SHOREBIRD MONITORING

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PURPOSE

With 20 species breeding regularly in arctic Canada and 9 additional species in the taiga shield, shorebirds are the most diverse and abundant group of birds at many northern locations. They are important consumers of invertebrates, and their eggs and chicks can be important prey of avian and mammalian predators. The roles that shorebird studies play in the Arctic WOLVES project are diverse, from observing and predicting impacts of environmental change, to studying indirect trophic linkages. The monitoring protocol we propose here has several components, but the overarching objectives are as follows:

- Monitor timing of shorebird arrival and breeding
- Determine breeding densities
- Generate estimates of hatch success
- Document species composition (and future changes in range)

Many components, such as small mammal monitoring or weather observations, constitute an important part of a shorebird research program but form another branch of the WOLVES project. In these cases, we identify our data needs but leave the methods to other WOLVES collaborators.

SUMMARY OF OUTPUTS

Component	Activity	Key Results	WOLVES Objectives Addressed	Projects
Plot Based Surveys	Nest Finding	Nest densities, species composition	Document current range and community composition, predict future change	IPY 1.2, NSERC 1
	Nest Ageing	Timing of breeding	Relate timing of breeding to environmental conditions	IPY 2.2, NSERC 3
	Nest Monitoring	Estimates of nest success	Establish baseline of nest success estimates, quantify future changes in success (e.g. due to climate), study indirect trophic interactions	IPY 1.2, NSERC 2
	Habitat Data	Establish preferred habitat	Document current range and community composition, predict future change	IPY 1.2
Transect Survey	Early Season Arrival Monitoring	Timing of arrival, passage of migrants	Relate timing of breeding to environmental conditions	IPY 2.2, NSERC 3
Optional Components	Nest Cameras	Positive Identification of Predators	Study indirect trophic linkages	NSERC 2
	Artificial Nest Experiments	Indices of nest predation	Study indirect trophic linkages	NSERC 2
Data from Other WOLVES Components	Weather Monitoring	charaterise season as "early" or "late", track snow-melt	Relate timing of breeding to environmental conditions	IPY 2.2, NSERC 3
	Invertebrate Monitoring	Index of invert. abundance, timing of emergence (full scale monitoring of invertebrates is optional).	Relate breeding success to invertebrate abundance	NSERC 3
	Daily Species Log	Timing of departure, passage of southbound migrants	Relate timing of breeding and migration to environmental conditions	IPY 2.2, NSERC 3

SUMMARY OF INPUTS

Component	Activity	Materials Required	Workforce Required	Timeline	Adaptable for Lower Effort?
Plot Based Surveys	Nest Finding	Compass, GPS, binoculars, tongue depressors, sharpie, 75m of ¼” rope, bamboo stakes, flagging tape, field guide (e.g. National Geographic)	2 people, devoting 50% of their time	Varies by site, roughly June 5th – end of June	Nest searching is inherently labour intensive. Plots are either monitored or not. "Low effort" protocol relies on checklist surveys, incidental observations, and monitoring of nests found incidentally.
	Nest Ageing	Tupperware, protractor, ruler, regression equations			
	Nest Monitoring	Compass, GPS	2 people, devoting 25% of their time	Approx. June 20th - July 10th, with a handful of nest checks until late July	
	Habitat Data	Digital camera, colour standard, ruler			
Transect Survey	Early Season Arrival Monitoring	Compass, GPS, binoculars, field guide (e.g. National Geographic)	1 person, <2h / day	Approx. May 25th - June 10th	YES
Optional Components	Nest Cameras	Cameras, GPS, laptop, generator, batteries, compact flash cards	1 person, 2h/day, for about 10 days	Approx. June 10th - July 20th,	NO
	Artificial Nest Experiments	Quail eggs, latex gloves, nails, tongue depressors	2 people, 2h/day, for 8 to 12 days	Approx. June 20th - July 10th,	NO
Data from Other WOLVES Components	Weather Monitoring	TBA	TBA	TBA	YES
	Invertebrate Monitoring	Modified pitfall traps, odour free detergent, 70% ethanol, whirlpacks, nalgene bottle, strainer, knife, plastic bags	2 people, <1h every other day	Approx. June 5 to August 10	YES
	Daily Species Log	None	5 minutes per camp, per evening	All season	YES

DETAILS OF "IDEAL" METHODS

PROCEDURE 1 – PLOT-BASED MONITORING

Selecting the plots.- Four plots are monitored in total; three should be selected in "good" shorebird habitat and one in "medium" quality habitat. At most sites, good shorebird habitat is composed of wetlands, while medium consists predominantly of vegetated uplands. The classification will vary between sites, and should be discussed at the meeting for each WOLVES site. This distribution of plots is meant only to capture the full suite of species represented at a site. If habitat is uniform, four plots from a single broad habitat type is not problematic.

Plots should be selected within easy walking distance from camp (< 2km), from non-randomly selected patches of appropriate habitat. While random plot selection is preferable from a statistical standpoint, in practice, this often results plots with few or no shorebirds. Thus, plots should be selected to contain a representative mix and density of shorebirds. This is difficult without detailed prior knowledge of shorebirds at a site. Careful plot selection is critical, however, as the same plots will be monitored in future years. If site leaders do not feel comfortable identifying shorebird habitat, they should contact V. Johnston (Vicky.johnston@ec.gc.ca, 867-669-4767) prior to the field season to discuss the options for plot selection.

Plots are 12ha, with dimensions of 300m East-West, and 400m North-South. This size and orientation follows the methods of the Program for Regional and International Shorebird Monitoring (PRISM), allowing these plots to serve as "intensive plots" in years when PRISM surveys target areas near WOLVES camps. A GPS unit displaying UTM coordinates should be used to orient plots and accurately locate plot corners. Bamboo stakes with flagging tape should be used to mark boundaries at approximately 50m intervals (or whatever the terrain dictates for adequate visibility).

Plot Monitoring Schedule.- Our goal is to find and monitor all shorebird nests on the plots, using single observer and rope-drag nest searching techniques. In order to achieve this goal, plots must be visited sufficiently often to find new nests before they are depredated. The schedule of plot visits is flexible, and can be adapted to suit the needs of particular camps. It is important, however, that search effort be equal on all plots, regardless of any differences in bird densities. During the late courtship/early incubation period, plot visits should be frequent. Daily visits of a minimum of 2h, or visits every two days for 3-4h are good suggestions. During mid incubation, when many of the nests have already been found, daily visits are less important. At this time, it may be more efficient to visit the plots every third day and remain for a longer period of time. When no new nests or territories have been discovered on three consecutive visits, and the observers are confident that they have not missed any nests, visits to the plots can be limited to what's required for monitoring nests for hatch success.

In addition to these visits by observers, each plot should be covered twice by a "rope-drag", where plots are searched exhaustively by 2-3 people pulling a rope designed to cause birds to flush. This should take place once immediately after most clutches are thought to be complete, and once in mid-incubation.

A guideline for adequate effort is 30-40 person*hours / plot, although sites with few birds may require less effort, and sites with exceptional densities may require more. Observers should exercise caution when deciding to reduce search effort because "all" nests have been found; modeling exercises conducted by us suggest that we rarely find more than 85% of the nests present.

We recommend that 2-3 observers search each plot. Different observers may have different nest searching abilities, and the task is less monotonous when shared. Too many observers is a detriment, however, as each observer must become familiar with the plot. When two people are responsible for nest searching on all four plots, the task will occupy roughly 50% of their time in early-mid June and 25% of their time in late June – early July.

Undoubtedly, shorebird nests will be found incidentally en route to the plots, or by other crews in other locations. If they are conveniently located, these should be marked and monitored as for all other nests. Records should clearly indicate that these nests were found incidentally, and are not associated with a plot. These nests can be incorporated into the estimates of nest success and used to assess breeding chronology.

Table 1. Schedule of visits by 2 single observers (X, Y) and rope drag crews (R) to shorebird monitoring plots. In this example, plot visits last approximately 3h.

	June																					July												
Plot	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13
A	X		Y		X		R		Y		X			R		X			Y			X			Y			X			Nest			
B	Y		X		Y		R		X		Y			R		Y			X			Y			X			Y			monitoring			
C		X		Y		X		R		Y		X			R		X			Y			X			Y			X		only…			
D		Y		X		Y		R		X		Y			R		Y			X			Y			X			Y					

Nest Searching with Single Observers.- The goal is simply to find nests and map territories; the methods to achieve this goal are not fixed. Shorebird nests are primarily found by flushing incubating birds or by watching birds return to the nest. Roughly 50% of shorebirds are not engaged in incubation at any given time, and skilled nest searchers are those who can identify which birds to watch. For uniparental incubators, this is achieved easily by focusing observation on the incubating sex. For biparental birds, the decision is more difficult, but many behavioural cues can be used. Species-specific tips appear in Appendix 1.

The techniques for actually finding the nests are not fixed, and will vary between sites and species. However, a number of methods should be employed to ensure that data collection is sufficiently standardised between the sites. Observers should ensure that the entire plot is searched, and not limit nest searching to the most productive areas. If this is not achieved on a given visit, a note should be made on the data sheets. In featureless terrain, observers may need to cover the plot in transects initially. Detailed maps of the plots should be created, noting any identifiable landforms or features (Appendix 2). The territorial birds or nests discovered should be recorded on these maps.

Observers may share information freely with regards to any nests found or suspected in the plots, and are encouraged to do so. The plot maps should also be shared, so that observers are clear on the locations of known territories and nests. We have found that this is easiest if a single field notebook is associated with each plot, and shared among observers. Observers should complete data sheets that record the nests and territories newly discovered, by using notes made in the field, plot maps, and UTM locations (Appendix 2). A small proportion of the local population may never establish nests. More commonly, birds may establish nests that are lost to predators before we find them. The presence of these birds and their territories should still be recorded, and in the absence of a known nest location, we must attempt to determine if their territory "centroid" (or their depredated nest site) is within the plot boundaries.

When birds are on the border, the decision of whether a territory centroid is within the plot is somewhat subjective. By carefully recording the location of bird sightings during visits (using the plot maps), a more reliable decision can be made. At the end of each visit, observers should make this decision on the data sheets (Appendix 2). If the bird's nest is not found (within or outside the plot) by the end of the field season, the history of the daily decisions should be used to arrive at a final decision.

In featureless terrain, a GPS set to display location in UTM is essential for plot surveys. It can be used to walk East-West transects simply by maintaining a steady Northing. The plot can be broken down into 50m wide transects by adding 50 to the Northing at the end of each East-West transect. Location within the plot can be mapped accurately by drawing the plot maps on grid paper and labelling axes with UTM's. All observers should carry and use GPS's to ensure that locations of territories are accurately mapped, and that the information shared between observers is clear. While nest searching, observers should monitor their location carefully with their GPS so that they do not spend time re-finding nests they have already found!

Nest Searching with Rope Drags.- Some shorebird species remain on the nest as predators approach, and are thus difficult to find by flushing. Some individuals can in fact be touched without causing them to flush. An effective means of finding these species is a technique known as rope-dragging. Tight-sitting, grass-nesting species such as the Red Phalarope or the White-rumped Sandpiper are especially susceptible to this technique, while it does not work for vigilant, early-flushing species such as the Black-bellied Plover.

In rope-dragging, 2 observers stretch a specially constructed 30m long rope between them, and cover the plot exhaustively with belt transects. When a third observer is available, this person can follow behind the rope and watch for flushing birds. In our experience, the third observer increases the effectiveness of the technique, but is not a necessity. When birds flush, the team should stop long enough to find and mark the nest and continue on. If a nest can not be found immediately, the team can drag the rope past the spot and then glass the suspected nest area with binoculars until the parent returns. If never found, these locations can be mapped with GPS and denoted as a suspected nest site. This information can be used in subsequent days by single observers.

The drag consists of a main line of 1/4 - 3/8" rope, with dropper lines (1/4" rope) tied to it perpendicularly at 1.5m intervals (Fig. 1). Improvised handles should be tied to the rope so that observers can maintain tension on it and keep it from snagging on irregularities in the ground. In normal terrain, with few large bodies of water to contend with, rope dragging a 12 ha plot should take approximately 3h. This time varies dramatically with terrain and bird densities, and some plots may take much longer; it is advisable to begin rope-dragging in the morning when possible.

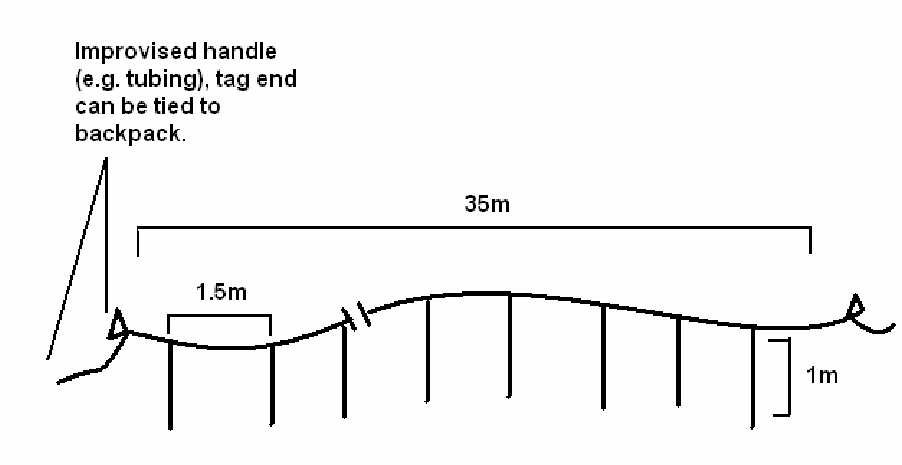

Figure 1. The construction of nest searching rope.

Marking Nests.- Shorebird nests are notoriously cryptic, and even with a GPS location they can be extremely difficult to locate when revisited. To facilitate regular monitoring, nests should be marked with a 15cm wooden tongue depressor. The tongue depressor should be placed on a hummock or another visible location 8-12m from the nest. The nest name, the distance (in paces) and the exact bearing to the nest should be recorded with a sharpie on the portion of the tongue depressor above the ground (about 8cm should remain exposed). Using a similar bearing for marking each nest can facilitate finding markers and nests, and helps reduce the risk of nest trampling.

For this technique to work, it is imperative that staff are familiar with the use of a compass, and have the declination properly set (or at least all must be using the same value). If observers are not comfortable using precise bearings, an alternative is to use an approximate bearing and a natural marker (e.g. feathers, coloured rock, etc.) half-way between the tongue depressor and the nest, forming a straight line.

The tongue depressors themselves can be difficult to find in tall grass; it is easiest to find them (and thus the nests), if the location of the nest marker is stored in the GPS. It is critical however that the location recorded in data files is the true location of the nest.

The crew must also share GPS coordinates at regular intervals, so that other members of the team are able to check nests they have not found. In order to keep clear which nests are which, the crew may wish to use a numbering system involving a 2 letter code for the species, 1 letter for the initial of the nest finder, and 2 numbers for the number of the nest. The third Red Phalarope nest found by Steve, for example, could be RPS03.

Nest Age Determination.- Knowledge of nest age helps to determine breeding chronology, and allows us to visit nests at appropriate intervals based on the expected date of hatch. When nests are found during laying (i.e. the clutch is incomplete), the dates of nest initiation and clutch completion can be estimated by assuming that 1 egg is laid per day. When nests are found with a full clutch (usually 4 eggs) they must be aged by other means. All nests found with 3 or more eggs should be aged with a technique known as egg flotation.

Complete details of the technique are available in Liebezeit et al. (2007). In brief, eggs are placed in water and the angle or height at which they float is recorded. Newly laid eggs sink to the bottom of a column of water and lay relatively flat, and as the embryos develop, eggs tip upward and eventually float on the surface.

The eggs should be placed in a small transparent container filled with water from a nearby pond (or carried by the observer in drier areas). Small, square (7 x 7 x 7 cm) Tupperware type containers with flat sides work well. Using a protractor, the angle between the horizontal plane and the longitudinal axis of the egg should be measured ±1°. If the egg is not resting on the bottom, observers should record the location of the egg within the water column. If the egg breaks the surface, the height at which it floats ± 1 mm should be measured with a clear plastic ruler (angle should also be recorded for floating eggs). Prior to the field season, protractors and rulers can be photocopied on to transparency sheets to make portable and expendable measuring devices.

For each nest, at least 2 of the eggs should be floated. If the readings differ substantially, which can occur if eggs are cracked or infertile, a third egg should be measured. The average of the two (similar) readings should be used to determine the age of the nest with species-specific regression equations when available, or with the “all species” regression if necessary (Appendix 3). These equations typically predict age ± 4d. Eggs with heavy star cracks or pips should not be floated.

Monitoring Nests.- The goal of nest monitoring is to visit nests frequently enough to determine fate, but not so frequently as to influence fate by disturbing the birds or attracting predators. By floating eggs, it is possible to predict the date of hatch, and these predictions allow us to plan a schedule of nest visits appropriately.

When nests are in early- to mid-incubation, they should be checked at least once per week. Longer intervals compromise the calculations of nest success when nests are lost to predators in the intervening time. The interval need not be exactly seven days, and should be combined with other visits to the plots when convenient. When nests are in late incubation, within one week of the predicted date of hatch, they should be checked every three days. At each visit in late incubation, eggs should be checked carefully for star-cracks or pips. Star cracks appear around the widest portion of the eggs, and can be extremely faint. Clutches with light starring on all four eggs will usually hatch within 2-4 days, but may take longer. Pips are small holes created as the chicks begin to pierce the eggshell. Pipped eggs will usually hatch within

24h. If stars are discovered when checking a nest, it should be revisited in 2d. If pips are found, it should be visited the next day.

At each nest visit, the date, time and condition of the nest should be recorded. A helpful tool for tracking the status of nests is the Mayfield Scroll (Mayfield 1961). An example is provided in Appendix 4. These can be made on paper, but using an Excel spreadsheet permits automatic sorting to determine which nests must be checked on a given day. If a nest is suspected to be abandoned, the temperature of the eggs should be checked by placing them against sensitive skin such as the underside of the wrist or the cheek. Incubated eggs are noticeably warm. Complete nest abandonment is rare in most years, at most sites (< 2 %). However, birds will occasionally incubate sporadically for a period of several days, especially after harsh weather events. Therefore, observers should be cautious when concluding that a nest is abandoned. Also, eggs are rarely incubated before the penultimate egg is laid. For a definitive test, turn one egg so the wide end is towards the middle of the nest. If a parent is attending the nest, the egg will be returned to its normal position.

Although nest success is defined as the hatching of 1 chick, there is increasing scientific interest in the hatchability of eggs. One full day after a nest has hatched, observers should revisit it to determine if any eggs remain. These eggs should be checked for signs of development (such as star-cracks or pips), and for temperature. If observers suspect that the remaining egg(s) is still incubated, they may revisit the nest as soon as is convenient. Monitoring hatchability requires little extra effort and may prove useful, for example, to gauge the current or future effects of contaminants (which is known to compromise hatchability in some species).

Although there are no reliable data to suggest that nest monitoring increases the risk of predation, these basic precautions should be taken:

- Nest searchers should avoid disturbing incubating adults whenever possible.
- Eggs should only be handled when floated or when checked for star-cracks or warmth.
- Do not stand immediately beside the nest while floating eggs.
- If a bird remains on the nest when it is approached, and the nest is in mid-incubation, it is not necessary to flush the adult to conclude that the nest is active.
- Belongings such as knapsacks or gloves should not be placed immediately beside nests when conducting checks.
- A nest check should be postponed if a predator is in the immediate vicinity

Nest Fate Determination.- A successful nest is one that hatches at least one chick. The best means of identifying a successful nest is to plan a nest visit that coincides with hatch. If an appropriate visit schedule is maintained, it should always be possible to accurately (± 2 d) estimate hatching date based on the appearance of star-cracks and pips. If a nest is found empty on a visit when it was predicted to hatch (i.e. it had stars or pips on the previous visit), other lines of evidence can be used to determine if the nest was successful. These include:

- Hatchlings observed within 20m of the nest
- Eggshell tops or bottoms within 5 m of the nest
- The nest lining contains "pip fragments"

Eggshell tops and bottoms are large, relatively intact, and have loosely adhering membrane. When chicks hatch, parents remove these and often deposit them within several metres of the nest. Pip fragments are small (1 – 4 mm) pieces of eggshell, found in the lining of the nest, with membrane absent or loosely adhered. They are created when chicks pierce the egg at emergence. Pieces of eggshell larger than 4 mm, are found in both successful and unsuccessful nests, and give no indication of fate. Pip fragments can be difficult to find as they are small, and often sink beneath the nest lining. To find them, the lining should be removed and placed in the fold of a field notebook. This shields the material from the wind and allows the observer to carefully sort through it. Pip fragments will usually remain in the notebook when the lining is sorted, and can be distinguished from small pieces of lichen by their coloured front and white back.

Nearly all failed nests will be the result of predation, however, some nests may be abandoned, trampled, or crushed accidentally by researchers. Recall that nest abandonment is rare; nests suspected to be abandoned should be monitored carefully for at least two additional visits over several days before reaching a final conclusion. Nest trampling by wildlife is very rare, and researchers should exercise extreme caution when checking nests to ensure that trampling by researchers is rarer still. When nests are depredated, it will not be possible to identify the predator in most cases. Predators do leave clues occasionally however, and these should be recorded as notes in the nest monitoring spreadsheets.

- Occasionally, foxes will urinate or defecate in nests that they have consumed. If this is the case, faeces will be visible, or the scent of urine easily noticed by smelling the nest lining.
- Foxes will cache larger shorebird eggs nearby, rather than consuming them at the nest site. If a cached shorebird egg is discovered near a failed nest, this should be noted.
- Avian predators will sometimes consume eggs by poking a hole in the side and removing the contents. If this is observed, the size of the hole should also be estimated.

Every effort should be made to determine nest fate conclusively but **if the fate is unknown, record it as such.** Data from these nests can still be used to estimate nest success; despite an unknown fate, they did survive over a known number of days.

Estimating Nest Success.- The Mayfield Method is used to estimate nest success. The method is based on the calculation of a daily survival rate, which is then applied over the incubation duration for the species in question. Estimated nest success is calculated as follows:

$$\text{Nest Success} = \text{Daily Survival}^{\text{Incubation Duration}}$$

where:

$$\text{Daily Survival} = 1 - (\text{\# of nest failures} / \text{\# of exposure days})$$

There are several slight variations on the calculation of exposure days. The method to employ here is as follows (see Appendix 4):

- Exposure days begin when the clutch is complete
- For successful nests with a known hatch date, exposure days are terminated on the date of hatch
- For nests with a known fate found empty (e.g. most failed nests), exposure days are terminated half-way between the last active and first inactive visit
- For nests of unknown fate, exposure days are terminated on the last active date.

A spreadsheet which calculates the Mayfield Estimate, as well as the associated standard error (following Johnson, 1970), will be provided. Alternative methods of calculating nest success (e.g. Program Mark) have several advantages over Mayfield estimation, but are much more complicated. The data collected here can be analysed by these methods readily, in addition to the simple and widely accepted Mayfield Method.

Nest Habitat Data.- Habitat data suitable for detailed analysis is labour intensive to collect, and suffers from pronounced observer effects. However, because the Arctic WOLVES project is meant to monitor changes in habitat use, we suggest that some basic habitat data be collected. Digital photographs of all nests will complement these basic data, and will allow for more detailed analyses when the desire arises.

The habitat data consist of vegetation heights and estimated percent covers of various habitat types within a 1m-diameter circle centred on the nest (Appendix 5). The height of the tallest vegetation should be measured with a ruler or wing bar ±1mm, 0.5m from the nest in each cardinal direction. The visual concealment of the nest bowl should be estimated ±10% from standing height. Percent cover of habitat types is estimated within a 1m-diamter, from standing height, ± 10%. Dominant soil moisture and surface roughness should be recorded, based on the criteria provided in Appendix 5. Distance to the nearest water should be estimated by pacing or measured with GPS.

In addition to these basic data, all nests should be photographed from standing height with a digital camera. Because differences in photographic exposure can change the appearance of the habitat, a colour standard should be placed in the top left corner of the frame, with the shot centred on the nest. The colour standard should, ideally, be the same for all sites participating in the study, and will be provided before the field season. The colour standard has a scale bar which also allows us to correct for differences in the height at which photographs were taken. A "non-use" site, randomly selected from within 3m of the nest, should also be photographed. A random bearing can be obtained by spinning the housing of a compass, and the colour standard can be tossed to yield a random location for the photograph.

When possible, all habitat data and photographs should be collected after nests have hatched, in mid-July.

Data Management.- Data sheets, and instructions on how to complete them, appear in the appendices.

PROCEDURE 2 – EARLY SEASON TRANSECTS

Transect location.- The transects are conducted to monitor the return of shorebirds to the area, and to record the passage of migrants en route to more northerly breeding destinations. The placement and orientation of the transect should be based in part on convenience, as it will be monitored regularly (usually daily). If possible, it should be placed such that all habitats in the study area are represented. It should contain areas where shorebirds congregate in the early season, if such locations are within easy walking distance of camp. These locations are often places where snowmelt is advanced, and where shallow wetlands are available for feeding before surrounding areas. Examples include the banks of large rivers, the windward side of large eskers, and coastlines.

The length of the transect needn't be consistent between sites, and may be tailored to suit the situation at a camp. A distance of approximately 1.5km will give an adequate number of bird sightings in most instances. A single observer with binoculars simply walks the transect line and records all birds sighted. As detectability of birds is limited beyond a distance of 25m, we distinguish between sightings within 25m, and beyond 25m from the centre line of the transect. Basic information such as start and end time should be recorded, and bird sightings should be accompanied by codes for the highest evidence of breeding (as per CWS checklist survey instructions, Appendix 6). Basic habitat information should be recorded for the transect, as per instructions on the CWS checklist survey forms.

As these transects are used for indices of relative abundance only, it is not necessary to record the exact distance from the centreline for birds sighted (simply </> 25m). The same transect should be walked in subsequent years however, and the start point, orientation and end point should be recorded. While a compass bearing can be used to stay on track, walking the precise line of the transect is much easier if it follows a cardinal bearing. In this case, a GPS set to UTM can be used to ensure that a steady Northing or Easting is followed.

Timing of the Surveys.- The transects should begin when there is a reasonable expectation of encountering shorebirds. Shorebirds arrive at most arctic locations between May 25th and June 15th, but the date in a given year can vary by up to two weeks based on the weather and snow conditions that birds encounter en route to the breeding grounds. When the first shorebirds are noted in the area, the transect should be surveyed daily. If possible, the surveys should take place at the same time each day; mid-morning or late-afternoon are often the times when birds are most active (and hence visible).

At most sites, the surveys will capture the arrival of breeders as well as a wave of northbound migrants. Some species, such as White-rumped Sandpipers, will arrive early in each year, while others, such as the Red Phalarope will arrive characteristically late. The surveys should be run daily until the numbers of birds encountered plateaus, and all birds known to breed at the site are present and engaging in breeding activities.

Data Management.- The data collected during these surveys are easily managed with a simple spreadsheet noting time and date of the survey, species encountered and their location along the length of the transect. The data are compatible with the CWS checklist survey, and will be incorporated into the database. The evidence of breeding activity collected as part of these surveys, and the timing of the sightings themselves, are extremely useful for monitoring interannual variation in timing of breeding.

OTHER DATA NEEDS

The items listed below form an important part of a shorebird monitoring program but fall under the purview of other collaborators. Below, we list the data required to address the objectives for the shorebird monitoring program.

Daily Species Log.- In order to capture year to year variation in the timing of arrival of shorebirds, we ask that observers maintain a daily log of birds seen within the study area. This log should include a daily estimate of abundance for each species, and a measure of the time spent in the field (observer*hours). These estimates, although somewhat subjective, have proven very useful in the past to determine relative abundance, timing of peak arrival, etc. Late season "species log" records capture events such as the southward migration of failed breeders and the departure of post-breeding adults. This log should be maintained daily throughout June and July, when birds are breeding and migrating. Outside of these times, the log can be maintained on a daily basis, or less frequently if necessitated by time constraints.

Climate / Environment.- A basic level of weather monitoring is desirable to place the phenological observations of breeding birds in the context of snow and weather conditions. Parameters of interest for a shorebird monitoring program include:

- Daily estimates of % snow, water and land in the study plot
- % ice coverage on ponds at end of each week
- Twice daily weather observations (8AM-8PM)
- Local weather readings such as: min, max, and mean temp, precipitation type and amount, wind speed and direction, humidity, cloud cover

Predators and Alternative prey.- The influence of generalist predators on shorebird nesting success depends on the abundance of alternative prey such as lemmings. Shorebirds may suffer increased predation in years after a lemming decline. An absolute population estimate is preferable, however, a relative abundance of lemmings, as well an index of predator abundance is adequate for categorizing year to year changes. These indices can be generated simply by recording encounter rates (encounters / person*hour in the field, e.g. Hochachka et al. 2000). These observations can be incorporated into the Daily Species Log.

The most common predators of shorebird eggs are the arctic fox and the Parasitic Jaeger. Long-tailed Jaegers, Ravens, Larus Gulls, red fox, and Sandhill Cranes also regularly prey upon shorebird nests. Weasels may be important predators at lower latitudes. The relative rate of predation by each of these species is unknown; any generalist predator should be considered a potential predator of shorebird nests.

Invertebrates.- Shorebird breeding is timed such that chicks hatch when invertebrate food is most available. If climate change alters the timing of dipteran emergence, or the magnitude of the burst of invertebrates, shorebird reproductive output may suffer. An invertebrate trapping protocol that tracks temporal patterns in abundance within and between seasons is ideal for meeting our objectives. Methods designed to meet the objectives of a shorebird program are provided in a separate document entitle “Arthropod Monitoring Protocol”.

DETAILS OF “REDUCED EFFORT” METHODS

The following ‘reduced effort’ protocols represent minimal levels of effort, suitable for camps that are not focusing on birds. The methods are basic and flexible. It is our hope that the WOLVES collaborators will opt for expending more effort. However, by collecting this minimum level of information, the site can be entered into the Arctic Breeding Conditions Survey database, as well as the NWT/Nunavut Bird Checklist Survey database.

Environment.- Nesting densities and breeding success of shorebirds can vary dramatically year to year, due in part to snow and weather conditions. For this level of effort, observers are asked to record basic observations which lead to characterizing the summer’s weather as early, average or late. The parameters of interest are:

- Date of 50% snowmelt
- Final date of disappearance of snow from flat areas
- Dates of major snowfall events
- Date of disappearance of ice from ponds and lakes (following the methods of “project IceWatch”)
- General comments on nature of weather (i.e. late/early year)

Snowmelt dates are based on estimates of the percent cover of snow and ice, versus land and water within the study area. Neither lakes and ponds, nor the snow and ice which may cover them, are included in these percentages. If a vantage point affords an adequate view, 1 km^2 or more should be used to arrive at the estimates. Observers should record the area observed so that it is consistent from year to year. Observers should record the date at which 50% of the area is either exposed land, or shallow water over land. Observers should also record the date upon which no snow or ice remains on flat areas. In addition, the dates of any major snowfalls should be recorded, as these events can have dramatic effects on shorebird breeding success, particularly if they happen during critical times such as the peak hatching date.

When one or more large lakes are present within the study area, observers should record the date of the complete disappearance of ice. If the ice reforms after complete disappearance, this event should be noted as well. Notes should be made to identify the lakes, such that observations can be made on the same bodies of water in subsequent years. These data will be incorporated into the Ecological Monitoring and Assessment Network (EMAN) Project Icewatch database (www.naturewatch.ca/english/icewatch/).

When ponds in the study area are small and/or interconnected, the range of ice off dates for a fixed area should be noted.

In addition to these quantitative records, observers should record general weather observations which might aid in classifying the breeding season as early or late.

Population Monitoring.- At this low level of effort, we ask observers to record presence/absence information for shorebird species in order to expand our knowledge of shorebird breeding ranges, and to document any future changes in range. A simple log of the species present within the study area, and an indication of their breeding activity, accomplishes this goal.

A fixed study area should be monitored from year to year. Once per week, observers should complete a CWS checklist survey, following the instructions on the checklist data sheet (Appendix 6). These sheets include codes for breeding activity; the highest code for evidence of breeding activity should be recorded for each species. These data will be contributed to the checklist survey database at: (http://www.mb.ec.gc.ca/nature/migratorybirds/nwtbcs/index.en.html)

Phenology.- In order to capture year to year variation in the timing of arrival of shorebirds, we ask that observers record the first observations for each shorebird species and maintain a daily log of birds seen within the study area. Details are in the section "Daily Species Log", above.

Breeding Information.- At this level of effort, no nest searching and monitoring is conducted. Observers are asked only to note the highest level of breeding activity observed, using the CWS Checklist criteria (Appendix 6).

Productivity.- As nests are not monitored, details of nest success will not be available. Any sightings of chicks should be recorded, however, as these can give an indication of timing of breeding.

Predators and Alternative Prey.- A simple count of the number of predators and lemming encounters per day, and an indication of the amount of time spent in the field yields a useful index of abundance that can be compared between years. These sightings should be incorporated into the Daily Species Log described above.

Invertebrates.- Pitfall trapping, or other insect collection techniques are labour intensive. The first date of emergence, and the estimated peak emergence, of winged invertebrates is a useful indicator of invertebrate phenology, and easily recorded. Any field notes regarding sightings or relative abundance of identifiable invertebrates may provide useful phonological information.

OPTIONAL "ADDED EFFORT" COMPPONENTS

In addition to these core data, some WOLVES collaborators have opted to collect advanced breeding ecology data. Most WOLVES collaborators will find this level of effort too intensive. The components are explained in detail in separate documents, but apply only to a small number of sites.

Nest Cameras.- A high proportion of shorebird nests are lost to predators in each year but the relative rate of predation by various predators is unknown. Remotely triggered cameras at nest sites can be used to document predation events. Methods for using cameras at nests are provided in a separate document entitled “Nest monitoring via camera surveillance”.

Artificial Nest Experiments.- Artificial nests can be used to track inter-annual variation in the “baseline” risk of predation. Methods for deploying and monitoring artificial nests are provided in a separate document entitled “Artificial Nest Experiments Protocol”.

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Manolis, J. C., D. E. Andersen, AND F. J. Cuthbert. 2000. Uncertain nest fates in songbird studies and variation in Mayfield estimation. Auk 117:615–626.

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APPENDIX 1. SPECIES SPECIFIC NEST SEARCHING TIPS

(*2 examples are provided below – site specific examples will be provided as required*)

Black-bellied Plover (BBPL)

Identification.- Easily distinguished from American Golden-Plovers by black and white on back and head, rather than the gold and black of the Golden. Female has less striking black, appears more faded on head, neck and breast. Call of BBPL is similar to AGPL but distinguishable with practice. It is higher pitched, a cleaner whistle, and typically consists of three, versus two, notes.

Habitat.- Often in transition areas between wetlands and uplands. Nests are often in drier upland sites (e.g. gravel bars) but the birds feed in or near wetlands. Use uplands as prominences for scanning when disturbed.

Behaviour.- Often heard before being seen. Loud call carries well. Often call in flight, especially early in the season. Both sexes incubate. Have large home-ranges (hundreds of meters across) and off-duty bird will often approach observer up to 200 meters from nest site. When not incubating, either member may follow observer, acting as if nest is nearby. Therefore, it is important to scan well ahead to detect the location of birds before they become aware of an approaching observer. Often readily observable at several hundred meters because they stand on elevated sites and vocalize. Behaviour at nest variable. One or both members may be conspicuous and may perform elaborate nest distraction displays. In other cases, both members may leave nest in advance and observer may not see either bird near or far from the nest. Will often return to nest if observer is very far away but may also engage in false incubation. Therefore, have to verify presence of eggs.

Red Phalarope (REPH)

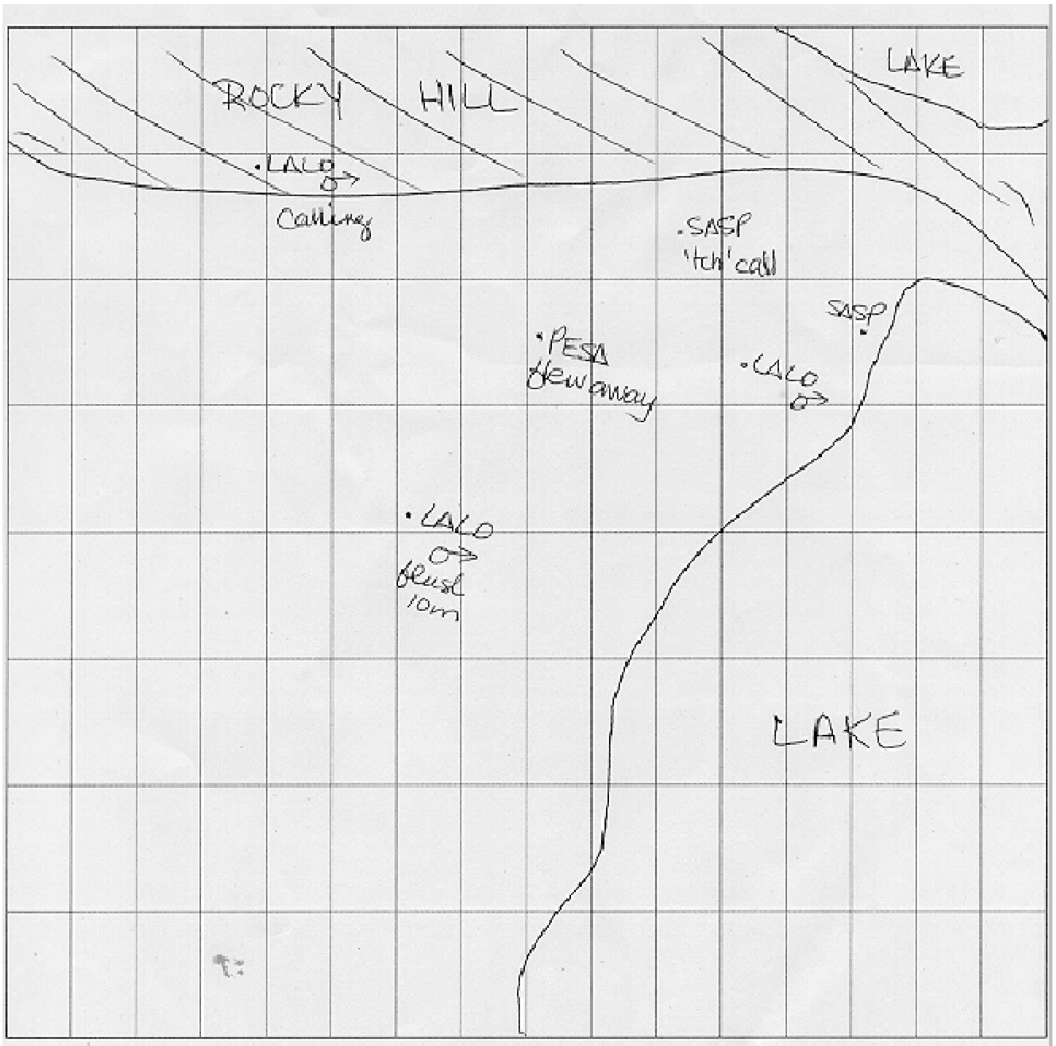
Identification.- Looks like a robin. Female larger and brighter but degree of sexual dimorphism is variable. Females tend to have brighter white eye patches, darker black around the eye patch and brighter red breasts. Some males may have fairly red breasts, however, and bright head markings. The thin line connecting the cap to the back is usually black in females and brown in males. Usually, only males have splotchy white patches on the breast. Look at as many known pairs as possible before assuming you can identify the sexes with certainty – it seems easy, but can be tricky. Red-phalaropes make distinctive whit-whit-whit CRRRRRREEEEET CREEEEEEET call. In flight, a broad white wing stripe is visible. Appears dark and plump in the air.

Habitat.- Some REPH nest in sedge marshes, several kilometres inland. Others nest in rocky areas near the coast. Their nests are well concealed, and occasionally are covered with a canopy of grass.

Behaviour.- Early in the season, females perform long-distance, very rapid chases. Later in the season, the females leave the area (well before the males and young), so one's only hope of counting the birds is to flush males from the nest of see them foraging. Red phalaropes feed mainly on the water, or the edges of ponds. It seems that females prefer the open water, while males focus on pond edges. In Red Phalaropes, the males incubate. Nests are fairly easy to find, and birds often make a PREEEEEP noise when they flush. Flush distance is variable, with some birds flushing from 50m or more, while others flush from 1-2 m.

APPENDIX 2. PLOT MAPS AND ASSOCIATED DATA SHEETS

UTM coordinates should be added to the side of plot maps in order to increase the accuracy of the map, and relocate specific birds on repeat visits.



INTENSIVE PLOT - DAILY SUMMARY FORMS

These data sheets are to be completed each time the plot is visited.

Site: Plot: Observer: Date: Start Time: End Time:

Pair/Bird I.D.	OBSERVATIONS[A]		DECISIONS[B]		Comments[C]
	Male or Bird-1 ON/OFF/BOTH /ND	Female or Bird-2 ON/OFF/BOTH /ND	Territory Centroid ON/OFF	Nest #	

Plot Coordinates – SW: NW: NE: SE:

[A] Record ON if the bird was on the territory, OFF if it was off, BOTH, or ND (not detected). Bird-1 and Bird-2 refer to the two birds of a pair when there is no sexual dimorphism. Be sure to cover the entire plot on each visit. [B] Record whether you feel that the territory centroid is ON or OFF after observing the bird that day. Record Nest # once nest is found, otherwise leave blank. If a probable nest (PN) is located, write PN-ON or PN-OFF in the Nest # column.[C] Record comments explaining decisions or describing territorial encounters, etc.

Example of a completed intensive plot daily summary form. These forms are used for recording daily observations and decisions of whether the territory centroid is in or out of the plot.

INTENSIVE DAILY SUMMARY

Site: Colville Riv. Delta	Plot: S. Tam 2	Obs: SLE	Date: 16 June 02	Start Time: 8:15	End Time: 18:00

Pair/Bird I.D.	OBSERVATIONS[A]		DECISIONS[B]		Comments[C]
	M or Bird-1 ON/OFF /ND	F or Bird-2 ON/OFF /ND	Centroid ON/OFF	Nest #	
SESA – A	BOTH	ND	ON		primarily on; observed off once
BBPL – A	ON	ON	ON	PN-ON	PN near Dune 2
DUNL-A	ON	ON	ON		DUNL-A & B terr. encounter on ground 3m inside border
DUNL-B	BOTH	ND	OFF		DUNL-A & B parallel aerial displays inside plot
BTGO-A	BOTH	BOTH	ON	14	

Summary of Intensive Plot – Final Decision

Site:__________ Plot:__________ Observers:__________ Date:__________

Plot Coordinates – Zone: **SW:** **NW:**

NE: **SE:**

Cum. hrs spent surveying plot (all observers): ________

TABLE:

SPECIES	Cum. NESTS	Cum. CENTROIDS	TOTAL

(continue on back of page if more space needed)

MAP

Completed Example,

Summary of Intensive Plot – Final Decision

Site: QMG #1 Plot: A Observers: VJ/JR Date: 15 July 05

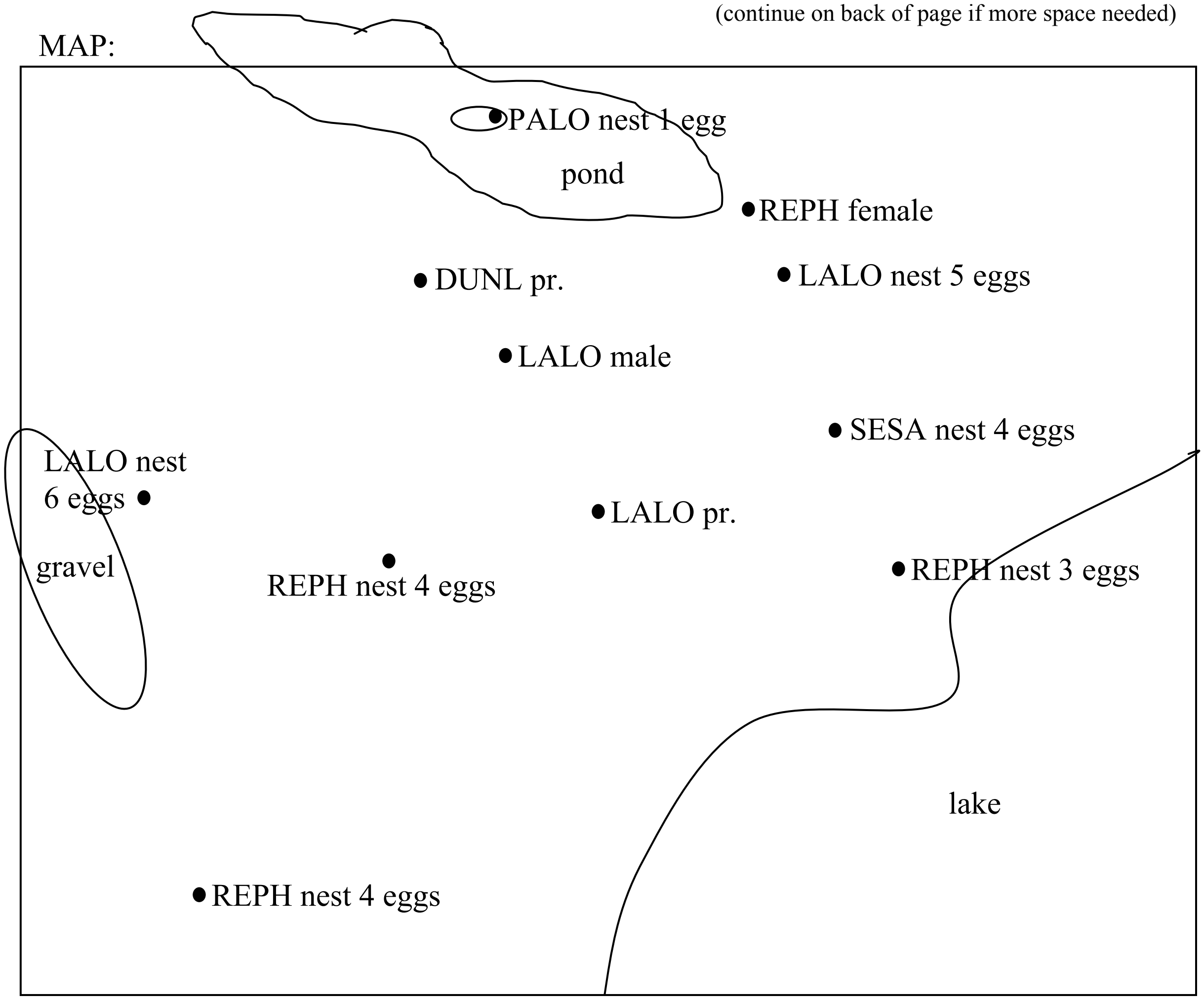
Plot Coordinates – Zone: 17 SW: 489570E, 7690993N **NW:** 489570E, 7691293N **NE:** 489970E, 7691293N **SE:** 489970E, 7690993N

Cum. hrs spent surveying plot (all observers): 40

SPECIES	Cum. NESTS	Cum. CENTROIDS	TOTAL
DUNL	0	1	1
SESA	1	0	1
LALO	2	2	4
PALO	1	0	1
REPH	3	1	4

(continue on back of page if more space needed)

MAP:



COMMENTS: - LALO nest with 6 eggs was predated before hatch.
- DUNL pr. must have a nest somewhere but we couldn't find it

APPENDIX 3. EGG-FLOATING REGRESSIONS

Adapted from:

Liebezeit, J.R., P.A. Smith, R.B. Lanctot, H. Schekkerman, I. Tulp, S.J. Kendall, D. Tracy, R.J. Rodrigues, H. Meltofte, J.A.R. Robinson, C. Gratto-Trevor, B.J. McCaffery, J. Morse, and S.W. Zack. 2007. Assessing the development of shorebird eggs using the flotation method: species-specific and generalized regression models. Condor 109:32-47.

DTH = “days to hatch"
Angle = the angle between long axis of the egg and horizontal, in degrees
Float Height = the height above the surface of the water at which the highest point of an egg floats

INCUBATION DURATIONS:

Species	Duration (d)	Species	Duration (d)
AMGP	26.5	REPH	19
BBPL	25	RNPH	20
BBSA	24	RUTU	22.5
CRPL	23	SAND	25
CUSA	21	SESA	20
DUNL	21	STSA	20
LBDO	21.5	TEST	20
LIST	20	WESA	21
PESA	22	WRSA	22
PGPL	25	MAGO	25
REKN	20		

SINKING EGGS:

AMGP		BBPL		BBSA		DUNL		LBDO	
Angle	DTH	Angle	DTH	Angle	DTH	Angle	DTH	Angle	DTH
21	25.8	21	25.3	21	27.8	21	21.3	21	22.4
25	23.4	25	23.1	25	24.2	25	19.8	25	20.0
30	22.2	30	22.1	30	22.6	30	19.1	30	18.9
35	21.5	35	21.5	35	21.5	35	18.6	35	18.2
40	20.9	40	21.0	40	20.7	40	18.3	40	17.6
45	20.4	45	20.5	45	20.0	45	18.0	45	17.2
50	20.0	50	20.1	50	19.3	50	17.7	50	16.7
55	19.6	55	19.8	55	18.7	55	17.5	55	16.3
60	19.1	60	19.4	60	18.1	60	17.2	60	15.9
65	18.7	65	19.0	65	17.5	65	16.9	65	15.5
70	18.2	70	18.6	70	16.8	70	16.6	70	15.0
75	17.6	75	18.1	75	16.0	75	16.3	75	14.4
80	16.9	80	17.4	80	14.9	80	15.8	80	13.7
85	15.8	85	16.4	85	13.2	85	15.1	85	12.6
89	13.3	89	14.2	89	9.7	89	13.6	89	10.2

PESA		RNPH		REPH		RUTU		SESA	
Angle	DTH	Angle	DTH	Angle	DTH	Angle	DTH	Angle	DTH
21	20.9	21	21.2	21	18.1	21	21.5	21	20.2
25	19.6	25	19.4	25	17.0	25	19.4	25	18.6
30	18.9	30	18.5	30	16.5	30	18.4	30	17.9
35	18.5	35	18.0	35	16.1	35	17.8	35	17.5
40	18.2	40	17.6	40	15.9	40	17.3	40	17.1
45	17.9	45	17.2	45	15.6	45	16.9	45	16.8
50	17.7	50	16.9	50	15.4	50	16.5	50	16.5
55	17.5	55	16.6	55	15.2	55	16.2	55	16.2
60	17.2	60	16.3	60	15.0	60	15.8	60	16.0
65	17.0	65	16.0	65	14.8	65	15.4	65	15.7
70	16.7	70	15.6	70	14.6	70	15.0	70	15.4
75	16.4	75	15.2	75	14.3	75	14.6	75	15.0
80	16.0	80	14.7	80	14.0	80	13.9	80	14.6
85	15.4	85	13.8	85	13.5	85	13.0	85	13.9
89	14.0	89	12.0	89	12.3	89	10.9	89	12.3

STSA		All shorebirds	
Angle	DTH	Angle	% of incubation complete
21	17.6	21	0.016
25	16.9	25	0.075
30	16.5	30	0.118
35	16.3	35	0.145
40	16.2	40	0.166
45	16.0	45	0.184
50	15.9	50	0.200
55	15.8	55	0.216
60	15.7	60	0.232
65	15.5	65	0.248
70	15.4	70	0.266
75	15.2	75	0.287
80	15.0	80	0.314
85	14.7	85	0.356
89	14.0	89	0.448

Floating Eggs:

AMGP			BBPL			BBSA			DUNL		
Angle	height	DTH	Angle	height	DTH	Angle	height	DTH	Angle	height	DTH
90	0	14.0	90	0	15.8	90	0	15.9	90	0	12.8
90	1	12.6	90	1	12.8	90	1	13.7	90	1	11.2
90	2	11.2	90	2	9.9	90	2	11.5	90	2	9.5
90	3	9.8	90	3	7.0	90	3	9.4	90	3	7.9
90	4	8.4	90	4	4.0	90	4	7.2	90	4	6.3
90	5	7.1	90	5	1.1	90	5	5.0	90	5	4.7
90	6	5.7	90	6	1.9	90	6	2.8	90	6	3.1
90	7	4.3				90	7	0.6	90	7	1.5
90	8	2.9	80	0	16.0				90	8	0.1
			80	1	13.1	80	0	15.1			
80	0	13.6	80	2	10.1	80	1	12.9	80	0	11.7
80	1	12.2	80	3	7.2	80	2	10.7	80	1	10.1
80	2	10.8	80	4	4.2	80	3	8.5	80	2	8.5
80	3	9.4	80	5	1.3	80	4	6.3	80	3	6.9
80	4	8.0	80	6	1.6	80	5	4.1	80	4	5.3
80	5	6.6				80	6	1.9	80	5	3.7
80	6	5.2	70	0	16.2	80	7	0.3	80	6	2.1
80	7	3.9	70	1	13.3				80	7	0.5
80	8	2.5	70	2	10.3	70	0	14.2			
80	9	1.1	70	3	7.4	70	1	12.0	70	0	10.7
80	10	0.3	70	4	4.5	70	2	9.8	70	1	9.1
			70	5	1.5	70	3	7.7	70	2	7.5
70	0	13.2	70	6	1.4	70	4	5.5	70	3	5.9
70	1	11.8				70	5	3.3	70	4	4.3
70	2	10.4				70	6	1.1	70	5	2.7
70	3	9.0							70	6	1.1
70	4	7.6							70	7	0.6
70	5	6.2									
70	6	4.8									
70	7	3.4									
70	8	2.1									
70	9	0.7									

LBDO			PESA			RNPH			REPH		
Angle	height	DTH	Angle	height	DTH	Angle	height	DTH	Angle	height	DTH
90	0	15.4	90	0	13.0	90	0	11.6	90	0	11.1
90	1	14.4	90	1	11.8	90	1	9.1	90	1	9.8
90	2	13.4	90	2	10.5	90	2	6.6	90	2	8.6
90	3	12.5	90	3	9.3	90	3	4.0	90	3	7.3
90	4	11.5	90	4	8.1	90	4	1.5	90	4	6.1
90	5	10.5	90	5	6.8				90	5	4.8
						80	0	11.7			
80	0	12.0	80	0	12.4	80	1	9.2	80	0	10.1
80	1	11.0	80	1	11.1	80	2	6.7	80	1	8.9
80	2	10.0	80	2	9.9	80	3	4.2	80	2	7.6
80	3	9.0	80	3	8.7	80	4	1.7	80	3	6.4
80	4	8.0	80	4	7.4	80	5	0.8	80	4	5.1
80	5	7.0	80	5	6.2				80	5	3.8
80	6	6.0	80	6	5.0	70	0	11.9	80	6	2.6
80	7	5.0	80	7	3.7	70	1	9.4	80	7	1.3
80	8	4.0	80	8	2.5	70	2	6.9	80	8	0.1
80	9	3.0	80	9	1.3	70	3	4.4			
80	10	2.0	80	10	0.0	70	4	1.9	70	0	9.2
						70	5	0.7	70	1	7.9
70	0	8.6	70	0	11.7				70	2	6.7
70	1	7.6	70	1	10.5				70	3	5.4
70	2	6.6	70	2	9.3				70	4	4.2
70	3	5.6	70	3	8.0				70	5	2.9
70	4	4.6	70	4	6.8				70	6	1.6
70	5	3.6	70	5	5.6				70	7	0.4
70	6	2.6	70	6	4.3				70	8	0.9
70	7	1.6	70	7	3.1						
70	8	0.6	70	8	1.9						

RUTU

Angle	height	DTH
90	0	13.4
90	1	10.0
90	2	6.7
90	3	3.3
90	4	0.0
80	0	13.8
80	1	10.4
80	2	7.0
80	3	3.7
80	4	0.3
70	0	14.1
70	1	10.7
70	2	7.4
70	3	4.0
70	4	0.6

SESA

Angle	height	DTH
90	0	11.5
90	1	10.2
90	2	8.9
90	3	7.5
90	4	6.2
90	5	4.9
90	6	3.5
90	7	2.2
90	8	0.9
80	0	10.8
80	1	9.5
80	2	8.1
80	3	6.8
80	4	5.5
80	5	4.1
80	6	2.8
80	7	1.5
80	8	0.1
70	0	10.0
70	1	8.7
70	2	7.4
70	3	6.1
70	4	4.7
70	5	3.4
70	6	2.1
70	7	0.7

STSA

Angle	height	DTH
90	0	11.2
90	1	10.4
90	2	9.5
90	3	8.7
90	4	7.8
90	5	7.0
80	0	10.5
80	1	9.7
80	2	8.8
80	3	8.0
80	4	7.1
80	5	6.3
80	6	5.4
80	7	4.6
80	8	3.7
80	9	2.9
80	10	2.0
70	0	9.8
70	1	9.0
70	2	8.1
70	3	7.3
70	4	6.4
70	5	5.6
70	6	4.7
70	7	3.8
70	8	3.0
70	9	2.1
70	10	1.3

All shorebirds*

Angle	height	% of incubation complete
90	0	0.42
90	1	0.48
90	2	0.55
90	3	0.62
90	4	0.68
90	5	0.75
90	6	0.82
90	7	0.89
90	8	0.95
80	0	0.46
80	1	0.53
80	2	0.59
80	3	0.66
80	4	0.73
80	5	0.79
80	6	0.86
80	7	0.93
80	8	0.99
70	0	0.50
70	1	0.57
70	2	0.63
70	3	0.70
70	4	0.77
70	5	0.84
70	6	0.90
70	7	0.97

* To calculate the “% of incubation complete” for species for which we do not have species-specific float tables, use the “all shorebirds” float table.

For example: You discover a Bar-tailed Godwit nest and float the eggs. The eggs are floating at the water surface at an angle of 80° and the egg is exposed 2 mm above the water line.

<u>% of incubation complete</u> = 0.59 (from “other shorebird” table) x 21 (mean incubation length for BTGO) = 12.4 days old
So, the eggs will hatch in approximately (21 – 12.4) = 8.6 days.

APPENDIX 4. MAYFIELD ESTIMATION

An example of a Mayfield Scroll:

			June										July												
Nest	Fate	Mayfield Days	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	CONT'D…		
RPE01	Succ.	19														3e		4e							
RPE02	Failed	0.5																			4e	0e			
RPL04	Succ.	14																		4e					
RPL01	Failed	10	3e			4e					4e				0e		*Assumed to fail halfway b/w the last active*								
RPL02	Failed	3.5										4e		4e			0e		*and first inactive checks*						
RPR03	Unknown	9																							

			July																		
Nest	Fate	Mayfield Days	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
RPE01	Succ.	19				4e		4e		4e		4e		4*	1c, 3e	Male with chick nearby, 1 egg left					
RPE02	Failed	0.5																			
RPL04	Succ.	14		4e				4e		4e		4e, *'d		1 Chick		*Mayfield days run from find to hatch*					
RPL01	Failed	10																			
RPL02	Failed	3.5																			

Mayfield estimate of nest success:

$$Nest\ Success = Daily\ Survival^{\ Incubation\ Duration}$$

where:

$$Daily\ Survival = 1 - (\#\ of\ nest\ failures\ /\ \#\ of\ exposure\ days)$$

Exposure days are summed for each species separately.
The standard error of the daily mortality or survival rate is equal to the square root of the variance. The formula for the variance is:

$$\text{Var}_{daily\ mortality} = ((\text{Exposure days} - \#\text{ of failures})*(\#\text{ of failures})) / (\text{Exposure days})^3$$

Appendix 5. Nest Habitat Data

Study area/Plot #:	**Species:**	**Date:**
Nest #:	**Observer:**	

Notes[1]:

Vegetation Height:	**Percent Cover[2]**
N	graminoid
E	dwarf shrub
S	shrub
W	emergent veg
	herb
Nest Concealment[3]:	moss/lichen
	open water
	bare ground
Distance to Water[4]:	
	Dominant Soil Moisture[5]:
	Surface Roughness[6]:
	Low Med High

[1] Notes: this should include a general description of the nest habitat. E.g. "located on the rim of a low-centre polygon"

[2] Percent Cover Descriptors

graminoid	sedges or grasses (e.g., *Carex*, *Eriophorum*, *Pucinellia*, *Dupontia*)
dwarf shrub	woody plants, 15 cm (ankle height or lower) (e.g., ericaceous, *Salix*, *Betula*, *Dryas*)
shrub	other woody plants, >15cm tall. Usually *Salix*, but some *Alnus*
emergent veg	vegetation emerging from standing water
herb	herbaceous - non-sedge/grass, non-woody flowering plants
moss/lichen	lichens or mosses covering ground
open water	ponds, standing water, etc.
bare ground	exposed substrate including dirt, mud, rock, gravel, etc.

[3] Nest Concealment: Estimated from standing height, this represents the proportion of the nest bowl obscured by vegetation or overhanging rocks, ±10%.

[4] Distance to nearest water: The estimated (by pacing or GPS) distance to the nearest lake, river, pond, or standing water. If the nearest "water" is a dried pond edge that would have been submerged at the time of nest initiation, this should also be recorded.

[5] Moisture- Dry (soil crumbles in hand), moist (soil retains shape of a ball when squeezed), saturated (water comes out of soil when squeezed in hand or squishes out of ground when stepped on), or standing water

[6] Surface roughness categories are low (very few or no dry 'bumps'), medium (moderate number of 'bumps') and high (lots of dry nesting spots within the wetland area).

APPENDIX 6. CWS CHECKLIST SURVEYS

NWT - Nunavut Bird Checklist Survey Form

This checklist is for recording bird data for scientific purposes. Complete the bird list portion by recording the number of birds of each species observed and an appropriate breeding code for **a 24 hour or shorter period in a 10x10 km or smaller area**. Please be sure to answer the questions on the next page. Record the number (or best estimate) of each species observed in the abundance column (#). In the "BR" column, record the most appropriate breeding evidence code from the list on the back page. If you observe species that are not on the list, record them in the blank space(s) provided at the end of the regular species list and describe your observations fully under "Comments". **There are new sections in this form as of 2004.**

Observer Name:______________________________

Please Answer Each Section (Check ✓one)

What Kind of Count Did You Do?

Casual Observation ☐
(feeder count, individual bird note, etc)
Point or Stationary Count ☐
(ensure duration is recorded on first page)
Transcect or Traveling Count ☐
Distance traveled during count __________km
Area Count/Search ☐
Area covered for count __________km^2
Non-Standard (>24 hrs) ☐

How Inclusive Was Your Count?

This list reports **all birds seen at the site** ☐
or is limited to **one or a few species at the site** ☐

What is your birdwatching skill level?

See PDF File for complete details