Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars

2009 Progress Report

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1. Introduction

The Central Platte River Valley (CPRV) is a resource area of continental significance to a variety of migratory birds. Habitats and foods provided in this area are important for migration and successful breeding in many species, including waterfowl, shorebirds, and passerines. The CPRV also provides breeding habitat for a variety of migratory birds, including Federally endangered interior least terns (*Sternula antillarum athalassos*) and threatened piping plovers (*Charadrius melodus*). Both of these species nest throughout the northern Great Plains, co-occurring on many large mid-continent river systems where they nest in loosely organized mixed colonies.

Prior to human alteration, the Platte River probably supported nesting least terns and piping plovers on midchannel sandbars that were largely devoid of vegetation due to high spring flows. Modification of the river's flow pattern has lowered the frequency and intensity of scouring events, resulting in vegetation encroachment and stabilization of sandbars. This has led to declining quality and abundance of unvegetated sand nesting habitat favored by least terns and piping plovers. Foraging habitat for piping plovers, consisting of sparsely vegetated moist or dry sand with high invertebrate production, has probably also declined in quality and abundance. However, least terns forage on small fish in side channels, sloughs, tributaries, shallow-water habitats adjacent to sandbars, and in the main channel. Therefore, changing quality and abundance of least tern foraging habitat is probably more linked to Platte River flow and water quality than to vegetation dynamics on midchannel sandbars.

A substantial sand and gravel excavation industry has developed in the Platte River floodplain, resulting in numerous sandpits in close proximity to the river channel. These sandpits often contain abundant unvegetated sand that can provide suitable nesting habitat for least terns and piping plovers. Sandpits also often contain impounded water and moist sand that can provide suitable foraging habitat for least terns and piping plovers. This emergence of suitable habitat features on sandpits in conjunction with declining quality of riverine habitat features has substantially altered the distribution of nesting least terns and piping plovers. The majority of nesting effort in the CPRV in recent years has occurred on sandpits, although the incidence of nesting on sandbars was higher in 2007 and 2008 than in 2006 and prior years.

Adult least terns and piping plovers differ in their means of obtaining food and in the degree of parental care offered to young. Piping plovers produce precocial young that forage for invertebrates alongside adults. Thus, breeding habitats must contain nesting areas and foraging habitat to support both adults and flightless young. However, adult piping plovers may be more flexible in their use of foraging habitat during courtship and nesting, exploiting high-quality foraging areas within flight distance of nesting territories. Least terns produce semi-altricial young that are incapable of acquiring food and are provisioned by adults carrying fish back to nesting colonies. Consequently, adult least terns are not constrained to foraging within their nesting colonies during brood-rearing, and can select the highest quality foraging habitats within profitable traveling distance of their nest sites. These differences in development of young and use of foraging habitats may have consequences for management of nesting habitats, particularly where single management strategies are intended to have multi-species benefits.

Least terns and piping plovers in the CPRV nest primarily in sandpit habitats, possibly due to the greater abundance of unvegetated sand in this habitat type than on riverine sandbars. There is substantial management interest in restoring a wide variety of habitat conditions that were present prior to human alteration. In the case of least tern and piping plover nesting habitats, the principal means of achieving this goal is vegetation removal on midchannel sandbars. Although it is known that least terns and piping plovers favor sandy substrates with sparse to absent vegetation for nesting, the extent to which these habitats must be linked to suitable foraging habitat is not known, as is the suite of features that define suitable foraging habitat.

Linkages between foraging and nesting habitat are also important to understanding the relative role and value of nesting habitats in supporting productive least tern and piping plover populations. For example, if birds nesting in both of the principal breeding habitats (sandpits and sandbars) tend to prefer feeding in only one of these habitats, then management efforts might focus on improving access to foods in the lesser-used foraging habitat, or might focus nesting habitat conservation on habitats closely linked to foraging habitat.

2. Objectives

This study addresses 4 specific objectives that will collectively contribute to understanding of foraging habitat use by adult least terns and piping plovers in the CPRV:

i. Movements

Quantify frequency and distance of movements away from nesting colonies for least terns and piping plovers nesting in sandpit and riverine sandbar habitats.

ii. Time Allocation

Quantify time allocation to foraging and foraging success rate for adult least terns and piping plovers in sandpit and riverine habitats.

iii. Foraging Habitat

Quantify features of foraging habitats used by adult least terns and piping plovers during nesting and brood rearing in sandpit and riverine habitats.

iv. Productivity

Evaluate linkages between indices of productivity and measures of foraging effort for adult least terns and piping plovers nesting in sandpit and riverine sandbar habitats.

3. Study Areas

This study addresses the population of interior least terns and piping plovers that nests within the CPRV, defined as a 3.5-mile buffer of the Platte River between Lexington and Chapman, Nebraska. Within this area, the Platte River Recovery Implementation Program (PRRIP) monitored least tern and piping plover productivity on 28 sites during 2007, including 12 sandbar and 16 sandpit sites. However, we focused our efforts on sites where the highest numbers of least tern and piping plover nests occurred. Based on recent PRRIP monitoring data, we selected 3 sandpits (Bluehole, Johnson, and Lexington) and 2 sandbars (Dinan Tract and Dipple Tract) as focal areas for 2009. We also sought out other potential sites for inclusion by 1) accompanying PRRIP staff during airboat surveys of the river in June, 2) conducting canoe surveys of the river in May and June, and 3) observing movements and distribution of birds during behavioral observations on the river. Because none of these approaches revealed additional concentrations of nesting birds, our work in nesting colonies was limited to the 5 pre-selected focal areas.

4. Methods

4.1. Movements

Our goal for collecting movement data was to estimate timing, frequency, and distance moved by birds beyond their nesting colony. We collected movement data using radiotelemetry with adult birds. We trapped birds on nests, with the goal of deploying radios on 8 birds per species on sandpits and 8 birds per species on sandbars. Our primary method of trapping birds was remote-triggered bow nets, which we deployed early or late in the day or when air temperature was between 15°C (60°F) and 32°C (90°F), wind was minimal or not disrupting nests, and there was no precipitation. All trapping took place after at least 1 week of incubation but prior to pipping of eggs. Trapping attempts were aborted if they exceeded 20 minutes (departure of the bird from the nest to completion of the trap attempt). Prior to trap deployment, we exchanged eggs from targeted nests with artificial eggs to reduce potential risk of injury to eggs; real eggs were stored in a small plastic container cushioned with synthetic batting. Once captured, we moved birds to a nearby area away from the colony and other nesting birds. Birds were weighed with a Pesola type spring scale, bill and culmen depth were measured with calipers, and natural wing chord was measured using a wing rule.

We banded each adult least tern with a numbered stainless steel band (size 1A) on the lower leg and up to three celluloid bands (XCL) on the upper leg (two bands per leg). However, birds receiving transmitters had the transmitter attached to a numbered aluminum band that was placed on the upper rather than the lower leg. We banded each adult piping plover with a numbered USGS aluminum band (size 1A) on the upper leg, a light blue Darvic short flag on the opposite upper leg, and up to two Darvic color bands on each of the lower legs. We coordinated band and color combinations with other agencies and research entities (e.g., Platte River Tern and Plover Conservation Partnership) to ensure consistency and prevent duplicating color combinations. We released birds adjacent to the colony within 10 minutes of capture, and observed them to document resumption of normal behaviors (e.g., incubation or foraging).

We used Holohil BD-2 transmitters (~1.1g) for both least terns and piping plovers. For terns, the transmitter was secured to the numbered aluminum leg band using dental floss. We attached the leg band/transmitter package to one of the upper legs. We applied 1-3 smears of indelible marker under the wings, on the side of the breast, or near the vent of radiomarked terns to facilitate identification of radioed birds during behavioral observations. For piping plovers, we glued the transmitter to feathers in the intrascapular region.

We monitored presence of radiomarked birds using automated dataloggers (ATS R4500S with one or more Yagi antennas), which were programmed to scan all deployed frequencies at a preset interval (every 5-10 minutes). All equipment (loggers, receivers, antenna) was housed in blinds or hidden so as not to provide a perch for raptors or other birds. Dataloggers were positioned strategically to provide meaningful records of bird use of target habitats (e.g., in colonies where birds are radiomarked, adjacent to potential foraging areas). We positioned blinds so that visits to download data or replace batteries did not disturb nesting or foraging birds; we conducted these maintenance visits in conjunction with other fieldwork.

4.2. Behavior

We observed behaviors of adult least terns and piping plovers with the principal goal of quantifying time allocation to foraging. Data included measures of timing, frequency, and location of foraging, capture success, and frequency of prey delivery to colonies for least terns. We collected these data from portable blinds or other inconspicuous locations, including blinds established to protect telemetry dataloggers. Observation points included "colony sites", which were within the focal sandpits and sandbars, as well as "off-colony sites" which were near the fixed telemetry stations.

We observed behaviors using binoculars or spotting scopes during 4-hr periods between sunrise and sunset (0600-1000, 1200-1600, and 1700-2100h). We divided the field season into 6 2-week blocks, with the goal of obtaining 3hr of observation at each colony and foraging site for each of the 4-hr periods during each 2-week block.

Our data collection approach differed between terns and plovers due to differences between the species in foraging ecology and location. For plovers, we attempted to follow focal adults and/or broods, whereas for terns we focused on foraging habitats rather than following individuals. A detailed behavior data collection protocol is provided as Appendix 1.

4.3. Foraging Habitat

We quantified features of habitat at locations where successful foraging by least terns or piping plovers was observed during behavioral observations. At least tern foraging locations, we recorded aquatic habitat variables, including water depth, temperature, turbidity, and flow rate. At piping plover foraging locations, we collected a suite of terrestrial habitat variables at 1-m^2 quadrats centered on the foraging location. For both least tern and piping plover foraging locations, we also collected data at two paired random points within 75m of the foraging location. We constrained random points to be within the same land cover classification (e.g, wet sand) as the foraging location. A detailed terrestrial habitat data collection protocol is provided as Appendix 2.

Our initial plan, as reflected in our fish sampling protocol (Appendix 3), was to sample sandpit ponds using minnow traps and sample riverine sites using mini-Missouri hand trawls. This plan was based on our expectation that hand trawls would be difficult to deploy in sandpit ponds. After further discussion and field evaluation, we found that sandpit ponds could be effectively sampled with hand trawls by three technicians (one deploying the net using a canoe and the other two drawing the net toward shore). Accordingly, we discontinued minnow trap sampling and collected all fish data on both river and sandpit sites using hand trawls.

We deployed trawls at locations where terns were observed successfully foraging, drawing the net horizontally through the surface of the water column for a distance of 100m. All fish caught were identified to species, measured, and counted. Our goal was to measure forage abundance once per week at each location where behavioral data were collected. We also accompanied the Platte River Program fish monitoring crew during their standard annual river sampling, and deployed our trawls at locations where Program monitoring was conducted. A detailed fish sampling protocol is provided as Appendix 3.

We used sticky sticks to measure surficial invertebrate abundance at locations where piping plover adults or broods were observed successfully foraging. Identical methods were used in both sandpit and sandbar sites. The sampling unit consisted of 4 paint stir-sticks (2 placed vertically and 2 placed horizontally) covered with Tanglefoot® insect trap coating. We deployed the traps for 30-minute intervals, after which all invertebrates >3mm in size were counted. We attempted to measure forage abundance 2-3 times per week for each pair of plovers. A detailed invertebrate sampling protocol is provided as Appendix 4.

For both terns and plovers, we spot-mapped locations at which foraging birds were observed using paper maps or GPS units with mapping capability (Trimble GeoXT). Each foraging location was recorded in a shapefile and the UTM coordinates were entered into a master database. These data include foraging events observed during behavior data collection sessions as well as opportunistic observations of foraging birds.

4.4. Productivity

Our goal was to quantify nest and chick survival for both target habitats (sandpits and sandbars). We searched suitable nesting habitat in each study site at approximately 2-3 day intervals, and monitored nests to determine fate. We classified each nests as Known Successful, Probable Successful, Known Failure, Probable Failure, or Unknown based on evidence at the nest site. For successful nests, we captured hatched young by hand and applied a unique combination of color bands. Tern chicks were marked with 3 celluloid color bands, and surviving chicks were recaptured at ~15 days of age to apply numbered metal leg bands. Plover chicks were marked with a numbered aluminum 1A band on the upper leg, a light blue Darvic short flag on the opposite upper leg, and 4 Darvic color bands on the lower legs.

We obtained resighting data for banded chicks by visually scanning plover brood-rearing areas and searching suitable habitat for tern and plover chicks. These searches were conducted during visits to each site for other purposes (e.g., behavior data collection, nest searching). When necessary to observe band combinations, we briefly (<1 minute) picked up chicks and immediately returned them to the location where they were encountered.

5. Results

5.1. Movements

Trapping and banding of adult birds was delayed until our Federal permit was issued on 15 May. Consequently, some opportunities to deploy radios on early-nesting plovers were missed. We radio-marked 16 adult terns and 6 adult plovers on our focal colonies (Table 1). We deployed dataloggers at each of the 5 focal colonies and at 10 off-colony sites that were strategically chosen to detect movements (Figure 1; Table 2).

The dataloggers recorded 512,759 data records, each record representing a possible detection of a radiomarked bird. In our telemetry studies of least tern movements on the Missouri River, we established filtering criteria for similar datalogger data. These criteria were based on data from "beacon" transmitters, which were identical to the transmitters deployed on birds but were placed in fixed locations and monitored by the dataloggers. We deployed beacon transmitters on the Platte River in 2009, but the number (n=3) and timing of these datasets were insufficient to establish sound criteria for filtering Platte River data. In 2010 we will establish sufficient beacon transmitter sites to improve filtering of Platte River telemetry data.

Our data records included 90,613 records of transmitter frequencies at locations other than the colony in which the transmitter was deployed ("noncolony" records; Table 3). These records represent potential detections of radiomarked birds at locations other than their nesting colony. We will examine patterns in these noncolony records, which may reveal differences between species or colonies, or movements of birds within the river corridor (Tables 4, 5). However, it is important to recognize that these records have not been filtered to remove unreliable or nonindependent data points. We suspect that interference from electronic communication equipment associated with Interstate 70 could produce false positive records in our pre-filtered data. It is likely that these false records would have different signal characteristics (e.g., strength) than true detections of radiomarked birds. Data from beacon transmitters will be useful in establishing filtering criteria to remove these false positive records. Our analysis of telemetry data will also consider independence of records when it is desirable to ensure that each event (e.g., movement of a bird to a foraging location) is only recorded once in the final dataset. As analysis of the telemetry dataset proceeds, we will establish criteria for reducing multiple records in short time periods to single "event" records.

5.2. Behavior

We conducted behavioral observations on least terns during 223 sessions, occurring between June 4 and August 14 (Table 6), and on piping plovers during 95 sessions, occurring between May 27 and August 5 (Table 7). Data collection on piping plovers was exclusively conducted on the focal areas where nesting plovers were documented. We searched for noncolony locations at which to conduct behavioral observations on piping plovers, but did not identify non-colony areas where birds spent time. In contrast, 49 of the 223 observation sessions on least terns were conducted at noncolony locations, with 40 of these occurring at the Kearney Canal diversion gates. We recorded a total of 2409 plunge dives by least terns; 207 (8.5%) of these occurred in sandpit ponds. The tern observation sessions totaled 225 hours, with 144 hours (64%) of the observation time occurring at the 3 sandpit ponds where terns nested. The majority of observation sessions (38/42; 84%; Table 7) and time (36:08/43:31;83%; Table 8) for piping plovers occurred on Bluehole and Lexington Pit, with the remaining observations occurring on the Dinan Tract and Johnson Pit. We did not obtain behavioral observations on foraging piping plovers outside these nesting colonies because no suitable sites for this data collection were identified.

5.3. Foraging Habitat

We spot-mapped 1877 locations where least terns were observed foraging. Braided channels were the dominant habitat classification at foraging sites, with the majority of observations occurring at the Kearney Canal Diversion Gates (Table 9). Foraging tern locations were spot-mapped in 3 sandpit ponds, accounting for <10% of the total number of observations (Table 9). We spot-mapped 367 locations of foraging piping plovers, all of which occurred within nesting colonies (3 sandpits, 1 sandbar; Table 10). An example of the spatial distribution of spot-mapped foraging locations for one of the more intensively monitored sites (Lexington Pit) is shown in Figure 2.

We collected 76 trawl samples in 2009, including 10 samples from RM 180, Johnson Pit, and Jefferies East that were deployed for a cooperative gear test with Platte River Program staff (Table 11). We sampled fish after observation of successful foraging by least terns, but we rarely observed terns foraging in sandpit ponds. Consequently, only 10 of these samples were collected in sandpit ponds, and no samples were collected at Bluehole Pit despite a relatively high abundance of terns at that site (6 of the 16 radioed tern adults; Table 1). Of the 76 trawl samples, only one (at Lexington Pit) caught no fish. Number of samples was greatest at the Diversion Gates, where foraging terns were frequently observed, and the greatest number of samples on riverine sites was at the Dinan Tract (Table 11). We caught a total of 2768 fish, with the greatest number of individuals and of fish species occurring at the Diversion Gates (Tables 11, 12). Excluding the gear test samples, these samples were arranged in 22 sampling sessions at tern foraging locations, with each session consisting of 1 sample at the foraging point and 2 samples at random points (Table 13).

We collected terrestrial surficial forage samples during 18 sampling sessions between June 17 and August 1. Each session consisted of sampling 1 plover forage location and 2 paired random points. We sampled at the Dinan Tract (2 sessions), Johnson Pit (2 sessions), Bluehole Pit (8 sessions), and Lexington Pit (6 sessions). For each sample, we quantified the number of large (>3mm) and small (<3mm) invertebrates caught (Table 14).

5.4. Productivity

We monitored 49 least tern nests in 2009. Only 3 tern netss occurred on sandbar sites (Dipple and Dinan Tracts); only 1 of these was successful (Table 15). Nests on sandpits primarily occurred on Bluehole and Lexington Pits (Table 15). We monitored 14 piping plover nests in 2009; 10 of these occurred on Bluehole and Lexington Pits, and only 2 nests occurred on sandbar sites (Table 16). We banded 16 adult least terns, 11 adult piping plovers (Table 17), 39 least tern chicks, and 25 piping plover chicks (Table 18).

We considered tern and plover chicks fledged if they survived to 20 and 25 days, respectively or if they were observed in flight. Based on these criteria, we estimate that 1 banded plover chick fledged from a sandbar, 1 tern chick fledged from a sandpit, and 6 plover chicks fledged from sandpits within our study area.

We based nest fate determinations exclusively on evidence observed at the nest site on the day that monitoring was terminated. Accordingly, several nests that were classified as Unknown fate (Tables 15, 16) may have hatched.

We received 4 reports of birds banded on our study area being observed outside of the Central Platte River. One observation was of a fledged tern chick that was observed, apparently during migration, in eastern Tennessee. The remaining 3 observations were of piping plovers we banded as adults. One bird was trapped on a subsequent nest by a Virginia Tech research crew on the Missouri River near Yankton, South Dakota, and the other 2 were observed after the nesting season near Corpus Christi, Texas (Table 19).

6. Regulatory Compliance

We conducted our research under a Federal Threatened and Endangered Species Permit (#TE-121914-5) and a Scientific and Educational Permit from the Nebraska Game and Parks Commission. We report the following observations and incidents of bird death, bird injury, and human disturbance in accordance with these permits:

6.1. Injury

No injury events were documented in 2009.

6.2. Death

Along the Central Platte River four dead piping plovers (two adults and two chicks) and six dead least tern chicks were found. Some individuals were collected for further examination.

- On 18 June at Bluehole Sandpit (RM 230.5) three tern chicks were found dead around a nest bowl. All chicks were decapitated indicating it was probably a predator but rains the night before washed away any evidence to further support this. The chicks were collected on that day.
- On 22 June at Bluehole Sandpit (RM 230.5) one decapitated tern chick was found approximately 1.5 meters from a nest bowl. There was an attempt to return and collect this chick a few hours later. The carcass could not be located, although drag marks suggested that it had been removed.
- On 24 June at Lexington Sandpit (RM 250.5) a banded adult plover was found dead underneath power lines approximately 200 meters from the colony. It was found and collected by Jim Jenniges from Nebraska Public Power District and given to us along with information regarding the event.
- On 26 June at Lexington Sandpit (RM 250.5) a plover chick was stepped on by a USGS technician while performing a systematic chick search. The chick was collected and the incident was reported to the USFWS.
- On 26 June at Lexington Sandpit (RM 250.5) a banded plover chick was found dead and dismembered. There was a wing approximately 0.25 meters away, but no other evidence present to determine what happened. It had been dead at least a week so this bird was not collected.
- On 26 June at Bluehole Sandpit (RM 230.5) one unbanded tern chick was found dead. There were no signs indicating cause of death, although death appeared to have happened quite a while prior to discovery of the dead bird.
- On 28 June at Bluehole Sandpit (RM 230.5) one unbanded adult plover was found dead. There was no evidence to determine cause of death and the bird was collected.

- On 13 July at Johnson Sandpit (RM 230) feathers from an adult tern were found in a nest bowl indicating it had probably been killed by a predator. There was also an egg missing, but a rain storm the night before washed away any evidence as to what type of predator it may have been.
- On 17 July at Bluehole Sandpit (RM 230.5) a dead tern chick was found during a systematic chick search. It had been dead a few days and there was no evidence as to the cause of death. This bird was collected.

6.3. Human Disturbance

No confirmed human disturbance events were observed along the Central Platte River in 2009.

7. Plans for 2010

We will follow the approved study plan as general guidance for research in 2010, making several adjustments to improve the quantity and quality of data collected. We will hire one additional crew member and will extend the appointments of our crew leader and crew members so that additional field time can be allocated to data collection. We are considering staggered appointment dates that would allow the crew leader and 2-3 crew members to start field work early in the season when the first plovers arrive on the study area. One of the crew's main priorities will be to enhance number of plovers radioed and number of behavioral observations conducted for plovers relative to 2009.

We will continue with mini-Missouri trawl sampling of sandpit ponds, and we are considering adjustments to our sampling protocol that would provide baseline data on fish abundance in both sandpit pond and riverine habitats. The current protocol calls for fish sampling only after observation of successful foraging by terns, which generated few opportunities for sampling sandpit ponds in 2009.

Our 2010 work will focus on the same 5 sites we studied in 2009, and we will conduct early- and mid-season reconnaissance along the river to determine if additional nesting areas are being used by the birds. If access to additional sites can be obtained through Program activities, we will take advantage of those opportunities to expand the spatial scale of our work.

8. Acknowledgments

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diverse types of ecological data. Finally, we appreciate the leadership, oversight, and quality control provided by Colin Dovichin, Nick Smith, and Mark Wiltermuth.

Table 1. Number of adult least terns and piping plovers to which radio transmitters were applied on the Central Platte River in 2009.

Site	Piping Plovers	Least Terns
Bluehole Pit	2	6
Johnson Pit	0	2
Lexington Pit	3	8
Dinan Tract	1	0
Dipple Tract	0	0

Table 2. Locations of telemetry dataloggers used to detect radiomarked least terns and piping plovers on the Central Platte River in 2009.

Datalogger Type	Location
Colony	RM 199 – Dipple Tract
Colony	RM 205 – Dinan Tract
Colony	RM 230 – Johnson Pit
Colony	RM 230.5 – Bluehole Pit
Colony	RM 250.5 – Lexington Pit
Movement	RM 190
Movement	RM 199 – Dipple Tract
Movement	RM 203 – Triplet Trail
Movement	RM 207 – Younkin Tract
Movement	RM 212 – Wyoming Tract
Movement	RM 229 – Diversion Gates
Movement	RM 235 – Cottonwood Ranch
Movement	RM 241 – Jefferies E.
Movement	RM 246 – Jefferies W.
Movement	RM 250 – Lexington Island

Table 3. Number of raw data records for frequencies of radio transmitters deployed on least terns and piping plovers on the Central Platte River in 2009. Because these data have not been filtered to remove unreliable or nonindependent records, the final number of detections suitable for analysis may be considerably lower.

Frequency	Species	Total Records	Noncolony Records	% Noncolony
169.008	Piping plover	47729	478	1.0
169.068	Piping plover	17030	140	0.8
169.106	Piping plover	22366	369	1.6
169.132	Piping plover	10448	417	4.0
169.155	Piping plover	91107	276	0.3
169.180	Least tern	11301	6087	53.9
169.207	Least tern	5723	5433	94.9
169.220	Piping plover	6927	130	1.9
169.295	Least tern	22141	2359	10.7
169.309	Least tern	6178	5729	92.7
169.321	Least tern	34388	12354	35.9
169.333	Least tern	31112	12936	41.6
169.357	Least tern	23488	2231	9.5
169.370	Least tern	22551	4028	17.9
169.382	Least tern	18773	1930	10.3
169.408	Least tern	16184	8445	52.2
169.522	Least tern	19329	9836	50.9
169.558	Least tern	14187	5474	38.6
169.621	Least tern	4510	223	4.9
170.358	Least tern	21453	5204	24.3
170.443	Least tern	26830	2229	8.3
170.472	Least tern	39004	4255	10.9

Table 4. Distribution of raw data records at noncolony locations for frequencies of radiotransmitters applied to adult least terns on the Central Platte River in 2009. Because these data have not been filtered to remove unreliable or nonindependent records, the final number of detections suitable for analysis may be considerably lower. Double asterisks (**) represent the corresponding colony datalogger.

	Nest Location			
Datalogger Location	**RM 230 Johnson Pit (n=2)**	**RM 230.5 Bluehole Pit (n=6)**	**RM 250.5 Lexington Pit (n=8)**	**Total**
RM 190	1	609	367	977
RM 199 – Dipple Tract	9	883	437	1329
RM 203 – Triplet Trail	0	806	3354	4160
RM 205 – Dinan Tract	9	511	1108	1628
RM 207 _ Younkin Tract	0	1852	1913	3765
RM 212 – Wyoming Tract	0	0	0	0
RM 229 – Diversion Gates	3061	30383	2265	35709
RM 230 – Johnson Pit	**	13648	1933	15581
RM 230.5 – Bluehole Pit	3314	**	4828	8142
RM 235 – Cottonwood Ranch	83	3940	910	4933
RM 241 – Jefferies E.	0	17	90	107
RM 246 – Jefferies W.	3	918	3295	4216
RM 250 – Lexington Island	0	214	7570	7784
RM 250.5 – Lexington Pit	4	468	**	472

Table 5. Distribution of raw data records at noncolony locations for frequencies of radiotransmitters applied to adult piping plovers on the Central Platte River in 2009. Because these data have not been filtered to remove unreliable or nonindependent records, the final number of detections suitable for analysis may be considerably lower. Double asterisks (**) represent the corresponding colony datalogger.

	Nest Location			
Datalogger Location	**RM 205 Dinan Tract (n=1)**	**RM 230.5 Bluehole Pit (n=2)**	**RM 250.5 Lexington Pit (n=3)**	**Total**
RM 190	17	3	4	24
RM 199 – Dipple Tract	48	16	13	77
RM 203 – Triplet Trail	10	6	2	18
RM 205 – Dinan Tract	**	105	142	247
RM 207 _ Younkin Tract	28	23	5	56
RM 212 – Wyoming Tract	100	127	243	470
RM 229 – Diversion Gates	13	335	25	373
RM 230 – Johnson Pit	16	72	38	126
RM 230.5 – Bluehole Pit	45	**	114	159
RM 235 – Cottonwood Ranch	93	44	24	161
RM 241 – Jefferies E.	0	2	0	2
RM 246 – Jefferies W.	3	7	1	11
RM 250 – Lexington Island	6	2	28	36
RM 250.5 – Lexington Pit	38	12	**	50

Table 6. Number of data collection sessions, hours of data collection (HH:MM), and summary of recorded All-Occurrence Behaviors for adult least terns on the Central Platte River in 2009.

			All-Occurrence Behaviors											
Location	**Sessions**	**Hours**	**Carry**	**Eat**	**Forage Deliver Adult**	**Forage Deliver Chick**	**Forage Deliver Unk.**	**Hover**	**Leave**	**Out of View**	**Plunge Not Success**	**Plunge Success**	**Plunge Unk.**	**Total**
RM 199 – Dipple Tract	18	15:25	4	1	5	0	0	227	1	11	70	12	57	388
RM 203	1	1:01	0	0	0	0	0	0	0	0	0	0	0	0
RM 205 – Dinan Tract	15	14:54	16	4	4	3	2	99	1	14	39	6	25	213
RM 212	2	2:01	1	1	1	0	0	13	0	2	4	1	3	25
RM 229 – Diversion Gates	40	39:51	190	116	1	3	0	1879	153	180	1480	321	162	4485
RM 230 – Johnson Pit	23	25:04	0	1	0	0	0	17	0	8	5	1	8	40
RM 230.5 – Bluehole Pit	58	57:03	23	0	4	3	2	28	4	18	31	1	16	130
RM 235	2	2:00	0	0	0	0	0	4	0	1	8	0	0	13
RM 241 – Jefferies E.	1	1:00	0	0	0	0	0	0	0	0	0	0	0	0
RM 246 – Jefferies W.	1	1:00	0	0	0	0	0	0	0	0	0	0	0	0
RM 250 – Lexington Island	1	1:00	0	0	0	0	0	1	0	1	1	0	2	5
RM 250.5 – Lexington Pit	59	61:51	28	6	1	11	1	77	4	25	92	1	52	298
RM 251.5	2	3:01	0	0	0	0	0	14	0	5	0	0	12	31
Total	223	225:11	262	129	16	20	5	2359	163	265	1730	343	336	5628

Table 7. Number of behavior data collection sessions and summary of recorded State Behaviors for adult piping plovers on the Central Platte River in 2009.

		State Behaviors								
Location	**Sessions**	**Active**	**Foraging**	**Inactive**	**Locomotion**	**Missing**	**Out of View**	**Stationary Parental Care**	**Active Territory/ Parental Care**	**Grand Total**
RM 199 – Dipple Tract	0	0	0	0	0	0	0	0	0	0
RM 203	0	0	0	0	0	0	0	0	0	0
RM 205 – Dinan Tract	9	17	81	58	69	108	12	23	4	372
RM 212	0	0	0	0	0	0	0	0	0	0
RM 229 – Diversion Gates	0	0	0	0	0	0	0	0	0	0
RM 230 – Johnson Pit	6	10	56	24	20	53	58	19	0	240
RM 230.5 – Bluehole Pit	38	59	305	135	158	452	61	119	6	1295
RM 235	0	0	0	0	0	0	0	0	0	0
RM 241 – Jefferies E.	0	0	0	0	0	0	0	0	0	0
RM 246 – Jefferies W.	0	0	0	0	0	0	0	0	0	0
RM 250 – Lexington Island	0	0	0	0	0	0	0	0	0	0
RM 250.5 – Lexington Pit	42	70	207	78	89	387	63	168	34	1096
RM 251.5	0	0	0	0	0	0	0	0	0	0
Total	95	156	649	295	336	1000	194	329	44	3003

Table 8. Observation time (HH:MM) and substrate pecks counted for foraging adult and young piping plovers on the Central Platte River in 2009.

	Adults		Young	
Location	**Time**	**Pecks**	**Time**	**Pecks**
RM 199 – Dipple Tract	0	0	0	0
RM 203	0	0	0	0
RM 205 – Dinan Tract	3:15	1139	1:13	561
RM 212	0	0	0	0
RM 229 – Diversion Gates	0	0	0	0
RM 230 – Johnson Pit	1:51	527	1:03	1405
RM 230.5 – Bluehole Pit	10:24	2980	8:22	6118
RM 235	0	0	0	0
RM 241 – Jefferies E.	0	0	0	0
RM 246 – Jefferies W.	0	0	0	0
RM 250 – Lexington Island	0	0	0	0
RM 250.5 – Lexington Pit	14:16	3225	3:06	3307
RM 251.5	0	0	0	0
Total	29:47	7871	13:44	11391

Table 9. Aquatic habitat classification at locations where foraging least terns were spot-mapped on the Central Platte River in 2009.

Location	Braided Channel	Sandpit Pond	Secondary Channel
RM 199 – Dipple Tract	55	0	0
RM 205 – Dinan Tract	57	0	0
RM 229 – Diversion Gates	1585	0	0
RM 230 – Johnson Pit	0	14	0
RM 230.5 – Bluehole Pit	0	14	12
RM 250 – Lexington Island	3	0	0
RM 250.5 – Lexington Pit	0	137	0
Total	1700	165	12

Table 10. Terrestrial habitat types in which foraging piping plovers were spot-mapped on the Central Platte River in 2009.

Location	Sandpit	Sandbar
RM 205 – Dinan Tract	0	46
RM 230 – Johnson Pit	43	0
RM 230.5 – Bluehole Pit	198	0
RM 250.5 – Lexington Pit	80	0
Total	321	46

Table 11. Locations at which fish samples were collected on the Central Platte River in 2009. Asterisks indicate samples collected for cooperative gear testing with Platte River Program staff.

Location	# Samples	# Fish Caught	# Fish Species
RM 180	3*	94	8
RM 199 – Dipple Tract	3	115	4
RM 205 – Dinan Tract	15	760	12
RM 212	3	47	1
RM 229 – Diversion Gates	33	1239	29
RM 230 – Johnson Pit	4*	91	8
RM 235	3	126	13
RM 241 – Jefferies E.	3*	78	5
RM 250 – Lexington Island	3	59	4
RM 250.5 – Lexington Pit	6	159	4
Total	76	2768	

Table 12. Fish species caught in 76 trawl samples on the Central Platte River in 2009 (includes 10 samples collected for cooperative gear test).

Fish Species	180	199 Dipple	205 Dinan	212	229 Diversion	230 Johnson	235	241 Jeff E.	250 Lex Isl	250.5 Lex Pit	Grand Total
Brook silverside					1					56	57
Bluegill					7		1			76	84
Bigmouth buffalo					4						4
Common carp			4		5	10	15	2			36
Creek chub						1	10				11
Central stoneroller							1				1
Channel catfish	3		5		30	1					39
Fathead minnow		1	1			2	2	8			14
Green sunfish					6						6
Gizzard shad	1										1
Hybognathus spp.	32		12				3				47
Largemouth bass					68		1			22	91
Longnose gar					2						2
Western mosquitofish	1					8	1				10
Orangespotted sunfish					4						4
Plains killifish			221		3	2	18	3			247
Quillback	6										6
River carpsucker					2						2
Shorthead redhorse					4						4
Smallmouth bass					13						13
Suckermouth minnow			2		15		1				18
Spottail shiner					1						1
Unidentified buffalo			4		25						29
Unidentified Cyprinella	4	19	74		225		12		7		341
Unidentified carpsucker					4	1					5
Unidentified sucker					3						3
Unidentified minnow			5		6						11
Unidentified Lepomis					1						1
Unk. narrow-bodied fish		1			8				1		10
Unk. insect/invertebrate					1						1
Unidentified					4						4
Unknown other			14		4						18
Unidentified shiner	46	94	407	47	777	66	56	64	49		1606
Unidentified redhorse	1				11						12
White sucker			11		4		5	1	2		23
Yellow bullhead					1						1
Yellow perch										5	5
Grand Total	**94**	**115**	**760**	**47**	**1239**	**91**	**126**	**78**	**59**	**159**	**2768**

Table 13. Number of fish and species caught in trawl samples during 22 sampling sessions (gear test samples excluded) on the Central Platte River in 2009. Each session consisted of 1 sample at a least tern foraging site and 2 samples at random points.

		Foraging Sites		Random Points	
Location	**Sessions**	**Fish**	**Species**	**Fish**	**Species**
RM 199 – Dipple Tract	1	71	2	44	4
RM 203	0	0	0	0	0
RM 205 – Dinan Tract	5	253	10	507	12
RM 212	1	36	1	11	1
RM 229 – Diversion Gates	11	386	16	853	27
RM 230 – Johnson Pit	0	0	0	0	0
RM 230.5 – Bluehole Pit	0	0	0	0	0
RM 235	1	95	12	31	5
RM 241 – Jefferies E.	0	0	0	0	0
RM 246 – Jefferies W.	0	0	0	0	0
RM 250 – Lexington Island	1	3	1	56	4
RM 250.5 – Lexington Pit	2	38	5	122	4
RM 251.5	0	0	0	0	0
Total	22	882	26	1624	31

Table 14. Number of large (>3mm) and small (<3mm) invertebrates caught on sticky traps during 18 sampling sessions on the Central Platte River in 2009. Each session consisted of 1 sample at a piping plover foraging site and 2 samples at random points. Numbers are raw counts of invertebrates that are uncorrected for differences in sampling area between vertical and horizontal sticks.

		Foraging Sites		Random Points	
Location	**Sessions**	**Large**	**Small**	**Large**	**Small**
RM 199 – Dipple Tract	0	0	0	0	0
RM 203	0	0	0	0	0
RM 205 – Dinan Tract	2	13	24	10	18
RM 212	0	0	0	0	0
RM 229 – Diversion Gates	0	0	0	0	0
RM 230 – Johnson Pit	2	4	325	8	847
RM 230.5 – Bluehole Pit	8	151	823	137	1985
RM 235	0	0	0	0	0
RM 241 – Jefferies E.	0	0	0	0	0
RM 246 – Jefferies W.	0	0	0	0	0
RM 250 – Lexington Island	0	0	0	0	0
RM 250.5 – Lexington Pit	6	92	243	120	614
RM 251.5	0	0	0	0	0
Total	18	260	1415	275	3464

Table 15. Number and fate of least tern nests monitored on the Central Platte River in 2009.

Site	Successful	Probable Successful	Failed	Probable Failure	Unknown	Total
RM 199 – Dipple Tract	0	0	0	2	0	2
RM 205 – Dinan Tract	1	0	0	0	0	1
RM 230 – Johnson Pit	1	0	0	2	3	6
RM 230.5 – Bluehole Pit	9	3	1	4	5	22
RM 250.5 – Lexington Pit	6	3	0	2	7	18
Total	17	6	1	10	15	49

Table 16. Number and fate of piping plover nests monitored on the Central Platte River in 2009.

Site	Successful	Probable Successful	Failed	Probable Failure	Unknown	Total
RM 199 – Dipple Tract	0	0	0	0	0	0
RM 205 – Dinan Tract	0	0	0	1	1	2
RM 230 – Johnson Pit	0	1	0	0	1	2
RM 230.5 – Bluehole Pit	2	0	0	2	1	5
RM 250.5 – Lexington Pit	1	0	0	2	2	5
Total	3	1	0	5	5	14

Table 17. Banding records for adult least terns and piping plovers on the Central Platte River in 2009.

Band Number	Date Banded	Species	Site	Nest #	Band Combination	Radio Frequency
2211-29913	6/18/2009	LETE	250.5	106	-T, - Y/V : - -, R R	169.180
2211-29915	6/18/2009	LETE	250.5	108	- T, - Y/V : - -, Y R	169.207
2211-29921	6/18/2009	LETE	250.5	117	- T, - Y/V : - -, O R	169.295
2211-29922	6/19/2009	LETE	250.5	109	- T, - Y/V : - -, G R	169.309
2211-29923	6/19/2009	LETE	230.5	212	- T, - Y/V : - -, L R	169.321
2211-29924	6/19/2009	LETE	230.5	210	-T, - Y/V : - -, C R	169.333
2211-29926	6/23/2009	LETE	250.5	114	- V, -R : - T, - V/K	169.357
2211-29927	6/23/2009	LETE	250.5	110	- V, - O : - T, - V/K	169.370
2211-29928	6/25/2009	LETE	250.5	116	- T, - Y/V : --, L O	169.382
2211-29930	6/30/2009	LETE	230.5	220	- T, - Y/V : - -, W R	169.408
2211-29939	6/30/2009	LETE	230.5	222	- T, - Y/V : - -, V R	169.522
2211-29941	6/30/2009	LETE	230.5	218	- T, - Y/V : - -, K R	169.558
2211-29946	6/25/2009	LETE	250.5	119	- T, - Y/V : - -, G O	169.621
2211-29992	6/25/2009	LETE	230.5	216	- T, - Y/V : - -, Y O	170.358
2211-29997	6/25/2009	LETE	230	305	- T, - Y/V : - -, O O	170.443
2211-29999	6/25/2009	LETE	230	306	- T, - Y/V : - -, R O	170.472
2301-46470	6/12/2009	PIPL	250.5	111	- LF, G V/P : -X, G G	169.220
2301-46472	6/8/2009	PIPL	230.5	203	- LF, G V/P : - X, C O	169.155
2301-46473	6/1/2009	PIPL	205	400	- LF, G V/P : - X, R C	169.132
2301-46474	6/1/2009	PIPL	230.5	202	- LF, G V/P : - X, R G	169.008
2301-46475	6/1/2009	PIPL	230.5	203	- LF, G V/P : - X, R R	
2301-46480	5/21/2009	PIPL	230.5	200	- LF, Y Y : - X, R R	
2301-46484	5/22/2009	PIPL	230	300	- LF, Y Y : - X, R K	
2301-46487	6/1/2009	PIPL	250.5	105	- LF, G V/P : - X, R K	169.106
2301-46489	6/1/2009	PIPL	250.5	102	- LF, G V/P : - X, R O	169.068
2301-46491	5/21/2009	PIPL	250.5	100	- LF, Y Y : - X, R Y	
2301-46496	5/22/2009	PIPL	230	301	- LF, Y Y : - X, R G	

Band Positions: Upper Left , Lower Left : Upper Right, Lower Right. Color Band Codes: - No Band; X= Metal; T= Radio Transmitter; R= Red; O= Orange; Y= Yellow; G= Green, (Kelly); C= Cobalt Blue or bright blue; L= Pastel Blue or light blue; K= Black; V= Violet; W=White; D=Dark Green; P=Pink; Examples split: V/W= Violet over White split; W/V= White over Violet split; Example flag: YF= Yellow Flag

Table 18. Banding records for least tern and piping plover chicks on the Central Platte River in 2009.

Band Number	Date Banded	Species	Site	Nest #	Band Combination
2301-46486	5/30/2009	PIPL	230.5	200	-LF , RC : -X , YY
2301-46493	5/30/2009	PIPL	230.5	200	-LF , KO : -X , YY
2301-46482	6/3/2009	PIPL	230	300	-LF , KR : -X , YY
2301-46476	6/3/2009	PIPL	230	300	-LF , KK : -X , YY
2301-46494	6/3/2009	PIPL	230	300	-LF , KC : -X , YY
2301-46471	6/5/2009	PIPL	230	301	-LF , GV/P : -X , GC
2301-46478	6/5/2009	PIPL	230	301	-LF , GP/V : -X , RC
2301-46490	6/1/2009	PIPL	250.5	100	-LF , OR : -X , YY
2301-46498	6/1/2009	PIPL	250.5	100	-LF , OG : -X , YY
2301-46499	6/1/2009	PIPL	250.5	100	-LF , OO : -X , YY
2301-46497	6/1/2009	PIPL	250.5	100	-LF , OK : -X , YY
2301-46495	6/8/2009	PIPL	250.5	102	-LF , GV/P : -X , CO
2301-46488	6/8/2009	PIPL	250.5	102	-LF , GV/P : -X , CC
1981-27636	6/16/2009	LETE	230.5	204	-- , -- : -- , -X
1981-27634	6/16/2009	LETE	230.5	204	-- , -- : -- , -X
1981-27635	6/16/2009	LETE	230.5	204	-- , -- : -- , -X
2301-46477	6/16/2009	PIPL	230.5	UNK	-LF , GV/P : -X , KK
2301-46483	6/16/2009	PIPL	230.5	UNK	-LF , GV/P : -X , KC
2301-46479	6/16/2009	PIPL	230.5	UNK	-LF , GV/P : -X , GO
2301-46481	6/16/2009	PIPL	230.5	UNK	-LF , GV/P : -X , GR
2301-46485	6/16/2009	PIPL	230.5	200	-LF , GV/P : -X , GK
2301-46462	6/22/2009	PIPL	205	400	-LF , GR : -X , YY
2301-46463	6/22/2009	PIPL	205	400	-LF , GG : -X , YY
2301-46464	6/22/2009	PIPL	205	400	-LF , GO : -X , YY
1981-27661	6/26/2009	LETE	230	UNK	-L , -V : -V/K , -X
1981-27654	6/26/2009	LETE	230	UNK	-L , -K : -V/K , -X
1981-27619	6/26/2009	LETE	230.5	UNK	-L , -O : -V/K , -X
1981-27623	6/26/2009	LETE	230.5	UNK	-V , -W : -V/K , -X
1981-27656	6/26/2009	LETE	230.5	213	-L , -L : -V/K , -X
1981-27662	6/26/2009	LETE	230.5	213	-L , -C : -V/K , -X
2301-46468	6/26/2009	PIPL	250.5	UNK	-LF , GK : -X , YY
2301-46451	6/26/2009	PIPL	250.5	UNK	-LF , GC : -X , YY

Band Number	Date Banded	Species	Site	Nest #	Band Combination
2301-46455	6/26/2009	PIPL	250.5	UNK	-LF , RR : -X , YY
1981-27684	6/26/2009	LETE	250.5	UNK	-V , -G : -V/K , -X
1981-27620	6/26/2009	LETE	250.5	UNK	-V , -L : -V/K , -X
1981-27622	6/26/2009	LETE	250.5	UNK	-V , -V : -V/K , -X
1981-27624	6/26/2009	LETE	250.5	113	-V , -C : -V/K , -X
1981-27618	6/26/2009	LETE	250.5	113	-V , -K : -K/V , -X
1981-27675	6/26/2009	LETE	250.5	UNK	-L , -R : -V/K , -X
2301-46469	6/26/2009	PIPL	230.5	UNK	-LF , RG : -X , YY
1981-27684	6/25/2009	LETE	250.5	UNK	-V , -G : -V/K , -X
1981-22000	6/28/2009	LETE	250.5	117	-- , -- : -- , -X
1981-21992	6/28/2009	LETE	250.5	117	-- , -- : -- , -X
1981-21990	7/1/2009	LETE	250.5	119	-L , -W : -V/K , -X
1981-27625	7/8/2009	LETE	230.5	216	-C , -W : -V/K , -X
1981-21987	7/14/2009	LETE	250.5	UNK	-- , CK : -- , V/KX
1981-27533	7/14/2009	LETE	250.5	UNK	-- , CV : -- , V/KX
1981-21994	7/14/2009	LETE	250.5	UNK	-- , CC : -- , V/KX
1981-21992	7/14/2009	LETE	250.5	117	-- , CL : -- , V/KX
1981-21788	7/14/2009	LETE	250.5	UNK	-- , CG : -- , V/KX
1981-21985	7/14/2009	LETE	250.5	UNK	-- , CR : -- , V/KX
1981-22000	7/14/2009	LETE	250.5	117	-- , CO : -- , V/KX
1981-21993	7/14/2009	LETE	250.5	UNK	-- , WW : -- , V/KX
1981-21997	7/15/2009	LETE	230.5	UNK	-W , -K : -V/K , -X
1981-21989	7/17/2009	LETE	230.5	UNK	-W , -V : -V/K , -X
1981-21984	7/17/2009	LETE	230.5	UNK	-W , -C : -V/K , -X
1981-27535	7/17/2009	LETE	230.5	UNK	-W , -L : -V/K , -X
1981-27655	7/21/2009	LETE	205	403	-W , -G : -V/K , -X
1981-27659	7/21/2009	LETE	205	403	-W , -O : -V/K , -X
1981-21995	7/23/2009	LETE	230.5	UNK	-- , WR : -V/K , -X
1981-21991	7/23/2009	LETE	230.5	226	-K/V , -W : -W , -X
1981-36333	7/23/2009	LETE	230.5	UNK	-K/V , -K : -W , -X
1981-36332	7/23/2009	LETE	230.5	UNK	-K/V , -V : -W , -X
1981-27625	7/23/2009	LETE	230.5	216	-- , CW : -V/K , -X

Band Positions: Upper Left , Lower Left : Upper Right, Lower Right. Color Band Codes: - No Band; X= Metal; T= Radio Transmitter; R= Red; O= Orange; Y= Yellow; G= Green, (Kelly); C= Cobalt Blue or bright blue; L= Pastel Blue or light blue; K= Black; V= Violet; W=White; D=Dark Green; P=Pink; Examples split: V/W= Violet over White split; W/V= White over Violet split; Example flag: YF= Yellow Flag

Table 19. Banded least terns and piping plovers from the Central Platte River that were observed in other locations in 2009.

Species	Observation Date	Observed Location	USGS Band Number	Color Bands [a]	Radio Frequency	Banded Age
Least Tern	8/21/2009	Clinton, TN	1981-21993	- -, W W : - -, V/K X	None	Chick
Piping Plover	7/21/2009	Corpus Christi, TX	2301-46480	- LF, Y Y : - X, R R	None	Adult
Piping Plover	11/3/2009	Corpus Christi, TX	2301-46491	- LF, Y Y : - X, R Y	None	Adult
Piping Plover	7/2/2009	Yankton, SD	2301-46484	- LF, Y Y : - X, R K	None	Adult

Band Positions: Upper Left , Lower Left : Upper Right, Lower Right. Color Band Codes: - No Band; X= Metal; T= Radio Transmitter; R= Red; O= Orange; Y= Yellow; G= Green, (Kelly); C= Cobalt Blue or bright blue; L= Pastel Blue or light blue; K= Black; V= Violet; W=White; D=Dark Green; P=Pink; Examples split: V/W= Violet over White split; W/V= White over Violet split; Example flag: YF= Yellow Flag

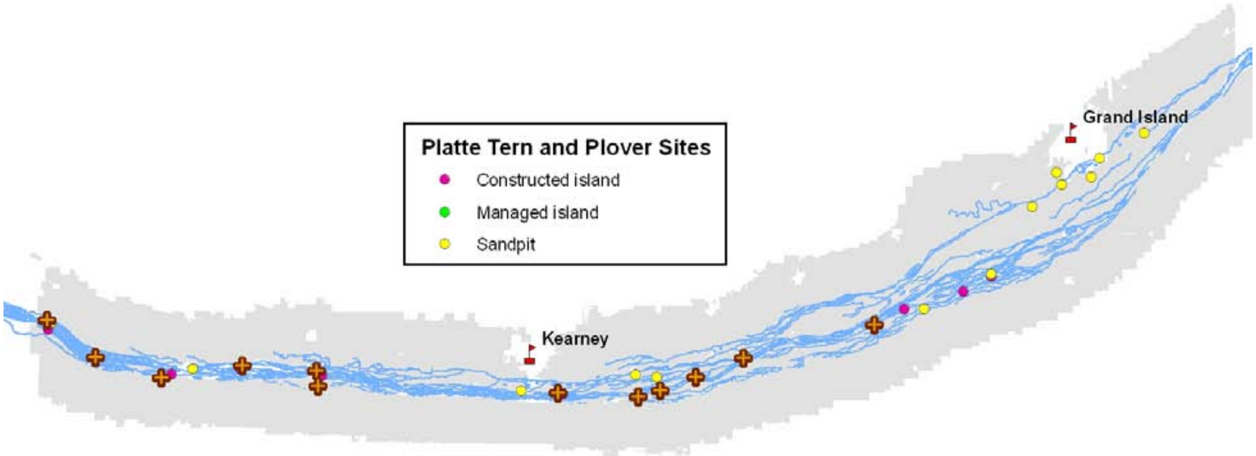

Figure 1. Locations of dataloggers (crosses) used to monitor presence of radiomarked least terns and piping plovers on the Central Platte River during 2009.

Figure 2. Example of spot-mapped foraging locations of least terns (yellow) and piping plovers (green) at Lexington Pit, near Lexington, Nebraska, 2009.

Figure 3. Bow net being deployed to trap a piping plover at a sandpit nest on the Central Platte River in 2009.

Figure 4. Adult piping plover with radio transmitter attached on the Central Platte River in 2009.

Figure 5. Piping plover chick during banding at a nest on Bluehole Pit in 2009.

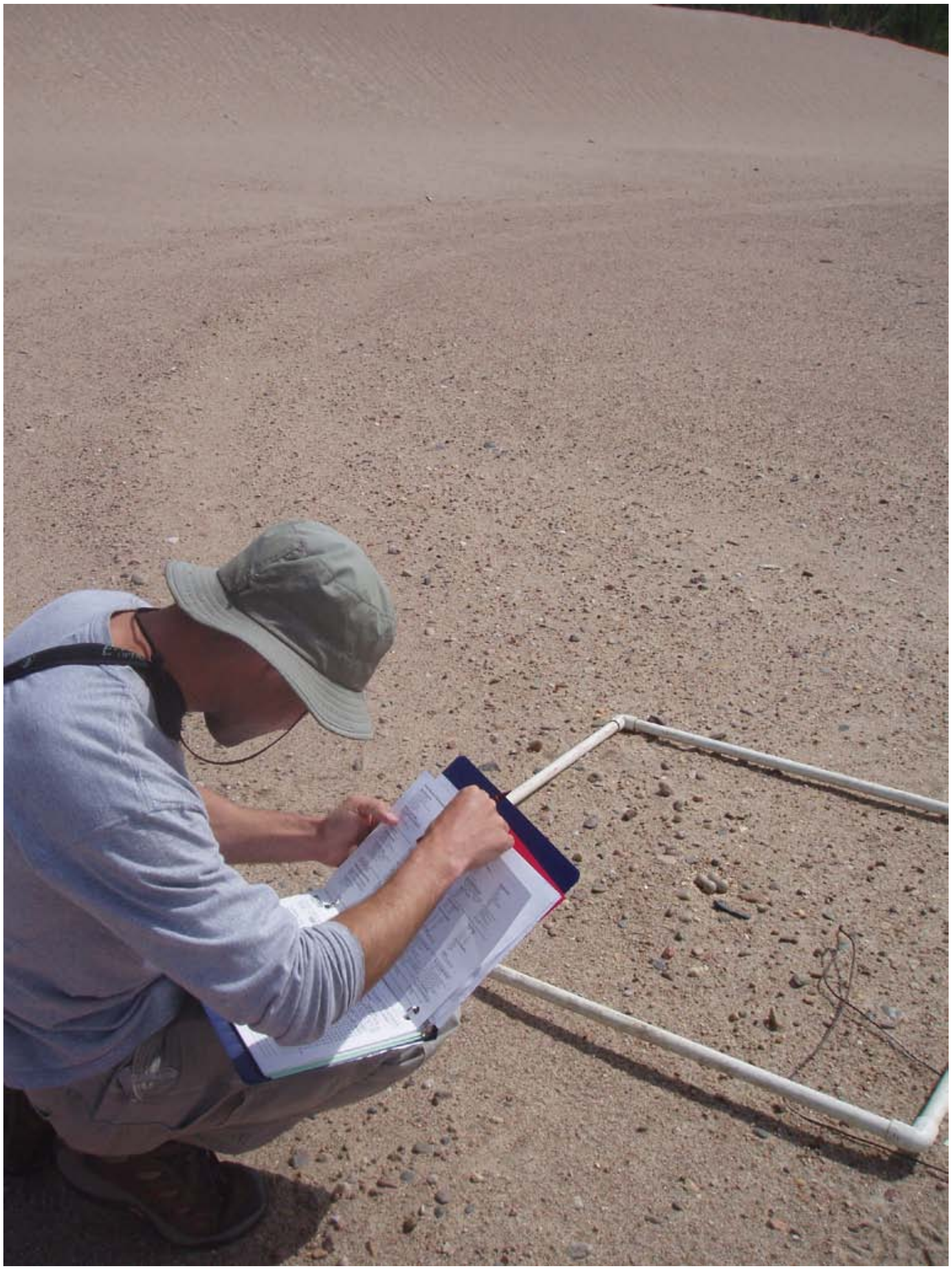

Figure 6. Technician checking status of a piping plover nest at Bluehole Pit in 2009.

Figure 7. Crew deploying a mini-Missouri trawl in a sandpit pond in 2009.

Figure 8. Telemetry station established to monitor radiomarked least terns and piping plovers on the Central Platte River in 2009.

Figure 9. Arrangement of sticky sticks used to measure invertebrate abundance in habitats used by foraging piping plovers on the Central Platte River in 2009.

USGS

APPENDIX 1: Behavior Sampling Protocol

The goal for behavior sampling of Least Terns and Piping Plovers is to identify the 1) proportion of time spent foraging; 2) estimate the rates of foraging behaviors (plovers); 3) habitats used for foraging; and 4) success rates of foraging (terns only).

Access and Timing of Behavioral Observations:

Behavioral observation sessions should occur within a 4-hr interval (0600–1000, 1200–1600, and 1700–2000h). Sessions should be allocated systematically to ensure that each location/pair is at least observed during each interval once every two weeks. However, if a session is missed, the next session should occur at the same time as the missed session to maintain balance in sessions among intervals.

Observers should take a path to the blind/observation location that minimizes disturbance to least terns and piping plovers. Sessions should not commence until 5 min has passed since the observer attained position and the observer can determine that their presence is no longer disturbing the birds. If a plover moves out of view during focal bird sampling and the observer is able to quickly reposition to maintain observations on that bird, a 5-minute no observation interval should be added after the observer has repositioned.

State Behavior Categories:

State behaviors will be observed and recorded into state-behavior categories for both least terns and piping plovers on 5-minute-intervals. We will use scan sampling techniques for least terns and focal animal sampling for piping plovers. At the beginning of the 5-minute-interval, observers should take 5 seconds to assess the state of each bird visible because some states may require up to 5 seconds to identify (e.g., foraging). If any foraging behaviors are observed during the bird specific 5-second scan, code the state as foraging (even if the foraging behavior is very brief), otherwise record the dominant behavior for the 5 second interval.

Below are lists of state behaviors (e.g., pecking, hover) grouped into the categories for data entry (e.g., Foraging):

1) **Foraging:**

> **PIPL:** pecking, gleaning (pecking food from vegetation), foot trembling (gently shakes/trembles extended foot on substrate).
>
> **LETE:** hovering, plunging or diving over water [including dives that don't conclude in a plunge], consumption of food item.

2) **Transport/Deliver Food (LETE only):** Carrying food items (e.g., movement through the field of view when diving is not observed), delivering food items to other adults, delivering food items to chicks (delivering may occur on the ground or by dropping food items from the air).

3) **Active Territorial/Parental Care:** Active attendance of site or brood (e.g., fight, chase, dive directed at another animal, mobile guarding often associated with a call to chicks, broken wing display).

4) **Stationary Parental Care:** Parental care directed at chicks or eggs that is not associated with movement, including incubation, and brooding and shading chicks.

5) **Locomotion:** Any movement from one location to another (e.g., running, walking, flying), excluding *Foraging* and *Territorial/Parental Care* behaviors. For least terns, locomotion does not include any flight when carrying fish.

6) **Active**: Active stationary behaviors (e.g., preen, bathe, courtship, copulation). Breast-wetting of least terns should be included in Locomotion.

7) **Inactive/Rest:** Inactive stationary behaviors, excluding *Parental Care* behaviors (e.g., sleep, rest, including alert resting).

8) **Out of View (PIPL only):** Bird is in area, but view is obstructed and state behavior cannot be assessed.

9) **Missing (PIPL only):** Bird leaves observation area.

Least Tern (LETE) Protocols:

Behavioral observations will be conducted at two main types of locations within a nesting colony (sandbar or sandpit) and on non-colony riverine or sandpit sites that are used by LETE. Colony nesting sites are static and include those outlined in the study plan as well as additional sites selected by the crew leader and PIs. Non-colony riverine or sandpit sites will be identified by traveling the river looking for aggregations of LETE and by examining data from telemetry data-loggers located outside colonies.

LETE colony observation sessions will be up to 3 hours long, the duration of sessions will be based on the following: 1) if there is only one pair/nest visible from a given location then sessions should be 1 hour; 2) if other pair(s), in the same colony can be observed the same location add one hour to the session for each additional pair visible (up to 3 hours); and 3) if other pair(s), in the same colony can be visible from different location(s), then observe up to 3 pairs/nests for 1 hour sessions each.

Observers will conduct scan sampling on 5 minute intervals; recording the number of adult LETE visible that are engaged in each state (see behavioral states). The interim time between each scan will be used differently depending on whether the observation is conducted at a colony site or a non-colony site.

Non-Colony Sites.–In the interim time between each scan (3 min), select any visible-foraging adult (if more than one in view, randomly select with a coin, dice, or PDA function, if none in view continue watching until one forages in view or interval is over), and record number of *all occurrence* (AO) behaviors for that selected adult, ignoring AO behaviors by any other adults in the area. If the adult leaves the area (with or without a prey item) or stops foraging (30 seconds without an AO), then reselect another foraging adult to observe; record when a new adult is selected. Conduct each subsequent observation interval the same as described above.

LETE Non-Colony AO behaviors:

Hover (hovering briefly over water)
Plunge non-success (includes dives that do not end in a plunge)
Plunge Success (prey item visible in bill; record length class for captured prey item)
Plunge unknown

Eat (consumed captured prey item)

Out of View (individual is partially hidden and AO behaviors cannot be determined)
Carry out of area (leaves area with captured prey item in bill)
Leave Area

Colony Sites.–The type of observation, done in the interim time between scans, will alternate between two different types: 1) observations of forage deliveries and 2) observations of forage behavior. For example, the first interval will be devoted to observing the colony for forage deliveries by adults, the second will be used to observe foraging behavior, and the third will be used for forage deliveries by adults, and so on. If on colony sites there is no ability to observe potential foraging locations, or it is apparent that no visible foraging occurs, then only conduct forage delivery observations.

Forage Deliveries.–For the 3 min interval, watch the whole colony for all forage deliveries to chicks or adults. Categorize each delivery by recipient (adult, chick, or unknown) and location of foraging (in view, out of view, or unknown).

Foraging Behavior.–In the interim time between each scan (3 min), select any visible-foraging adult (if more than one in view, randomly select with a coin, dice, or PDA function, if none in view continue watching until one forages in view or interval is over), and record the colony AO behaviors for that selected adult. If the adult leaves the area (with or without a prey item) or stops foraging (for at least 30 seconds), then reselect another foraging adult to observe; record when a new adult is selected.

LETE Colony AO foraging behaviors:

Hover (hovering briefly over water)
Plunge non-success (includes dives that do not end in a plunge)
Plunge success
Plunge unknown

Eat (consumed captured prey item)

Out of view (individual is partially hidden and AO behaviors cannot be determined)
Carry: out of area (leaves area with captured prey item in bill)
Leaves Area

Forage delivery to adult
Forage delivery to chick
Forage delivery; recipient unknown

For all foraging AO recording intervals when a foraging AO is recorded (Hovers and Plunges), also record the habitat class associated with the behavior.

LETE Foraging habitat class (predominate type within in 10-20 m):

- Sandpit
- Main channel
- Secondary channel
- Braided/dendritic channel (includes shallow water areas near tails of sandbars)

During AO observations, map all locations where foraging was observed (see below). If it is a forage sampling day then sample fish at the most recent successful foraging location observed and at two random locations (see fish sampling protocol).

Piping Plover (PIPL) Protocols:

The position of each PIPL adult and accompanying brood (if applicable) will be monitored. Our behavioral observations on PIPL will be focused on individual adults, pairs, or adult(s) with broods (hereafter focal unit). Thus, observations will be conducted from moveable blinds that are relocated specifically to watch the targeted focal unit, regardless of location (i.e., river or sandpit). When possible use hand-held telemetry units to help locate targeted adults, so that observers can position themselves for observation in a way that minimizes disturbance.

Each session will last 1 hour per focal unit. Three hours are allocated for behavioral sampling, so that up to 3 focal units can be sampled per day of field work. Observers will record behavioral states and habitat classes for each individual within the focal group on 5-minute-intervals. Each individual (adult and chick) should be observed for 5 seconds to determine the dominant behavioral state (see above classes), with behaviors being linked to marked individuals if possible. If any foraging behavior (no matter how brief) is observed during the 5-second observation period, the period should be classified as Foraging. Otherwise, the dominant behavior class occurring during the 5-second period should be recorded. If the focal observation interval is classified as Foraging, the location of the bird should be spot-mapped.

If marks are not present or can not be readily observed, record each individual as Unknown Adult or Unknown Chick. This type of sampling may be most easily conducted by two people, with one continually observing through a spotting scope to track individuals and verbally calling out data to the second crew member.

Habitat Classes (dominant classes within the foraging area):

Landform:

1) River shoreline
2) Sandbar
3) Sandpit

Moisture:

1) Dry substrate
2) Wet substrate

Vegetation:

1) Bare (<30%)
2) Sparse (31–50%)

3) Vegetated (>50%)

In the interim time between all focal observation intervals, the observer will record all pecks (including gleans) for a 3-min. interval on a randomly selected adult or chick (using a dice or PDA function). Record when an individual goes out of view or when that individual returns into view. Randomly select (from all visible individuals within the focal unit) a new adult or chick (alternating between adults and chicks for each peck-recording interval.

If it is a forage sampling day then sample forage at the most recent foraging location observed and two random locations (see invertebrate protocol).

Non-colony observations of foraging piping plovers should be obtained if the opportunity is available. The data collection approach should be identical to colony locations, and the data card should reflect that a non-colony site with zero known nests/broods was sampled. Opportunities to collect this data might occur at unexpected times (such as when collecting other types of data, when floating the river, when checking telemetry stations, during non-colony tern behavior observations, etc.). This kind of data will be very informative regarding the birds' choices of foraging habitat, so it would be worthwhile to spend the extra time collecting the data when opportunities arise.

Active Nests/Surviving Broods

During each session, the number of known active nests/broods in the area should be recorded. For colony sites, this should be the number for the species within the colony, not just the number visible from a behavior data collection location. For non-colony locations where foraging terns or plovers are observed, it is also important to record zero known active nests/broods in the area to identify these areas as off-colony foraging locations.

Spot Mapping

For piping plovers, each time a Foraging state behavior is recorded, the location should be spot-mapped. It will be impossible and not necessary to spot-map each time Foraging AOs (e.g., pecks) are recorded for plovers.

For least terns, each time a plunge or dive is recorded as an AO, an attempt should be made to spot-map the location, including notation of success/fail/unknown status of the dive. However, if number of unsuccessful dives occurring makes this cumbersome, the approach may be modified after discussion with the PIs so that spot-mapping is only conducted for successful dives.

APPENDIX 2: Terrestrial Habitat Sampling Protocol

Terrestrial habitat data will be collected in conjunction with piping plover forage sampling. A terrestrial habitat quadrat should be deployed at each invertebrate sampling location (including both plover foraging sites and random points). Because collecting the invertebrate data can disturb the substrate due to placement of sticks and the exclosure, terrestrial habitat data should be collected before invertebrate sampling is started.

At each invertebrate sampling location, center a 1-m^2 quadrat at the location where the exclosure will be placed. Within the quadrat, record the following data:

Land Cover: Record the dominant class within the quadrat (* indicates cover types unlikely to occur at plover foraging locations):

Dry Sand – Sand substrate with no obvious moisture or vegetation
Wet Sand – Areas of moist sand with little or no vegetation
Sparsely Vegetated – Mostly sand substrate with 30-50% vegetation
Mixed Vegetation – Areas of >50% vegetation with interspersed visible substrate
Wetland – Water areas with green vegetation present
*Submerged Sand – Submerged sand substrate visible through water
*Open Water – No substrate visible through water

Vegetation Visual Coverage Estimates: Record the adjusted Daubenmire cover class (Table 1) for each of the following response variables:

Total Woody Vegetation – Include all woody species
Terrestrial Herbaceous Vegetation – Include all terrestrial species
Wetland Herbaceous Vegetation – Include all wetland species

Stem Counts: Record the total count of all woody stems in the quadrat, counting each stem as an individual if it protrudes independently from the substrate (i.e., substrate is visible between stems).

Vegetation Height: Record mean and maximum vegetation height classes as follows, including all vegetation within the quadrat:

Mean Height – **1** = 0 – 0.5 m, **2** = 0.5 – 1 m, **3** = > 1 m
Maximum Height – **1** = 0 – 0.5 m, **2** = 0.5 – 1 m, **3** = > 1 m

Substrate Visual Coverage Estimates: Record the Daubenmire cover class (Table 1) for each substrate class according to its grain size:

Silt	< 0.125 mm
Sand	0.125 – 2mm
Small Pebble	2 – 10 mm
Gravel	10 – 64 mm
Cobble	64 – 256 mm
Boulder	> 25.6 cm

Debris Visual Coverage Estimates: Record the Daubenmire cover class (Table 1) for each debris type according to its size:

Terrestrial Leaf Litter	All leaf and grass litter
Wrack	< 2cm stem diameter
Large Debris	> 2cm stem diameter; include other debris (e.g., trash)

Table 1. Daubenmire classification of cover.

Class	% Cover Range	Midpoint %
0	0	0
1	>0-5	2.5
2	6-15	10
3	16-30	23
4	31-45	38
5	46-70	58
6	71-100	85

APPENDIX 3: Fish Sampling Protocol

The goal of fish sampling is to describe the fish abundance, species and size, and aquatic habitats where terns forage in relation to available sites.

Sampling will occur on successful tern foraging locations and two random points selected relative to foraging location at the end of evening behavior session (1600 – 2000). Forage sampling will be conducted with minnow traps on sandpit-ponds and mini-Missouri River trawls on the river.

Two random points will be selected within 75 m of the forage location. Use the two-column random number table, to modify the Northing and Easting (-75 to 75) of the GPS point collected at the forage site. Random points will be located by navigating with the GPS. If a random point is not within the same habitat class as that of the forage location then select the next set of numbers from the tables, continue until an appropriate point is selected; record unsuitable points. During river sampling always sample the foraging location first and if the sampling path (50 m downstream of the point) overlaps with a previous sampling path from that day, select another random point. If river sampling points are unsafe to sample (e.g., excessive flows or depths > 1.5 m) then select new sites for random points and discontinue sample for forage points.

River Sampling

Once at a sampling point, first collect the following habitat data: UTM, water temperature (± 1˚C), turbidity (± 1 NTU), depth (± 0.1 m), flow (± ? m/s), benthic substrate (predominantly: sand, clay/silt/organic, or gravel), and habitat class (main channel, secondary channel, braided/dendritic channel).

A 50 m floating line will be used to guide the direction and distance of the trawl. Anchor one end of the floating line ~2 meters from the point, perpendicular to the current; use a stake or weight to anchor the line. The trawl will begin at the sampling point and will be towed downstream by 2 people spaced ~3 m apart; thus, one person is within 0.5 m of the floating line. The trawl needs to be towed slightly faster than the current; if the trawl-net inverts during sampling, the sample will not be counted. If the net inverts or the trawl otherwise fails, then record this and attempt again on the other side of the floating line. Once the trawl is complete, hold the trawl mouth out of the water and process the sample at a nearby sandbar or shoreline that is not currently used by PIPL or LETE.

All captured fish will be 1) identified to species, 2) total length measured (± 1 cm), and released as soon as possible. Invert net to confirm removal of all captured fish and detritus. If so many fish are caught that they cannot be measured and identified while they are being pulled out of the net , then place fish in a bucket with adequate water to reduce chance of mortality. Fish identification guides and taxonomic keys used on the Missouri River are available to assist in identification.

Sandpit Pond Sampling

Use a canoe to navigate to sandpit sampling points on sandpit ponds. On windy days, it may be necessary to anchor the canoe to maintain location; if so, deploy anchor as far up-wind as possible and scope the anchor line out until the point is reached. Once at a sampling point, first collect the following habitat data: UTM, water temperature (± 1˚C), turbidity (± 1 NTU), depth (± 0.25 m; increment minnow traps and anchor lines for minnow traps accordingly), benthic substrate (sand, silt/clay/organic, gravel, or >0.75 m deep).

Minnow traps will be deployed by driving the stake ends into the substrate and point lead to the center of the pond, if depth is <0.75 m, or floated at the surface for points with depths >0.75 m. When minnow traps are floated ensure that they are anchored in place with and anchor; the line length should be only slightly longer than the depth to prevent trap from moving if wind direction changes. Record the time the trap was deployed (± 1 minute). The traps should be left in place for 24 hours. After 24 hours, retrieve the traps, recording the collection time (± 1 minute), and process samples exactly as above.

Sampling Equipment:

1. Fish Kit
    - Fish ID binders
    - Aquatic habitat description key
    - Fish sampling data cards
    - 2 m pole
    - 50 m float cord (throw ropes)
    - Turbidity meter
    - Flow Meter
    - fish sampling pans + grid laminate sheetsrulers
    - headband- magnifying loup
    - thermometer
    - paper cups
    - Preservative + jars
    - bucket
    - camera
    - index cards
    - GPS
2. Missouri Trawl – clean and mended.
3. 3 Minnow traps, lines, and anchors (incremented with 1 m and 0.25 meter hash marks).

APPENDIX 4: Invertebrate Sampling Protocol

The goal of invertebrate sampling is to describe the invertebrate taxa, abundance, and terrestrial habitats where piping plovers forage in relation to available sites. We will conduct invertebrate sampling using four paint stir-sticks coated with Tanglefoot ® (The Tanglefoot Company, Grand Rapids, MI) insect trap, two placed horizontally and two vertically within a 1m^2 exclosure (hereafter, sticky sticks). Sampling will occur at both brood-specific-foraging locations and two random points selected relative to foraging location at the end of each 1-hour behavior session, if foraging was observed (see Behavior Protocol). Invertebrate sampling will only occur 1) after behavioral observations during the morning interval (0600–1000 hours), and 2) when there is minimal chance of rain and wind speeds are expected to be below 30 kph (18 mph) during the sampling period.

Two random points will be selected within 75 m of the forage location, and must be the same habitat classes (i.e., Landform, Moisture, and Vegetation) as those of the foraging location. Use the two-column random number table to modify the Northing and Easting (-75 to 75) of the GPS point collected at the forage site. For example, if the UTM of the foraging site is 493,962 by 4,500,757, and the random numbers from the table are +18 and -17, then the random point is at UTM 493,980 by 4,500,740. Random points will be located by navigating with the GPS. If a random point is not within the same habitat classes as those of the forage location then select the next set of numbers from the tables; continue until two appropriate points are selected; record number of unsuitable points. If a foraging location is within a narrow linear habitat class, random point selection will be constrained to the same habitat class using the change of easting as the distance from the forage sampling location (positive number move N or E; negative number move S or W). If the random point is within 100 m of an active LETE or PIPL nest or brood, choose another location.

Habitat characteristics will be taken at each sample site prior to collection, following the NPWRC Riverine Habitat Protocol (attached below).

Small exclosures must be used around sticky sticks to keep piping plovers and other birds from being entangled during sampling. The exclosures will be made of 0.25 m tall 1cm^2 nylon mesh netting held up in the corners by four wooden stakes. The traps consist of four paint stir-sticks thinly covered with 20 cm of Tanglefoot ® insect trap. Two sticks will be covered on 1 side of the non-handle end (horizontal stick) and the other sticks will be covered on both sides (vertical stick). The vertical sticks will be driven into the ground handle first (with a wide side facing into the wind) so that the start of the Tanglefoot ® is even with the surface of the substrate. The horizontal sticks will be placed flat on the substrate (sticky side up) 10 cm away from the vertical stick (perpendicular to the direction of the wind).

The handle of the sticks will be labeled with study area, site, brood/nest number, point type (i.e., forage or random), stick number (H1, V1, H2, V2), date, and time set. Record the study area, site, brood/nest number, point type, date, time set, habitat class, and weather on the forage sampling data sheet.

Movements in the immediate area should be avoided to prevent invertebrates or sand to be driven into traps. The traps will be retrieved after 2 – 3 hours; the end time must be recorded on the forage sampling data sheet. Invertebrates on retrieved sticks will be identified and counted immediately outside study area. Invertebrates <3 mm should be counted, but not identified. Invertebrates 3 mm or greater will be counted and identified to order (all) and to family in order Diptera. If unknown invertebrates are encountered, consult reference materials for identification, if identification is still unresolved 1) preserve a voucher specimen in ethanol, 2) name and label it (e.g., "unknown A"), and 3) make sure all references in data use the same name, especially if the unknown taxa occurs in another sample. When invertebrates cannot be counted and identified on the same day the sample was collected, we will freeze sticky sticks for later identification.

Sampling will include up to 10 minutes of disturbance to chicks and adult plovers during setup of the exclosure, sticky sticks, and substrate sampling, a 2 – 3 hour passive sampling period when investigators are outside the area, and another period up to 10 minutes of potential disturbance to remove the exclosure and sticky sticks.

Equipment List:
Paint stir-sticks
Tanglefoot
Putty knife
At least 3 exclosure
Hammer
GPS
Datasheets