U.S. Fish and Wildlife Service
U.S. Department of the Interior

National Wildlife Refuge System

Regional Protocol Framework for the Inventory and Monitoring of Breeding Atlantic Coast Piping Plovers

Southeast and Northeast Region

Version 1.0 **February 2019**

ON THE COVER
Piping plover (*Charadrius melodus*)
Photograph by: Gene Nieminen (https://digitalmedia.fws.gov/cdm/singleitem/collection/natdiglib/id/7519/rec/18)

NWRS Survey Protocol Signature Page

Protocol Title: Regional Protocol Framework for the Inventory and Monitoring of Breeding Atlantic Coast Piping Plovers		
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Approvals		
Action	**Appropriate Signature/Name**	**Date**
Survey Coordinator[2] Submitted by:	/ Erin King	2/14/19
Zone I&M[3] or equivalent Approval:		
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Version[1]	Date	Author	Change Made	Reason for Change

[1] Version is a decimal number with the number left of decimal place indicating the number of times this protocol has been approved (e.g., first approved version is 1.0.; prior to first approval all versions are 0.*x*; after first approval, all minor changes are indicated as version 1. *x* until the second approval and signature, which establishes version 2.0, and so on). Only two signatures are required: one from the submitter (lead author)[2] one from the approving official, which is dictated by the scope of the protocol[3,4,5].

[2] Signature of station or I&M representative designated lead in development of a site-specific survey protocol.

[3] Signature signifies approval of a site-specific survey protocol.

[4] Signature by Regional I&M Coordinator signifies approval of a protocol framework to be used at multiple stations within a Region.

[5] Signature by National I&M Coordinator signifies approval of a protocol used at multiple stations from two or more Regions.

Survey Protocol Summary

This regional protocol provides a framework for quantifying the number of breeding pairs and productivity of Atlantic Coast piping plover (*Charadrius melodus*) populations during the breeding season. A primary purpose of this protocol is to standardize piping plover monitoring during the breeding season. The survey techniques described herein involve repeated visual counts of adults, nests, eggs, and chicks within a defined survey site (i.e., beach) as well as visual identification of potential threats to survival and productivity. Resulting data can be compiled and analyzed across multiple geographic units (i.e., sites, states, and recovery units) to assess progress toward recovery goals, inform local management decisions, assess management effectiveness, and improve monitoring efforts.

This protocol framework was developed as part of the United States Fish and Wildlife Service (USFWS) National Wildlife Refuge System (NWRS) Inventory and Monitoring (I&M) Initiative in coordination with Ecological Services (ES) and state coordinators within the Southeast and Northeast Regions (4 and 5, respectively). Although this protocol framework is to be used primarily by NWRS to inform recovery goals, assist with local management decision-making, and meet State reporting requirements, the approach strives to assist monitoring efforts of non-NWRS partners, such as other federal agencies (e.g. National Park Service), State wildlife agencies, non-governmental organizations, and private landowners. This protocol framework and associated data management system (PIPLweb) aims to interface with existing data management and analysis tools (i.e., PIPLODES, NestStory, and PiperEx) to ensure that data collection is efficient and comparable across scales, and supports management decisions across partners.

The content and structure of the protocol framework follows standards set forth in the USFWS's How to Develop Survey Protocols: A Handbook (Version 1.0; 2013). The eight elements addressed include: introduction, sampling design, field methods, data management and analysis, reporting, personnel requirements and training, operational requirements, and references. A series of standard operating procedures (SOPs) provides greater detail on recommended methods and technical aspects of this protocol. Data entry, archival, and multi-scale analysis are handled through a secure web application (Plover Inventory and Productivity Library; PIPLweb) developed by the United States Geological Survey (USGS). When management activities and survey objectives are similar across management units, partners (Refuges, other federal agencies, State, NGOs, private) are encouraged to use this protocol framework to develop stepped-down site-specific survey protocols that include guidance for conducting on-the-ground monitoring and management plans.

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This protocol is available from ServCat [https://ecos.fws.gov/ServCat/Reference/Profile/95108]

Acknowledgments

We thank many persons who contributed to the Revised Atlantic Coast Piping Plover Recovery Plan (USFWS 1996), the Waterbird Monitoring Protocol for Cape Cod National Seashore and other Coastal Parks, Refuges, and Protected Areas (Erwin et al. 2003), and USFWS NWRS Initial Survey Instructions, as well as protocols and data management systems developed by State agencies (i.e., Massachusetts Division of Fisheries and Wildlife; PIPLODES; MAWF 2016), federal partners (USGS; iPlover), and private citizens (Jim Verhagen; NestStory). This regional protocol framework synthesizes the best practices across these efforts and emphasizes important linkages between monitoring and successful management and conservation.

This template (version 2.0) and the *Survey Protocol Handbook* were developed by the NWRS National I&M Coordination Team. Many individuals have contributed to the development of the protocol through field testing survey methods and providing suggestions for improvement. Skilled monitors have reviewed the protocol for clarity, accuracy, and thoroughness. Pat Ward (NRPC I&M) provided valuable guidance for structuring the elements, technical edits and coordinating the review process. Brandy Winch (USGS) provided insights on the metadata strategy and Jonathan Cohen (State University of New York (SUNY), College of Environmental Science and Forestry) provided statistical and decision modeling support. Ruth Boettcher (Virginia Department of Game and Inland Fisheries), Pam Denmon (USFWS), Kate O'Brien (USFWS), Jonathan Regosin (Massachusetts Division of Fisheries and Wildlife), and Michelle Stantial (SUNY) provided thoughtful reviews on protocol drafts. Caleb Spiegel (USFWS, Migratory Bird Program), Lori Randall (USGS), and Kathryn Spear (USGS) provided I&M reviews, which greatly improved the quality of the protocol. Any use of trade, products, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Narrative

Element 1: Introduction

Background

The Atlantic Coast piping plover (*Charadrius melodus*) is a small shorebird listed since 1986 as a threatened species under the Endangered Species Act of 1973 (ESA). Once a common breeder on beaches from Newfoundland to North Carolina, piping plover numbers were greatly reduced in the late 19th century by uncontrolled hunting for feathers to decorate hats. Following passage of the Migratory Bird Treaty Act in 1918, plovers recovered to a 20th century peak in the 1940s. Increased development and beach recreation after World War II caused a subsequent population decline that led to Endangered Species Act protection in 1986 (USFWS 1985). Under intensive management by federal, state, local agencies, and private organizations, the population has more than doubled since listing (USFWS 2017). The 1996 revised Atlantic Coast Recovery Plan provides the overall strategy and tasks for recovery, as well as the criteria for removing the population from ESA protection. These efforts are integrated in multiple conservation efforts along the Atlantic Coast, including the following: 1) 11 State Wildlife Action Plans in piping plover's Atlantic Coast breeding range, which designate piping plover as a Species of Greatest Conservation Need (https://www.fishwildlife.org/afwa-informs/state-wildlife-action-plans); 2) the Atlantic Flyway Shorebird Initiative Business Plan (2015; https://atlanticflywayshorebirds.org, which identifies the piping plover as a focal species; and 3) the North Atlantic Landscape Conservation Cooperative (2010; https://northatlanticlcc.org/), which classifies the piping plover a high priority species.

Population monitoring on breeding grounds has been an integral part of the recovery program for Atlantic Coast piping plovers since 1986 (Melvin et al. 1991; USFWS 1996; Hecht and Melvin 2009a). Full-time and seasonal biologists, researchers, and trained volunteers monitor piping plovers at breeding sites to collect field data to inform abundance, distribution, and productivity. State coordinators, employed by or under contract with State wildlife agencies, synthesize and report findings to the United States Fish and Wildlife Service (USFWS) Atlantic Coast piping plover recovery coordinator. Monitors conduct repeated surveys at most sites and record observations such as locations of each pair, dates of nest discovery and clutch completion, nest fate, numbers of eggs laid and hatched, and number of chicks fledged. State coordinators communicate regularly with local cooperators at breeding sites to ensure that monitors follow appropriate protocols and that effort is sufficient to adequately census both known occupied and potential breeding sites each year. To facilitate quality control of data, supervisory biologists oversee monitoring at multiple sites and state coordinators review summary reports prepared by monitors. State coordinators typically contact local cooperators to obtain missing information or to resolve inconsistencies or clarify ambiguities in data.

Piping plover monitoring can serve multiple goals and is used to inform decision-making at various spatial and temporal scales. At the Atlantic Coast scale, state and federal agencies aggregate site-level data to inform regional piping plover status and trends in population size, recruitment, changes in distribution, and other population parameters to track progress towards recovery in accordance with section 4(c)(2) of the ESA and to implement State Wildlife Action Plans, sections 7 and 10 of the ESA, and State statutes. In 2016, nineteen percent of U.S. Atlantic

Coast breeding piping plovers were found on and/or managed by USFWS National Wildlife Refuges or Refuge Complexes (Rachel Carson, Parker River, Eastern Massachusetts, Long Island, Rhode Island, Edwin B. Forsythe, Prime Hook, Chincoteague, Eastern Shore of Virginia, and Pea Island) in Regions 4 and 5. The National Wildlife Refuge System (NWRS) is also a core contributor to several collaborative projects benefiting management across the region, such as the development of linked models to forecast effects of sea level rise on the habitat of piping plovers and other beach-dwelling species (iPlover; Thieler et al. 2016), and the PiperEx Decision Support Tool for predator exclosures (Darrah and Cohen 2017a, 2017b).

At the site or state scale, State agencies and other beach managers provide technical assistance in the collection and synthesis of monitoring data annually to identify factors that may be limiting abundance of nesting pairs or productivity. Although some factors are uncontrollable (e.g., weather), others (i.e., human disturbance, predation, habitat) can be affected by direct or indirect management actions. Habitat changes that affect nesting or brood foraging locations may necessitate adjustments to protection zones or other management methods. Predator management may also be warranted and managers should consider best management practices to improve decision-making (see Karpanty et al. 2018). Management actions occur most years at the local (i.e., site) level and are predicated on frequent monitoring of individual breeding pairs during territory establishment and courtship, nesting, and chick-rearing periods. For example, deployment of wire predator exclosures to protect nests (Rimmer and Deblinger 1990, Melvin et al. 1992) depends on prompt detection of egg-laying. Minimizing the spatial extent and duration of restrictions on use of off-road vehicles (ORV) is contingent on precise hatching date predictions and daily verification of brood locations (USFWS 1996). Adjustment of beach buffers established with warning signs and symbolic fencing to protect piping plover courtship habitat, nests, and incubation behavior requires regular observations of breeding activity. Almost all of these actions require continued monitoring during the breeding season to counter threats, which may vary from year to year. The intensity and frequency of piping plover monitoring efforts are primarily driven by these day-to-day management decisions at the site-scale. Additionally, the presence and distribution of piping plovers trigger regulatory reviews and protections under many state statutes (e.g., Massachusetts Wetlands Protection Act).

Although piping plover survey methods have been fairly standardized since 1989 (USFWS 1996, Hecht and Melvin 2009b), the list of data collected at many sites has expanded in recent years to improve management, increase ecological understanding, and address public concerns. This protocol framework is designed to guide consistent piping plover data collection and reporting by the NWRS and Ecological Services (ES) in the Atlantic Coast breeding range. Because NWRS monitoring data must be compatible with data reporting and piping plover management at larger geographic scales (i.e., state), we anticipate that the field protocols, data reporting, and analysis will have broad utility for all Atlantic Coast piping plover recovery partners. This protocol also aims to provide an explicit and transparent framework to link monitoring with management decisions at the site level to improve the ability of managed sites to meet recovery goals. Furthermore, this protocol framework may provide a model for the development of standardized protocols for monitoring wintering and migrating piping plovers, per Actions 3.1W – 3.3W in the Draft Revised Recovery Plan for the Wintering Range of the Northern Great Plains Piping Plover and Comprehensive Conservation Strategy for the Piping Plover in its Coastal Migration and Wintering Range in the Continental United States (USFWS 2015a).

Objectives

Clearly stated objectives are foundational to a successful monitoring program. *Management objectives* represent what you fundamentally want to achieve (i.e., conservation target or goal), and *survey objectives* represent primary reasons for collecting and analyzing data, which could include understanding system dynamics, estimating status or trends, deciding when to implement actions, or assessing their outcome (Reynolds et al. 2016). Both management and survey objectives are critical to monitoring success, yet are often missing from survey instructions and designs (Lindenmayer and Likens 2010), which can delay or prevent implementation of effective management (Lindenmayer et al. 2013). *Sampling objectives* are quantitative statements about how survey objectives will be achieved with a particular study design and sampling effort. Clear sampling objectives ensure that sufficient details are collected during surveys to inform management decisions. Sampling objectives, survey design, and data analysis should be developed after management and survey objectives have been articulated.

This protocol framework provides guidance on how to articulate management, survey, and sampling objectives for site-specific survey protocols (SSP; USFWS 2013) for any agency or entity monitoring piping plovers within the Atlantic Coast breeding range. We provide common examples of objectives for piping plovers across agencies (state, federal, non-profit, private; Table 1.1), which have been adapted from the Atlantic Coast Piping Plover Recovery Plan (hereafter recovery plan; USFWS 1996) and from state Habitat Conservation Plans (MDFW 2016) and NWRS plans (Comprehensive Conservation Plans, Habitat Management Plans). All objectives should follow the SMART model (specific, measurable, achievable, results-oriented, time-fixed, and supported by a rationale statement; Adamcik et al. 2004) when stepped down to SSPs.

First and foremost, the protocol framework addresses the inventory (status assessment) and monitoring (trend detection) of two primary recovery criteria (metrics): total number of breeding pairs and productivity (number of fledged chicks per breeding pair). Thus, survey objectives include estimating trends in these metrics over time or in response to management activities with a defined level of precision (sampling objective; Table 1.1). These metrics are measured at the site-level and can be aggregated across local, state, recovery unit (3 out of 4 occurring within the US), and Atlantic Coast breeding range. In addition to these metrics, the survey design in this protocol framework can be used to inform effectiveness of management actions (i.e., effectiveness monitoring for predator exclosures) within and across sites to increase learning and adapt management strategies accordingly. Overall, results of surveys that follow this protocol framework will be useful for informing status and trends of breeding pair abundance and productivity and increasing understanding of threats and management challenges (i.e., effectiveness and controllability) at multiple-scales (local, state, recovery unit, region). Data collected at the site, nest, and brood levels can be used to estimate survival of various life stages (nest, egg, chick, and adult) and rates of renesting, and to explore relationships between environmental conditions, survival and productivity. This protocol does not provide guidance on how to collect all possible information used to improve local or regional management decisions, in part, because conditions driving the selection of actions are variable across breeding sites (i.e., number of plover pairs, habitat quantity and quality, predator communities, landowner support, and co-occurring species of conservation concern). Cooperators should consult with a statistician and/or decision analyst when developing SSPs to ensure survey objectives align management

objectives and associated decision-making processes. Although sites with few pairs may be limited in terms of their ability to measure management effectiveness with statistical power, data collected at all sites (regardless of the number of pairs, nests, or chicks) are encouraged to use the protocol in order to allow for monitoring trends across larger spatial scales.

Table 1.1. Examples of management, survey, and sampling objectives for monitoring of breeding piping plover populations at the site, multi-site, state, or recovery unit level.

Management Objectives	Survey Objectives	Sampling Objectives
Increase the total number of breeding pairs	Estimate breeding pair abundance and productivity	90% confidence in detecting a 5% decrease abundance of breeding pairs, with a 10% chance of inferring a decrease when one does not exist
Increase productivity (total number of fledglings or fledglings/pair)	Estimate trends in breeding pairs abundance and productivity over time	80% confidence that fledgling survival rate threshold (i.e., 1.5/pair) has been achieved within 20% of the true mean
Increase population growth rate	Estimate effectiveness of management actions (i.e., exclosures or predator management)	90% confidence in detecting an effect of management, with a 10% chance of inferring management is effective in error
Increase carrying capacity	Estimate effects of habitat quality and quantity on distribution of breeding pairs	95% confidence in detecting all (100%) breeding pairs, with a 5% chance of missing less than 5% of breeding pairs during the breeding period
Increase distribution of breeding pairs	Estimate colonization and local extinction probabilities (source-sink dynamics) across sites over time	90% confidence in detecting colonization of at least one new site in any given year, with a 10% chance of inferring a site is not colonized when it was

Element 2: Sampling Design

Sample design

To meet survey objectives of the recovery plan, "census" methods are used to measure the total number of breeding pairs and the productivity per pair. This framework does not provide a sampling design that selects representative sampling units to be surveyed or managed from a larger possible set of units. Therefore, we refer to survey sites (or "sites") instead of sampling units. Almost all known or recently occupied breeding sites are repeatedly surveyed starting early in the breeding season. Most sites that appear suitable for breeding piping plovers, but for which there are no recent records, are surveyed one or more times during the first part of the breeding season (at a minimum they are included in the annual June 1-9 window survey), resulting in an extremely low likelihood of breeding pairs occurring outside identified sites. In 2002, for example, breeding pairs were reported at 281 sites in Atlantic Coast states, including 208 sites with 1-5 pairs, but surveys were also conducted at 177 sandy coastal beaches and spits where no breeding was detected (Hecht and Melvin 2009b). A survey of partners monitoring almost three-quarters of the U.S. breeding population in 2008 found that sites supporting 67 percent of the pairs were monitored 30 or more times between May 1 and July 31, only 6 percent of sites were surveyed less than 10 times, and 87 sites where no pairs were found were surveyed three or more times (A. Hecht, USFWS, personal communication).

Survey sites and sample frame

Survey sites are designated areas of a beach in which a survey occurs during the breeding season. A site should encompass all suitable breeding habitat prior to the start of the breeding season and can be partitioned into more than one site based on access or the ability of conducting a complete survey during a single survey event (i.e., day). Although the method of delineating sites may vary (e.g., one refuge or state may define an island as a site, while another considers pairs on opposite ends of a single island two distinct sites; USFWS 1996), site boundaries should be fixed throughout the breeding season and across years to ensure data comparability. If a new site must be delineated (e.g., site boundaries substantially change due to changes in habitat, accessibility, or land ownership), then new site names and boundaries must be clearly defined. Details related to delineating or updating site boundaries are described in Standard Operating Procedures (SOP) 1. Within each site, a management unit is defined as a fixed area where plover-related management actions are frequently applied. Management units are often the same spatial scale as the site but may be smaller if management approaches vary within the site.

The sampling frame for plover breeding surveys spans all dates during the breeding season. Within the breeding season, three stages are defined: territory establishment and courtship, nesting and incubation, and brood-rearing (or chick-rearing). Stages may be delineated for individual pairs (as opposed to survey events or dates), as stages are asynchronous and pairs may renest within a single season (with an interval between the loss of one nest and commencement of egg-laying for the next).

Spotting scopes can help to detect the first arrival of birds, to observe territorial behavior, and to identify the start of the breeding season. Although scoping is not required in this protocol, it is useful for confirming incubation from a distance, locating and counting chicks, detecting transient birds (i.e., on migration or moving among beaches prior to establishing territories) during the pre-breeding period (i.e., March in southern latitudes and mid-March to early April in northern), locating adults foraging outside nesting and brood-rearing habitats, and documenting presence and abundance of post-breeding plovers. Although not critical to informing the survey protocol framework objectives, accurately reading and promptly reporting band combinations prior to, during, or after the breeding season (see SOP 2; https://www.fws.gov/northeast/pipingplover/report_bands.html) provides valuable data to studies of migration behavior, site fidelity, and annual life cycle mortality estimates.

Surveys should begin during the territory establishment and courtship stage, which commences with males beginning to traverse their territories in brief flights and runs, and responding to intruders with horizontal threat charges, parallel runs, and ground and aerial chases. Typical courtship displays include aerial “figure eights”, high-stepping, tilt-displays, and scraping (see Cairns 1982 for detailed descriptions of these and other behaviors). These behaviors start shortly after males arrive from the wintering grounds in mid- (southern latitudes) to late-March (northern latitudes) and surveying should begin when at least one individual displays these behaviors. Mounting and copulation ensue, followed by commencement of egg-laying, which signals the transition into the nesting and incubation stage, although incubation is typically delayed until completion of the full clutch. The first nests of the season are usually discovered in mid- to late-April and establishment of new nests can continue until early July due to renesting (see SOP 2), although most nests initiated after July 1 are abandoned prior to hatch. The beginning of the brood-rearing (or chick-rearing) stage occurs with the first hatch.

The end of the sampling frame (i.e., end of the brood-rearing stage) is defined as the date in which zero chicks are present at the site. Zero chicks at the site is a result of chicks fledging, moving to staging habitat outside of the site, or dying. Chicks are considered fledged when they reach 25 days after hatch or are observed flying for at least 15 meters, whichever occurs first (note, however, that chicks >25 days may not be flight-capable, necessitating continuation of protective management (USFWS 1994, 2015b). Chicks can fledge as early as late-June, depending on the start of the nesting stage and fledging can continue until the end of August (very rarely into early September) if nests are laid late in the season. Monitors should conduct at least two additional surveys after the first survey detecting zero chicks to ensure all chicks are truly absent. Chick survival and productivity estimates may be biased low if the last survey occurs the first time zero chicks are detected and detection rate of chicks is imperfect (< 1.0). Two additional surveys will allow for a more accurate estimate of true productivity, and five or more surveys may be appropriate when no chicks are observed before chick protection activities (e.g., symbolic fencing or special practices for ORV use, including essential vehicles) are discontinued.

Observations during periods before the territory establishment and courtship stage, or after all chicks have fledged may provide useful information for protection of pre- or post-breeding migrants, but are considered outside the breeding sampling frame of this protocol. All survey dates should fall within the defined sampling frame to allow comparisons across survey sites and years. Monitors should use previous survey data (collected by refuge staff and/or non-refuge partners), as well as early season observations of territory establishment and courtship, to evaluate the start and end of the sampling frame annually.

Survey timing and frequency

Repeated surveys throughout the sampling frame must be completed at each site to achieve local and regional plover breeding pair abundance and productivity survey objectives. The frequency of surveys from the start of the territory establishment and courtship stage through the end of the brood-rearing stage can influence the magnitude of errors and biases (see *Sources of Error*). Collecting data on individuals pre-nesting and at the nest- or brood-level is essential for obtaining estimates of the average number of fledglings per pair, as well as estimating causes of nest and chick loss and management effectiveness (Darrah et al. 2017; Cohen et al. 2016). Thus, the frequency of surveys each week should be carefully determined and revised annually during the survey planning stage using multiple site-level factors, including but not limited to previous abundance and productivity estimates, current habitat conditions, potential causes of nest loss (e.g., predator activity, frequency of overwash events, and human disturbance), and the range of management activities under consideration ("management complexity"). Even in the absence of complex habitat types, predation, adverse weather events, human disturbance, or management actions, surveys should be conducted twice per week to achieve a relatively low level of bias in estimating number of pairs and productivity.

Overall site and habitat conditions should be assessed during the planning stage prior to the nesting season. Sites may require more frequent surveys if the nesting habitat includes dense vegetation, coarse substrates or frequent overwashes, which can make plover tracks and adults difficult to detect. Additionally, wide beaches, or those with high nest density, may also require

higher frequency of surveys to achieve high confidence in breeding pairs and productivity estimates.

Some site factors important for determining survey frequency cannot be known with certainty prior to sampling (i.e., predator activity and overwash frequency). Thus, we encourage survey coordinators to consult historic data to plan for worst and best-case scenarios (i.e., no to high predation, few to many overwash events) and develop survey schedules that reflect the likelihood of stochastic environmental events occur on any given sampling year. Sampling frequency should be explored for a range of scenarios to evaluate whether staffing constraints are likely to result in high error rates and potentially undermine effective management decisions if unpredictable events are higher than expected in any given year.

Additionally, weather conditions prior to surveying can influence the accuracy of survey data in several ways. Frequent rain during the breeding season can wash away evidence of birds, predator tracks, scrapes, and even nests if the rain is severe. High winds can have a similar effect with blowing sand that removes tracks and may cover eggs. Storms can produce higher than average tides causing nest overwash, which may be difficult to detect if the survey frequency is inadequate. If plovers are experiencing frequent nest loss due to predation or flooding, birds may attempt to renest several times within the window of clutch establishment, laying up to five nests (MacIvor 1990, Claassen et al. 2014; see SOP 2 for assigning renests). Eggs may be laid in different scrapes and at various distances to the original scrape, which can make them difficult to accurately assign to the correct nest or nesting pair. All of the above instances suggest an adaptive, yet frequent, survey schedule to maximize detecting changes in nests or chicks following potentially disruptive weather events.

Sites that employ a variety of intensive management techniques (i.e., ORV or pedestrian closures, nest exclosures, intensive predator management) or have high levels of public use may require more frequent surveys than twice per week to ensure proper timing of management activities. These sites may be thought of as “high management complexity” (see SOP 2). At the other end of the spectrum, sites with minimal management activity (i.e., very small numbers of pairs, minimal predator pressure, infrequent non-motorized visitation by the public) may be considered “low management complexity”. Sites with a combination of management activities contingent on monitoring data (e.g., beach closures, exclosure use, predator control activities), but low public use, may be considered “moderate management complexity” sites. Management complexity may also be elevated if co-occurring species, such as the American oystercatcher (*Haematopus palliatus*) or least terns (*Sternula antillarum*), are also managed or monitored at the site. All management activities at a site that take place during the breeding period should be considered when assessing management complexity. Using all factors discussed above, survey frequency and per stage of the breeding season should be assessed for each site to create a practical guide for planning (see Table 2.1; Figure 2.1). Survey frequencies may be adapted during the breeding season as information regarding potential threats or sources of mortality increase (i.e., predator activity or high human use). Essentially, sites require more frequent surveys if management techniques rely on territory, nest, and brood check data to determine whether management activities need to be adjusted to protect nesting plovers.

The daily timing (day, time of day, and high tide) of survey events should also be considered to minimize observational and counting errors. Surveys conducted at or near high tide when plovers are easier to detect may yield more accurate survey estimates or be completed more quickly. However, if surveys conducted on narrow sites at high tide result in broods being pushed closer together, surveys may be conducted another time to avoid unintentional stress. Early morning surveys are also preferable because of lower ambient temperatures, reduced human traffic, and a greater likelihood of determining the cause of nest losses that occurred overnight. When possible, it is advisable to conduct surveys immediately before and after storm events so that associated effects may be clearly determined. Surveys should not be conducted when winds are high (e.g., >20 mph or when sand is blowing above the knee), precipitation is present (wet fog to heavy rain), or temperatures are below freezing, especially during the brood-rearing period when chicks are on the ground and difficult to detect.

All sites with marginal to suitable habitat should be surveyed at least once during the "June 1-9 census window." Based on historical data, this nine-day window is when it is assumed that the probability of emigration and immigration is at its lowest point during the breeding season. If more than one survey is conducted during the census window, the survey with the highest count of pairs is reported to the state coordinator. Variable counts during the census window may be driven by incomplete detection or new birds being detected with each additional survey. Thus, a higher survey frequency results in the most accurate counts (fewer missed birds) during the census window. Hatch dates occurring after the window confirm that the pair must have been on site during the window and should be added to the census count since they could not have been counted on another site.

Conducting surveys at the site-specific desired frequency may be impractical due to logistical (i.e., access) and resource constraints (i.e., number of monitors). The protocol framework recommends surveying at least twice per week (or at least once during the June 1-9 census window) to minimize errors in productivity estimates and increase the ability to measure management effectiveness. However, survey coordinators with sites surveyed less frequently are highly encouraged to use this protocol and enter data into the USFWS centralized database (PIPLweb; see Element 4). Although surveyed less frequently, observations of breeding pairs, nests, and chicks at these sites are important to document and these data can be used to inform larger scale trends analysis when combined with other sites.

Table 2.1. Example table illustrating potential survey frequencies at two sites (A and B) during the territory establishment and courtship (T) stage compared to the nesting, incubating, and brood-rearing stages (N/B). Site A has moderate or high potential for survey errors and site B has low potential for survey errors. Survey frequency in a given year can be determined based on the sites' low, moderate or high management complexity (i.e., combinations of management activities such as beach closures, exclosures, predator management). For example, daily surveys (7x) are recommended for all sites with moderate to high sampling errors and moderate or high management complexity during the N/B stages to maximize likelihood of preventing mortality events. Biweekly surveys (twice per week) are recommended for most sites with no management (with the exception of nesting stage at sites with moderate or high potential error rates). Surveying twice per week can also be justified at sites with low potential survey errors and low management complexity during the territorial stage and three times per week during the N/B stage. Generally, surveys during the N/B stages should be conducted more frequently as this stage is most vulnerable to mortality and can highly influence productivity at the end of the breeding season.

Chicks are especially vulnerable to predation and adverse weather during the first two weeks of age so monitoring those younger broods should be a priority.

Site	Potential for sampling errors*	Level of Management Complexity			
		none	low	moderate	high
A	moderate or high	T: 2x week N/B:3x week	T: 3x week N/B:4x week	T: 3x week N/B:7x week	T: 4x week N/B:7x week
B	low	T: 2x week N/B:2x week	T: 2x week N/B:3x week	T: 3x week N/B:5x week	T: 3x week N/B:7x week

*Moderate or high potential for sampling errors may occur if vegetation is dense; overwashes are wide; substrate is not fine grain; monitors have little experience; sampling occurs during mid-day, in evenings or at low tide; density of pairs is high; multiple pairs are renesting; predator activity and/or human disturbance is high; or plovers are nesting in close proximity to other beach nesters (i.e., least terns).
T= Territory establishment and courtship stage.
N/B = Nesting, incubating, and brood-rearing stages.

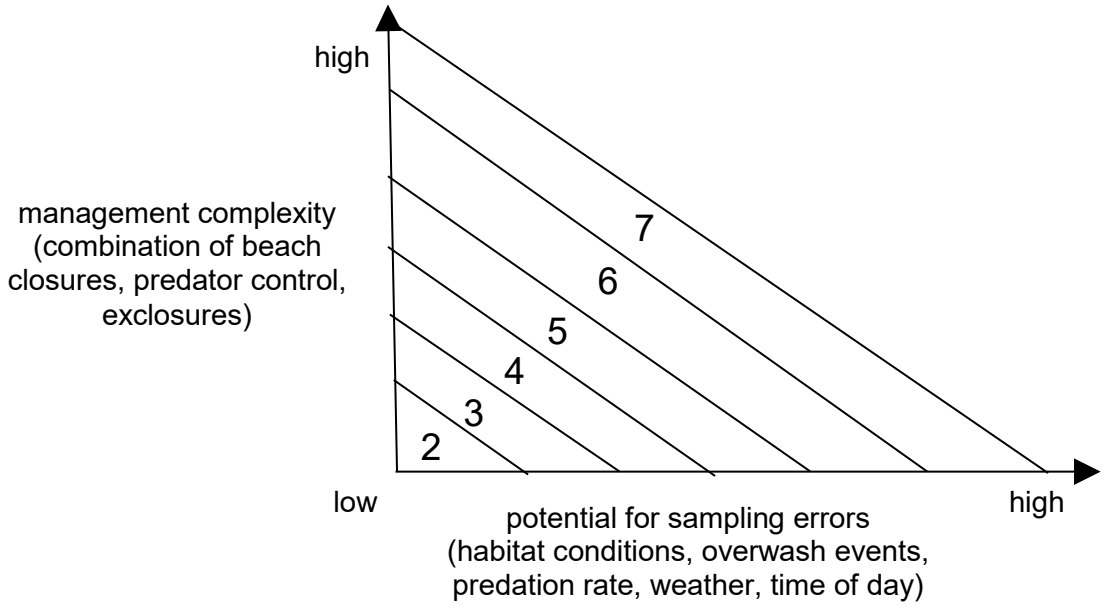

Figure 2.1 Survey frequency per week (2 through 7) based on the relationship between management complexity (y-axis) and the potential for sampling errors (x-axis). Management complexity can include combinations of actions and levels of intensity or duration including (but not limited to), beach closures, exclosures, and predator control. Sources of error can result from a combination of factors including (but not limited to) habitat conditions, overwash events, predation rate, weather, and time of day.

Sources of error

Failing to acknowledge and include key uncertainties in monitoring and management plans can lead to a false sense of achieving survey or conservation objectives. Key sources of uncertainty can include environmental stochasticity, partial observability, measurement error, sampling errors, partial controllability, and structural or model uncertainty (Williams et al. 2002, Regan et

al. 2002). To accurately monitor trends in breeding pair abundance and productivity, partial observability (the inability to perfectly detect, identify, or count individuals) must be addressed and considered when determining survey frequency and timing. If not accounted for, partial observability may lead to under- or over-estimation of the number of breeding pairs and/or productivity. For example, nests that are formed after a survey and lost prior to the next survey would result in an underestimation of nest loss and potentially influence perceived effectiveness of management actions. Additionally, chicks that are never observed (lost prior to the survey) may result in confounding nest and chick survival and effects of management. When detection rates are lowered due to dense vegetation or presence of cobble substrate, survey frequencies may be increased to increase detection. In contrast, high winds, heavy rain, or hot temperatures can result in inaccurate counts and pose a risk to the birds, therefore surveys must be postponed to another day during the week when conditions have improved.

Skilled monitors are essential to reducing errors throughout the survey. For example, skilled monitors can better detect the first arrival of breeding pairs (i.e., correctly identify territorial behavior prior to nesting) and thus reduce error in classifying the beginning of each stage, especially the nesting and incubation stage. Multiple-observers can be used to reduce these errors by increasing detection and by avoiding double-counting nesting pairs and broods. Data entry errors may be substantially reduced by using a web or phone application for data collection in the field, which minimizes errors by using previous data collected at the nest-level and limiting entries to a select range of numbers (see Element 4). Training of monitors with periodic supervisory feedback and early review of data records can reduce field and data entry errors (see Element 6).

Element 3: Field Methods and Processing of Collected Materials

Pre-survey logistics and preparation

Planning for field work should begin at least five months prior to the start of piping plovers arriving from the wintering grounds. This period of time is based on estimations made by the recovery lead and refuge biologists. The survey coordinator oversees the logistics at each station (i.e., a single or set of sites), hires and trains seasonal staff (Element 6), purchases necessary equipment and supplies, and determines survey timing and frequency. Each monitor requires binoculars, notebooks, rain gear, etc. (for full equipment list refer to SOP 2). Equipment should be ordered before the start of the breeding season. Field crews should familiarize themselves with previous years' site boundaries, nest locations, and potential nesting habitat as early as possible prior to the arrival of the first bird.

NWRS survey coordinators will need to write a SSP for each refuge station in the survey. Multiple stations within a NWRS Complex can use the same SSP, changing mainly the maps and survey locations. The survey coordinator should review the SSP and recovery plan and share with seasonal staff as early as possible prior to the start of surveys.

Some survey coordinators will need to obtain state and federal permits depending on management actions. Authorizations from State wildlife agencies are required for the use of predator exclosures and most states require permits for trapping mammal and avian predators. If

considering predator removal, survey coordinators should consult with the U.S. Department of Agriculture's Animal and Plant Health Inspection Services (Wildlife Services) several months prior to the breeding season to obtain assistance in developing a predator management strategy. A federal bird permit issued from the Migratory Bird Program is required for the destruction of any avian predator nests or the removal of any adults (i.e., for gull control). Survey coordinators will need to include instructions for obtaining these permits in the SSP (see Guidance and best practices for coordinated predation management to benefit temperate breeding shorebirds in the Atlantic Flyway; Karpanty et al. 2018).

Site establishment

Information regarding the establishment of survey sites can be found in SOP 1 (Delineating Site Boundaries). Survey sites should be established during the pre-survey preparation and prior to data collection. Survey coordinators will use GPS technology to mark the boundaries of the survey site and create polygon GIS shapefiles. Survey sites need to be modified when either considerable habitat changes alter the site boundary, or breeding pairs occur outside of the site boundary for two consecutive years. If either of these events occur, a new map or shapefile will need to be created prior to sampling the new site. If survey sites are unchanged, survey site boundaries should be verified every five years by taking new GPS locations and comparing to previously established site boundaries.

Data collection procedures (field, lab)

Survey data, at a minimum, should include nest or brood checks for each pair observed during each survey. Metrics collected during each survey include whether an adult is observed incubating, nest status, the number of adults observed, and, number of chicks (see SOP 2 for complete list). Banded birds, although not required by this protocol, can be recorded throughout the season during territorial, nesting, and incubating phases (SOP 2). Survey data can then be used to determine the hatch date, initial and maximum number of eggs, number of eggs hatched and unhatched, and the number of chicks observed during surveys (SOP 2). Data analysis can be conducted to estimate nest and chick survival, as well as the number of fledglings (Element 4). Since survey frequency is, in part, determined by management complexity at the site (see Element 2), the type, timing, and intensity of select management activities should also be recorded during the survey (i.e., exclosures).

Processing of collected materials

This protocol framework does not include procedures for routine collection or processing of biological or abiotic materials. If carcasses of piping plovers are found, follow the guidelines in Supplemental Materials 1 (SM1). Observed evidence regarding suspected cause of mortality and associated evidence should be recorded as well as reported in annual reports to state coordinators.

End-of-season procedures

Seasonal staff and interns should clean and turn in all borrowed equipment. Government vehicles and boats that were used to access field sites should be washed and repairs or maintenance needs addressed. Seasonal staff should compile a list of needed purchases or repairs so the survey coordinator can start planning for the following season.

Survey coordinators will obtain original field sheets (paper or electronic), maps, and any additional digital files and archive copies. Using standardized protocols, survey coordinators will upload data to the online database (see Element 4). If data entry does not occur throughout the season (as recommended via the use of web-application or the PIPLweb portal), data are entered at the end of the season, with final breeding pair and nest assignments reviewed by the survey coordinator at end of the field season (see Element 4).

Element 4: Data Management and Analysis

Data entry, verification, and editing

Survey data are entered into the centralized, online database via the Plover Inventory and Productivity Library (PIPLweb), a secure web application developed and hosted by the USGS Wetland and Aquatic Research Center (USGS WARC). PIPLweb user accounts will be provided to all cooperators. Differential access to the data and features in the application will be determined for each user (see SOP 4).

PIPLweb will offer three methods to enter or edit data: 1) manual entry of records through online forms, 2) upload of a standardized Excel (.xlsx) or Comma Separated Values (.csv) file, and 3) automated import from other survey data management systems (i.e., NestStory, Survey123, and PIPLODES; Figure 4.1; Table 4.1). Users of NestStory or Survey123— mobile field collection applications that store both site- and nest-level data—will be able to import data into the PIPLweb database. Data will also be accepted via the State of Massachusetts' PIPLODES application, but will need to be supplemented with additional data entry, as PIPLODES does not capture the full range of data requested in this protocol. Cooperators with other digital data management systems can contact USGS to discuss developing an automated import process or use the standardized Excel or Comma Separated Values spreadsheet format for uploading their data through the PIPLweb interface. Templates will be provided for these formats within the PIPLweb help menu.

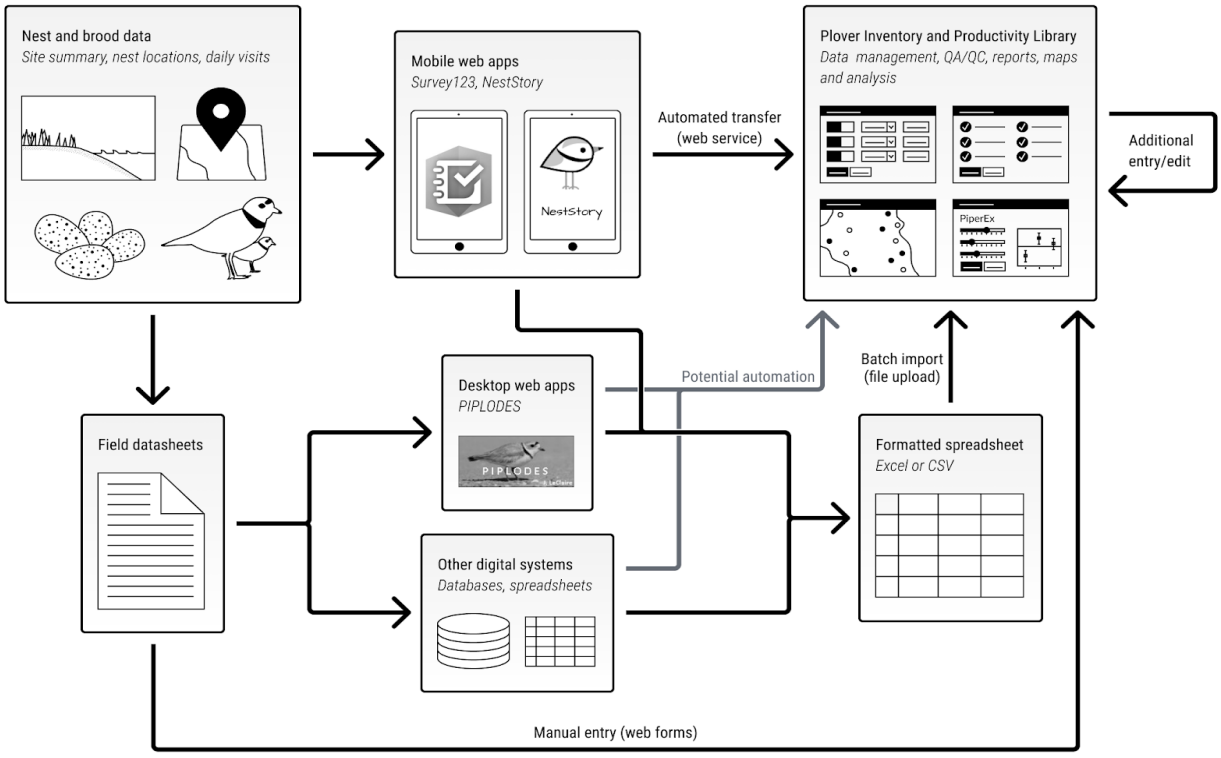

Figure 4.1. Workflow diagram depicting how survey data (i.e., pre-nesting, nest and brood data) are recorded and transferred to PIPLweb.

Table 4.1. Data management systems available to users for storing, managing, and analyzing Piping Plover monitoring data.

System Name	System Type	Description
iPlover	Habitat data collection and storage	Smartphone application for habitat data collection for Hurricane Sandy-funded USGS projects used to inform habitat modeling (Thieler et al. 2016). Used to collect habitat data in 2014-2016. *Application no longer supported.*
NestStory	Nest data collection and storage	Smartphone and desktop platform for nest data collection and management. Used to collect nest data 2016-2018 by diverse partners. Application supported by neststory.org.
Survey123	Nest data collection and storage	Smartphone and desktop platform for nest data collection and management. Developed by ESRI and customized by NWRS as an alternative application.
PIPLODES	Nest data storage	PIping PLover and tern Online Data Entry System for the State of Massachusetts. Used by coordinators in the state to enter data. Created and maintained and by MassAudubon and MassWildlife (https://www.massaudubon.org/pipldatabase/).
PiperEx	Decision tool	Online web (rshiny) application that uses nest data to predict effectiveness of exclosure use for individual sites

		during early- and mid-breeding season. Application created by Abigail Darrah and Jonathan Cohen at SUNY (https://sdms.cr.usgs.gov/shiny/piplexclosuretool/).
PIPLweb	Nest data storage and analysis	Online database and web application developed for this protocol framework to store and analyze monitoring data for the Atlantic Coast breeding population and diverse partners. Created and maintained by USGS (https://warcapps.usgs.gov/pipl).

To maximize consistency and minimize data entry errors, all input data must pass basic validations (reasonable egg and chick counts, nest locations, order of event dates, etc.) before acceptance to the database. Once entered, data should be visually inspected and compared to field sheets to minimize data entry errors and marked as approved in the database (see SOP 4). At the end of the season, users can visualize data summaries and suggest modifications to previously entered data if errors have occurred. All modifications require a justification and final approval by the survey coordinator.

Survey data are organized in the PIPLweb database by site and year, which together are known as an annual survey record (ASR). An ASR consists of survey events and nest records (if present), each of which represents a nest (or renest and any associated brood) observed in the respective site and year. Nest records contain a common set of data values collected at initial nest discovery, during daily nest/brood checks, and after fate of nest and/or brood has been determined (see SOP 2.1–2.3 for a complete list of expected data fields). Nest records also indicate associated renests. Each site in the database will also be related to a state and recovery unit to facilitate data access and reporting.

To add a new survey site to the database, or to obtain a user account with appropriate permissions, NWRS users should contact their regional I&M data manager. Other partners interested in using PIPLweb should contact USGS via email at piplweb@usgs.gov.

Metadata

The longevity and utility of a dataset are greatly improved when accompanied by documentation of the background, assumptions, processes, and conditions surrounding its collection. Each survey coordinator creates a metadata record alongside the centralized survey database that contains, at a minimum:

- a project title and description;
- contact information for the responsible parties;
- a geospatial boundary or description of the project area;
- a list of fields collected, including descriptions and/or possible values;
- descriptions of any data processing routines or analyses applied to the raw data; and
- any necessary legal information (limitations on data use, disclaimers, etc.).

The metadata record adheres to the International Organization for Standardization (ISO) 19115 standard endorsed by the Federal Geospatial Data Committee for the preparation of Federal metadata records and complements this protocol framework in providing detailed context for

future understanding of the survey data in the database. In further support of this goal, NWRS cooperators and other partners are encouraged to document any deviations from this protocol framework that may affect the quality or interpretation of collected data in site-specific protocols and record deviations into the database when setting up a new site through the web application.

Data security and archiving

Access to survey data is controlled through the PIPLweb user management system. For each geographical unit (site, multi-site/refuge, state, or recovery unit), one or more users are designated as account administrators. These administrators create and approve new user accounts and assign the appropriate level of user access for each site they manage (see SOP 4 for specific details about data access and sharing).

Per-user access levels are assigned for all data collected within a site by specifying the individual actions a user can perform (enter, edit, review, etc.) or one or more roles a user fulfills (field collection, QA/QC, site coordinator, etc.). Each role will define a group of common actions performed by various survey participants. For example, a field data technician may be granted permission to enter and edit data for a single site, but not to review and approve those data as final; conversely, a state coordinator may be able to view and report on data at all sites in their state, but not be able to edit those data. Although default permissions will be specified for each role, the permissions system will be flexible, allowing account administrators to combine roles and individual actions as needed to accommodate a wide range of user access scenarios.

USGS will maintain a small number of website administrator accounts for application developers. Website administrators are granted read-only access to all data in the production database for testing, development, and support purposes. Survey data will not be modified by website administrators, except by request of or with permission from the appropriate data owner. Website administrators work with site, state, and regional coordinators to manage permissions for account administrators.

The hosting facility (USGS WARC) will back up the centralized database according to the following schedule: (1) 30-minute transaction log backups onsite, (2) daily differential backups onsite, and (3) weekly full backups onsite and to an offsite cloud storage container. Separate from these backups, the web application will provide data owners the ability to download their data to an open-standard, machine-readable format (e.g., Comma Separated Values; .csv) at any time.

Web applications hosted on USGS servers are subject to DOI Assessment and Authorization (https://www.doi.gov/ocio/customers/assessment) security protocols, as required by the Federal Information Security Management Act of 2002. Application servers are patched and scanned at least monthly for vulnerabilities in installed software and network configuration. Individual applications are scanned and penetration-tested on at least a semi-annual basis. Additionally, all USGS-hosted web applications are protected against common malicious attacks by a web application firewall that is monitored and regularly updated by a dedicated security team.

NWRS survey coordinators will archive digital holdings (e.g., completed field data sheets, notes, maps, etc.) in ServCat following data storage procedures (see https://ecos.fws.gov/ServCat/Reference/Profile/95005). For all partners, digital holdings that

meet file size and type limits may be archived directly in the online database through the web application.

PRIMR— All Refuges should use the "Inventory and Monitoring of Breeding Atlantic Coast Piping Plovers" PRIMR template to create the survey record for their Refuge in the PRIMR database. The Regional Data Manager will work with each survey coordinator to add refuge specific text to the PRIMR record. This information will be used to populate the Survey Profile Table in the Refuge's Inventory and Monitoring Plan (IMP).

ServCat—All Refuges have projects set up in ServCat under the "Inventory and Monitoring of Breeding Atlantic Coast Piping Plovers in Region 5" program (https://ecos.fws.gov/ServCat/Reference/Profile/103137). Final reports, datasets, and other documents should be uploaded to that Refuge's project. Region-wide reports and datasets will be cross-referenced at the program level. Additional regional guidance on how to create references in ServCat is located here: https://fishnet.fws.doi.net/regions/5/nwrs/im/GDN/GuidanceHelp/Forms/ServCat.aspx.

Analysis methods

Survey, sampling, and management objectives, as defined in a stepped-down site-specific protocol (SSP), will drive the types of analyses that are conducted with the data collected at the site or multisite scale. Analysis and reporting methods are defined at the time the sampling design (frequency and timing of surveys) is developed (Element 2). Data analyses that meet the survey objectives of this protocol framework include: 1) providing summaries of breeding pair and productivity data for annual reporting, 2) analyzing trends in breeding pair abundance, productivity, and survival over time and across spatial scales, 3) estimating nest and chick or brood survival and effects of management activities (i.e., exclosures) on survival rates. Hierarchical logistic-exposure and/or multinomial regression modeling frameworks can utilize nest-level data (number of eggs, number of chicks, and nest fates) to estimate daily nest and chick survival rates and to predict overall survival rates. These models have been previously applied to piping plovers and are further explained in scientific publications (see Shaffer et al. 2004, Rotella et al. 2004, Hecht and Melvin 2009a, Catlin et al. 2011, Cohen et al. 2016, Darrah et al. 2017). Additionally, data collected using this protocol can be used to build models to estimate carrying capacity, population growth and vulnerable life stages; however, additional field data may be required for these analyses.

Selecting an appropriate analysis requires knowing the survey objectives, key assumptions for each analytical technique, if the data are fit for the intended use, and the limitations of interpreting results. This protocol framework does not provide guidance on measuring local habitat quantity or structure, predator activity, or human disturbance (i.e., ORV use or pedestrians) because these metrics will vary greatly among sites and with the objectives of each survey. Linking habitat conditions to the number of pairs or productivity will either require a protocol for collecting habitat metrics or use of a habitat suitability model (e.g., Thieler et al 2016, Maslo et al. 2016). I&M staff (i.e., Biometrician) can be consulted for analytical advice for more complex sampling and management objectives.

Summary tables and nest and brood survival analyses are available from PIPLweb and can be used to generate a central tendency (median) survival and confidence (95% credible intervals)

across sites and years. Currently, PIPLweb uses the Dinsmore et al. (2002) nest survival model in RMark (Laake 2013), a package that makes features of the FORTRAN-based Program Mark software accessible to users of the R program (SOP 4). However, other models (e.g. Bayesian hierarchical logistic-exposure model) will become available to accommodate additional analytical needs. Using summaries and survival outputs, users can plot trends in the central tendency or variability among sites in breeding pairs and productivity over time. PiperEx, which estimates daily mortality using a mixed effects multinomial logistic exposure model (Cohen et al. 2016), will be available on PIPLweb. Users can download the raw or summarized data from PIPLweb and conduct additional analyses, such as trends analyses or test for management effectiveness, and create their own maps, tables, and figures. SSPs should describe summaries and analyses that correspond to the sampling objectives.

Software

A range of software applications are available for data analysis and display. Simple data summary tables and graphs can be prepared using the data visualization and analysis tools available through the online database interface at the site, state, or regional scales (see SOP 4). Users can also download data and plot summaries using MS Excel or specialized graphing software such as Sigma Plot. More complex statistical analyses of survey data will require specialized statistical software such as SAS, SPSS, PROGRAM MARK, JAGS, or R and depend on the goals and objectives of the SSP.

Element 5: Reporting

Implications and application

Data review and evaluation during preparation of annual summary reports for each site (or set of sites) provide a crucial check on accurate assignment of nests and renests (e.g., using chronologies), which influences end-of-year total numbers of breeding pairs and average productivity. Reports synthesize important information that informs future monitoring and management needs at a site (i.e., additional monitors, volunteers, or management activities) for the landowner, State agencies, USFWS field offices, and the recovery coordinator. Annual reports should summarize and interpret field data in relation to survey objectives and critical management needs. Procedures (format, schedule, distribution and archiving) for reporting survey results will depend on the audience intended to receive the report and the users generating the reports. Generally, reports could include site or landowner end-of-season annual reports, state reports to the recovery coordinator, and an Atlantic Coast summary report. Annual reports can be used to share information across partners (i.e., fact sheets, summary tables) and should be submitted to the state coordinator in accordance with recovery plan task 1.12 (USFWS 1996). Atlantic Coast reports should be created to summarize findings across recovery units by (or with guidance from) the recovery coordinator. NWRS site-specific protocols should clearly indicate the report type and schedule, which may also include mid-season reporting when summary information is used to inform management activities. The USFWS encourages publication of significant findings in scientific journals or USFWS publications (USFWS 2007).

Site and landowner annual reports

Objectives and methods— Site-specific annual reports should be generated in accordance with the organization responsible for monitoring and managing piping plovers at the site (i.e., State

agencies, NWRS). In general, reports should include an introduction that explicitly states the survey objectives (if deviated from the objectives of this protocol framework), reporting date, and authors. This should be followed by a methods section that references this protocol, and describes local application, including a clear articulation of conditions that led to a particular survey frequency (i.e., habitat conditions, weather, management activities, field crew limitations, and other logistical constraints) and the realized survey frequency (date range and number of surveys per week). If methods for determining the survey design differed from those outlined in the protocol, document the reasons the methods differed, the specific procedures followed, and describe analytical methods and assumptions of those methods. Each state coordinator may require additional elements than those listed here and should be consulted prior to generating reports.

Summary of results— All reports should include basic summary information and results. This information includes, but is not limited to:

- survey frequency and effort (number of monitors),
- dates when monitoring began and ended,
- the total number of breeding pairs (number of unique breeding pairs),
- counts of breeding pairs during the window census and the pertinent survey dates,
- total number of fledglings observed during the breeding season,
- average (and range) in productivity per pair (if more than one pair were present),
- nesting chronology (dates when plovers were first and last seen on the site, nest establishment dates, dates when unfledged chicks were present on the site),
- a map of the survey area with locations of all nests or territories of pairs (if no nest was found), and
- results of investigations of salvaged dead specimens (see SM 1).

PIPLweb can be used to generate much of these results, including a map of the locations of nests (Figure 5.1), nest chronology plots (Figure 5.2), number of unique breeding pairs, number of fledged chicks per pair (productivity), nest and brood-level summaries (Table 5.1), and estimated daily and seasonal nest and brood survival rates (Figure 5.3).

Nest-level summaries may include the number of nests observed, number of broods detected without a prior observed nest, and total nesting attempts; number of nests that hatched at least one egg, number of nests destroyed and/or abandoned, number of nests with unknown fates; number of unique breeding pairs, and number of renest attempts (Table 5.1). Brood-level summaries may include the number of broods observed, number of chicks observed (maximum), number of chicks fledged, average number of chicks fledged per successful brood, number of broods with at least one fledged chick, number of failed broods, number of broods with an unknown fate, unique number of breeding pairs, and number of chicks/unique pairs map with the location of nests with no eggs hatched and 1+ eggs hatched (Figure 5.1). Maps with the location of failed nests, nests with 0 chicks, nests with the number chicks fledged (i.e., 1+), and nest and brood survival estimates over time can also be produced using the PIPLweb reporting features.

Discussion— It is important to discuss implications of survey results and how they relate to survey objectives and relevant management decisions. Findings can include identification of new threats, suspected causes of nest or chick loss, renesting rates, and other sources of mortality. Unique, noteworthy events from the project record should be described in detail sufficient that

other monitors and data analysts can interpret conditions under which data were collected. Equipment failures or limitations should be explained and advice for future field crews should be articulated. Reports should provide recommendations for future monitoring and management at local, state, or recovery unit scales.

Although the protocol framework does not currently collect all metrics that may be important for understanding change in plover abundance or productivity or informing management decisions, documentation of the following additional information can contribute to recovery efforts and identify important areas to develop in subsequent versions of the protocol framework:

- Known and suspected causes of nest and chick loss,
- Indices or qualitative assessments of predator abundance (and diversity) throughout the breeding season,
- Locations of commonly used foraging areas during each stage of the breeding cycle,
- Available information about use of the site by post-breeding or migrating plovers, other shorebirds, and other rare species,
- Recommended improvements in monitoring or management for future implementation, including recommended changes in the frequency of monitoring (and the supporting rationale).

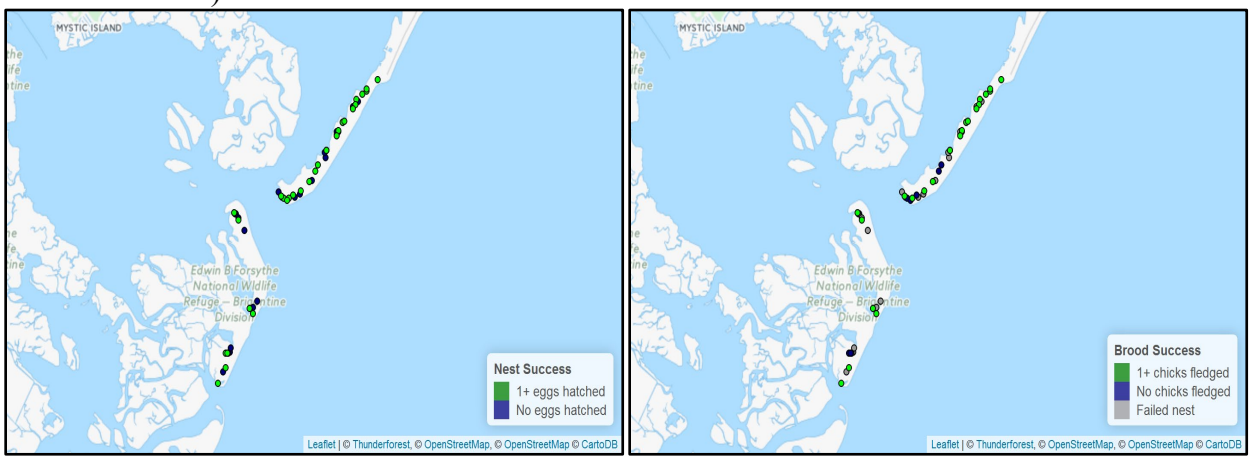

Figure 5.1. Example map of the survey area with locations of all nests (left) and broods (right).

Figure 5.2. Example nest chronology for each nest (i.e., nest 1 A through 5 A; color) or renest (B) with the status of each nest (diamond= laying or incubating, circle = brooding, triangle = fledged, star = lost) and the observed number of chicks.

Table 5.1. Example summary data available as output from PIPLweb. Similar output may be developed for multiple sites and years.

Summary	
Nests observed	54
Broods detected without prior observed nest	0
Total nesting attempts	**54**
Fate	
Succeeded (hatched ≥1 egg)	29
Failed (destroyed)	21
Failed (abandoned)	2
Unknown	2
Pairs	
Unique breeding pairs	**37**
Renests	17

Summary	
Broods observed	29
Chicks observed (maximum)	94
Chicks fledged	47
Average chicks fledged per successful brood	2.14
Fate	
Succeeded (fledged ≥1 chick)	22
Failed	7
Unknown	0
Productivity	
Unique breeding pairs	37
Chicks fledged ÷ unique pairs	**1.27**

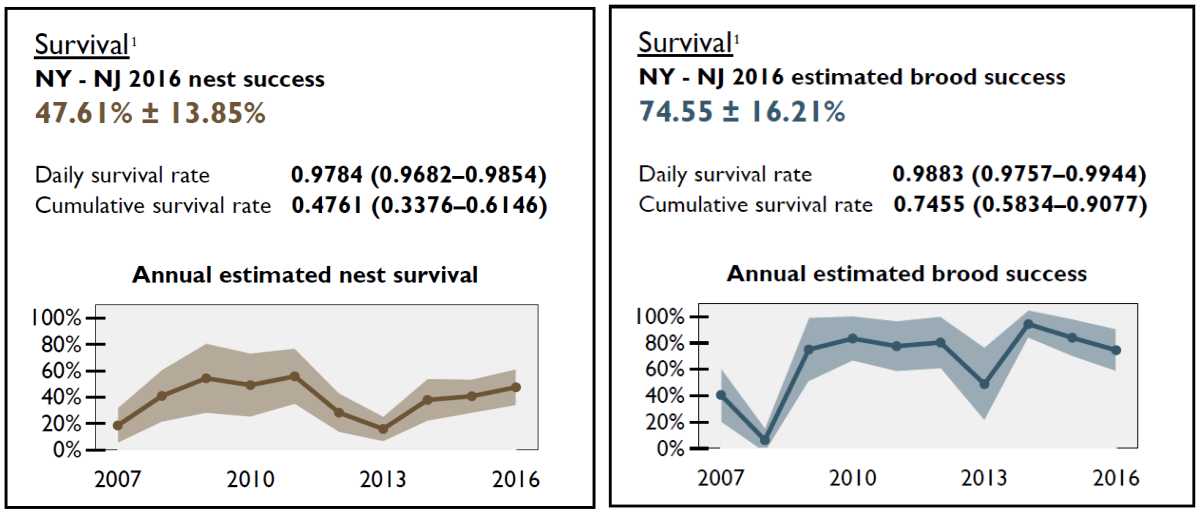

Figure 5.3. Example mean (± 1SD) daily and cumulative (annual) nest survival (left) and brood survival (right) across all pairs detected at two sites from NY/NJ in 2016. Survival estimates may be computed for each site or year or across sites or years, depending on data availability.

State reports

The state coordinators should provide the following information (available from PIPLweb if users grant data access to state coordinators) annually to the USFWS piping plover recovery coordinator:

- State nesting pair count from the window census conducted June 1-9.
- Best estimate of the state's breeding population (total number of pairs), consistent with census methodology used in previous years, if it differs from the window count methodology.
- Productivity per pair estimates and the number of pairs and criteria used to define productivity (chicks flying or 25 days of age, per pair). Productivity information for chicks that were monitored for less than 25 days should clearly be distinguished from data that meet the "25 days or flying" standard.
- Breeding phenology that deviates from previously observed limits as described in the 1996 recovery plan. Nest chronologies can be used to describe deviations. Examples include (but are not limited to) nests that hatched prior to May 15 or after July 31; chicks >35 days old that remained incapable of sustained flight for >15 meters; chicks that attained flight capability after August 31; nests that hatched after >38 days of incubation (no need to include long incubation periods if no hatching occurred). Such cases may indicate a need to revise recommendations for managing piping plovers, so more information may be requested about these particular observations and surrounding circumstances.

Additionally, state reports should include a brief assessment of any factors that contributed to changes in statewide abundance of breeding pairs or productivity since the previous year.

Atlantic Coast reports

Regional summary reports can aggregate data across sites, states and recovery units to assess broad geographic or temporal trends in breeding pairs and productivity, with permitted data access from PIPLweb administrators. Biometricians and statisticians can conduct regional

analyses to identify spatial trends in breeding pairs or productivity, and ask regional questions about distribution of nests, productivity, and survival.

Reporting schedule

Annual site or landowner reports should be produced at the end of the field season (see Element 7) and include any interpretations relevant to the survey objectives and management effectiveness or other concerns. State annual reports should be produced by the end of October and sent to the USFWS piping plover recovery coordinator. Reporting deadlines may vary slightly to meet information requests from other partners (e.g., for Canadian Wildlife Service recovery team meetings). State coordinators unable to provide breeding pair and productivity metrics by the requested deadline may send the best available estimates, clearly denoting that these are preliminary estimates to be revised as soon as possible. Regional or multi-year reports can be completed less frequently (every 2-5 years) or on an as needed basis to inform regional management strategies.

Report distribution

Site-specific protocols should identify to whom reports should be given and the appropriate medium for communications. A strategy for archiving reports should also be described. USFWS cooperators should ensure that field notes and reports are stored in compliance with Service Enterprise Architecture (270 FW 1), Data Resource Management (274 FW 1), and Electronic Records (282 FW 4) policies.

Annual reports produced by NWRS staff should include accurate metadata documents, maps, graphs, tables and any other relevant survey documentation and uploaded to ServCat by February of the following calendar year, but after state coordinators verify and submit reports to the recovery coordinator (see Element 6). Annual reports prepared by monitors facilitate quality control of data by supervisory biologists overseeing monitoring at many large sites or multi-site landownership and by state coordinators. State coordinators contact local cooperators when necessary to obtain missing information or to resolve inconsistencies or clarify ambiguities in census data.

Site annual reports should be shared and (whenever possible) discussed with the local land manager(s). Copies of reports (annual and state reports) should also be forwarded to the USFWS piping plover recovery coordinator and to the local Ecological Services field office. Local organizations, including NWRS, provide monitoring results to their state coordinators (State wildlife agency or its designee) at the end of each season. Specific information requirements are established by the States. State coordinators communicate regularly with local cooperators to ensure that appropriate protocols for monitoring abundance and productivity are followed and that effort is sufficient to adequately census both occupied and potential breeding sites each year.

Element 6: Personnel Requirements and Training

Roles and responsibilities

- Recovery lead (USFWS recovery coordinator) –Verifies and synthesizes state data within each recovery unit
- State coordinator –Verifies and submits state data to recovery lead
- Survey coordinator –Oversees project at the site/multi-site level; assigns and verifies pair,

nest, and productivity data; coordinates with partners, state and local government, and private landowners; and advertises and hires seasonal staff
- Data manager –Oversees data management for NWRS in the Northeast Region, assists NWRS with data access, entry, and QA/QC
- Biometrician –Consults on data analysis for NWRS Refuge or Regional staff and monitoring designs of NWRS SSPs
- Biological technician –Oversees interns and day-to-day tasks, conducts surveys, enters data
- Interns –Conducts field work under supervision of biotech(s) and/or survey coordinator, may or may not assist with data entry

Qualifications

All surveys should be conducted by a qualified monitor, which is a person who has the skills, knowledge, and ability to accurately observe and record shorebird breeding activities while causing minimum disturbance to birds under observation. Skills of a qualified monitor include, but are not limited to: identifying potential nesting habitat, detecting and recording locations of territorial and courting adults, interpreting plover behavior, identifying distinct nesting pairs or territories, confirming incubation through hatch date, counting eggs, locating broods, confirming fledging of chicks, and documenting observations in legible, complete field notes. Aptitude for monitoring includes keen powers of observation, familiarity with avian biology, experience observing birds or other wildlife for sustained periods, and patience.

At a minimum, monitors must be able to:
- Identify piping plovers, tracks, and nests;
- Observe territorial behavior and identify territories;
- Age chicks;
- Identify mammalian and avian tracks and other signs of predators;
- Use a GPS to collect geospatial data; and
- Follow survey protocols outlined in SSP.

Training

Field crew members with no or limited prior experience monitoring piping plovers should spend a minimum of five days in the field with an experienced qualified monitor focused on bird identification, interpreting territories and behavioral cues, nest searching, locating and aging chicks, and identifying predator tracks. Additionally, crews will need training in how to erect predator exclosures if they are used at the site (see Guidelines for the Use of Predator Exclosures to Protect Piping Plover Nests, USFWS 1996, Appendix F). Survey coordinators should conduct additional training to ensure all crew members are comfortable setting up exclosures without direct supervision. Step by step instructions should be included in the SSP. Survey coordinators should frequently review and evaluate seasonal staff's abilities in the skills mentioned above. Supervisors or survey coordinators should review crew members' field notes, ability to locate birds and nests, and adherence to protocols. Survey coordinators should be available for questions from field staff and encourage open discussion.

The survey coordinator should check in with field crews to ensure technicians and interns are capable. The following are suggestions on how to evaluate monitoring staff. Field crews should be able to:

- Quickly and accurately detect territorial males and courting pairs.
- Promptly detect nests (or incubating pairs, where thick vegetation precludes locating the nest) using appropriate cues (e.g., tracks, scrapes, vocalizations, foraging adults) without causing undue disturbance to the birds.
- Ensure symbolic fencing (or other protection) is sufficient to encompass habitat where adult plovers are conducting courtship displays. Refer to "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" (USFWS 1994).
- Ensure symbolic fencing (or other protection) provides sufficient buffer to prevent flushing of incubating adults.
- Estimate ages of chicks (see SM 3 for general guide to aging chicks).
- All areas where unfledged chicks are present are detected and receiving protections in accordance with Guidelines cited above and/or site-specific protocols.
- Quickly and accurately determined predator tracks present at the site.

Element 7: Operational Requirements

Budget

The costs associated with monitoring Atlantic Coast breeding piping plovers vary substantially depending on the landowner responsible for monitoring and managing the site, the accessibility and size of each site, selected predator management strategies, regulation of beach recreation activities, law enforcement, and number of breeding pairs. Estimated staffing and costs for a site supporting approximately 30 pairs and a moderate level of management complexity (closed areas to public, no ORV use, use of exclosures and predator management) are provided in Table 7.1. Costs of exclosures and predator management will range widely depending on site characteristics and desired management effectiveness. To coordinate monitoring and management activities, it is recommended that staffing include at least one crew member for every 10 plover pairs. Thus, under moderate management complexity, one survey coordinator, one field technician, and one intern are recommended (3 staff for 30 breeding pairs; Table 7.1). If a site requires high management complexity or contains more than 30 pairs, the number of technicians or interns may increase accordingly.

Table 7.1. Estimated annual costs for one Survey Coordinator (Coord), one USFWS biotech (Tech; GS-5; 26 weeks) and one American Conservation Experience intern for 14 weeks based on FY18 costs and the option of conducting predator management. These estimates do not include outreach or law enforcement costs.

Staff (hours)							Operational Expenses			
Staff	**Plan**	**Train**	**Field-work**	**Data Entry**	**Analysis & Report**	**Total hrs**	**Staff**	**Fuel**	**Equip**	**Pred Mgmt**
Coord	160	60	80	20	60	380	$18,000			
Tech	80	160	600	120	80	1040	$25,000			
Intern	0	0	520	40	0	560	$11,500			
Total:	240	220	1200	180	140	1980[1]	$54,500	$8,000	$5,000	$10,000

[1]Total excluding Intern = 1420 hrs (0.68 FTE)

Staff time

The survey coordinator is responsible for the bulk of the planning and preseason preparations. Most of the off-season time is devoted to coordinating with landowners and other partners and preparing for the next field season. Acquiring funds, ordering supplies, hiring seasonal help, and requesting permits can take up to several months.

It is optimal for biological technicians to be employed for at least six months out of the year. This allows enough time for the technicians to become familiar with the sites, train interns, conduct the fieldwork, and enter data. Biological technicians can also help with end of the season reporting and analysis.

Interns are brought on to conduct the bulk of the fieldwork. Once properly trained, most of their time is spent monitoring. The recommended minimum time is for 15 weeks at 40 hours per week of fieldwork. Interns can also be entering data throughout the season.

Schedule

Although much of the required staff time is primarily dedicated to conducting field surveys, survey coordinators and technicians may devote considerable time to planning, analyzing, and reporting findings outside of the breeding season (Table 7.2) to ensure proper preparations for surveys in the following year.

Table 7.2. Schedule of year-round activities associated with monitoring plovers. Note that fieldwork applies to both monitoring and implementing management activities.

	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Planning	X	X	X	X							X	X
Training			X	X	X	X						
Fieldwork			X	X	X	X	X	X	X			
Data Entry				X	X	X	X	X	X	X		
Analysis								X	X	X	X	
Reporting										X	X	X

Coordination

Survey coordinators should be communicating with their respective state leads and the federal recovery lead over the course of the season. Survey coordinators also should be in frequent communication with landowners, field crews, and partners.

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Standard Operating Procedures (SOP)

SOP 1: Delineating Site Boundaries

To maintain consistency in data collection over time, site boundaries (the area in which a survey is conducted) should be accurate and should remain the same throughout, and across years when possible. Site boundaries should be delineated using GPS locations and/or permanent landmarks or defined based on historical surveys of the site. Occasionally, changes in coastal geomorphology, land ownership, or access may require the shifting of site boundaries. When boundaries must be shifted, the date and reason for the change should be prominently recorded to prevent inaccurate comparisons between years when the boundaries were not the same.

Site boundaries should be re-evaluated for accuracy at the beginning of each nesting season (Figure SOP 1.1). For those NWRs conducting the Ocean Shoreline Position survey, the survey polyline could be used to establish the site boundary along the intertidal zone and surveyors could create an additional polyline for the upper boundary of suitable habitat. Ideally, site boundaries should encompass an area large enough to account for shifts in habitat suitability or growth of the piping plover population. For example, if most nesting occurs on the northern end of a beach, the site boundary should still contain the entire beach length despite the lack of current nesting on the southern end. Nesting habitat is likely to shift over time, especially in dynamic beach systems and defining the boundary by the end of nesting habitat may not be appropriate for long-term monitoring. All potential nesting habitat including historically unused areas or borderline habitat must be included in a site since it will be surveyed, at a minimum, during the June census window.

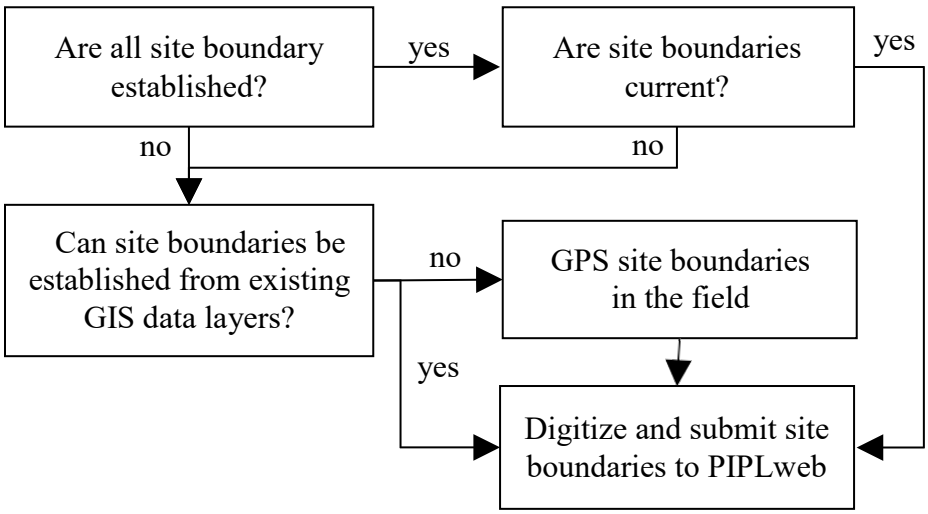


Figure SOP 1.1. Workflow for how and when to establish site boundaries prior to conducting a survey.

Equipment or supplies

- GPS
- Printed aerial maps
- GIS and digital imagery software
- Maps of land ownership. For some town/private sites, this may be important.

Survey coordinators should confirm site boundaries annually. Based on length of site, land ownership, and accessibility, sites can be broken up into multiple sites to facilitate efficient surveys. It is expected that monitors will be able to cover the entire site in less than six hours while maintaining a high-level of search effort. In other words, if monitors require more than a single 8-hr workday to complete a survey start to finish (including drive time, accessing the site, and conducting management activities), then the site should be split into more than one site for functional purposes. If the monitor cannot maintain high search effort, then the site should be split into multiple sites. Cooperators may need to survey sites ranging from unprotected to intensively managed to unprotected, with attendant variability in survey frequency. Survey coordinators should walk the boundary of each site using a GPS unit to track their locations. All areas surveyed should be included in the site regardless of the presence of plovers. A map of the survey area can be created in either ArcGIS or Google Earth and is uploaded to the PIPLweb database every year. The shapefile delineation should include the entire area surveyed during the window June census window, including poor habitat or densely vegetated dunes that were surveyed. If the entire site is not evenly searched during each survey, notes describing why (e.g., habitat in an area is currently unsuitable or marginal, management needs are uneven) should be included in the project record.

Different types of habitat may require slightly different parameters when delineating sites. If an island has multiple landowners, it may be considered a single site or multiple sites depending on the collaboration of the survey coordinators managing the site. The entire coastal edge of the island should be surveyed during the June census window. If portions of the shoreline do not contain piping plover nesting habitat, it should still be considered part of the site (i.e., dunes may eventually be overwashed). If a nesting site is a peninsula, the site will only have a GPS point delineating the starting location of the survey. The entire width of the peninsula will be included in the site. If the site is accreting or eroding, the terminal end of the peninsula will be GPSed on an annual basis though the area surveyed will remain the same.

Once the boundaries of a site have been determined, the survey coordinator submits a digitized file with identified accuracy, projections, and coordinate system (ArcGIS shapefiles or KML digitized from Google Earth) through the webportal. Permission to access locality information is defined by the user in PIPLweb. If a site undergoes a significant geomorphological change (e.g., a new inlet forms, an island or spit progrades), the site would no longer have current boundaries. Sites should be delineated after storms create large areas of new habitat or result in significant accretion. This protocol does not use site area for calculating density estimates or evaluating available habitat.

Changes in land ownership should be noted in PIPLweb if surveys are continued under new ownership. This may or may not result in a change in the site boundaries. Regardless, the date land ownership changed and contact information for the new owners should be noted in the database with user-defined permissions to access these data,

SOP 2: Conducting a Survey

Several steps are necessary for conducting a survey: 1) creating a site record in PIPLweb (Table SOP 2.1), selecting survey frequency, gathering equipment and supplies (Table SOP 2.2), and considering appropriate survey conditions; and 2) survey activities, such as observing territorial behaviors, recording both survey-level (Table SOP 2.3) and nest-level attributes (Table SOP 2.4). PIPLweb can calculate some attributes after the survey if nest-level data are properly recorded (Table SOP 2.5). The specific timing of survey activities at a site may depend on migration phenology, the number of pairs and monitors, and timing of management activities; thus, each survey coordinator is encouraged to develop a timeline of survey activities in their site-specific protocol.

Survey coordinators are encouraged to enter all collected data into PIPLweb, even if all monitoring metrics are not collected or if survey frequency is below the recommended level (e.g., twice per week). Partial information is still valuable for regional summaries and trend analyses. Non-refuge partners who are not able to collect information according to this protocol may contact the recovery coordinator to inquire about availability of additional resources.

Prior to Conducting Survey

Complete a site record

After establishing site boundaries (SOP 1), the survey coordinator fills out an initial site record to detail site-level attributes (Table SOP 2.1; SOP 4) and enters this information into PIPLweb prior to the start of the field season. Each site is assigned a unique 3-7 letter site code. NWR sites use the Refuge's three letter literary code (i.e., LIT code), with 2-4 letters added to each site if more than one site occurs on the Refuge. Planned predator management is recorded as a site-level attribute at this time. Additional predator management information (i.e., total number and species of predators targeted or captured) may also be recorded (or exported from an APHIS database) at the end of the season; however, this version of the protocol framework does not require these data to be entered into PIPLweb.

Table SOP 2.1. List of site-level attributes to be entered into PIPLweb at the beginning of the season.

Attribute Name	Description	Required
Site Name	Name of site	Y
Site Code	3-7 letter code for each site Note that NWR sites use three-letter LIT code, with 2-4 letters added to each site if there is more than one site per Refuge	Y
Site Boundary	Shapefile or digitized map of site	Y (required for NWRS only)
Predator Management	Yes or No	N

Determine survey frequency

Survey coordinators select a preferred survey frequency based on the complexity of management and potential sources of error (i.e., level of nest detectability; see Element 2 for general guidance). This may be adjusted based on changing site conditions and threats throughout the

season (i.e., predator activity may be low at the onset of the season but could increase over time). Each week, survey coordinators discuss with monitors the desired frequency of surveys and preferred timing of surveys (i.e., add an additional survey event after a large storm, overwash event, or suspected or observed predator activity at the site). Circumstances that necessitate changes in monitoring frequency that are likely to occur in subsequent years should be discussed in the site and landowner annual report (see Element 5). Survey coordinators must make sure that each site is surveyed at least once during the census window. This census takes place at all breeding sites on the Atlantic Coast from June 1-9.

Monitor preparation and environmental considerations

Before beginning a survey, monitors review previous survey notes and observations to ensure familiarity with the site and increase nest detection. Monitors print out data sheets (SM 2) if not using a mobile device for field data collection and have a field notebook to record any additional observations. Survey coordinators ensure monitors have all field equipment and personal items in working condition before conducting a survey (Table SOP 2.2). Monitors evaluate the weather before deciding to begin a survey. Surveys should not be conducted when winds are high (e.g., >20 mph or when sand is blowing above the knee), during wet fog (concern is mainly for very young chicks), or heavy rain. Monitors use caution when conducting surveys in temperatures over 80°F. In these conditions, disturbance to chicks and adults is kept to a minimum.

Table SOP 2.2. List of field equipment and personal items to collect before conducting a survey for monitors to bring to a site on each survey.

Field Equipment	Personal Items
Binoculars	Identification credentials
Spotting scope (minimum 25x magnification)	List of emergency telephone numbers
Camera	First aid kit
Watch (if no cell phone)	Water and/or fluids
GPS unit	Food
Field guide(s) (e.g. SM 3)	Sunscreen
Field notebook	Sunglasses
Field datasheets (SM 2)	Hat
Pencil	Insect repellent
Cellular phone or tablet for data collection using web applications, if applicable available (see Conducting the Survey)	Sturdy closed toe shoes; sandals may not be adequate if you are walking long distances or are traversing rough terrain
	Windbreaker jacket

Conducting the Survey

Record survey-level attributes

When birds have started nesting, monitors record both survey-level and nest-level attributes during each survey (Table SOP 2.3 and Table SOP 2.4, respectively). Survey-level attributes include the site name, date, start and end time of the survey, number of monitors, and the total number of adult plovers observed at the site. The total number of adults is not a required metric, but may provide some additional information to the survey coordinator. Each monitor uses their own data sheet to record survey information (SM 2: Survey Datasheets). An alternative to using

data sheets in the field is to use a web application on a cellular phone or tablet, such as Survey123 or NestStory. Contact your Regional Data Manager to set up a Survey123 account and become familiar with the application prior to the start of the field season (see SOP 5), and contact help@neststory.org to discuss the feasibility of setting up a NestStory account and training.

Find active territories

Monitors start the survey by conducting an overall scan of the beach to look for movement of piping plover, as it is helpful to get an overall idea of bird presence and potential territory locations before the birds are disturbed by monitors on the beach. Piping plovers are well camouflaged and can be difficult to detect. During the territorial phase, monitors walk the beach between the foredune and wrack line noting adults and territorial behavior, plover tracks, and scrapes (shallow depressions in the sand that birds create prior to the establishment of a nest) exercising due care to minimize disturbance, including stepping on scrapes. Territorial males will exhibit a number of behaviors when setting up a territory. It is important to make note of these while in the field. Examples include flying in a figure eight display while peeping, running parallel along the beach, and chasing other adults. Courting behavior can include tilting of the head, tossing shell fragments, high stepping, and making continuous vocalizations (for a detailed account of these behaviors see Elliott-Smith and Haig 2004). Pairs can form several scrapes before the establishment of a nest. An abundance of scrapes can indicate imminent egg-laying. Monitors may physically enter potential nesting habitat to locate nests, but should scan the ground for scrapes and eggs prior to every step. Birds may also nest in the vegetation behind the foredune, so these areas should also be surveyed and included within the boundaries of the site delineation (see SOP 1).

Count adults

During surveys, monitors may report the total number of adults observed (Table SOP 2.3). Unmated territorial males are also noted, but not counted as part of a pair until a pair-bond is established. If multiple monitors survey an entire site on the same day, the higher count of adults is recorded. If monitors survey different sections of a site, then monitors compare the number of adults observed and report a total agreed upon number of unique adults observed.

Although band-reporting is not required in this protocol, banded birds should be recorded and reported following the USFWS guidelines (see *Reporting Banded Birds* section below). Note that band combinations are only stored in PIPLweb for pairs that have established nests as a nest-level attribute (Table 2.4), thus monitors are encouraged to keep a list of banded birds and survey dates during the territorial phase.

Table SOP 2.3. List of survey-level attributes collected during each survey event.

Attribute Name	Description	Required
Site Name	Name of site	Y
Date	Date of survey	Y
Start time	Time monitor starts the survey	Y
End time	Time monitor ends the survey	Y
Number of monitors	Number of monitors conducting the survey	Y
Number adults	Total number of adults observed at the site during the survey	N

Banded birds	Band combinations for each bird, if applicable. Note band information is only stored in PIPLweb for birds associated with established nests (Table SOP 2.4).	N
Comments	Can include comments on ORV use, dog presence, and human disturbance here or any other important observations from the survey	N

Locate nests

Once territories are well-established, monitors will observe an increased number of tracks and scrapes. Active nests often have many tracks approaching the nest from all directions like the spokes of a wheel. Birds may use alarm calls and/or pretend to have broken wings to lure potential or perceived predators away from a nest or territory. If an adult is observed displaying one or more of these behaviors, the immediate area can be quickly scanned (approximately $10m^2$ for 5 minutes) for a nest, however, extreme care should be taken to minimize disturbance to the birds and ensure a nest is not stepped on. A better approach, especially if a scope is available with a minimum magnification of 25x, is to carefully walk away to a spot approximately 20-30 meters away where the bird can be observed without disturbance. Typically, the bird will return to the nest within a few minutes and monitors can track it to the exact location of its nest. It is helpful to pick out a landmark within a few meters of the incubating bird. Monitors can use the landmark to help pinpoint the nest location. However, specific steps on how to locate and mark nests should be specified in a SSP. In general, birds should not be off the nest for more than 10 minutes, and caution should be used when temperatures exceed 80°F or if corvids, gulls or other potential nest predators are nearby.

Record nest-level attributes

Once a nest is located, monitors immediately document nest contents and record the location and GPS coordinates as a nest-level attribute (Table SOP 2.4 and SM 2: Nest/Brood Record Survey Form). Monitors back away from the nest to a safe distance (i.e., 20-30 m or the distance where the bird no longer reacts to the presence of monitors) to fill out the datasheet (or use a smartphone or tablet if using a web application). The first pair observed with a nest during the field season will be assigned the numeric value of "01". The corresponding nest will be assigned a letter value of "A," resulting in a NestID of "01A". Each additional pair with a nest are numbered in the order in which they are found, unless the pair renests. Piping plovers have a propensity to renest, especially if the nest is lost early in the breeding season. Assigning renests to particular birds or pairs can be challenging (see SOP 3 for additional guidance). If the nest is deemed to be a renest from a previous pair, then the nest receives the same numeric value, but a "B" is used to indicate the first renest (i.e., "C" and "D" are used for the second and third renest, respectively, if applicable).

Table SOP 2.4. List of nest-level attributes collected during each survey event. Attributes in bold are only entered once on the data sheet at the top of Nest/Brood Survey Form (SM2).

Attribute Name	Description	Required
Site Name	**Name of site**	**Y**
Nest ID	**Identifier for nest; Pair # coupled with letter; A=first nest, B=second nest, etc. Ex. 01A**	**Y**

GPS coordinates	**x- and y-coordinates for nest location (or brood if nest never found). Can be taken in decimal degrees or UTM.**	**Y**
Coordinate system	**Name or EPSG code of the coordinate reference system used when recording GPS coordinates.**	**Y**
Actual hatch date	**Actual hatch date - only enter if observe first chick emerging, otherwise NA**	**Y**
Estimated age	**Estimated age of chicks if nest was never found**	**Y**
Brood fate	**Fledged, Lost, Unknown**	**Y**
Band combinations for adult(s) 1 and 2	**Band combinations for pair if applicable (see *Reporting Banded Birds*)**	**N**
Exclosure type	**Standard (defined as circular structure with a 10' diameter and netting top) or Non-standard**	**N**
Exclosure description	**Exclosure description if not standard**	**N**
Date	Date of nest check	Y
Observer	Observer initials	Y
Nest status	Active, Hatched, Abandoned, Depredated, Flooded/Buried, Unknown Fate, Unknown Cause of Failure, Other Cause of Failure	Y
Number adults	Number of adults near or at the nest	Y
Number of eggs	Number of eggs (if observed; do not need to check every time)	Y
Number of chicks	Number of chicks observed; NA if unhatched	Y
Incubating adult observed	Yes or No	Y
Exclosure	Yes or No	Y
Comments	Comments especially on predator activity and evidence of nest/ brood loss	N

If the nest is difficult to locate, monitors write step-by-step instructions, draw a picture, or take photos to facilitate relocating the nest on subsequent surveys. This is particularly important if different individuals will be monitoring the same nest and because GPS devices often lack sufficient precision for accurate re-location (i.e., 5-10 m). Once a nest is located, the survey coordinator determines the survey frequency and additional management actions (Element 2). During each survey subsequent to nest discovery, monitors record the nest status, number of adults near the nest, number of eggs (if observed), number of chicks observed, presence (yes) or absence (no) of incubating adults, exclosure presence (yes) or absence (no) (note that the first "Yes" would be the day after the nest was exclosed), and any comments of note, especially on predator activity or evidence of nest loss (Table SOP 2.4). The number of eggs observed is recorded during each survey leading up to the establishment of a full clutch (generally four eggs unless a renest). Once a full clutch is observed, the number of eggs should be confirmed only once per week to minimize disturbance. Nest incubation typically occurs for 27 to 30 days after a full clutch is established, although eggs can occasionally hatch after a shorter or (more often) longer incubation period. Expected hatch dates should be estimated based on this information and nests are monitored daily around the approximate hatch date to record the actual hatching date, if possible. Monitors should only fill out the actual hatch date field if they observe the first chick emerging, or if it has just emerged, making notes in the comments field if pipping eggs are observed.

Monitors checking nests stay near the intertidal zone if possible, only entering nesting habitat when necessary to locate new nests or to determine the fate of the nest if incubation is not

observed. Disturbance is kept to a minimum and incubation should not be disrupted to count eggs during every nest check. As stated above, the number of eggs is confirmed weekly, unless there is reason to suspect that avian predators could be cued to the presence and location of unexclosed nests.

Nest status is recorded during every nest check and nest fate will be derived from the final nest status recorded. Darrah and Cohen (2017) developed the following categories for the PiperEx exclosure decision tool: hatched, abandoned (adult missing or potential abandonment), depredated, flooded/buried, unknown cause of failure, unknown fate, or other. See more detailed information about nest fate categories in SOP 3.

Once a nest hatches, piping plover chicks are monitored frequently (on a daily basis in areas allowing ORV use and/or that have high levels of other types of human disturbance; see Element 2 for survey frequency recommendations). Each brood is located and chicks are counted. Chicks will often stay with one or both parents and can move hundreds of meters from the original nest site within the first 24-48 hours after hatching. When chicks move between survey sites, communication with other agencies or landowners is often required to locate and manage the brood. Spotting scopes are helpful for locating chicks without disturbing them. If possible, monitors remain in, or immediately adjacent to, the intertidal zone, and move quickly but carefully through areas where adults and/or chicks are foraging.

If a brood is located without previously finding its nest, monitors assign the brood a new pair number (or designate it as a renest if determined by the survey coordinator). Monitors record GPS coordinates of the brood when first observed and estimate the age of the chicks (see SM 3). Monitors should keep in mind that chick development rates can differ greatly by site and broods, so caution is urged when aging chicks based on materials in this document alone. Broods found without a corresponding nest should be monitored and recorded until flight ≥15 m is observed, since the true hatch date and corresponding fledge date are unknown.

Monitors survey broods, at a minimum, until all chicks fledge (25 days after the hatch date or first flight for the purpose of measuring productivity). Brood fate is recorded as fledged, lost, or unknown (see definitions in SOP 3). Assessment of actual flight capability is required before many protections from disturbance can be discontinued.

Derive additional attributes

Many attributes can be derived (Table SOP 2.5) using the survey-level and nest-level attributes collected using this protocol. Therefore, these attributes are not explicitly recorded during surveys to minimize redundancy. PIPLweb can calculate these values using the survey data and provide summaries as output for reports.

Table SOP 2.5. Derived attributes calculated using all survey data in PIPLweb. This information is not entered into PIPLweb, but is available as output.

Attribute Name	Description
Pair ID	Identifier for breeding pair in any given year at a site; Two digit pair number
Unique Nest ID (across years)	Unique identifier for nest: Ex. PIPLCHNCIS01A2017 “AOU Code” & “Site Code” & “NestID” &“Year”

Date Found	Date nest (or brood) was found
Date Clutch Complete	Date of full clutch
Number eggs	Maximum number of eggs
Brood date	Date chicks found (if nest missed)
Hatch date	Date nest hatched; estimated unless hatch date is observed
Date incubation	Date incubation last observed
Number eggs hatched	Number of eggs hatched
Number eggs unhatched	Number of eggs that did not hatch
Estimated date nest loss	Estimated date nest was lost if actual date unknown; will calculate automatically from last active observed and failure dates
Nest fate	Final nest fate derived from nest status; Hatched, Abandoned, Depredated, Flooded/Buried, Unknown Fate, Unknown Cause of Failure, Other Cause of Failure - should match final nest status determination
Max Number of Chicks	Maximum number of chicks observed in brood
Date last young observed	Date of the last day chicks were observed
Fledge date	Date chicks fledged. Observed or actual
Number chicks fledged	Number of chicks that reach day 25 or first flight observed
Date zero chicks confirmed	Date when 0 chicks first observed

Reporting Banded Birds

Although reporting banded birds is not required in this protocol framework, resights of banded piping plovers have enormous value to research studies that are partitioning mortality in the annual cycle and analyzing environmental covariates. Monitors are urged to use a spotting scope with high resolution zoom lens (minimum 25x magnification) to identify alphanumeric tags. Reporting banded piping plovers (band combinations, date, location, and photos) —both nesting birds and transient migrants—should follow USFWS guidelines (https://www.fws.gov/northeast/pipingplover/report_bands.html). There are eight possible positions on the legs of a plover that can have a band as shown in Figure SOP 2.1. Pay special attention to the location and color of the bands on the plover. It is important to remember that the left leg is defined as the bird's left leg; i.e., if the bird were to look down, it would be its left side. Note that upper bands can be challenging to read, especially if they are not flags. Flags on birds that carry no lower leg bands are almost always coded with either two or three alphanumeric characters that must be reported to identify the bird's banding and resighting history. If a bird also has lower leg bands, then the flag is generally plain (no alphanumerics, only the color matters).

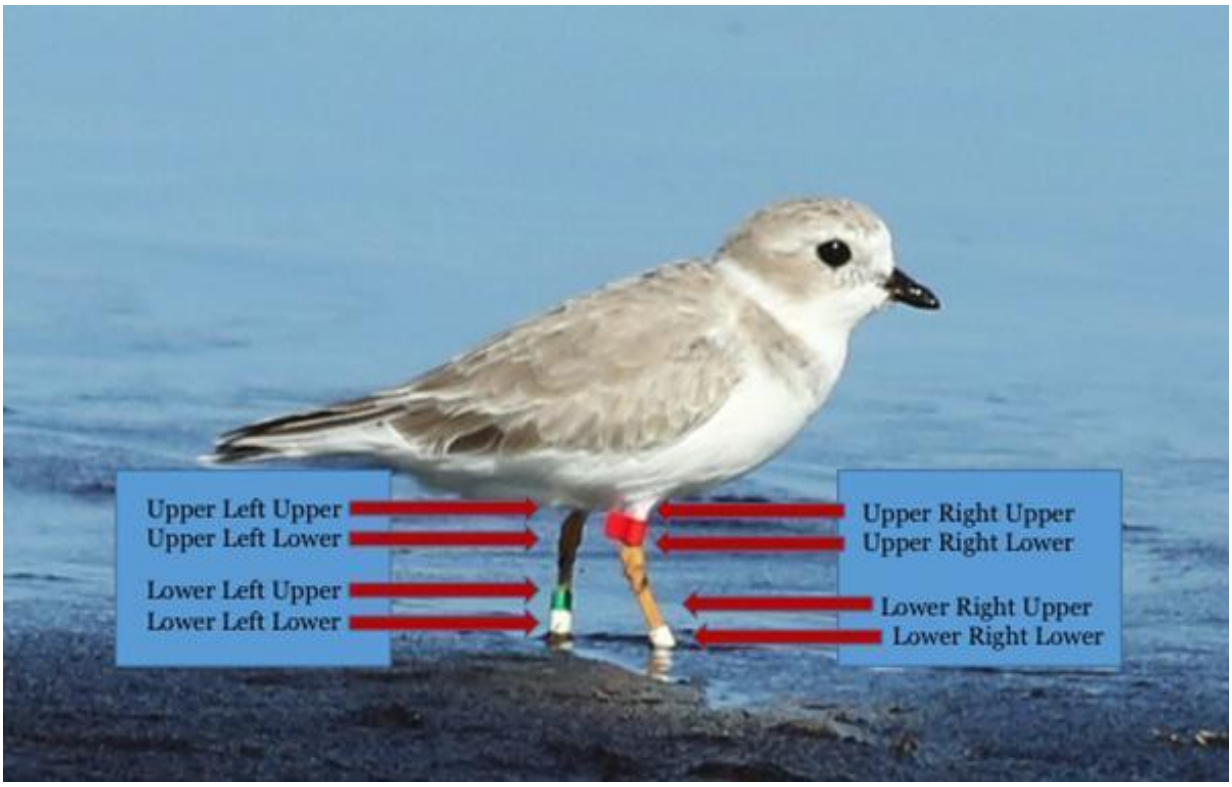


Figure SOP 2.1. Photo illustrating eight possible piping plover band positions (ULU, ULL,LLU,LLL:URU,URL,LRU,LRL). Original photo from Flickr Creative Commons, Dennis Cooke

References

Darrah AJ, Cohen JB. 2017. PiperEx Piping Plover Decision Support Tool, Version 1.0 User Instructions. State University of New York, College of Environmental Science and Forestry.

Elliott-Smith E, Haig SM. 2004. Piping Plover (*Charadrius melodus*), version 2.0. In The Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.2

SOP 3: Assigning Renests, Nest Status/Fate, and Brood Fate

Assigning Renests

Assigning a renest to a pair of unbanded birds is critically important for accurate estimates of productivity, but can be difficult at sites where nesting density and/or nest failure are high. Nest-level data from the banded Great Lakes piping plover population (1993 to 2010, Claassen et al. 2014) found that, overall, piping plovers replaced 49% of failed nests. The likelihood of renesting was especially high when nest loss occurred early in the previous incubation cycle and/or early in the season. Females may establish a "continuation nest" immediately after a nest loss if egg laying is imminent and the prior clutch was lost before completion. Although up to five renests have been observed, renesting propensity decreased with the number of previous nest attempts. Renests are more likely than first nests to have less than four eggs present (Houghton 2005), but this is not diagnostic.

Factors that should be considered when assigning renests include the time interval between the loss of one nest and initiation of another, and the location of the potential renest. Claassen et al. 2014 found a mean observed renesting interval of 5.9 days, but the interval was shorter (~4 days) when nest failure occurred shortly after incubation, and longer (~8 days) when nest failure occurred during the middle of the expected incubation period. Renesting propensity was also related to the cause of failure, with flooding losses most likely to be replaced, followed by predation, abandonment, and mate loss. Renesting intervals were ~3 days longer for birds that renested with a new mate (and 80 percent of mate changes occurred after the death of the first mate).

Most renests are situated relatively close to the location of the previous nest. Seventy-nine percent of detected renesting attempts at Great Lakes Sleeping Bear Dune Lakeshore (2006 to 2017) occurred within 300m of the previous nest (F. Cuthbert, University of Minnesota, personal communication). Field maps with the locations of each nest and nest chronology displays (see Figure 5.2) can assist with assigning pairs to renests. Monitors should do their best to gather these data; however, the final assignment should be done by the survey coordinator. Pairs that lose nests early in the season and do not renest, and pairs that arrive at a site and establish nests late the season, should be considered in estimates of the site's piping plover abundance and productivity. However, these pairs should also be brought to the attention of monitors at adjacent sites and the state coordinator. If there is evidence that the pair is also tallied at another site, the state coordinator may determine that these pairs should only be included once in the statewide total season estimate (typically, state reports use footnotes to denote pairs tallied at more than one site, but only once in the statewide total).

If a nest is determined to be a renest of an already established pair, the pair ID stays the same as earlier attempts and the letter changes according to the renest attempt number. For example, the first pair observed with a nest is assigned the numeric value of "01." The first nest attempt is assigned a letter value of "A," resulting in a NestID of "01A". See below for example:

- First Nest: 01A
- Second Nest (First Renest): 01B
- Third Nest (Second Renest): 01C

Assigning Nest Status and Fates

The nest status is recorded during each nest check survey until the nest hatches. Once hatched, monitors only need to record the number of chicks observed. The final nest fate is derived from the last recorded nest status. The nest status options are defined below and match the final nest fate with the exception of an active nest. If a nest has a partial depredation or flooding event, but is still active, the nest status should be recorded as active and notes should be made in the comments section for any evidence as to why the decrease in eggs occurred. Currently, PiperEx definitions (Darrah and Cohen 2017) are used to assign nest fates. These definitions can be revised if there is agreement among cooperators in consultation with data analysts. Note that collaborators are working on how to best incorporate confidence in the determination of nest fates.

- Active: Active indicates that eggs are present and the nest is being attended by an adult, or if no adult is present that there is additional evidence that the nest has not been abandoned (e.g., fresh plover tracks).
- Hatched: A nest is determined as hatched when at least one egg fully hatches and produces a live chick. The newly hatched chick or brood should be observed nearby, or eggs are missing, and it is after the expected hatch date with no evidence of nest failure.
- Abandoned: Eggs remain in the nest with no plover tracks, or nest is lightly sanded over (as a result of adult absence rather than due to a storm or unusually strong winds). Supporting evidence includes known mortality of one or both adults and absence of adults during at least the last two (or more) checks during which sustained monitoring from a distance failed to detect nest attendance by previously attentive adults. Provisional determinations may warrant additional monitoring prior to confirmation of abandonment.
- Depredated: Predation of the nest as determined by the following criteria: eggs broken, or eggs missing plus presence of predator tracks of scat/pellets at the nest; or a lack of direct evidence other than eggs missing but other factors such as flooding or abandonment were ruled out.
- Flooded/Buried: Nest is completely or partially washed out following heavy rain or high tides, and must be determined by a person already familiar with the nest's location; or nest completely or partially sanded in following a storm or unusually strong winds. Note that plovers may excavate and resume incubation of eggs that have been sanded in, so we recommend continued monitoring before making this determination.
- Other Cause of Failure: Use this code to indicate known sources of nest failure that do not fit in the other failure categories (e.g., eggs trampled by pedestrians).
- Unknown Cause of Failure: Eggs are missing and nest is unlikely to have hatched based on estimated nest age, but cause cannot be assigned based on the criteria listed for predation, abandonment, and flooding/weather.
- Unknown fate: When the fate of the nest is completely unknown, meaning that the eggs could have hatched or the nest could have failed. Use this code if uncertain whether a nest has failed or hatched. Eggs are missing but evidence is lacking to determine the cause.

Nest fate definitions may be revised in future versions of the protocol to improve modeling and decision tools in consultation with data and decision analysts. Monitors should note the evidence used to determine the fate observed in the field, including recent weather events, predator activity (tracks or other), or human related disturbances.

Assigning Brood Fates

The brood fate must be recorded as fledged, lost, or unknown (definitions below):

- Fledged: At least one chick is observed on or after the 25th day since hatch, or at least one chick is observed in flight prior to the 25th day since hatch.
- Lost: No chicks are observed before the 25th day since hatch and the presumed lost chicks are not observed during the subsequent three consecutive surveys.
- Unknown: Chicks are observed before the 25th day since hatch, but are never directly observed in flight, and no survey is conducted on the 25th day since hatch or later, therefore fledged chicks cannot be confirmed.

References

Claassen AH, Arnold TW, Roche EA, Saunders SP, Cuthbert FJ. 2014. Factors influencing nest survival and renesting by Piping Plovers in the Great Lakes region. The Condor 116: 394-407. http://www.bioone.org/doi/abs/10.1650/CONDOR-13-146.1

Darrah AJ, Cohen JB. 2017. PiperEx Piping Plover Decision Support Tool, Version 1.0 User Instructions. State University of New York, College of Environmental Science and Forestry.

Houghton LM. 2005. Piping plover population dynamics and effects of beach management practices on piping plovers at West Hampton Dunes and Westhampton Beach, New York. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg VA. https://www.researchgate.net/publication/267952938_Population_Dynamics_of_Piping_Plovers_Charadrius_melodus_on_the_Missouri_River

SOP 4: Data Management

Database description

The Plover Inventory and Productivity Library (PIPLweb) is an online data portal for storing, managing, and generating reports from pair, nest, and brood data recorded during regular surveys throughout a breeding season. PIPLweb is an ASP.NET web application backed by a Microsoft SQL Server relational database. End users with appropriate permission can log in to PIPLweb to manually enter and edit individual nest and brood data at their assigned site(s), or perform a bulk data import by uploading a formatted spreadsheet or Comma Separated Values (.csv) file. The system also has an integrated reporting engine, built on the R statistical programming language and software environment. For those sites accessible by an end user, PIPLweb can produce an Adobe Portable Document Format (PDF) fact sheet detailing nest and brood outcomes for any year with available data. Along with basic summary metrics (nesting attempts, unique breeding pairs, occurrence of various possible fates, etc.), generated fact sheets include estimates of productivity, modeled nest and brood survival rates, survival trends charted over the prior decade (if available), and maps illustrating the spatial distribution of nests. Administrative-level functions of PIPLweb include management of user accounts and data access permissions.

The database is organized at the highest level by site and year, referred to in PIPLweb as an annual survey record (ASR). A site is the minimum area on which a piping plover survey was performed (see SOP 1). When a new site is setup in PIPLweb, the site is tied to other geographical units, including refuge/management area, state, and recovery unit, enabling PIPLweb users with appropriate access to synthesize data at multiple scales for analysis and reporting.

Tables SOP 2.1–2.5 list the specific survey attributes stored in the database.

Data access and roles

PIPLweb features and data will only be accessible with an active user account. Registration of a new account will require a current email address, a password, and a list of geographical units (sites/states/recovery units) for which the user is requesting data access. Upon registration, the new account will undergo a two-step verification process. First, an email will be sent to the registered email address containing a link to a verification page in PIPLweb; by following this link, the registrant will confirm their ability to access the registered email address and that registration of the address with PIPLweb was a deliberate action. Second, the system will notify PIPLweb administrators for each requested location that a new account has been created. Administrators can then use the registered email address to contact the registrant, if necessary, and determine the appropriate user role. Finally, administrators can use a user management panel

in PIPLweb to activate the requested account and assign location-specific access roles for the new user. Potential user roles for each location include:

- basic user (read-only access),
- data entry operator,
- editor (including data deletion),
- reviewer (QA/QC),
- coordinator (state or recovery), and
- administrator.

The user management panel also allows PIPLweb administrators to temporarily deactivate or permanently delete an existing user account and to manage the roles that each account has been granted.

Various data access and sharing options are available to users. Rules for access and sharing were adopted and modified from the Avian Knowledge Network (http://www.avianknowledge.net/). Access to all data is controlled by the data owner and limited to registered users of PIPLweb (Table SOP 4.1); however, each State coordinator will have read-only access to all data within his/her respective state, and the piping plover recovery coordinator will have read-only access to all data. Additionally, the level of data sharing available to the data owner may be dependent upon the organization the owner represents. A non-NWRS dataset will typically belong to the survey coordinator for that site and data sharing will be determined by this person. NWRS datasets will be the responsibility of each refuge's survey coordinator; however, data access (read-only) will be allowed by other USFWS personnel. NWRS users will be required to upload annual reports to ServCat. Non-NWRS users will be asked to share their annual reports with state and recovery coordinators.

Table SOP 4.1. Levels of data access and sharing available to PIPLweb users. Rules were adopted and modified from the Avian Knowledge Network access levels. Data owners designate their preferred access level upon adding data to PIPLweb.

Access Level	Description of Data Access and Sharing Rules
Level 1	General information about dataset available to registered users of PIPLweb. Direct access to the primary dataset is limited to the data owner(s). The state coordinator and piping plover recovery coordinator have read-only access to the data.
Level 2	Data can be used in predefined visualizations and summary tools (e.g., maps and graphs). General information about dataset available to registered users of PIPLweb. Direct access to the primary dataset is limited to the data owner(s). The state coordinator and piping plover recovery coordinator have read-only access to the data.
Level 3	Data can be used in predefined visualizations and summary tools (e.g., maps and graphs). General information about dataset available to registered users of PIPLweb. The complete dataset is available to download upon approval by the data owner. The data owner may set terms for cooperation (e.g., acknowledgement or co-authorship in publications). The state coordinator and piping plover recovery coordinator have read-only access to the data.
Level 4	Data can be used in predefined visualizations and summary tools (e.g., maps and graphs) and are fully available for download to registered users of PIPLweb. The state coordinator and piping plover recovery coordinator have read-only access to the data.

Data entry, verification, and editing

All data collected in the field or otherwise must undergo quality assurance/quality control (QAQC) procedures to ensure the accuracy and completeness of the data. Data collectors should proofread all field datasheets the same day data were collected. Timeliness of data review increases the likelihood of correcting errors that may not be fixable if QAQC procedures are postponed until the end of the field season. Initial data review should be performed by the original data collector, and followed by additional review(s) by at least one other person. PIPLweb users will be asked to certify that their data have undergone satisfactory QAQC review.

Getting started

A PIPLweb user guide explaining application features and common use cases will be maintained by the application developers. The guide provides additional background information not included here and step-by-step instructions for data entry, editing, verification, and report

generation. Registered users can find the latest version of the user guide within the PIPLweb help menu.

Before survey data can be entered into PIPLweb for a site, the site must be set up by an NWRS regional data manager or by the USGS PIPLweb administration team (piplweb@usgs.gov). The information needed to set up a site includes:

- site name,
- landowner(s),
- managing agency,
- location description (and, if possible, a geospatial boundary file),
- state, and
- point of contact.

If applicable, cooperators should also note the use of a site-specific protocol, or describe any deviations from this protocol that may lead to misinterpretation of survey data collected at this site.

Reporting

PIPLweb has the ability to automatically generate a standard annual summary report at multiple geographic scales. The purpose of this report is to supplement common reporting metrics (e.g., the number of unique breeding pairs and the standard productivity estimate of chicks fledged per breeding pair) with additional summary data, spatial and historical context, and estimated nest and brood survival rates that can offer a finer view of overall population stability in areas of interest to decision makers. Results are independently calculated and reported for both nests and broods.

To estimate daily survival rates for nests and broods in a given area, PIPLweb uses the Dinsmore et al. (2002) nest survival model in RMark (Laake 2013), a package that makes features of the FORTRAN-based Program Mark software accessible to users of R. The model uses previously entered data from each nest record to estimate daily nest and brood survival rates, or the likelihood that any given nest or brood will survive each day. Cumulative survival rates across the entire season are then calculated by raising the daily survival rates by a period of 34 days for nests and 25 days for broods. These rates are translated into nest success (the percent of nests from which at least one egg hatched) and brood success (the percentage of broods from which at least one chick fledged). All metrics produced by the model are accompanied by 95% confidence intervals estimated by using the Delta method (Seber 1982, Powell 2007).

Metadata

As mentioned in Element 4, a regional protocol-level metadata record that describes the general purpose and contents of the database will be maintained and made available in PIPLweb. The applicability of this record to survey data will assume typical collection procedures and conditions as outlined in this protocol. Deviations from this protocol, such as when following a site-specific protocol or because of unexpected site conditions (e.g. extreme weather), should be noted in either the site description or the ASR note field within PIPLweb. Consistent recording of such metadata will contribute to the long-term usefulness of the database in reporting and analysis.

Supplemental Materials (SM)

SM 1: Processing Collected Materials

Dead piping plovers (adults or chicks) or crushed/cracked eggs suspected to be possible evidence of illegal take must be immediately reported by monitors to the nearest USFWS Office of Law Enforcement (OLE; https://www.fws.gov/le/), unless OLE has pre-established other local communication procedures (e.g., reporting via local Refuge Officers, State environmental law enforcement officials). Monitors should follow OLE's standard procedures or case-specific directions provided for collecting and preserving evidence (e.g., scene and specimen photographs prior to collection; note-taking; handling, transport, and preservation of birds or eggs). Procedures described below pertain to salvage where there is absolutely no evidence of illegal take or (in cases where there is any doubt) following confirmation from OLE that the carcass and eggs are not needed for evidence.

In accordance with 50 CFR 17.21 and 17.31, employees or agents of the USFWS, other Federal land management agencies (e.g., National Park Service), or a State conservation agency who are designated by their agency for such purposes may, when acting in the course of official duties, salvage a dead piping plover specimen that may be useful for scientific study. Situation-specific planning is almost always needed to accomplish specific scientific inquiries, and field biologists should coordinate these activities with a State or USFWS endangered species biologist.

Unless the cause of death is known with a high degree of certainty, plover carcasses should be considered for submission by a USFWS biologist to the National Wildlife Health Center (NWHC) in Madison, Wisconsin for necropsy. State wildlife agency biologists may also submit specimens to NWHC. When a monitor from another organization is authorized to collect dead specimens and ship them to NWHC, a USFWS or State agency biologist should be the official submitter. Fresh carcasses discovered on a Sunday, Monday, Tuesday, or Wednesday should be carefully wrapped in plastic and refrigerated (not frozen) pending prompt discussion with NWHC (608-270-2400) regarding the utility and feasibility of shipping specimens suitable for histopathology. NWHC collects tissue samples and gizzard contents that are useful for other studies when it necropsies piping plovers. When timing prevents shipping of unfrozen carcasses, directions for freezing and shipping are provided by NWHC. A copy of the NWHC submission form should also be sent via email to the USFWS piping plover recovery coordinator at the same time or as soon thereafter. If a dead plover in suitable condition for necropsy is not submitted to NWHC, the survey coordinator should contact the piping plover recovery coordinator for information about how to collect these samples and where to send them.

At the discretion of the field station, dead piping plovers may also be submitted to veterinary diagnostic laboratories other than NWHC for necropsy and disease testing. In such cases, the submitter should notify the local USFWS endangered species biologist and the Atlantic Coast piping plover recovery coordinator in case they are aware of possible related cases. The submitter should also forward diagnostic updates and final reports to the local USFWS endangered species biologist and the Atlantic Coast piping plover recovery coordinator.

Eggs deemed unhatched or abandoned should never be removed from a nest if there is any reasonable chance they may hatch. In the case of unhatched eggs from a partially hatched clutch, eggs should not be collected until at least 72 hours after the known hatch date of the other eggs. The recovery plan (USFWS 1996, page 92) states that "full clutches should not be collected unless it is known that 40 or more days have elapsed since the last egg was laid and the adult is no longer attending to the nest. Collection of abandoned clutches should only be done after substantial monitoring over at least five days has established that the adults are not going to return *and* the on-site biologist has conferred with a State or U.S. Fish and Wildlife Service endangered species biologist." A few cases of eggs hatching after more than 40 days of incubation have been reported in recent years. Therefore, monitors should confer with a State or USFWS biologist before removing "overdue" clutches to be sure that salvage is not premature and to formulate a plan for gleaning useful information (e.g., whether the eggs are fertile and the stage when development was arrested). All information regarding egg, chick, or adult plover collection activities should be included in annual site reports

SM 2: Survey Datasheets (Survey Record Form)

SURVEY RECORD						
Site	**Date**	**# Monitors**	**Start Time**	**End Time**	**# Total Adults Observed**	**Notes**

SM 2: Survey Datasheets (Nest/Brood Record Survey Form – Front)

NEST RECORD				
Site Name:	**Nest ID[1]:**	**X-coord[2]:**	**Y-coord[3]:**	**Coordinate system[4]:**
Actual Hatch Date[5]:	**Est Age of Chicks[6]:**	**Brood Fate[7]:** Fledged Lost Unknown		
Adult 1 Band Combo[8]:	**Adult 2 Band Combo:**			
If exclosed, Type[9]: Standard or Non-Standard	**Describe non-standard exclosure:**			

NEST/BROOD CHECK DATA								
Date[10]	**Observer Initials**	**Nest Status[11]**	**# Adults**	**# Eggs**	**# Chicks**	**Inc.[12] (Y/N)**	**Exc.[13] (Y/N)**	**Comments:**

SM 2: Survey Datasheets (Nest/Brood Record Survey Form – Back)

Date[10]	Observer Initials	Nest Status[11]	# Adults	# Eggs	# Chicks	Inc.[12] (Y/N)	Exc.[13] (Y/N)	Comments:

[1] **Nest ID**: Pair ID (01-99) and nesting attempt; A=1st nest, B=2nd etc.
[2]**X-coord**: X-coordinate in decimal degrees (longitude) or Easting if using UTM of nest or brood
[3] **Y-coord**: Y-coordinate in decimal degrees (latitude) or Northing if using UTM
[4]**Coordinate system:** WGS 1984 (or EPSG:4326), WGS 84 / UTM zone 18S (or EPSG:32618), etc.
[5]**Actual Hatch Date:** Record date if pipping or newly hatched chicks in bowl
[6]**Est Age of Chicks:** If nest never found, estimate age of chicks using SM3
[7] **Brood fate**: Fledged (>25 days or sustained flight); Lost, Unknown (See SOP2 for more details)
[8]**Adult Band Combo:** Record location and color of each flag/band (ULU, ULL, LLU, LLL:URU,URL,LRU, LRL) – see SOP2 for definitions.
[9]**Exclosure**: Standard is a circular structure with a 10' diameter and netting top
[10]**Date:** in format of YYYYMMDD
[11]**Nest Status**: 1. Active, 2. Hatched, 3. Abandoned, 4. Depredated, 5. Flooded/Buried, 6. Unknown Failure, 7. Unknown Fate, 8. Other Cause of Failure
[12]**Inc**: Yes for presence of incubating adult and No for absence (not observed)
[13]**Exc**: Yes for presence of exclosure and No for absence

SM 3: Piping Plover Chick Aging Guidelines

These guidelines are taken from the U.S. Army Corps of Engineers Omaha District

Age Class 1-5 days

4 Days Old

Plover chicks in Age Class 1-5 Days are distinguished by:

A. entirely downy

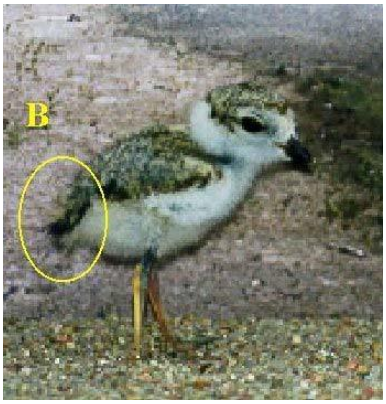
B. no sign of tail or wings at a distance

C. as tall as adult's belly

D. often brooded by an adult

E. quite small in size, resembles a marshmallow with two toothpicks protruding out of the bottom.

Age Class 6-10 days



6 Days Old

Plover chicks in Age Class 6-10 Days are distinguished by:

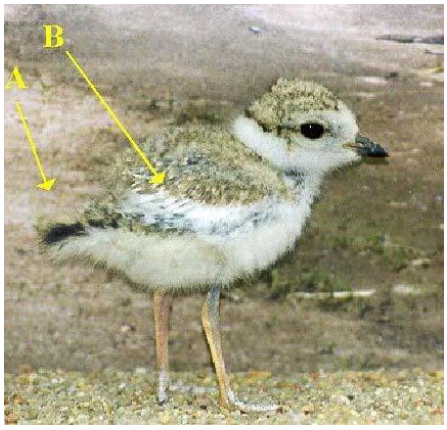
A. feather development

B. small downy tail (B in top photo)

C. wings still purely downy (C in bottom photo)

D. at age 10 days, chick is about 1/3 the size of an adult

Age Class 11-15 days



11 Days Old

Plover chicks in Age Class 11-15 Days are distinguished by:

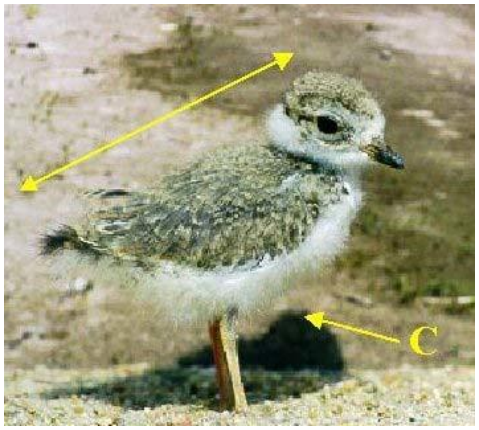
A. more defined tail but still downy

B. feather tips of the primaries may be seen

C. upper body color still mottled

D. at age 15 days, chick is about 1/2 the size of an adult

Age Class 16-20 days



18 Days Old

Plover chicks in Age Class 16-20 Days are distinguished by:

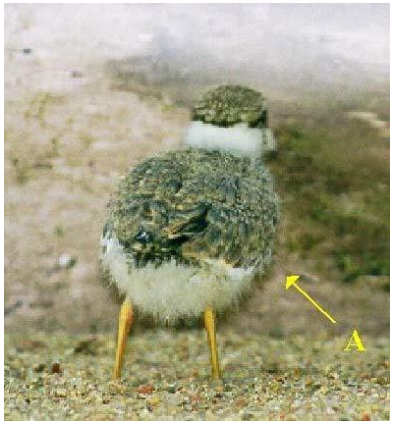
A. less compact shape, longer profile from head to tail (see top photo)

B. mottled color begins to fade

C. appears darker with smooth contour feathers over entire upper body

D. at age 18 days, chick is about 2/3 the size of an adult

Age Class 21-24 days



21 Days Old

Plover chicks in Age Class 21-24 Days are distinguished by:

A. primaries have grown almost to the length of the tail

B. defined tail (see top photo)

C. sleeker body and sleeker head

D. close to adult height and size, but not fully feathered

E. cannot fly

Age Class 25+ days

25+ Days Old

Fledged Plovers are distinguished by:

A. fully developed primary feathers

B. white under parts fully feathered, very little fuzzy down still visible

C. close to adult height and size

D. capable of sustained flight

E. often seen without adult

Piping Plover Age Groups

U.S. Army Corps
of Engineers
Omaha District

Piping Plover Aging Guidelines

4 day old

6 day old

11 day old

18 day old

21 day old

24+ day old

1-5 Day Age Class

•No visible wing or tail.
•Clearly defined black line between upper parts and lower parts.
•As tall as adult's belly.
•Often lies motionless when alarmed.

6-10 Day Age Class

•Downy tail form emerging.
•Black line fading due to emerging feathers.
•Approx. 1/3 size of adult at 10 days.
•Very adept at feeding and mobile on feet.

11-15 Day Age Class

•Feather shafts emerging on wing.
•Emerging contour feather shafts give bird a scaly appearance.
•Looks "chunky" as bird fills out.
•Rarely lies motionless.

16-20 Day Age Class

•Downy head.
•Contour feathers noticeably developed giving bird a rough fuzzy appearance.
•Approx. 1/2 the size of adult at 16 days.
•Less compact, longer profile from head to tail.

21-24 Day Age Class

•Black wing tips and tail feathers noticeably protruding.
•Upper parts nearly fully feathered.
•Almost adult height by 22 days.
•Body begins to look sleek. Will take short hop flights.

24 + Day Age Class

•Fully developed primary feathers.
•White underparts fully feathered, very little fuzzy down still visible.
•Capable of sustained flight.
•Often seen without adult.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