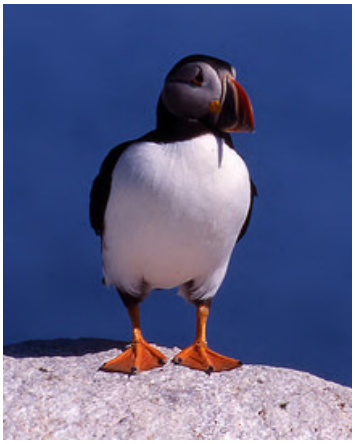
Developing Standardized Protocols for Monitoring Nesting Colonial Waterbirds in Region 5: Recommendations



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Atlantic Puffin (Katherine Whittemore/USFWS), Arctic Terns (Kayla Pelletier/USFWS), Black Guillemot (Jennifer Goyette/BRI)

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Developing Standardized Protocols for Monitoring Nesting Colonial Waterbirds for Region 5:

Recommendations

SUBMITTED TO:

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Table of Contents

PROJECT SUMMARY

Monitoring the relative abundance of a species can highlight declining and vulnerable populations, as well as inform important management decisions (Thomas & Martin 1996). The U.S. Fish & Wildlife Service (USFWS) contracted with the Biodiversity Research Institute (BRI) to develop standardized monitoring protocols for colonial waterbirds across the northeastern United States (USFWS Region 5).

First, we gauged the general interest in this approach by polling the views of the primary colonial waterbird monitors in 10 coastal states in the region via an online questionnaire (see Stenhouse & Goyette 2012). We received responses from monitors in six of these states. Despite some concerns over data sharing, and balancing local vs. regional needs, an overwhelming majority of respondents indicated a clear willingness to 1) collaborate to reach regional monitoring goals, 2) share protocols and techniques, with the aim of creating a central repository, 3) adopt standardized protocols that provide information on regional population trends, and 4) participate in a centralized data storage and management system on a regional level.

Most respondents indicated that access to regional information, such as population trends, would be of benefit to their local management and conservation efforts. In general, they also expressed a strong desire to see a firm federal commitment to long-term regional monitoring efforts, such as the development and maintenance of an accessible database on regional populations and trends.

In this report, we provide general recommendations on establishing a coordinated regional monitoring program for colonial waterbirds through a series of specific options.

CURRENT MONITORING PROGRAMS & FOCAL SPECIES

Responses to the questionnaire indicated that at least 28 waterbird species are regularly monitored throughout the region, including several species of federal and/or state concern. In general, the frequency of surveys ranged from annual to every three to ten years (Stenhouse & Goyette 2012).

Based on the distributions of taxonomic groups, there is some variation in the species on which states focus their monitoring. In general, long-legged waders, such as herons and egrets, are monitored in the southern part of the region, where they are more abundant; while cliff and burrow-nesting seabirds, such as auks and storm-petrels, are monitored in the northern part of the region.

Three waterbird species of high conservation concern occur in the northeastern region. The Roseate Tern (*Sterna dougallii*) is federally listed as *Endangered* (USFWS 2010), the Piping Plover (*Charadrius melodus*) is federally listed as *Threatened* (USFWS 2012), and the American Oystercatcher (*Haematopus palliatus*) is listed as a *Species of High Concern* in the U.S. Shorebird Conservation Plan (Brown *et al*. 2001). These species are monitored in all northeastern coastal states in which they regularly breed. They are largely the focus of single-species monitoring programs with highly specific protocols (e.g. see Blodget & Melvin 1996), and often involve coordinated volunteer efforts. Individual states in Region 5 also list species of local conservation concern (Table 1).

Overall, cormorants, gulls, and terns are monitored widely across the region (Stenhouse & Goyette 2012) and would make extremely good candidates for a pilot cooperative monitoring program. Since many states in the region are already monitoring some or all of these species to some extent, organizing a monitoring program around these species may be relatively simple, requiring limited adjustment to existing survey protocols and a blending of survey schedules to ensure regional coverage in the same years. A measured, stepped approach, such as this, would provide a good opportunity for federal agencies to clearly indicate a firm commitment to long-term monitoring efforts, develop a strong monitoring network, and improve communication among agencies, organizations, and individuals involved in monitoring. If successful, a pilot project of this nature could set the stage for greater coordination in monitoring of other colonial waterbird species across the whole region.

Table 1: Waterbird species of concern in USFWS Region 5, their federal conservation status, and listed status in each of the coastal states (T = Threatened, E = Endangered, SC = Special Concern, Ex= Endangered-extirpated).

	Federal	State Listing									
Species	Listing[1]	ME[2]	NH[3]	MA[4]	RI[5]	CT[6]	NY[7]	NJ[8]	DE[9]	MD[10]	VA[11]
Leach's Storm-Petrel		SC		E							
Brown Pelican										SC	
Great Cormorant		T									
Cattle Egret					SC			T			
Great Blue Heron		SC			SC			SC			
Great Egret					SC	T					
Little Blue Heron					SC	SC		SC			
Snowy Egret					SC	T		SC			
Black-crowned Night Heron		T			SC			T	E		
Yellow-crowned Night Heron					SC				E	SC	
Glossy Ibis					SC	SC		SC			
American Oystercatcher		SC			SC	T		SC	E	SC	
Piping Plover	T	E	E	T	T	T	E	E	E	E	T
Wilson's Plover										E	E
Spotted Sandpiper										SC	
Red Knot								E			SC
Laughing Gull		SC								SC	
Arctic Tern		T	SC	SC							
Black Tern		E					E				
Caspian Tern								SC			
Common Tern		SC	T	SC		SC	T	SC	E		
Forster's Tern									E		
Gull-billed Tern								SC		E	T
Least Tern		E	E	SC	T	T	T	E	E	T	
Roseate Tern	E	E	E	E	E	E	E	E		Ex	E
Royal Tern										E	
Sandwich Tern										SC	
Black Skimmer								T	E	E	
Razorbill		T									
Atlantic Puffin		T									

Notes: [1]USFWS 2012; [2]MDIFW 2010; [3]NHFGD 2009, 2011; [4]MassWildlife 2011; [5]RINHS 2006; [6]CTDEEP 2010; [7]NYDEC 2007; [8]NJDFW 2012, 2008; [9]DDFW 2012, [10]MDNR 2010, [11]VDGIF 2011.

There are a number of good reasons to coordinate monitoring of breeding colonial waterbirds in Region 5. For example, monitoring and evaluation has been identified as a key component of the North Atlantic Landscape Conservation Cooperative's (LCC) mission (USFWS 2009). The LCCs Development and Operations Plan identifies monitoring as an important science need, and aims to "establish comprehensive monitoring and evaluation programs to track changes in fish and wildlife populations and their habitats, assess population responses to conservation actions, and evaluate progress toward population and habitat objectives". Working within the LCC framework would be an effective way to establish coordinated colonial waterbird monitoring across the region.

Should further justification for this effort be required, however, highlighting pervasive and/or emerging region-wide threats to waterbird populations, such as climate change, changes to the marine food web, and coastal and offshore wind energy development, could be critical. The potential for wind generation along Atlantic coast is considerable and the U.S. government aims to deploy over 50 gigawatts of offshore wind energy capacity by 2030. Furthermore, the current administration has put offshore wind power development on an expedited approval track, and several agencies are working to advance the timeline for deployment of offshore wind energy systems. A number of offshore wind energy projects have already been proposed off the coast of Region 5.

Based on studies at terrestrial sites in the U.S., and marine wind power facilities in Europe, birds are among the most heavily affected wildlife species. This includes many migratory species as well as those that live and breed in close proximity to wind energy facilities. In addition to mortality resulting from collisions with infrastructure, waterbirds can be impacted by wind energy facilities directly through increased energetic costs, related to disturbance and displacement, and indirectly through changes in habitat or prey species. The extent to which coastal and offshore development of this nature will affect breeding colonial waterbirds, especially threatened and endangered species, is largely unknown.

ESTIMATION OF ERROR

No survey protocol is perfect, and there are always errors (usually underestimation) in resulting colony nest counts or population estimates (Kress & Hall 2004). There are existing recommendations, however, that can be taken to limit and quantify the sources of errors. These include randomly selecting colonies and/or subsamples, timing surveys based on annual breeding phenology, refining estimates with correction factors, and using experienced observers familiar with the species and survey method in question (see Steinkamp *et al* 2003, Kress & Hall 2004, Schmidt *et al*. 2008).

Counts and Count Units

Ground-based nests counts provide the most acceptable estimates of breeding colony size for many colonial waterbird species(Steinkamp *et al*. 2003), but surveys employing this method can miss some birds, such as failed breeders or late nesters (Frederick *et al*. 2006). The primary drawback with ground nest counts is colony disturbance, and the acceptable level of disturbance varies enormously among species. Surveys should not be carried out for species or specific colony locations where human presence causes breeding adults to leave their nests for extended periods, i.e. long enough to put eggs or chicks at high risk of predation and/or environmental exposure.

For some species, it will not be possible to see and count all active nests (due to the nest type, adult behavior, vulnerability to disturbance, or colony layout/location). In these cases, a count of apparently occupied nests (AON) may be possible from a suitable distant vantage point (e.g. in the case of inaccessible colonies), or in the absence of birds (e.g. in the case of nocturnal burrow nesters). Such a count would include birds that appear to be incubating, unattended broods, attended and well-built nests (with or without eggs or young), and burrows or crevices that show recent activity at the entrance, such as evidence of fresh digging, feathers, guano, or prey remains.

In large colonies (>500 pairs), or at sites where large areas of the colony are not clearly visible, it may not be impossible to count all nests, or all apparently occupied nests, and monitoring will have to rely on a sub-sample of the colony. This does not provide a total colony count, but population trends can be accurately measured using transects through a colony, or selected permanent monitoring plots (Rodway & Lemon 2011). With care, results can sometimes be extrapolated to the whole colony.

Permanent study plots should be established in sections of the colony that can be monitored during ground counts. Where this is not practical, due to issues of accessibility, for example, study plots may be established for areas of the colony that are clearly visible from a good vantage point on land, or from a boat. On cliff colonies, care should be taken to select areas that can be viewed from an appropriate distance and angle (see Walsh *et al*. 1995). Monitoring plots are then randomly or systematically distributed throughout the colony, or the visible sections of a colony. Plot boundaries should be clearly defined i.e. highlighted on recent high-definition annotated photographs, and/or indicated on the ground with long-lasting markers (e.g. stakes, flags, poles, rock cairns, etc.).

The optimal number, length, and width of transects, and the number and size of plots, will vary among species, nesting density, and colony layout, and will involve a trade-off between statistical confidence and practicality. In general, many small plots are more effective than few large plots (Walsh *et al*. 1995).

Correction Factors

Ground Counts

For larger colonies (>50 pairs), ground-based nest counts should be corrected using the ‘mark-recapture’ Lincoln Index, a simple correction calculation. This involves sweeping through the study area (a

subsection of the colony), marking nests as they are counted (*a*). A second sweep through the study area recounts marked nests (*b*) and any additional unmarked nests (*c*) that were missed in the first sweep.

The corrected nest count (*N*) is calculated as: $N = [\ b + c \div b\ ] * a$

Distant Counts

Colonies or study plots surveyed from a distance should be counted simultaneously by two independent observers, who then compare their results. If this is not possible, then one observer should repeat the complete count. If there is a significant discrepancy between counts 1 and 2, the survey can be repeated until this is reduced to an acceptable level (<5%), or the average of the two counts can be used.

Optimum Timing

Monitoring surveys are best carried out at specific periods in the breeding cycle, usually mid-incubation to early chick-rearing (King 1978, Schmidt *et al*. 2008), which can vary considerably among species or taxonomic groups. Given the geographic scale of Region 5, latitudinal variation in breeding phenology also exists, with the same species initiating breeding in the southern end of the region perhaps several weeks in advance of the northern end. Region-wide surveys should be carefully coordinated and scheduled to maximize both the local and regional relevance of survey results and trend information, but we recommend they be carried out across the region within a 14-21 day window.

Survey Frequency

Species are generally monitored to detect the degree and direction of population changes. Colonial waterbirds are relatively long-lived species with high rates of breeding site fidelity. Thus, long-term population trends can be tracked with regular but infrequent monitoring efforts (Walsh *et al*. 1995). Although many individual colonies in the region are surveyed annually, coordinated region-wide monitoring is probably not practical or realistic on an annual basis for any species or taxonomic group, other than perhaps terns.

Scheduling coordinated region-wide surveys every three to five years would most likely be sufficient to track long-term population trends in colonial waterbird species, and provide important contextual information required for local and regional conservation and management decisions. A three-year schedule would fit well with a number of existing monitoring schemes in the region. Since terns are surveyed across much of the region on an annual basis, with concerted effort, it *may* be possible to increase the frequency of region-wide, coordinated surveys for this particular group.

Review and Revision

Standardizing survey protocols across the region will clearly facilitate the elucidation of long-term region-wide population trends. Monitoring approaches and survey methods can improve, however, as technology advances and innovative techniques and analyses are developed. Any long-term regional monitoring program should include periodic review of operating procedures (Oakley *et al*. 2003), and be flexible enough to adapt and revise as necessary to improve the accuracy of results, or lessen the amount of effort invested to acquire the same degree of information.

Recommended Monitoring Protocols

1 – Island and Beach-Nesting Species

This large focal group includes a broad suite of ground and ledge-nesting species that utilize a great variety of beach and rocky island habitats in the region (Table 2). Systematic ground counts of active nests are considered the most accurate for most of these species in small to large colonies, or in mixed colonies of seaducks, gulls, and terns (Kress & Hall 2004). Some species in this focal group, however, do not lend themselves to systematic ground counts of nests, due to their sensitivity to disturbance, or colony inaccessibility. In these cases, distant counts, either from a vantage point on land or from boats, can be a useful alternative.

Carrying out ground counts across hundreds of small island colonies within the same breeding season is impractical, however, and aerial survey may be the most effective method for broad-scale monitoring (see MCINWR 2010 for a carefully executed example).

1-A. Systematic Count of Ground-Nesters

- Preferred survey type for: eider, gulls, terns, skimmer

We recommend censuses every three to five years, following ground count procedures such as those described by Walsh *et al*. (1995), Blodget & Melvin (1996), Steinkamp *et al*. (2003), and Kress & Hall (2011). Disturbance to the colony should, of course, be kept to a minimum (<30 mins is recommended) and observers should be attentive for signs of stress and/or predation caused by their presence or extreme environmental conditions.

Record colony location with a GPS unit. Draw colonies boundaries as accurately as possible on a recent map of the site. Record site conditions, including anything notable, such as storm damage or storm-thrown flotsam (e.g. lobster traps, buoys, ropes, etc.). Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc. Prior to initiating the nest count, make an estimate of the number of birds at the colony, in the air and on the ground.

Table 2: The general habitat type, nest type, preferred and secondary survey types, and count units for island and beach-nesting colonial waterbird species in Region 5.

Species	Habitat type	Nest type	Preferred Survey Type	Units	Secondary Survey Type	Units
Common Eider	Island	Ground	ground count – 1A	active nests	distant count – 1B	AONs
Leach's Storm-Petrel	Island	Burrow/Crevice	ground count – 1C(i)	AOBs	ground count – 1C(ii)	AOBs
Double-crested Cormorant	Island	Ground/Ledge/Tree	distant count – 1B	AONs	aerial survey – 3	AONs
Great Cormorant	Island	Ground/Ledge	distant count – 1B	AONs	aerial survey – 3	AONs
Piping Plover	Beach	Ground	ground count – 1A	active nests	distant count – 1B	AONs
American Oystercatcher	Beach/Island	Ground	ground count – 1A	active nests	distant count – 1B	AONs
Laughing Gull	Beach/Island	Ground	ground count – 1A	active nests	aerial survey – 3	AONs
Ring-billed Gull	Beach/Island	Ground	ground count – 1A	active nests	aerial survey – 3	AONs
Herring Gull	Island	Ground	ground count – 1A	active nests	aerial survey – 3	AONs
Great Black-backed Gull	Island	Ground	ground count – 1A	active nests	aerial survey – 3	AONs
Forster's Tern	Beach	Ground	ground count – 1A	active nests	distant count – 1B	AONs
Common Tern	Beach/Island	Ground	ground count – 1A	active nests	distant count – 1B	adults
Arctic Tern	Beach/Island	Ground	ground count – 1A	active nests	distant count – 1B	adults
Roseate Tern	Beach/Island	Ground	ground count – 1A	active nests	distant count - 1B	adults
Least Tern	Beach/Island	Ground	ground count – 1A	active nests	distant count – 1B	AONs
Black Skimmer	Beach	Ground	ground count – 1A	active nests	distant count – 1B	AONs
Razorbill	Island	Ledge/Crevice	ground count – 1C	AONs	distant count – 1B	AONs
Black Guillemot	Island	Crevice	distant count – 1B(i)	adults	ground count – 1C	AONs
Atlantic Puffin	Island	Burrow/Crevice	ground count – 1C(i)	AOBs	ground count – 1C(ii)	AOBs

To count nests, observers should line up across the beach/colony. The size, shape, and configuration of the colony will determine the best path to take. Distance between observers will depend on the characteristics of the substrate and ease of observing nests (i.e. sand beach vs. thick vegetative ground-cover), but observers should be no more than roughly arm's length apart. As a unit, observers should then proceed to move slowly through the colony scanning carefully at their feet for nests, eggs, and chicks. Observers should mark each nest with an unobtrusive marker such as a tongue depressor or popsicle stick. Observers should communicate amongst themselves to avoid double-counting or missing any nests. Observers should relay all results to a designated recorder, or use hand held counters for each species. The recorder should follow close behind the line of observers, noting the number and details of all nests identified and marked.

Nests should be identified to species, whenever possible, based on nest type, nest materials (e.g. grass, down), egg characteristics (size, shape, ground color, color/pattern of markings), and chick appearance.

If the colony is large, it may require additional sweeps to count all nests. In this case, on the first sweep, the observer on the inside end of the line can place survey flags intermittently along the edge of the surveyed area. Once they have exited the colony, the line of observers then move over and employ the same nest count and marking procedure in a return sweep through the colony. On this return sweep, the observer on the outside end can remove the flags as they go, or leave them in place for removal once the survey is complete.

On completion, observers should record all relevant details of the precise methods used, describing locations and procedure followed, including any variations from the standard protocol and reasons for this, and who was involved in the survey. Further comments on the perceived accuracy of the count are also important to note at the time of the survey.

As discussed (see 'Correction Factors' above), for larger colonies (>50 pairs), systematic ground counts should be corrected using an additional sweep through the colony (or a subsection of it) counting marked and unmarked nests and then applying the Lincoln Index.

<u>General procedure</u>:

1) Record colony location with a GPS unit. Clearly define the outer boundaries of the survey area, such as a length of coastline or colony. Subdivide the area into smaller segments based on natural features obvious on an annotated map or photograph.
2) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
3) Divide the colony area into narrow strips and station observers 2-3 m apart. Observers walk slowly through the colony in a line, relaying information to a recorder who closely follows the line.
4) Count and note the contents of each complete/active nest within a strip. Depending on the time of year, or the species being monitored, observers may have to part longer vegetation or look under scrub to find ground nests.
5) Mark each active nest when it is encountered, with a tongue depressor, popsicle stick, or other marker.

6) Counts should include an objective assessment of the stage of breeding, and should include a separate count of any birds loafing or displaying nearby.
7) On completion, observers turn around and take a second sweep through the same area of the colony, or a smaller subsample area, counting all marked and unmarked nests.
8) Use Lincoln Index correction to calculate final ground nest count.

1-B. Distant Count of Ground- and Ledge-Nesters

- Preferred survey type for: cormorants, guillemot (adult counts)

- Secondary survey type for: herons, egrets, night-herons, ibises

For ground-nesting species that are vulnerable to disturbance (such as cormorants), or ground and ledge-nesting species whose colonies are generally conspicuous but are inaccessible for some reason (such as murres and razorbills), counts of nesting birds can be made from a distance. Where a whole colony is visible, surveys could be undertaken from a suitable vantage point on land, or from a boat. To the extent possible, boat-based surveys should be carried out in calm, clear conditions. This method will likely underestimate the number of nesting adults, but should provide a reliable index of relative abundance and spatial distribution (Trocki *et al*. 2011).

Complete counts of visible and *apparently occupied nests* (AONs; see 'Counts and Count Units' above) should be attempted using a high-powered telescope (on land) or binoculars (on boat). Repeated counts should be carried out from the same location, thus, the precise coordinates should be recorded with a GPS unit. Wherever possible, observers should record the stage of each nest (trace vs. well built), as well as the contents (empty, eggs, chicks), and the presence/absence of attendant adults and their behavior (nest building, incubating, defending nest, etc.).

Counts of loafing or displaying adults nearby, but not associated with nests, should also be included. Where this is possible, an indication of the proportion of immature birds in loafing flocks is important.

In large colonies, it is unlikely that observers could find and assess all nests and may have to rely on a sub-sample. This is achieved by counting nests in a series of survey plots, preferably randomly distributed. The precise number and size of plots should be based on the species present and the general density of nests. Using this method, observers carefully scan through survey plots using a telescope or binoculars and count all AONs (see 'Counts and Count Units' above).

General procedure:

1) Choose and map a suitable vantage point on land, or an appropriate point and angle of view from a boat. Record the location with a GPS unit.
2) Clearly define the outer boundaries of the survey area, such as a length of coastline or colony. Subdivide the area into smaller segments based on natural features obvious on an annotated map or photograph. The count area and subdivisions should remain consistent between years.

3) Counts should be carried out when the maximum number of nests are occupied (late incubation to early chick-rearing). This will vary by species and geographically across the region, but is likely to be around early to mid-June. Repeated counts, if possible, between late May and late June will likely pick up the peak number of nests.
4) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
5) Count AONs, including active nests (bird sitting tight whether or not eggs or young are seen, or an unattended brood), and other attended, well-built nests (capable of holding eggs). Poorly constructed, unfinished, or potentially abandoned nests should be noted separately. Nests should be assigned to species, where possible.
6) Counts should include an objective assessment of the stage of breeding, and should include a separate count of any birds loafing or displaying nearby.
7) Note and map any areas of the colony that are not visible from the vantage point, and, if possible, estimate the number of nests potentially out of view.

1-B(i). Modified Distant Count

- Preferred survey type for: guillemot
- Secondary survey type for: razorbill

An exception to the general distant count described above is the Black Guillemot. For this species, distant counts should be made early in the day, ideally 2 hours immediately after first light, ideally during the pre-laying period. Counts should be made from shore, or from boats if the shore line is inaccessible or does not provide good views of the water. Observers traverse the length of the shore used by nesting guillemots, scanning the area frequently. Counts include all guillemots seen on shore or on the sea within 300 m of land. Birds observed to be foraging should be counted separately, as they are not likely associated with the breeding colony. This method is also used for Razorbills at inaccessible colonies.

General procedure:

1) Choose and map a suitable vantage point on land, or an appropriate point and angle of view from a boat. Record the location with a GPS unit.
2) Clearly define the outer boundaries of the survey area. Subdivide the area into smaller segments based on natural features obvious on an annotated map or photograph. The count area and subdivisions should remain consistent between years.
3) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
4) Move along the stretch of shore used by guillemots, scanning frequently for birds. Count all guillemots on shore or on the water within 300 m of shore. Count foraging birds separately.
5) Note and map any areas of the colony that are not visible, and, if possible, estimate the number of nests potentially out of view.

1-C. Systematic Count of Burrow and Crevice-Nesters

- Preferred survey type for: storm-petrels, puffin, razorbill

- Secondary survey type for: guillemot

Burrow and crevice-nesting species, where incubating birds, nests, and eggs are hidden from view, present unique challenges. These species require specific monitoring methods, and are generally time-consuming to survey (Diamond 1997). Timing of surveys is important as these species are generally prone to disturbance during early incubation. Surveys should be carried out as early as possible, so as not to miss failed breeding attempts, but not sooner than late egg laying – early incubation (Steinkamp *et al*. 2004)

Given that incubating adults are not visible, the count unit in this survey method is *apparently occupied burrows* (AOBs) or *apparently occupied nests* (AONs). Traditionally, burrows and crevices have been explored manually (called 'grubbing') for signs of occupancy, but this is a time-consuming and generally inefficient method and many burrows and crevices are too long to determine occupancy in this manner. Indirect evidence, such as fresh digging, feathers, guano, or other signs of recent activity may also be used to assess occupancy (see 'Counts and Count Units' above).

There are a couple of alternative options, however. Burrow occupancy may be assessed with use of a burrow-scope, or using a vocalization playback method. A burrow-scope is an infra-red camera with a flexible fiber-optic, but this method is time-consuming and relatively expensive (Ambagis 2004), and its' effectiveness may depend on the type of substrate in which birds are nesting. The playback method involves playing a recording of a suitable call at a burrow/crevice entrance, which will often elicit a vocal response from an incubating bird (James & Robertson 1985). Care must be taken to choose a recording of an appropriate vocalization, paying close attention to the breeding biology of the species being surveyed, such as their behavioral repertoire, sex differences, etc.

In large colonies, it is unlikely that observers could find and assess all burrows/crevices and may have to rely on a sub-sample of nests. This could be achieved by assessing burrows along a series of narrow (2 m wide) transects running through a colony area, or in a series of sample plots. Where colony boundaries are relatively well known and burrow density does not vary enormously across the colony, then sample plots should be distributed randomly throughout entire colony. In situations where colonies can be easily divided, by topography or habitat, and burrow density is known to vary among these, each section should be treated separately. Sample plots should be distributed randomly throughout each separate section (known as *stratified* random sampling).

The precise width of transects, and the size or diameter of plots, should be based on the species present and the general density of nests. Where possible, we recommend 20+ transects of 2-3m width, or 10-20+ circular plots with a radius of at least 1.8 m (10 m^2). Using these methods, observers count all burrow/crevice entrances present, and the number of AOBs/AONs, within the defined area.

General procedures:

1-C(i). Sample Plots

1) Record colony location with a GPS unit. Clearly define the boundaries of the survey area(s) on an annotated map or photograph.
2) Place a fine grid over the map and, using a random numbers table or generator, determine random sample points on the map.
3) Use these points as the center of your sample plots. Record these points with a GPS unit. These points may be marked permanently for use in future monitoring, or a new set of random points may be generated each time.
4) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
5) Count all burrow/crevice entrances (where >50% of the entrance falls within the plot) and all apparently occupied burrows/crevices.

1-C(ii). Transects

1) Record colony location with a GPS unit. Clearly define the boundaries of the survey area(s) on an annotated map or photograph.
2) Divide a map of the colony area into strips of your transect width and number these. Select as many transects as desired using random numbers.
3) Establish transects lines running through the colony, to begin and end in apparently unoccupied areas on either side of the colony. Mark the lines at regular intervals with stakes or flags. Record the start and end points with a GPS unit.
4) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
5) Count all burrow/crevice entrances (where >50% of the entrance falls within the transect) and all apparently occupied burrows/crevices. Record numbers for each transect separately.

The procedure used to calculate an estimate of the colony population, and the variance around that estimate, differ between true random sampling and stratified random sampling methods. For the steps involved in these calculations, follow the clear explanations provided by Walsh *et al*. (1995) in their puffin census method 1a and 1b.

2 – Long-Legged Wading Birds

This focal group includes herons, egrets, and ibises that nest in trees and shrubs on the edge of wetland habitats in the region (Table 3). Aerial and ground based methods are typically employed for wading birds, often in combination (Frederick *et al*. 1996).

Table 3: The general habitat type, nest type, preferred and secondary survey types, and count units for tree and shrub-nesting colonial waterbird species in Region 5.

Species	Habitat type	Nest type	Preferred Survey Type	Units	Secondary Survey Type	Units
Great Blue Heron	Wetland/Island	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Little Blue Heron	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Tricolored Heron	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Great Egret	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Snowy Egret	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Cattle Egret	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Black-crowned Night-Heron	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Yellow-crowned Night Heron	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Green Heron	Wetland	Tree	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs
Glossy Ibis	Wetland	Tree/Shrub	ground count – 2A	active nests	distant count – 2B or aerial survey – 3	AONs

2-A. Systematic Count of Tree- and Shrub-Nesters

- Preferred survey type for: herons, egrets, night-herons, ibises

For the northeast region, when logistics are favorable, we recommend censuses for long-legged wading birds every 3-5 years, following ground count procedures such as those described by Trocki (2011) and Steinkamp *et al*. (2003). Ground counts have been shown to have the least bias and highest accuracy for wading bird colonies (Gibbs *et al*. 1988, Green *et al*. 2008). Aerial methods are employed in many areas; they can be less expensive, cover greater area, and may be less disruptive to nesting birds (Kelly *et al*. 2007, Green *et al*. 2008). Aerial counts have been shown to underestimate true populations and are typically used in tandem with ground counts to correct for bias (Frederick *et al*. 1996). Disturbance to the colony should, of course, be kept to a minimum (<1 hour in the colony with less than 10 minutes disturbance to any individual nest) and observers should be attentive for signs of stress and/or predation caused by their presence (Steinkamp 2003).

Ground based colony counts should be carried out when the wind speed is less than 20 km/hr, and restricted to a temperature range of 16-27°C (Trocki 2011). Counts should take place before chicks are large enough that disturbance would cause premature fledging. Choose the type of ground survey based on the physical characteristics of the study site and numbers of nests to survey. USFWS (2008) recommends the following:

- Perimeter count when all nests are visible from the perimeter (e.g. nests are in a row of trees)
- Within colony counts when colonies have less than 1000 nests, or when all nests cannot be seen from the perimeter, or
- Strip transect counts when disturbance needs to be limited (for instance in large colonies of >1000 nests).

For small colonies, a single transect can often be walked and nests counted without the need to mark them. For larger colonies, transects should be walked for the entire colony or for a sub-sample; sub samples should survey at least 40% of the colony. In some cases, it may be beneficial to establish permanent transect markers to be used each year (Steinkamp *et al*. 2003). The distance between transects will depend on the characteristics of the substrate, density of nests, and ease of observing nests (i.e. open and shrubby vs. thick vegetative ground-cover); this will also dictate the width of strip transects, which can vary from 2-5m up to 30-60m in open areas (Steinkamp *et al*. 2003). To count nests, observers should line up and proceed slowly in the same direction, communicating when needed to prevent double counting. The size, shape, and configuration of the colony will determine the best path for transects to take. Melvin (2010) defined active nests as those with eggs or young present, or evidence of recent activity, such as white wash, feathers, and fresh nesting material. Observers should relay counts to a recorder or use hand held counters for each species. The recorder should follow closely behind the line of observers. Care should be taken to prevent double counting (e.g. a nest should be counted by the observer closest to the base of any tree or shrub in which the nest is located, regardless of the position of the nest).

Although it can be difficult to distinguish between species (e.g. Little Blue Herons, Cattle Egrets, and Snowy Egrets), nests should be identified to species, whenever possible, based on nest type, nest materials, egg characteristics (size, shape, color), and chick appearance. Melvin (2010) suggests pooling counts of all nests of these species and deriving species-specific estimates, based on the ratio of adult counts of each species at the colony. If colonies are of a size were flushing of adults is not feasible for an accurate count, the flight-line method described by Erwin (1981) has been recommended by Steinkamp *et al*. (2003). Kushlan (2011), however, considers flight-line counts to be highly inaccurate and suggests their use only as a last resort or simply for species inventory purposes.

In specific cases where disturbance is extreme, post-breeding counts of long-legged wader nests can also been conducted (Steinkamp *et al*. 2003).

An independent double observer count method is recommended (Steinkamp *et al*. 2003). In large colonies where sub-sample transects are conducted, 5 to 10 transects should be counted with the double observer method to determine observer bias.

General procedure:

1) Record colony location with a GPS unit. Clearly define the outer boundaries of the colony/ survey area on a recent map or aerial photograph of the site. If necessary, subdivide the area into smaller segments based on natural features obvious on an annotated map or photograph. The count area, subdivisions, or transects should remain consistent between surveys.
2) Counts should be carried out when the maximum number of nests are occupied (late incubation to early chick-rearing). This will vary by species and geographically across the region.
3) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
4) Prior to initiating the nest count, make an estimate of the number of birds at the colony, in the air and on the ground. If multiple counts are made during a season, report the peak count as a general rule.
5) Observers line up and walk slowly through the defined area or along transect, communicating when needed to prevent double counting. Observers should relay counts to a recorder who closely follows the line, or use hand held counters for each species.
6) Count AONs, including active nests (eggs or young present), and other well-built nests showing evidence of recent activity (fresh guano, feathers, and nesting material). Poorly constructed, unfinished, or potentially abandoned nests should be noted separately.
7) Counts should include an objective assessment of the stage of breeding, and should include a separate count of any birds loafing or displaying nearby.
8) Note and map any areas of the colony that are not accessible on the ground, and, if possible, estimate the number of nests in these areas.

2-B. Distant Count of Tree- and Shrub-Nesters

General procedure:

1) Choose and map a suitable vantage point on land, or an appropriate point and angle of view from a boat. Record the location with a GPS unit.
2) Clearly define the outer boundaries of the survey area, such as a length of coastline or colony. Subdivide the area into smaller segments based on natural features obvious on an annotated map or photograph. The count area and subdivisions should remain consistent between years.
3) Counts should be carried out when the maximum number of nests are occupied (late incubation to early chick-rearing). This will vary by species and geographically across the region. Repeated counts, if possible, between late May and late June will likely pick up the peak number of nests.
4) Note environmental/weather conditions, such as cloud cover, wind speed, wind direction, etc.
5) Count AONs, including active nests (bird sitting tight whether or not eggs or young are seen, or an unattended brood), and other attended, well-built nests (capable of holding eggs). Poorly constructed, unfinished, or potentially abandoned nests should be noted separately. Nests should be assigned to species, where possible.
6) Counts should include an objective assessment of the stage of breeding, and should include a separate count of any birds loafing or displaying nearby.
7) Note and map any areas of the colony that are not visible from the vantage point, and, if possible, estimate the number of nests potentially out of view.

3 – Aerial Survey

- Secondary survey type for: cormorants, gulls, herons, egrets, night-herons, ibises

In cases involving conspicuous species using many breeding colonies distributed over a large geographic area, aerial surveys may be the only practical option for waterbird monitoring. With this method, however, observer safety and colony disturbance are issues that need to be carefully considered early in the planning stages. In general, the use of aerial surveys can be expensive, but this method usually proves to be highly cost-effective when surveying over broad spatial scales.

Aerial surveys can be used to identify colonies and count birds directly, or provide a platform for aerial photography or videography, allowing birds to be counted later. This method is well-suited to large, long-legged wading species that nest in treetops or shrubs, but has also been successfully used to count ground-nesting cormorants and gulls (MCINWR 2010). Direct aerial counts can result in the over-estimation of some species and the under-estimation of others (Rodgers *et al*. 2005, Green *et al*. 2008). Simultaneous systematic ground surveys should be used to verify the results of aerial surveys, estimate detection errors, and develop correction factors (Frederick *et al*. 1996, Green *et al*. 2008). The rapid development of high-definition digital imagery (photography and video) has improved this particular technique considerably in recent years, and practically eliminates observer-related error.

Generally, aerial surveys are performed with small fixed wing aircraft flown at a constant speed (150-180 kph) and low altitude (150-250m) over known colonies or suitable breeding habitat. Observers should be well-acquainted with the species involved as identification of some waterbird species from the air requires considerable experience (Steinkamp *et al*. 2003). Surveys can be carried out by running strip transects over large expanses of habitat to locate colonies, or by following the coastline or edge of appropriate breeding habitat. Several passes over a colony may be required to cover the appropriate area and count nests.

For direct count surveys, three people are required (two observers, and one recorder). Depending on the arrangement of the plane, or survey design chosen, observers may look out opposite sides and count different areas, relaying their counts to the recorder, or look out the same side and provide independent counts of the same area to the recorder. Or, one person may be identified as the 'primary' observer, while the 'secondary' observer focuses on any areas the first missed.

A crew of three is also useful for aerial photography surveys (two photographers, one recorder). One photographer should focus on capturing broader overview photographs of the entire colony, while the other can focus on documenting nests/birds. Photographers should use good quality digital cameras with telephoto lenses and fast shutter speeds. Images should be as high a resolution as possible. The recorder will keep track of the survey route and specific locations where shots were taken (using the aircraft's navigation system to identify coordinates), as well as the specific photo numbers for each pass. Photographs should be examined by two independent reviewers. Each individual nest should be marked and counted. Traditionally, this was done using a projection onto paper, but digital images are easier to handle and the whole process can be done on a high quality computer screen.

High definition videography is proving to be an extremely efficient and effective method for surveying pelagic species using offshore marine habitats (Mellor & Maher 2008), and could be equally useful for monitoring breeding colonial waterbirds. One of the major advantages of this method is that surveys can be flown at a much greater altitudes (up to 600m), essentially eliminating direct disturbance to birds (Hexter 2009).

DATA STORAGE & MANAGEMENT

Based on responses to the questionnaire, there was strong overall support for the development of a centralized regional monitoring database (Stenhouse & Goyette 2012). Ideally, a federal agency (the USGS or USFWS) should lead the development of an Access database, specifically designed to store time-series data from monitoring surveys for the express purpose of tracking population trends at the regional scale. The Maine Department of Inland Fisheries and Wildlife and the US Fish and Wildlife Service recently funded the development of an Access database for the more than 350 seabird colonies in Maine that will allow mangers to enter survey data and monitor population trends across the state.

To facilitate merging new data with this database, colonial waterbird monitors implementing standardized protocols could be sent an empty copy of the database with appropriate data entry forms for entering data annually. Depending on the level of technical support and hosting, another option would be to design a web-accessible portal for direct data entry and query. This portal could have secure access for staff entering and editing data, but could allow public queries of the database through a more restricted web page, perhaps withholding specific locations and other information on sensitive species. While this is a more elegant and widely accessible solution, database structure and housing would inevitably need to be changed and a longer-term plan for the database would need to be developed. Furthermore, dedicated funding would need to be established to support the hosting and maintenance of the database and website.

The long-term goal, however, should be to feed monitoring survey data directly into the USFWS-USGS Atlantic Colonial Waterbird Database (ACWD). Like other broad-scale bird monitoring databases, this could be made publicly accessible via the webpage of the Migratory Bird Data Center (USFWS/USGS 2012). The USFWS is currently planning to resurrect the ACWD and bring it back online, but a time-frame has not yet been outlined. Until the ACWD is available, the data and database could be designed and implemented as described above.

In either case, the database should be managed for the region in perpetuity by the USGS or USFWS, with open access for contributing organizations and individuals involved in monitoring. The hosting agency could also consider producing an annual (or regular) report on the status

and trends of colonial waterbird species across the region, presented as a printed or downloadable document (e.g. see JNCC 2009, Dragoo *et al*. 2009) or an online update (e.g. see JNCC 2012).

Alternatively, adopting another existing database designed to meet the needs of colonial waterbird monitors in the region could also be an efficient and effective path forward. The Integrated Waterbird Management and Monitoring (IWMM) Program has an Access-based database that is available for download online (Anonymous 2011). So far, the IWMM Program is focused on monitoring wetland-dependent migratory birds (waterfowl, shorebirds, other wading birds) within the National Wildlife Refuge system to inform wetland conservation and management. Potentially, this program could be expanded to include additional taxonomic groups or ecological guilds, such as breeding colonial waterbirds, and extended beyond the Refuge system.

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