior for presence/not detected relative abundance, and absolute abundance.
2. To document the occurrence of rare and vagrant species.
3. Where accurate estimation is required.

Ground surveys are commonly used to survey migrating shorebirds along mudflats and beaches, both along the coast and in the interior (e.g., Bradstreet *et al.* 1977; Butler and Cannings 1989; Bradley and Bradley 1993). This survey method involves counting all shorebirds visible from land-based points. Ground survey data can be used to determine presence/not detected relative abundance, and absolute abundance at a given time. In conjunction with data on turnover rates of migrants, it can be used to estimate total migratory populations using a site (Butler *et al.* 1987; Butler and Kaiser 1995).

Long term shorebird monitoring projects such as the International Shorebird Survey (ISS) and the Maritime Shorebird Survey (MSS) in North America (Morrison and Campbell 1983; Howe 1990; Morrison *et al.* 1994), and the British Birds of Estuaries Enquiry and others (Prater 1981; Kirby 1987, 1990; Furness and Greenwood 1993) have used amateur ornithologists at various areas with wintering concentrations to conduct ground surveys of shorebirds. The methods used by all these projects are similar. Sites for ISS and MSS are chosen non-randomly by participants on the basis of use by large numbers of shorebirds and the convenience of coverage (Howe 1990; Morrison *et al.* 1994). In both the MSS and the ISS volunteers are asked to adopt a clearly defined site and conduct surveys at the same stage of the tide cycle, two to three times a month (Howe 1990; Morrison *et al.* 1994).

Advantages

- Ground surveys are thought to give the most accurate estimates of total numbers of birds present within smaller areas, but error rate increases as area surveyed increases.
- Methodologically simple and requires very little specialized equipment.
- Since methodology is simple, a large number of experienced amateur birdwatchers can be trained quickly and used to survey many sites. Volunteers tend to need continuous training.
- Most common method of censusing shorebirds and hence comparison between sites and with literature is more feasible; however, a great deal of variation in accuracy of counts probably occurs.
- Inexpensive, especially if most observers are volunteers.
- Thorough coverage of an area is possible if accessible.
- Multiple counts are easily feasible and improve the accuracy of estimates.
- Higher probability than with aerial surveys that rare species will be detected.
- Since observation conditions are better than in aerial surveys, there is less chance that similar-appearing species will be misidentified.

- Notes on habitat use and other environmental factors can be easily documented at the same time as the counts.
- It is sometimes possible to collect information on age and sex classes for some species when viewed at close range during ground surveys. This information is useful in determining migration phenology of adults and juveniles of each species and to associate age groups with peaks in counts.
- Colour-banded birds are detectable.

<u>Disadvantages</u>

- This method is labour intensive.
- For the same investment in time and labour, fewer sites can be censused than by aerial surveys.
- Only accessible areas can be censused by this method. Impractical to census remote regions by this method.
- Ground counts are less instantaneous than aerial surveys. 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).
- Error increases probably exponentially with flock size.
- To cover large areas, a number of observers are required. This increases the inter-observer variability in the census.
- If surveys are carried out by volunteers, it is difficult to maintain continuity and intensity of surveys between years. This type of inter-year variation in inventory intensity and methodology has plagued the analysis of long term population trends.

Office procedures

- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- Survey areas are selected on the basis of personal experience, existing information, and 1:20,000 or 1:50,000 maps. Although maps may be scanned into the computer, hard copies should be kept as well.
- For coordinated surveys, a number of personnel have to be assembled. If insufficient staff biologists are available, then volunteers can be solicited from local natural history groups.
- Detailed maps (1:5 000) of the study sites should be prepared with the census routes pencilled in lightly and distributed to all surveyors.
- Data forms should be photocopied.
- Instruction on timing of survey, data collection, flock size estimation and identification should be provided to all census takers to ensure equal ability among observers.
- Permission or permits required to access the study area may have to be obtained.

- On completion of the survey, all the data forms have to be collected from individual teams and data compiled.

Sampling design

- Simple random sampling at discrete sites, or systematic sampling using transects.
- At smaller sites it may be possible to count all the birds from a single viewing position. However, for larger sites, a series of vantage positions are chosen and observers at each of these vantage points count all the birds present synchronously, within predefined boundaries (Burger *et al.* 1977; Colwell 1987; Colwell and Oring 1988a; Colwell and Cooper 1993). Since observers remain in one position during the whole survey, disturbance to the birds is minimized and multiple counts during different times of the tidal cycle are possible. Multiple counts probably provide better estimates of shorebird abundance than single counts (Colwell and Cooper 1993). If the numbers of observers is limited, then count areas with highest concentrations first, and move to secondary sites as possible. If birds are moving, then counts must be relatively instantaneous to avoid double-counting.
- In some cases, a simple transect method may be best. In this method, an observer or observers move along a pre-determined path (transect line) and count all shorebirds in view, using a spotting scope or binoculars. This can be done either on foot (Ehrhardt 1971; Bradstreet *et al.* 1977; Hicklin 1987; Colwell and Oring 1988a; Withers and Chapman 1993; Skagen and Knopf 1994a,b), or by vehicle (Skagen and Knopf 1994a,b).

Sampling effort

- Ideally, surveys will sample the peak movements of each species. Sampling intervals need to take into consideration the turnover rates of migrating birds. A single-mid winter count may be scheduled, or the census may be repeated at regular intervals if resources are available. For repeated counts, the interval between counts should be not less than 7 days. If possible, survey for 3 days in a row at peak times to allow calculation of variance.
- Howe (1990) suggested that surveys at 10 day intervals (using Semipalmated Sandpipers as the benchmark) should provide one to three counts during peak migration periods, assuming a 2-3 week turnover rate (Page and Middleton 1972; Dunn *et al.* 1988). However, studies on Western and Least sandpipers in coastal British Columbia have found average lengths of stay between 3 and 5 days respectively (Butler *et al.* 1987; Butler and Kaiser 1995). This suggests that sampling should occur at more frequent intervals on the west coast for these species if absolute numbers are required.

Time of Survey

- The time required for each survey varies with: 1) the length of the census route, 2) terrain, and 3) density of the birds. Surveys need to be timed to coincide with maximum numbers and detectability.
- Additional time is required for transportation to and from the survey site.

- Time of year: Single counts during migration should be scheduled on a day estimated to occur during the migration peak, as determined from existing data.
- Weather: Surveys should be carried out on fair weather days if possible.
- Tidal cycle: Surveys are usually scheduled for about two hours on either side of high tide. Optimal time of surveys depends on tidal cycles and varies between locations. Before beginning formal surveys, it may be advantageous to conduct counts every 10 minutes on the rising tide to identify when peak numbers are recorded. Future surveys can then be timed to best suit local conditions.

Personnel

- Ideally, two persons knowledgeable in shorebird identification should be assigned to each site or route. In areas where the bird density is low, one person can combine the functions of both a counter and record keeper.
- In teams of two, one person is the spotter, who calls out the species and number of birds seen. The second person is the data recorder who keeps a running total of all species detected on the data form.
- The biologist coordinating the surveys should have considerable experience with shorebirds.

Equipment

- Maps of the survey site.
- Data forms on waterproof paper and mechanical pencils.
- Each observer should have a good pair of 7-10X binoculars and each team should have a spotting scope ≥20X and precision watches.
- Most ground surveys of shorebirds are done on foot, but surveys can be carried out from cars in some areas.
- A clip board with a plastic cover over the data form should be used to reduce soiling of pages.
- A camera (video or still) is often useful for recording flock sizes, rare vagrants, habitat, and weather conditions.

Field procedures

- If the study site is large, it may be divided into sectors that can be covered by each team within a maximum of two hours. Observers should note times and direction of arrival and departure of flocks so birds that move from one sector to the next will not be counted twice.
- All teams at a study site start the survey at the same time to minimize biases due to movement of birds. This may involve the teams being driven out to their starting point before the survey. The watches of all teams should be synchronized.
- One member of the team (usually the more experienced birder) scans ahead, and identifies and counts all the shorebirds in view. The other member of the team keeps a running count of all the birds counted on the data sheet. An alternate method would be for one observer to count and record birds to the left of the survey route and the

other observer to do the same on the right. When the number of birds is low one observer would be sufficient for spotting and recording.

- All shorebirds seen are counted. Small flocks are counted directly but sizes of larger flocks are estimated (see Section 3.5). Shorebirds should be identified to species if possible. However, in cases where specific identification is not possible due to large mixed flocks, or birds seen at a distance in poor light, then they can be assigned to one of three size categories - small, medium or large (Table 1). These unclassified species may then be assigned to specific categories according to their proportion of occurrence in the clearly identified counts.
- Notes on the age, sex and behaviour of the birds can also be noted. Colour-banded birds should be noted, but should not be a priority if large areas are to be covered because of time constraints. Records of the weather, start/stop time of the survey, and tide conditions should be kept by each team.
- Notes are also kept of the size and direction of flight of any large flocks of birds into or out of the survey sector.
- The exact survey route followed should be clearly traced on the map.
- If high tide roost sites are seen, these should also be clearly marked on the map.

Data Analysis

- The data from the forms should be entered into a common data base with mapping capabilities as soon as possible.
- A database of 1:20 000 maps of the survey sites, survey routes and areas observed should also be maintained.
- Data may be displayed as:
    - Presence/not detected: This data may be displayed as for aerial surveys.
    - Relative abundance: Various measures of relative abundance can be calculated.

        1. 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).

        2. Birds/kilometre: K = B/Z
           where K = birds per kilometre of survey route (Birds/km)
           B = No. of birds observed
           Z = Length of survey route measured from maps

        3. Peak counts:
           The total number of a species at a site is graphed against the date of the survey for a season. The peak count is then determined by visual inspection. The peak count is then used as an index of relative abundance for comparison of relative use between site or for temporal comparison.

4. Annual Index:
   For trend analysis of populations of migratory shorebirds the annual index is calculated as:
   Annual Index: $A = \text{Log}(\text{Average of } X_1+X_2...X_n)$
   Where $X_1,X_2...X_n$ are individual counts on the period (e.g., 21 days) centred around the peak migration.

- Absolute Abundance:

1. Total Counts: The sum of all the counts of all the sectors at a study area gives the total population of the species at that site on that particular day.

2. Seasonal Total Counts: The sum of all counts at a study site may be used as an index of the total population of migratory birds using the site. Must use mark-recapture data to refine population estimates.

3.3.4 At-sea Transects

Recommended use: Presence/not detected and relative abundance for migrating populations of Red and Red-necked Phalaropes. Pelagic marine surveys are the only means of censusing these populations. However, they are recommended only as part of a broader based seabird survey because of the cost and logistics involved.

Offshore marine surveys are required to census Red and Red-necked Phalaropes. Red-necked Phalaropes tend to occur close to shorelines, but occur regularly beyond the view of land-based observers or observers that are surveying shorelines from boats. The Red Phalarope is almost entirely pelagic outside the breeding season. It is seen near shore only during storms, and is not practical to inventory because of its pelagic habits.

The cost and logistics involved in these surveys preclude their use, apart from a broader-based seabird survey. More work is needed on developing census methods for shorebirds at sea.

Office Procedures

- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- From marine charts, personal experience and existing data, select survey areas.
- Select the routing of the survey and draw transect lines on maps. For large geographic areas random transects may be drawn over the study area.

Sampling design

- Systematic sampling.
- Surveys are conducted from ocean going boats travelling at speeds of 10-25 km/hr along transect lines between predetermined points. The sea is scanned with 7-10X binoculars in a 180° field forward. Surveys must be conducted from small watercraft because phalaropes are not clearly visible beyond about 50 m.

Sampling effort

- Numerous transects are done over the area of study.
- Repeat transects several times during peaks in migration, and for breeding oystercatchers during nesting period.

Time of Survey

- 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.

- 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 migration or, for breeding oystercatchers, during the nesting period.
- Since migrant shorebirds that use offshore islands pass through the province during a brief period, ensure that the survey coincides with this period (Table 1).

Personnel

- An experienced boat operator with knowledge of local waters and navigational techniques. The boat operator can also act as a backup observer.
- A survey crew of (2-4 people) should be led by a biologist experienced with shorebird census.
- All crew members should have a high tolerance for motion sickness.

Equipment

- A suitable boat for surveying nearshore marine waters. A smaller boat or inflatable is preferred for moving 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 a 7-10X binoculars.
- Appropriate safety equipment (life jackets or survival suits, flares, HF radio, spare fuel, emergency rations, etc.).

Field Procedure

- The transect routes are surveyed at 10-25 km/hr.
- The sea ahead is surveyed at a 180^{o} field forward with binoculars. With two spotters, each observes from one side of the boat, while a third crew member records observations.
- The number and species of birds seen and distance from transect line is also noted.
- Additional notes on weather and wind conditions are taken.

Data Analysis

- The data from the field note books should be transferred to a data base with mapping capabilities.
- A database of 1:20 000 maps of the survey sites, survey routes and areas observed should also be maintained.

- Relative abundance: The number of birds seen may be expressed either as: (1) No. of Birds/km of transect or (2) No. of birds/km^2.

    1. Birds/kilometre of transect: $K = B/Z$
       where K = birds per kilometre of transect (Birds/km)
       B = No. of birds observed
       Z = Length of transects (km)

    2. Birds in an area: $D = B/A$
       where D = density of birds (Birds/km^2)
       B = No. of birds observed
       A = area of quadrat that was intensively surveyed using parallel transects.
       Note: For random marine transects the effective width of the transect is calculated as twice the mean distance to the birds observed. Effective area surveyed is therefore, length of transect multiplied by effective width of transect.

3.4 Protocols for Breeding Shorebirds

Twelve species of shorebirds breed regularly in British Columbia and five others are rare breeders in the province (Campbell *et al.* 1990). Breeding habitats include forest bogs, marshes, grasslands, open beaches, rocky islets, and alpine stream beds (Table 4). The variety of habitats, behavioural differences between species, and terrain result in many difficulties in inventory of breeding shorebirds.

In general, presence of common species is relatively easy to determine, but becomes more difficult with thinly distributed species. Relative abundance and absolute abundance are more difficult to determine, and require intensive research effort. In most cases, separate methods are needed for each species to make estimates of absolute abundance.

Table 4. Summary of breeding habitat, general nest site location, density of nests, and practical method of determining breeding status for breeding shorebirds in British Columbia.

Species	Breeding habitat	Nest site	Nest distribution	Evidence of breeding
Lesser Golden-Plover	Alpine tundra	Ground/open	Dispersed	Behaviour/ nest search
Semipalmated Plover	Coastal sand dunes/subalpine wetland	Ground/ concealed or open	Clumped/ dispersed Linear along coast	Nest search/ behaviour
Killdeer	Open fields, grasslands, beaches	Ground/ open	Dispersed	Behaviour/ nest search
Black Oystercatcher	Gravel pockets on rocky islets	Ground/ open	Linear along shorelines	Nest search
American Avocet	Open edges of wetlands	Ground/ open	Dispersed	Nest search
Greater Yellowlegs	Fens and bogs in forests	Ground/ concealed	Widely dispersed	Behaviour
Lesser Yellowlegs	Fens and bogs in forests	Ground/ concealed	Widely dispersed	Behaviour

Species	Breeding habitat	Nest site	Nest distribution	Evidence of breeding
Solitary Sandpiper	Fens and bogs in forests	Tree/old songbird nests	Widely dispersed	Behaviour
Wandering Tattler	Alpine stream beds	Ground/ open	Extremely dispersed	Behaviour/ nest search
Spotted Sandpiper	Open river/lake shores	Ground/ concealed	Dispersed	Nest search
Upland Sandpiper	Grasslands	Ground/ concealed	Thinly dispersed	Behaviour/ nest search
Long-billed Curlew	Grasslands	Ground/ open	Dispersed	Nest search
Hudsonian Godwit	Subalpine wetlands	Ground/ concealed	Isolated	Behaviour
Least Sandpiper	Subalpine, coastal bogs	Ground	Clumped	Nest search
Short-billed Dowitcher	Subalpine, coastal bogs	Ground/ concealed	Thinly distributed	Behaviour/ nest search
Common Snipe	Bogs and swamps	Ground/ concealed	Dispersed	Behaviour/ nest search
Wilson's Phalarope	Upland edges of wetlands	Ground/ concealed	Linear along edge	Nest search
Red-necked Phalarope	Subalpine bogs	Ground/ concealed	Dispersed	Nest search/ behaviour

3.4.1 How to determine if a shorebird is breeding

Data on breeding populations can be collected at two levels: indirect (behaviour of adults) or direct (nests, eggs, or young). Breeding shorebirds (territorial males, birds with nests and/or young) all exhibit defensive/evasive/protective behaviour that can be used to indirectly identify individuals as breeding birds. Most species are monogamous (except phalaropes, Spotted Sandpiper, and possibly Common Snipe), so that one bird (i.e., the male) found exhibiting "breeding" behaviour can be assumed to have a mate (although a small percentage will not), and the pair can be assumed to be breeding. Therefore, observations of breeding behaviour, detected while conducting transects, spot maps, point counts or other general bird surveys can be used to document breeding. See Bent (1927), Johnsgard (1981), Cramp and Simmons (1983), Hayman *et al.* (1986), and Paulson (1993) for descriptions of breeding behaviour.

For some species, this indirect approach may be the only feasible method. For example, Lesser and Greater Yellowlegs, and Solitary Sandpiper nests are sparsely dispersed in difficult terrain, and nests are extremely difficult to find, but territorial birds or birds with young can be detected at considerable distances. Common Snipe and Short-billed Dowitchers are restricted to wet meadows, bogs, and swampy ground, and incubating birds must be almost or actually stepped on to make them flush, but males performing aerial displays prior to mating are fairly easily detected.

A few species breed at sufficient densities, and have nesting behaviour and sites that make finding nests feasible. These species include Semipalmated Plover, Killdeer, Black Oystercatcher, Spotted Sandpiper, Long-billed Curlew, Least Sandpiper, Common Snipe, Wilson's Phalarope, and Red-necked Phalarope.

Some species are so rare that nest searches should be conducted whenever individuals are found and nesting is suspected (Lesser Golden Plover, American Avocet, Wandering Tattler, Upland Sandpiper, Hudsonian Godwit), but systematic searches in suitable habitat without evidence of breeding birds would be senseless.

A variety of methods are recommended to census breeding shorebirds (See Table 2 and Table 3).

3.4.2 Transect Method

Recommended use: Presence/not detected and relative abundance of breeding shorebirds.

The transect method is more suitable for sampling a mosaic of habitats over larger areas. The transect method provides a partial count from which relative abundance indices and total population numbers can be estimated. All birds encountered are assumed to be breeding, unless their behaviour suggests otherwise.

Office procedures

- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- Select study sites based on existing data, personal experience, and topographic maps.
- Select species to be surveyed and plan timing of surveys.

Sampling design

- Systematic sampling.
- The methodology of transect counts varies depending on the species and whether an index of relative abundance or absolute is required (Mannan and Meslow 1980).
- Relative abundance: To obtain an index of relative abundance, an observer walks, drives, or floats down rivers or along lake shorelines for a specified distance. As the observer moves along the transect he/she counts the number of individuals detected. The index calculated is usually expressed as the number of detections per unit distance travelled (Gibson 1971).
- Absolute abundance: Fixed-width transects are used when the absolute density of birds is required. In the Fixed-width-census method, the observer walks a transect and counts all the birds detected within a fixed-width strip on either side of the line. The width of the strip is selected so that all the birds within the boundaries are detected and varies according to the species under study and the habitat. Bird density is then calculated by dividing the number of birds detected by the area of the transect strip. This density is then assumed to be the density of birds in the study area and the total population is estimated. The decline in detectability with increasing distance from the observer, and species differences in detectability are considered major limitations of this method.
- Species-specific designs are outlined below for Common Snipe, Spotted Sandpipers, and Lesser and Greater Yellowlegs. However, these methods may be applied to other species.

Sampling effort
- Repeat transects several times during breeding period.

Time of Survey
- Common Snipe:
  Time of year: mid May to late June
  Time of day: The calling period at dusk, during the 10 day period after females arrive at the breeding site is considered the best time for this count. (Tuck 1972).
- Lesser and Greater Yellowlegs:
  Time of year: May and June

Personnel
- One or more biologists with experience in transect surveys and shorebird biology

Equipment
- Vehicle canoe, or raft as needed
- Waterproof data forms and notebooks
- Mechanical pencils
- Maps

Field Procedures and Data Analysis

Note: Table 3 lists the species that can be surveyed using these transect methods (Ground; Shoreline; Roadside). The following field procedures and data analysis apply to all species that are recommended for that specific transect type. Species-specific information is given as appropriate.

Ground Transects

Species-specific information: Common Snipe.

A straight line census route counting the number of birds heard winnowing may be used for calculating a relative population index for breeding Common Snipe. A fixed-width transect method suggested for total population estimation involves walking along a predetermined route and noting all the birds flushed and the distances at which they flush. The average flush distance is used to calculate the effective width of the census strip. The total population is estimated as the number of birds flushed divided by the area of the census strip (i.e., average density), multiplied by the total area of the site (Tuck 1972).

Field procedures
- Select transect lines and mark with flagging and/or permanent markers.
- Walk along transects, recording shorebirds heard or seen, the distance from the transect line, and with notes on numbers, behaviour, and habitat.
- Note that each species has a different detectability bias which must be accounted for. The effective width of the transect can be estimated to equal the average of the

distances of all birds of one species detected. For example, plovers will sneak off nests unseen, only to expose themselves at a considerable distance from the nest. Other species will sit tight and are only detectable at close range.

Data analysis

- Relative abundance index can be calculated as birds per km of transect
- Absolute abundance can be estimated as density of birds per km^2.

River and Lake Shoreline Transects

Species-specific information: Spotted Sandpipers

Spotted Sandpipers can be censused along "transects" when floating down rivers or paddling along lake shorelines. Non-incubating birds that tend to feed along shorelines react to rafts and canoes by flushing and flying along the shore. In this way, an estimate of breeding pairs/km of shoreline can be made; however, because this shorebird is polyandrous, females may have more than one mate. This technique is most useful on long, medium to large rivers, and larger lakes with considerable amounts of suitable nesting habitat. This technique can also be used to inventory post-breeding populations when adults and juveniles concentrate along the edges of rivers and lakes.

Field procedures

- Circumnavigate lake or pond with boat, or on foot and record numbers of birds seen, noting if they fly across the lake or ahead so that they are not double counted.
- On rivers, drift downstream and count birds seen, noting the direction they fly off so as not to double count them downstream

Data analysis

- A relative abundance index can be calculated as the number of birds (N) divided by shoreline length (km).
- Because Spotted Sandpipers are polyandrous and the degree of polyandry tends to increase with the numbers of birds present, birds observed may represent breeding pairs or *individuals*. Without follow-up nest searches, it is best to use only the number of birds observed and calculate relative abundance, rather than absolute abundance.

Roadside Transects

Species-specific information: Lesser Yellowlegs, Solitary Sandpipers, and Common Snipe

In the Taiga Plains and Boreal Plains ecoprovinces of northeastern British Columbia, Lesser Yellowlegs and Solitary Sandpipers can be detected by driving along roads and seismic cutlines through spruce muskeg habitat. Estimates of individuals or pairs/km of road can be made during May and June, across considerable distances (Campbell and McNall 1982; Campbell *et al.* 1990). Roadside counts for winnowing Common Snipe are also feasible in some areas. Although nests will not be found, assumptions about breeding status can be made from behaviours noted.

Field procedures

- Drive along roads at moderate speeds and watch for shorebirds in ditches or perched on trees near the road. For Common Snipe, stop every 200 m and listen for 5 minutes for winnowing.
- From a known starting point, record birds seen, noting species, number, behaviour and distance (km) from the starting point.
- This technique can also be used by personnel on foot, walking along cutlines or through swampy areas.

Data analysis

- A relative abundance index can be expressed as birds per kilometre of road.

3.4.3 Call Playback

Recommended use: Presence/not detected, relative abundance, and absolute abundance in a given area for Common Snipe.

The broadcasting of territorial calls of Common Snipe and enumeration of individual responses is one of the most accurate methods available to census males and locate nesting sites (Fogarty *et al.* 1980). Data on presence/not detected, relative abundance, and total population estimates in a given area are possible with this method. Note that, because Common Snipe may be polygamous, the detection of one breeding male may actually correlate with the presence of more than one nest (Green 1985), so estimates of breeding populations, without follow up nest searches, should be considered as minimum estimates. Playbacks may be useful for other species whose vocalizations are detectable at relatively long distances (e.g., curlews, yellowlegs, godwits), but remain unproven at this time and is not considered a standard inventory method.

<u>Advantages</u>
- Provides good data on abundance of breeding Common Snipe populations.

<u>Disadvantages</u>
- Species-specific data; does not account for other species.
- May underestimate number of nests.

Office Procedures
- Review the section on Planning and Procedures in the Introductory manual.
- Obtain relevant maps for study 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 survey areas from maps.
- Select study sites based on appropriate habitat. Select transect routes or plots within these sites.
- Prepare audio tapes with calls of selected species.

Sampling design
- Relative abundance: Conduct surveys along transect lines.
- Absolute abundance: Completely search discrete areas.

Sampling effort
- Time will vary depending on the area to be surveyed and the intensity of the survey.
- Surveys are conducted during the breeding season when call playbacks are most likely to elicit a territorial response in male Common Snipes.

Personnel

- One or more biologists experienced in shorebird biology and survey methods.
- At least one person should be familiar with the collection of habitat data.

Equipment

- Audio tapes
- Tape recorder
- Amplifier (megaphone)
- Waterproof data forms and notebooks
- Mechanical pencils
- Maps
- Compass
- Binoculars

Field procedures

- Walk or drive along transects in appropriate habitat.
- At the first call playback station, play a recording of the territorial call once, listen for one minute then play again.
- When responses are detected record locations on field map, noting type of response, distance and direction from your location. If doing an absolute abundance survey, search the area for a nest.
- Record the appropriate habitat data for the call playback station on the Ecosystem Field Form.
- Move 100 m along the transect and repeat the procedure until the transect is completed.
- Continue surveying using transects (and searches as required) until the survey area has been covered.

Data analysis

- The number of responses by males can be used to estimate the number of breeding pairs.
- For Common Snipe, estimates must consider that males may be polygamous and have more than one mate.
- If surveys are done along transect lines then express relative abundance as number of males per km of transect.
- If discrete areas are completely covered, then express absolute abundance as number of males (M) per unit area (km^2).

3.5 How to Count Flocks of Shorebirds

3.5.1 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).

When the number of birds is greater than a few hundred birds, estimation procedures have to be used (Figure 3). The birds in a large flock may be estimated by counting a block of 50 or 100 birds and then estimating how many similar-sized groups make up the entire flock (Butler *et al.* 1991). Hicklin (1987) used photographs to estimate the average density of flocks on the Bay of Fundy and then measured the area covered by the flocks using terrestrial markers. He then multiplied area by density to estimate the total number of birds within the flock. Total number of birds estimated by the above two methods were within 10% of each other (Hicklin 1987). However, Mawhinney *et al.* (1993) used photographs and 1 m^2 quadrats to estimate the size of the same population; their estimates were 37-67% higher than Hicklin's, which underscores the tendency of even experienced observers to underestimate large, dense flocks.

Additional problems arise if the flock is moving or if it is a mixed flock with many different species.

3.5.2 Counting mixed-species flocks

In a large mixed-species flock, observers estimate the proportion of the various species making up the flock and then the total number of birds in the flock is divided up into individual species counts according to these estimated proportions. In some cases, where the observers are unable to determine the proportions of each species, only the species composition of the flock is noted. The total count of these unallocated birds is then divided up into individual species counts assuming that the proportions of the unallocated birds is similar to the proportions of identified species in the rest of the site (Stenzel and Page 1988; Skagen and Knopf 1994a,b).

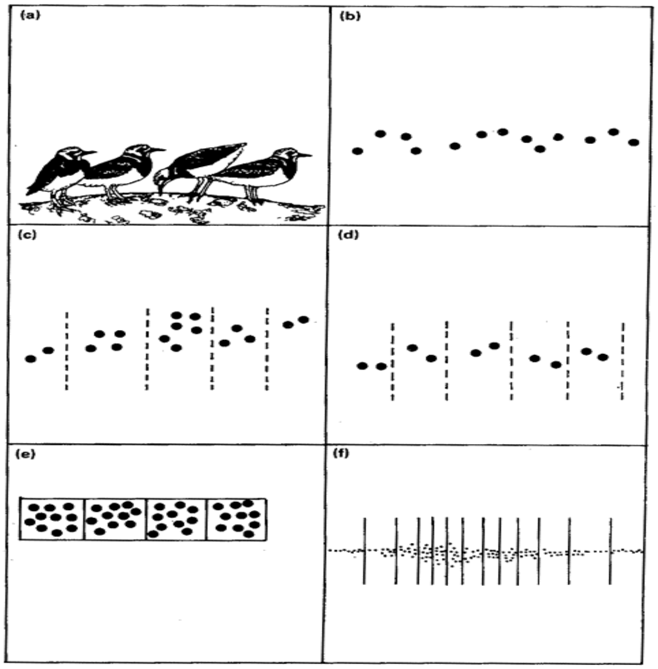

Figure 2. Methods of estimating numbers of shorebirds in flocks (Bibby *et al.* 1992).

(a) In small roosts and feeding flocks, the number of birds can be counted directly.
(b) For small flocks of even density, the birds can be counted individually (1, 2, 3, 4, 5 etc.) to produce an accurate total. If a suitable landmark is present it can be used to help count the birds.
(c) In unevenly distributed flocks with small groups of varying size, each group of birds should be rapidly counted and added together.
(d) For larger numbers of birds in evenly distributed flocks the birds should be counted in multiples e.g. 2, 4, 6, 8 or 3, 6, 9, 12, etc. Again if landmarks are present they can be used to help divide the flocks in order to count them more accurately.
(e) For densely packed flocks in flight or at a roost, the birds should be counted in estimated blocks. The size of the blocks used (10, 100, 1000 etc.) varies according to the size of the block. The largest flocks of 10 000 birds or more present the biggest counting problems with even the block method giving a rough estimate of numbers.
(f) Flying flocks often bunch in the centre. In this case it is important that the blocks are closer together in the centre of the flock than towards the edges, but in practice this may be difficult to achieve.

3.6 Nest Finding Techniques

Several general techniques are useful for finding nests of shorebirds. A short summary follows.

In open habitats, dragging a long rope held by two people walking through good nesting habitat is an efficient method of finding nests with incubating birds. Incubating birds often flush ahead of the walkers or after the rope is dragged over their nest (Mickelson *et al.* 1980). This technique works on Least Sandpipers, Short-billed Dowitchers, Red-necked Phalaropes, and Wilson's Phalaropes (e.g., Cooper 1993). Nests of Wilson's Phalarope and other species may be located by watching a pair of birds as they visit nest scrapes during courtship or laying or by observing males returning to incubate clutches (Colwell and Oring 1988b).

Killdeer, Semipalmated Plovers, and Lesser Golden Plovers leave their nests secretively when approached and it is usually not obvious where the nest is located after the bird is spotted. They often display a "broken-winged" behaviour in an attempt to lure intruders from the nest area (Armstrong and Nol 1993). After a suspected incubating bird is spotted, observers should back away and find a hiding spot >50 m (may have to be > 100 m in some cases) distant and sit down and watch the bird until it returns to its nest. Plovers often sit down as if on their nest in an attempt to lure intruders away so watch them for several minutes to ensure they are on the real nest before leaving your hiding spot. Focus on the spot that the nest is in, use landmarks to line the nest up, and walk quickly directly towards it, never letting your gaze waver. Plover eggs are usually very difficult to see, even when you know where they are. Black Oystercatcher nests can also be found in this way, but considerable time may be required and a blind is often needed because there are few places to hide, far enough away, where a good view is provided. Once a few nests have been found, likely sites are easily identified.

Common Snipe nests are very difficult to find. Incubating birds usually do not flush until they are virtually stepped on (sometimes literally) by humans. Pointing hunting dogs are useful for finding snipe on nests.

Wandering Tattlers nest in alpine dry stream beds. Birds are best found by walking up gravely stream beds, then backing away and watching from a distance when birds are found.

Spotted Sandpiper nests are relatively numerous in good habitat and are easily found by walking along open areas with rich herbage between shorelines and heavier vegetation. Incubating birds flush ahead as you approach. Nests are often under tiny bushes.

Greater and Lesser Yellowlegs nests are extremely difficult to find, and no systematic surveys have been attempted. Solitary Sandpiper nests are very difficult to find, but searches of the edges of swampy areas for old nests of blackbirds, thrushes, and waxwings, as long as birds are present, is feasible, but very time consuming.

Long-billed Curlew and Upland Sandpiper nests can be found by watching territorial birds visit nest scrapes or nests during egg-laying. Later in the season, plots can be dragged with ropes to flush incubating birds.

GLOSSARY

ABSOLUTE ABUNDANCE: This level of survey intensity requires inventory techniques to estimate total populations or densities of individuals within defined areas.

ACCURACY: An estimate that is free of systemic errors is said to be accurate. Some methods either under or over estimate and are said to be inaccurate although they may be precise.

AUTUMN: Used synonymously with Fall. Typically September to November. Also used to indicate the southward movement of migrants, which often occurs from July through September.

AVERAGE LENGTH OF STAY: Birds are captured using mist nets and marked at migratory stopovers. The length of stay or turnover rate is measured as the average of the number days between marking a bird and the last day the birds was resighted.

CRYPTIC: Well camouflaged; colours and patterns that match habitat.

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

FALL: Used synonymously with Autumn. Typically September to November. Also used to indicate the southward movement of migrants.

FIDELITY: Tendency of individuals to return to the same nesting, migration, or wintering areas year after year.

FIXED-WIDTH TRANSECT: Census method where all the birds within a predetermined width and length of area (strip transect) are counted. The density of birds within this area is then calculated as no. of birds/square kilometre, which can then be used to estimate the total population of birds with in a site.

MARK/RECAPTURE: Birds in an area are first captured using mist nets or other means of capture and then marked using leg bands, patagial tags, flags or dyes and then released. In a closed population, the probability that the birds will be recaptured or resighted depends on the total population size. Therefore, using the number of birds recaptured the total population can be estimated using statistical methods. Mark/resighting methods are also used to estimate the length of stay or turnover rate of migratory birds.

MIGRANT: A species that passes through British Columbia during the spring or autumn migration or both.

OVERVIEW: Overviews are a "broadbrush" approach based on data collected in a variety of non-systematic ways and often include broad extrapolations across regions where there are no supporting data.

POLYANDRY: The mating of one female with more than one male while each male mates with only one female.

POLYGYNY: The mating of one male with more than one female while each female mates with only one male.

PRECISION: An estimate that is free of random errors is said to be precise. Increasing sample size and standardizing methodology will increase precision.

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).

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.

RESIDENT: A species that remains throughout the year in British Columbia (e.g., Black Oystercatcher)

SPRING: Typically March to May. Also used to indicate the northward movement of migrants.

TRANSIENT: A species that appears during migration but does not breed or winter.

TURNOVER RATE: In this report, used synonymously with average length of stay of migratory birds.

VAGRANT: A wanderer outside the normal migration range of the species.

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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