

Southeast Coast Network

National Park Service
Inventory & Monitoring Program



Standard Operating Procedure (SOP) #2.4.17

Wintering and Migratory Shorebird Data Analysis

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Summary

This Standard Operating Procedure explains some of the data summaries and analyses possible with data collected under the Wintering and Migratory shorebird monitoring protocol (Byrne et al. 2009). Two forms of reports and data summaries exist as part of this protocol; those conducted by the SECN Shorebird Monitoring Database and those necessitating raw- or summary-data export from the database for further analysis in other software packages.

Revision Log

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1	3/18/2013	SECN	SOP number changed	Incorporated into SECN SOP library.	1.1

Database Summaries and Reports

Summaries and reports available from the SECN Shorebird Monitoring Database used for this protocol are available on the SECN SharePoint site

(<http://inpserosecn2/DataReports/Lists/Shorebird%20Reports/AllItems.aspx>). Summaries and reports generated by the database are:

- International Shorebird Survey (ISS) reporting form
- North Carolina Wildlife Resources Commission (NCWRC) shorebird reporting form
- Total observations chart
- Total observations by habitat chart
- Closure observations chart
- Car, people, and dog count charts
- High counts export

Database exports requiring further analysis include:

- Power analysis output
- Distance sampling raw data export
- Beached/Dead bird raw data output
- Walking transects with distance sampling raw data output
- Walking transects without distance sampling raw data output

ISS Reporting Form

This report allows you to auto-populate an International Shorebird Survey form, suitable for printing and submission, based upon a user-defined query of the park, site(s) within a park, and date range (Figure 1).

INTERNATIONAL SHOREBIRD SURVEY'S

c/o Manomet Center for Conservation Sciences

Box 1770, Manomet, MA USA 02345

Name:

Address

CAHA - Bodie Island Spit

DATE (mm/dd)	01/04	01/07	01/15	01/14	01/24	01/25	02/04	02/05	02/15	02/24	02/25	03/04	03/05	03/13	03/24	08/05	08/15	08/25	09/15	10/06	10/04	10/15	10/14	12/04	01/15	10/24	09/05
Piping Plover	33	0	0	0	13	0	0	2	0	0	5	0	2	9	30	95	55	24	49	0	15	0	38	0	0	0	0
Wilsons Plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	0	0	0	2	0	0	0	0	0	0
Red Knot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51	13	36	1	0	99	0	120	0	0	0	0
American Oystercatcher	0	0	0	0	2	0	0	2	2	0	1	0	2	7	2	10	16	19	1	1	0	11	0	0	0	0	0
Wilsons Phalarope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Disturbance-see below																											
Census time	10:10	00:00		00:00			00:00	12:10	11:00	00:00	12:55			00:00	00:00		08:16	07:55		09:00	08:46	07:40	09:23	07:15	12:30	09:52	11:00
Tide (or water level)			3										6		1	10	16	18		9	6	8	8	13	11	4	11

Human Disturbance:

During this census, shorebirds were:

A=undisturbed, B=disturbed 1-2 times, C=3-4 times, D=5-10 times, E=>10 times, X=unknown

TIDE (coastal sites):

1=high, 2=near high, RISING, 3=near high, FALLING, 4=half RISING

5=half FALLING, 6=near low, FALLING, 8=LOW, 9=unknown

WATER LEVEL:

(non-tidal sites): N=normal, H=higher than normal, L=lower than normal, X=not observed

ACCURACY:

Please indicate in each block whether your count is:

* a true count, ** an extrapolated estimate, or circle a "guestimate"

Please use separate forms for different census localities.

Enjoy your shorebirding! If possible, please send your report to Manomet by the end of the year. Thanks.

Figure 1. International Shorebird Survey reporting form export from SECN Migratory and Wintering Shorebird Monitoring protocol data.

NCWRC Shorebird Reporting Form

This report allows you to auto-populate a North Carolina Wildlife Resources Commission (NCWRC) shorebird reporting form, suitable for printing and submission, with piping plover observations (Figure 2). Currently, this report is only designed to report piping plover observations.

Date	Location	Piping Plover Count	Activity	Habitat	Tide
07/27/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
07/27/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	0		Unknown	High (~1 hour before to after peak)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	2	Moving	Foreshore	Almost high, and rising (~1.5 hours before high tide)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	20	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	1	Sedentary	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	1	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
07/27/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
07/28/2006	Cape Hatteras National Seashore, Other	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
07/28/2006	Cape Hatteras National Seashore, Other	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
07/28/2006	Cape Hatteras National Seashore, Hatteras Island Spit	0		Unknown	High (~1 hour before to after peak)
07/28/2006	Cape Hatteras National Seashore, Hatteras Island Spit	0		Unknown	High (~1 hour before to after peak)
07/28/2006	Cape Hatteras National Seashore, Hatteras Island Spit	0		Unknown	High (~1 hour before to after peak)
07/29/2006	Cape Hatteras National Seashore, Cape Point	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
07/29/2006	Cape Hatteras National Seashore, Cape Point	2	Moving	Salt Marsh / Tidal Creek / Brackish Marsh	Almost high, and rising (~1.5 hours before high tide)
08/02/2006	Cape Hatteras National Seashore, Bodie Island Spit	5	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
08/02/2006	Cape Hatteras National Seashore, Bodie Island Spit	2	Moving	Foreshore	High (~1 hour before to after peak)
08/02/2006	Cape Hatteras National Seashore, Bodie Island Spit	2	Moving	Mud Flat / Algal Flat	High (~1 hour before to after peak)
08/02/2006	Cape Hatteras National Seashore, Bodie Island Spit	0		Unknown	High (~1 hour before to after peak)
08/05/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/05/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/05/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/06/2006	Cape Hatteras National Seashore, Other	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
08/24/2006	Cape Hatteras National Seashore, Other	1	Moving	Foreshore	
08/24/2006	Cape Hatteras National Seashore, Other	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
08/24/2006	Cape Hatteras National Seashore, Other	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
08/24/2006	Cape Hatteras National Seashore, Cape Point	0		Unknown	High (~1 hour before to after peak)
08/24/2006	Cape Hatteras National Seashore, Cape Point	1	Moving	Salt Marsh / Tidal Creek / Brackish Marsh	High (~1 hour before to after peak)
08/25/2006	Cape Hatteras National Seashore, Bodie Island Spit	1	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
08/25/2006	Cape Hatteras National Seashore, Bodie Island Spit	3	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
08/25/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/25/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/25/2006	Cape Hatteras National Seashore, Bodie Island Spit	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
08/26/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	9	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
08/26/2006	Cape Hatteras National Seashore, Other	0		Unknown	High (~1 hour before to after peak)
08/26/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	6	Moving	Mud Flat / Algal Flat	Almost high, and rising (~1.5 hours before high tide)
08/26/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	2	Moving	Primary Dune	Almost high, and rising (~1.5 hours before high tide)
08/26/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	0		Unknown	Almost high, and rising (~1.5 hours before high tide)
08/26/2006	Cape Hatteras National Seashore, Ocracoke Island Spit	0		Unknown	Almost high, and rising (~1.5 hours before high tide)

Figure 2. North Carolina Wildlife Resources Commission shorebird reporting form output from SECN Migratory and Wintering Shorebird Monitoring protocol data.

Total Observations Chart

This function depicts the number of normalized observations by Park, Site, Species, and Date Range (Figure 3). Normalized counts are presented, but non-normalized output is also available.

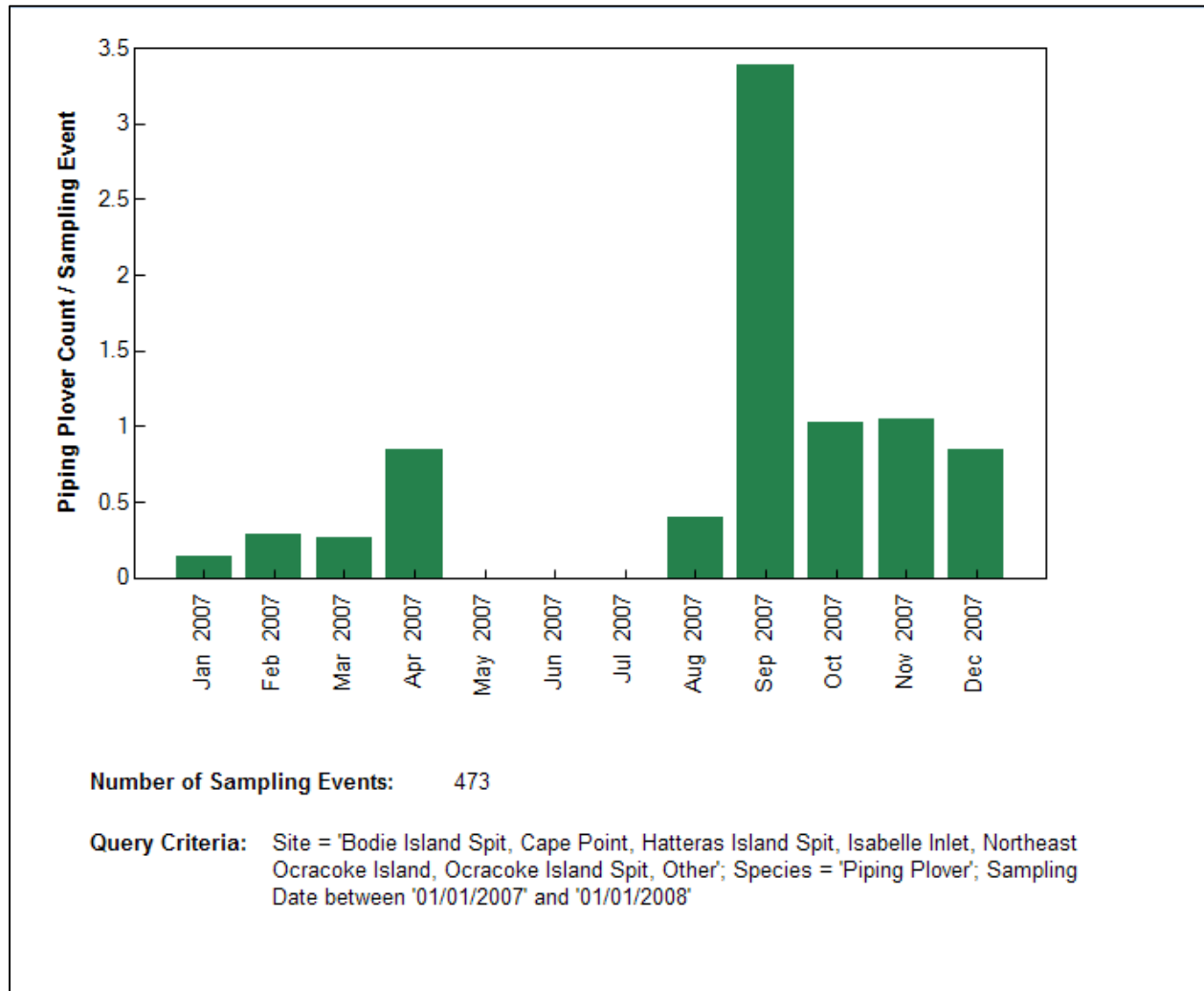


Figure 3. Total normalized count export, SECN Migratory and Wintering Shorebird Monitoring protocol.

Total Observations by Habitat Chart

This function depicts the proportion of total observations by habitat type as defined by Park, Site, Species, and Date Range (Figure 4). These data are also available in bar charts as total number of observations in each habitat.

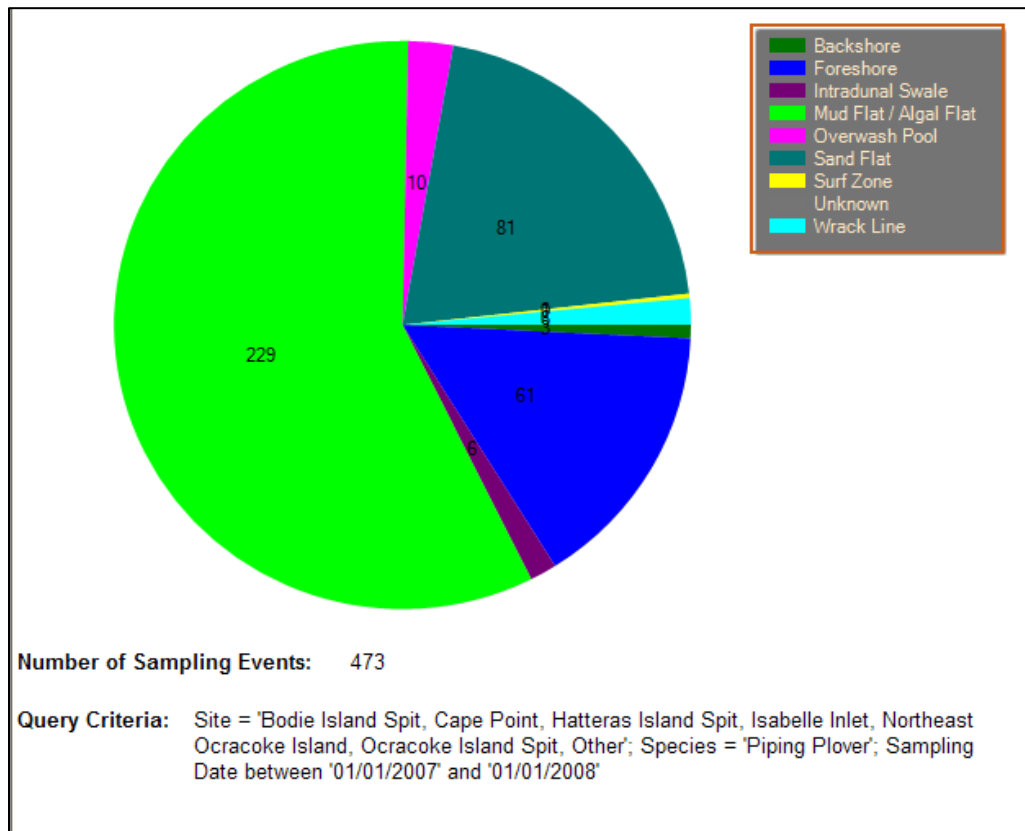


Figure 4. Proportion of total observations by habitat type export, SECN Migratory and Wintering Shorebird Monitoring protocol.

Closure Observations Chart

This function depicts the number of normalized observations “Inside” and “Outside” closures by Park, Site, Species, and Date Range (Figure 5). Normalized counts are presented, but non-normalized output is also available.

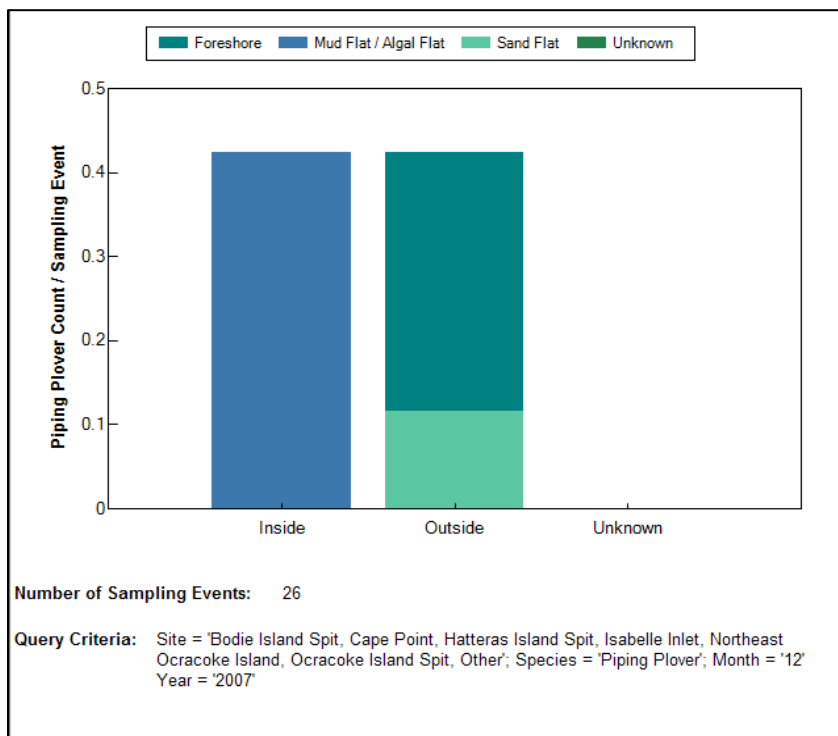


Figure 5. Normalized counts relative to closures and habitat type of observation, SECN Migratory and Wintering Shorebird Monitoring protocol.

Car, People, and Dog count Charts

This function depicts normalized counts of cars, people, and dogs by Park, Site, and Date Range (Figure 6). Normalized counts are presented, but non-normalized output is also available.

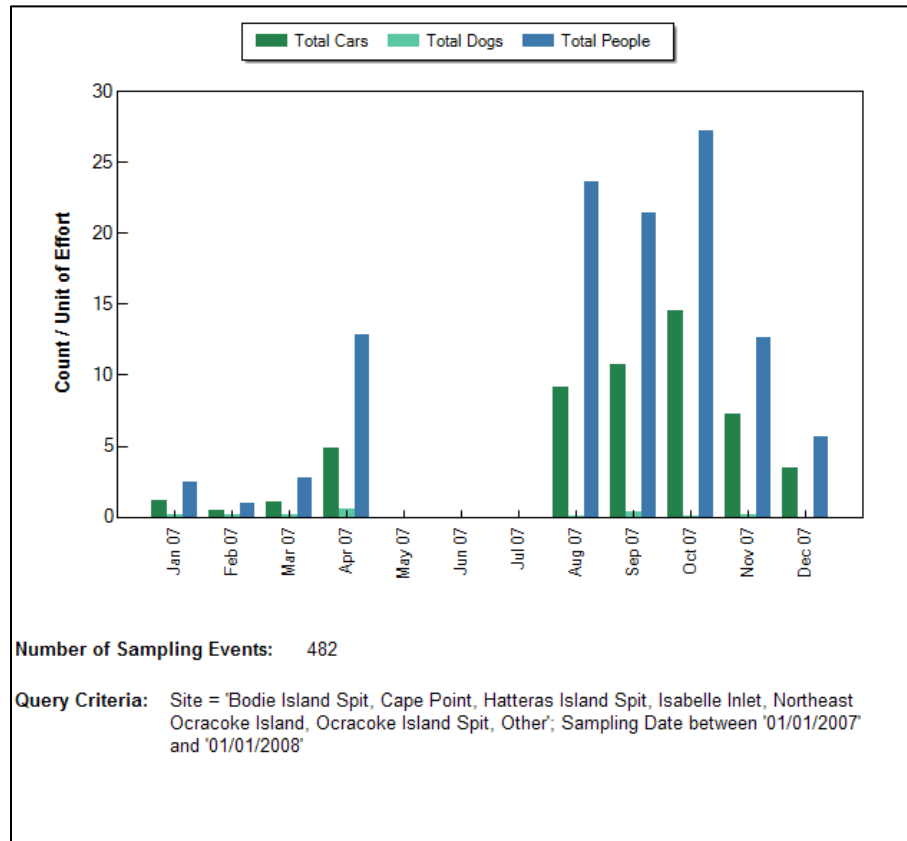


Figure 6. Normalized car, people, and dog counts, SECN Migratory and Wintering Shorebird Monitoring protocol.

High Counts Export

This function depicts the three highest counts of a selected species by Park, Site, and Date Range (Figure 7).

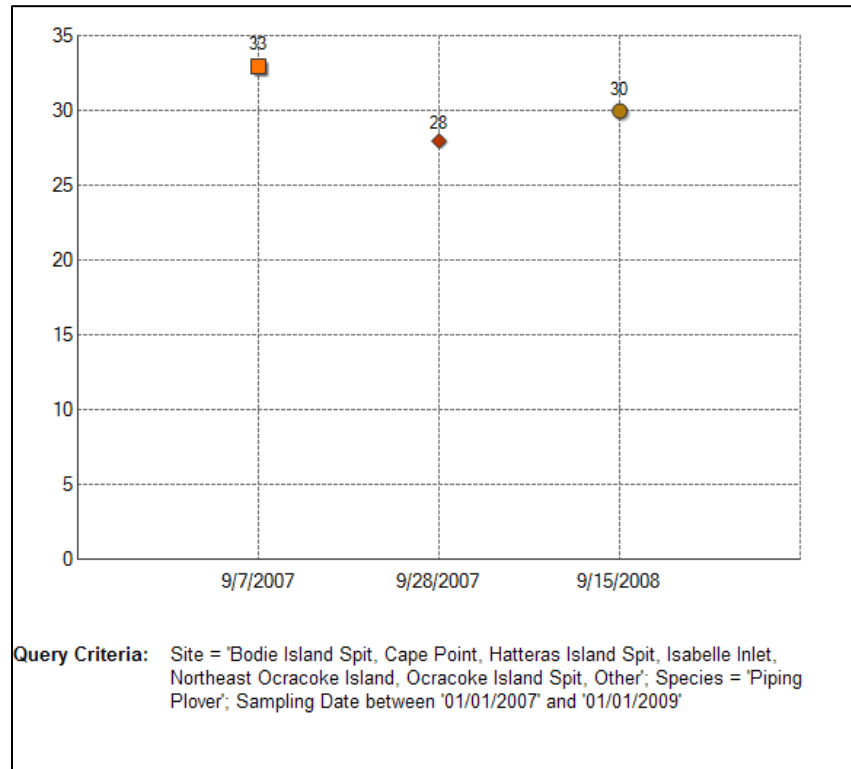


Figure 7. Three highest count export, SECN Migratory and Wintering Shorebird Monitoring protocol.

Analyses from Database Exports

Raw data or summarized data outputs are available through the database to facilitate the following data analyses to be conducted in external software packages.

Power Analysis

The accompanying database will export the information necessary for a monthly and annual power analysis. The power analysis is not performed in the database.

Power Example 1 – Accreted Sampling Units only at CAHA. The sampling design described SOP 1.4.29 Sampling Schedule. Generally, this design consists of five sampling units sampled three times per month. To estimate statistical power under this design, means and variability from pilot data were used, but sample size was adjusted to reflect the sampling effort of the new design. Our sampling objective is to secure 90% assurance (i.e., power) that we can detect an annual change of 20% in the mean of normalized counts (i.e., minimum detectable change) with a 5% chance of a false-change error (i.e., detecting a change when one does not actually exist). Data are evaluated on the ability to detect annual and monthly trends. Further, sensitivity to changes in normalized counts is also evaluated in three seasonal groups, (1) fall migrants, (2) wintering birds, and (3) spring migrants, where monthly data are pooled. The power to detect trend is calculated with the equation for permanent plots without the finite population factor (Elzinga et al. 1998).

This power analysis was based on (1) our pilot data variability, and (2) a proposed design to sample five sites three times per month (i.e., totaling 45 samples per month). We do not expect to have adequate power to detect monthly trends in normalized counts. We expect good power (approximately 90%) to detect large changes (i.e., 40%) changes annually (Figure 8). Due to the high variability in counts during the migratory period, we only expect the power to detect large annual changes for the fall (i.e., 86% to detect a 60% change) and spring (i.e., 90% power to detect a 50% change) migrant groups (Figures 9 and 10 respectively). The results of the power analysis of the wintering group exceeded our sampling objective, as we expect good power (i.e., 90%) to detect a 15% change in the wintering group (Figure 11). If the across-group and spring and fall groups exhibit patterns in variability similar to that which we observed during the pilot year of protocol implementation, we recommend increasing the number of samples collected to improve power. For example, if the variability collected during our pilot year is an adequate representation of variability in shorebird count data, collecting one additional sample at each site per month would provide approximately 80% power to detect a 30% change annually. One additional sample would also provide adequate power to detect 40% changes in normalized counts.

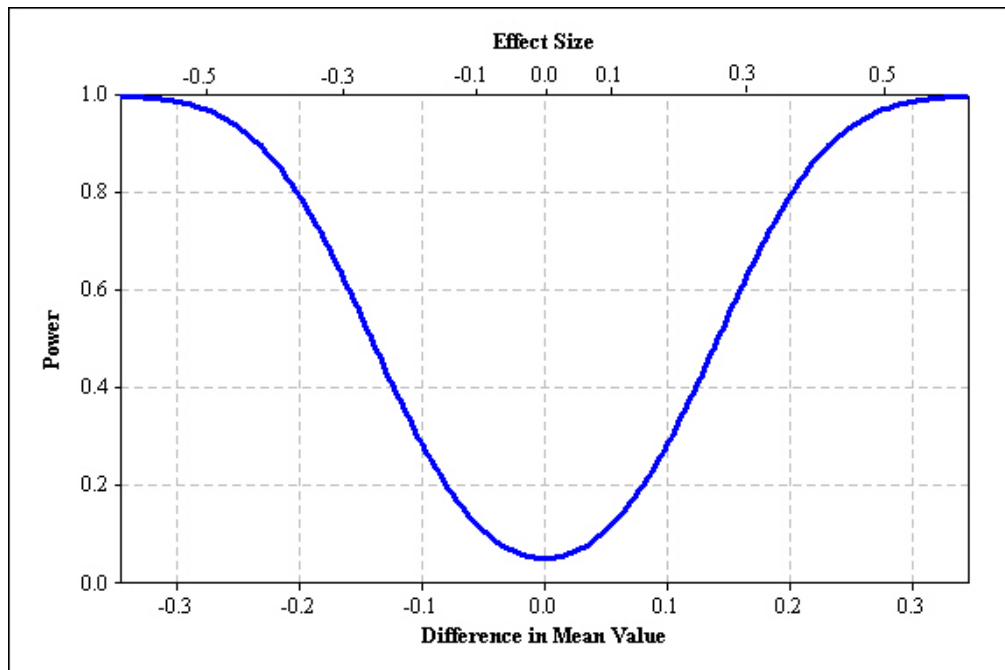


Figure 8. Predicted power across groups to detect annual trends in normalized counts, where $\bar{x} = 0.5533$, $s = 0.5902$, $n = 135$.

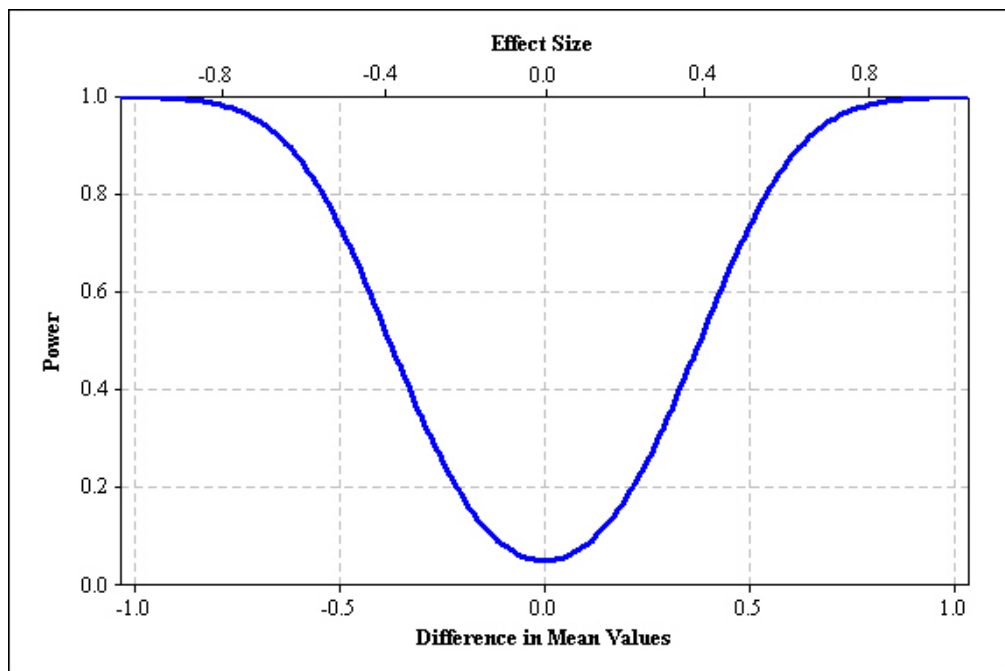


Figure 9. Predicted power to detect annual trends in normalized counts for the fall group, where $\bar{x} = 0.9838$, $s = 0.9049$, $n = 45$.

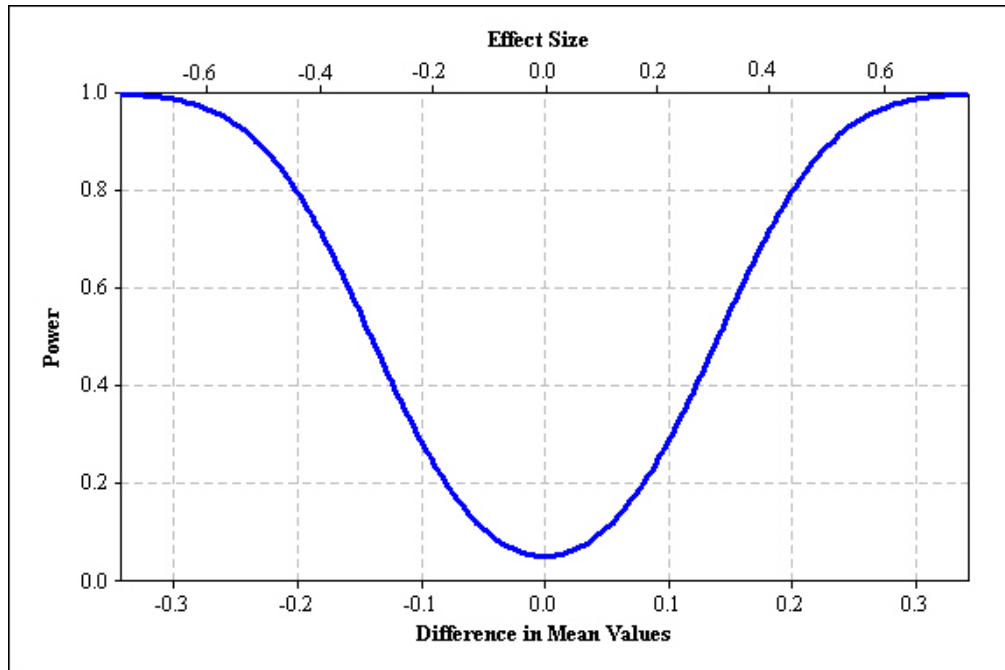


Figure 10. Predicted power to detect annual trends in normalized counts for the spring group, where $\bar{x} = 0.4569$, $s = 0.3362$, $n = 45$.

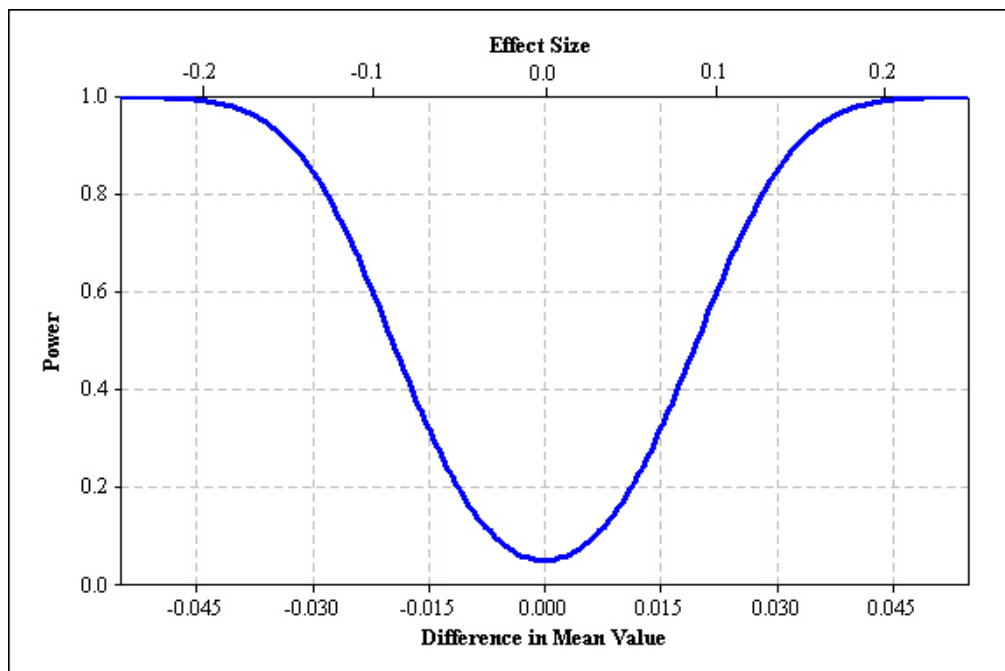


Figure 11. Predicted power to detect annual trends in normalized counts for the winter group, where $\bar{x} = 0.2192$, $s = 0.0471$, $n = 45$.

Power Example 2 – Park-wide Sampling Design of 60 Sampling Units. This sampling design is described in Byrne et al. 2009. In summary, it consists of a park-wide sampling frame that includes all beachfront areas and is sampled for nine months per year. To estimate statistical power under this design, means and variability from pilot data were used, and an average-monthly sample size was used. Our sampling objective remains the same as above, to secure 90% assurance (i.e., power) that we can detect an annual change of 20% in the mean of normalized counts (i.e., minimum detectable change) with a 5% chance of a false-change error (i.e., detecting a change when one does not actually exist). Data are evaluated on the ability to detect annual and monthly trends. Further, sensitivity to changes in normalized counts is also evaluated in three seasonal groups, (1) fall migrants, (2) wintering birds, and (3) spring migrants, where monthly data are pooled. The power to detect trend is calculated with the equation for permanent plots without the finite population factor (Elzinga et al. 1998).

This power analysis was based on (1) our pilot data variability, and (2) a proposed design to sample 60 sites in a randomly assigned order (i.e., averaging 70 total samples per month). As with the previous power analysis example, we do not achieve adequate power to detect even large monthly trends. We do meet our sampling objective in our expected ability to detect a 20% change in normalized counts annually with 92% power (Figure 12). Fall and spring improved over the previous example, where we expect 92% power to detect a 30% change in the fall group (Figure 13), and we expect 80% power to detect a 20% change in the spring group (Figure 14). We expect excellent power (i.e., 99%) to detect even small changes (10%) in normalized counts of the wintering group (Figure 15). From a purely statistical-power perspective, this type of design is far superior in terms of its ability to detect trend, but involves a significant tradeoff between power to detect trend and a substantial increase in the monitoring workload.

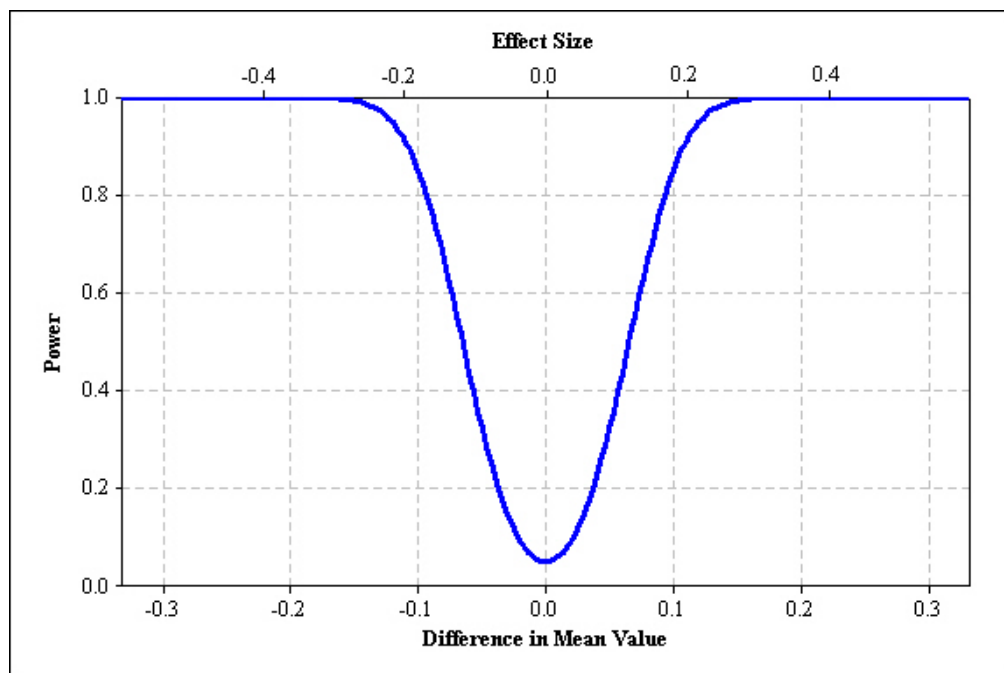


Figure 12. Predicted power across groups to detect annual trends in normalized counts, where $\bar{x} = 0.5533$, $s = 0.5902$, $n = 630$.

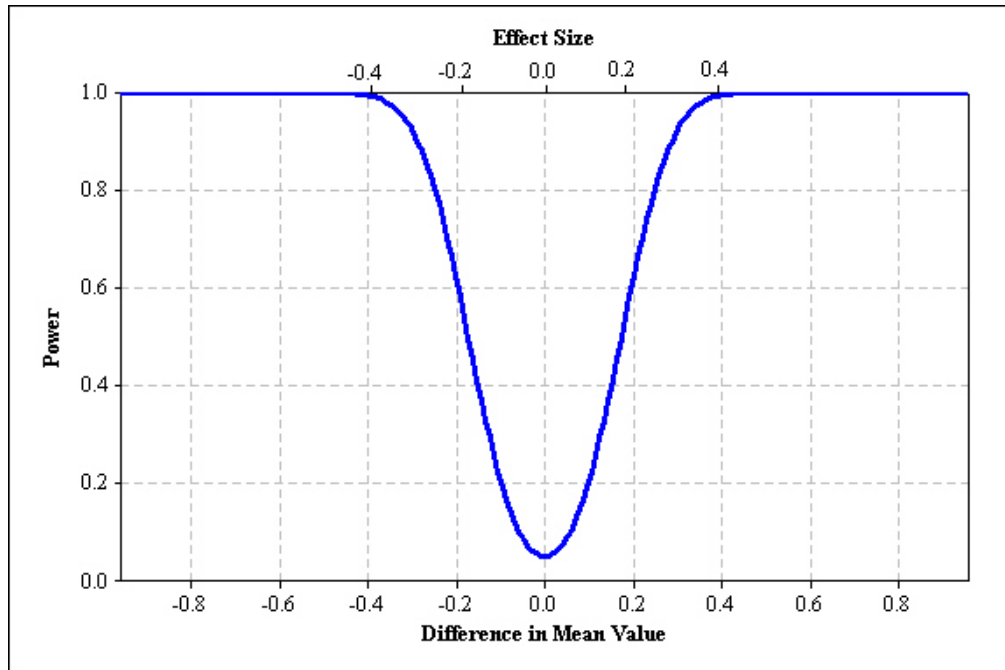


Figure 13. Predicted power to detect annual trends in normalized counts for the fall group, where $\bar{x} = 0.9838$, $s = 0.9049$, $n = 210$.

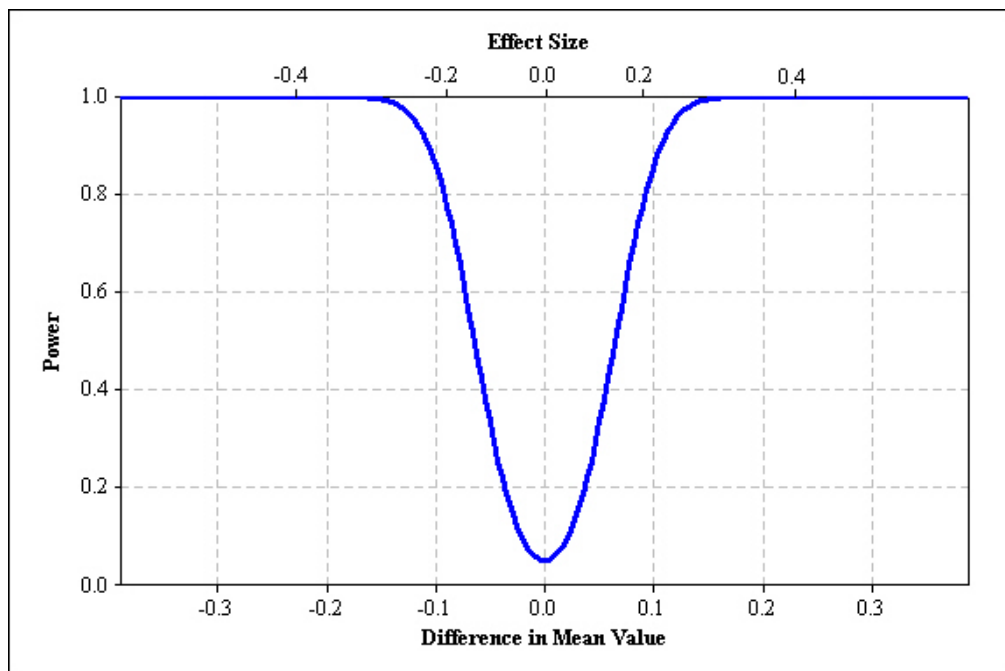


Figure 14. Predicted power to detect annual trends in normalized counts for the spring group, where $\bar{x} = 0.4569$, $s = 0.3362$, $n = 210$.

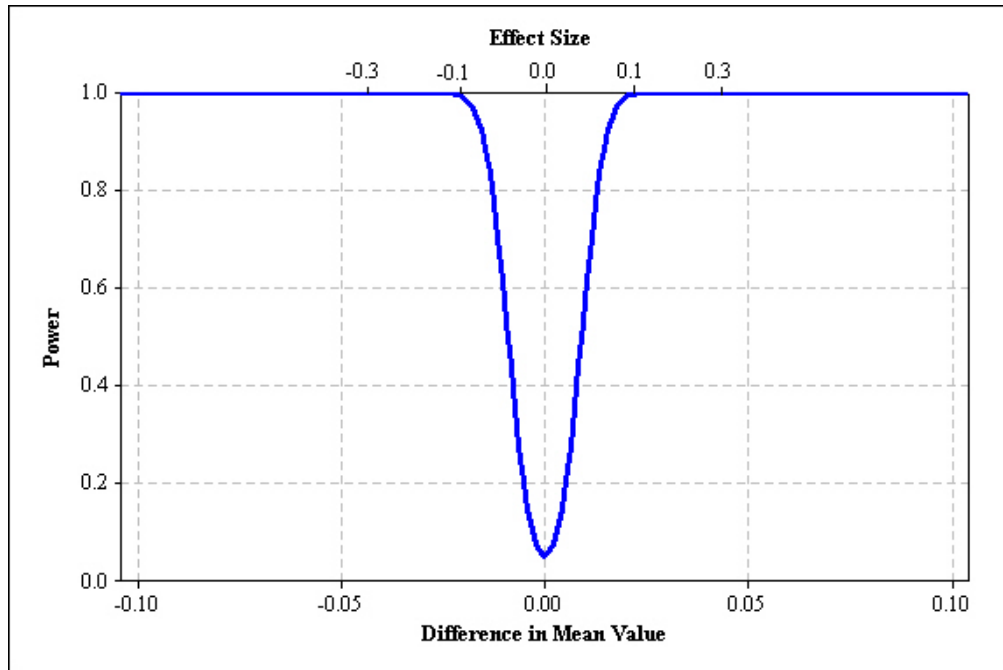


Figure 15. Predicted power to detect annual trends in normalized counts for the winter group, where $\bar{x} = 0.2192$, $s = 0.0471$, $n = 210$.

Abundance Estimation

If the distance sampling results in the required number of distance measurements (i.e., ≥ 80 statistically independent samples), abundance estimates of the wintering population can be made. Program DISTANCE is used to calculate a detection function and abundance estimates (see Buckland et al. 2001). The database exports observation data where distance estimates were collected for this analysis.

Index Validity

Due to the expected small population size of wintering focal shorebirds, it is not expected that a valid abundance estimate for focal-shorebird wintering populations will be generated using distance-sampling methods. Abundance estimation of the migratory population of focal shorebirds is not possible because these populations violate a basic assumption of abundance estimation in that they are considered “open” (i.e., the population is subject to births, deaths, immigration, or emigration).

Shorebird count data collected under this protocol results in a constant-proportion population index $E(C) = \beta N$, where $E(C)$ = the expected count, β = probability of detection, and N = the actual population size. The primary assumption of this index is that performance remains constant for varying values of N (i.e., it is linearly correlated), and this protocol is not designed to address this assumption or the efficacy of the index. As is frequently the case with population indices, difficulty exists in establishing the true relationship between index performance (i.e., validity) and true population abundance. Further implementation of the distance sampling component, however, will serve as a preliminary means to address the validity of the index by

determining if detectability remains constant over time. For example, if the index reveals two counts that are substantially different at the same site between time year 1 and year 2 but detectability also varies between the two sampling events, it is more likely the differing counts reflect differences in detectability rather than differences in true population size. Other potential ways to assess index validity are: (1) if the monitoring effort has moderate to good power (i.e., $\beta \leq 0.2$), this increases the confidence in index performance, (2) if distance sampling does result in a valid detection function and subsequent abundance estimate, the relationship between these two values can be explored, (3) the proportion of banded birds in a sample over time may also serve as a means to evaluate index validity (i.e., a mark/recapture – re-sight study); which can be done easily as part of this protocol, (4) implement a double-sampling approach, or (5) since the wintering piping plover population assumed to be small, coordinated simultaneous counts repeated over several days would result in a timelier estimate with an associated confidence interval, however detectability will not be accounted for using this technique. It is important to note that inferences of abundance based on an index that has not been validated can result in incorrect conclusions and assumptions.

It is unknown if normalized counts generated from data collected under this protocol are proportional to abundance. Therefore, normalized counts should not be used to infer patterns in abundance unless the aforementioned index-validity procedures are conducted.

Relationships Among Variables

Frequency of focal shorebird detections by habitat type can be explored with contingency tables (Zar 1999). A Pearson correlation can be used to explore the relationship between potential sources of disturbance (e.g., cars, people, unleashed dogs) and the number of focal shorebird observations (Zar 1999). The relationship of the proportion of observations in each habitat type to tidal stage can be explored with a Spearman correlation (Zar 1999). As monitoring continues and the number of observations increases, the null hypothesis of no relationship among tidal stage and habitat use can be tested with log-linear models; with detection/non-detection (i.e., the observation) as the response variable and tidal stage, habitat type, and weather variables as explanatory variables (i.e., included if these variables are not correlated; Zar 1999).

Key Area Use

Normalized counts (i.e., observations / unit effort) of migratory and wintering shorebirds from pilot-year implementation were not normally distributed with equal variance, nor was normality achieved through transformations. If future data are normally distributed, 2-sample t tests can be used to test the null hypothesis of no difference between sites (Zar 1999). For non-normally distributed data, a Mann-Whitney test should be used for comparisons among sampling units to test the null (Zar 1999).

Trend Analysis

Time-series analysis will provide us information regarding the pattern of observations over time and facilitate forecasting and prediction. Based upon data from pilot implementation of this protocol, the authors assume the data will rarely be normally distributed with equal variance. Therefore, a non-parametric test will be used for trend analysis. A Kendall trend test (Hirsch et

al. 1982) will be used to evaluate trends in normalized counts of migratory and wintering shorebirds. This technique accounts for seasonal variation by allowing data to be grouped according to a predefined season. Defined analysis groups for this analysis are (1) fall migrants, (2) wintering birds, and (3) spring migrants. The analysis groups, or “seasons”, used for the Kendall trend test can be adjusted slightly (i.e., +/- one month) to account for inter-annual variability in migratory phenology. Migrants are split into two separate groups in an effort to account for the influence that variability in over-winter survival could have on trends in an aggregate of migration groups. For example, a specific shorebird population exhibits high productivity in a given breeding season and subsequently high recruitment into the fall/migrating population, but over-winter survival is low resulting in fewer returning spring migrants. Pooled values across the two migratory periods would exhibit high variability, but mean values would likely mask true changes, result in misleading conclusions, reduce the ability to associate changes with a particular period; and decrease our ability to potentially mitigate these effects with management actions.

Literature Cited

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