

**2016
Interior Least
Tern and
Piping Plover
Monitoring,
Research,
Management,
and Outreach
Report for the
Lower Platte
River,
Nebraska**



2016
Interior Least Tern and Piping Plover
Monitoring, Research, Management, and Outreach
Report for the Lower Platte River, Nebraska

Prepared by

Mary Bomberger Brown

Tern and Plover Conservation Partnership
School of Natural Resources
University of Nebraska
3310 Holdrege Street
Lincoln, Nebraska
68583
(402) 472-8878
mbrown9@unl.edu
<http://ternandplover.unl.edu>



Lauren R. Dinan

Joel G. Jorgensen

Nongame Bird Program
Wildlife Division
Nebraska Game and Parks Commission
2200 North 33rd Street
Lincoln, Nebraska 68521
(402) 471-5440
ngpc.nongamebird.temp@nebraska.gov
joel.jorgensen@nebraska.gov



Recommended Citation

Brown, M.B., L.R. Dinan and J.G. Jorgensen. 2016. 2016 Interior Least Tern and Piping Plover Monitoring, Research, Management, and Outreach Report for the Lower Platte River, Nebraska. Joint report of the Tern and Plover Conservation Partnership and the Nongame Bird Program of the Nebraska Game and Parks Commission. Lincoln, NE.

Unless otherwise noted, all photographs by Lauren R. Dinan.



PREFACE

This document reports on our monitoring, research, management, and outreach activities during the past 12 months (2015 – 2016). We prepared it to inform our partners, cooperating agencies, funding sources, and other interested parties of our activities and to provide a preliminary summary of our results.

The data, data analyses, results, summaries, and interpretations found in this document are not final and should be considered as such when being cited or referred to in documents, reports, proposals, or presentations. Please contact us before using any of this material and for additional information that may be available.

In an effort to make the information in this document more accessible, it is divided into five (5) sections: Introduction, Monitoring, Research, Management, and Outreach.

Introduction: This section describes the project area and summarizes conditions encountered during the 2016 field season.

Monitoring: This section describes the data we collect every year for basic demographic analyses and includes the number of nests and chicks found in the focus area. These data are collected and summarized in a form that allows comparison across the ranges of both species.

Research: This section describes our research objectives, research methods, data collection, and data analyses.

Management: This section describes our actions intended to protect Interior Least Terns and Piping Plovers and their nests from interference and disturbance.

Outreach: This section describes our efforts to increase public awareness and understanding of Interior Least Terns and Piping Plovers and to promote environmental literacy.

The following icons are used on maps to designate nest locations.



Interior Least Tern nest



Piping Plover nest

“Fortunately protection has come in time to save this beautiful species from complete extermination with which it certainly was threatened.”

Arthur Cleveland Bent
Life Histories of North American Gulls and Terns

ACKNOWLEDGEMENTS

We extend special thanks to our 2016 lower Platte River field technicians Alisa Halpin and Courtney Everhart and our 2016 Lake McConaughy field technicians Peyton Burt and Tiffany Riffle. We thank Diane Pratt for her work on off-river sites along the lower Platte River in 2016. We also thank the U.S. Fish and Wildlife Service and agency biologists including Robert Harms, Matt Rabbe, Amanda Ciurej and Jeff Runge for their assistance surveying river sandbars along the lower Platte River. We gratefully acknowledge the cooperation and coordination that occurs between various Piping Plover research groups across the Great Plains and thank all of the individuals that provided reports and photos of our plovers during the nonbreeding season.

We extend our thanks to everyone who worked and volunteered with us on this program in 2015-2016 including: Linda Alley, Tony Amos, Amanda Anderson, Carol Aron, Fran Baer, Mark Bartosik, Deborah Bifulco, Stephanie Bilodeau, Steve Blaser, Dave Brakenhoff, Mark Brohman, Lindsay Brown, Bryan Campbell, Keith Carroll, Dan Catlin, Kevin Christman, Willard Clark, John Cooper, Susan Daughtrey, Karie Decker, Lauren Deets, Rangel Diaz, Robin Diaz, Collin Dovichin, Rick Drapal, Barbara Dubas, Shaun Dunn, Gil Eckrich, Robert Finer, Florida Park Service, Michael Forsberg, Jolene Foster, Jim Fraser, Meryl Friedrich, Murray Gardler, Cheri Gratto-Trevor, Andrew Haffenden, David Hanson, Monica Hardin, Doug Harrison, Jenevieve Hartung, Peter Hawrylyshyn, Susan Heath, Leslie Hershberger, Brooke Hill, Petra Hockey, Jack Huck, Kelsi Hunt, TJ Hyland, David Jones, Sarah Karpanty, Mike Kelley, Joseph Kennedy, Stephen Kloiber, LaVern Kwapnioski, Dave Lanoha, Greg Lambeth, Robert Lane, Gustino Lanese, Greg Lasley, Delaina LeBlanc, Kim Leedom, Hannah Maciver, Robert Maciver, Sidney Maddock, Lorraine Margeson, Michael Marks, John McNamara, Tom Melton, Mark Mesarch, Timothy Moffett, Dave Moore, Dan Muhleisen, Conrad Muilenburg, John Murphy, David Newstead, Scott Norman, Andrew Orgill, Melissa Panella, France Paulsen, Gary Pearson, Bob Pelkey, Edward Pivorum, Larkin Powell, Raya Pruner, Kory Renaud, Tim Reznicek, Troy Richter, Peter Rogers, Megan Ring, Doug Ritthaler, Erin Roche, Matt Rogosky, Meg Rousher, Danny Sauvageau, Rick Schneider, Roger Severin, Mark Sherfy, Holley Short, Ken Shuster, Rachel Simpson, Meghan Sittler, Jon Sohl, Ken Spilios, Kristal Stoner, Jennifer Stucker, Willis Sylvest, Marilyn Tabor, Brooke Talbott, Mary Thies, Dennis Thomas, Lezlie Thomas, Joel Throckmorton, Dave Titterington, Jack Toriello, Dustin Toy, Gaylene Vasaturo, Ron Vasaturo, David Ward, Carol White, Scott Willers, Jennifer Wilson, Nick Winstead, Sara Zeigler, Suzanne Zuckerman, and Tim Zuehlke.

Support for the monitoring, research, management, and outreach activities described in this report was provided by Bluewater Homeowners' Association/Lanoha Development Company, Lake Allure Homeowners' Association, Lyman-Richey Corporation, Ritz Lake Homeowners' Association, Western Sand and Gravel Company, Lower Platte South NRD, Nebraska Environmental Trust, Nebraska Game and Parks Commission, Nebraska Wildlife Conservation Fund, Nebraska State Wildlife Grants, and University of Nebraska-School of Natural Resources.



We extend our thanks to all of our partners including: Arps Gravel and Concrete, Big Sandy Homeowners' Association, Bluewater Development Corporation, Cedar Creek Homeowners' Association, Central Sand and Gravel, Lake Allure Homeowners' Association, Lake Socorro Homeowners' Association, Lanoha Development Company, Loup Public Power District, Lower Platte North Natural Resources District, Lower Platte River Corridor Alliance, Lower Platte South Natural Resources District, Lyman-Richey Corporation, Mallard Landing Homeowners' Association, Nebraska Natural Legacy Project, Nebraska Public Power District, Old Castle Materials, Overland Sand and Gravel, Papio-Missouri Natural Resources District, Paulsen Sand and Gravel, Preferred Rocks of Genoa, Pilger Sand and Gravel, Ritz Lake Homeowners' Association, Riverview Shores Homeowners' Association, Sandy Pointe Lake Development, Stalp Sand and Gravel, Tri-County Sand and Gravel, Ulrich Sand and Gravel, United States Army Corps of Engineers, United States Geological Survey, and Western Sand and Gravel Company.



DEFINITIONS

Off River Site Definitions

Active mine – an off-river site managed by a sand and gravel mining company that is actively mined and is regulated by the Mine Safety and Health Administration (MSHA).

Inactive mine – an off-river site managed by a sand and gravel mining company but is no longer actively mined and is no longer regulated by the Mine Safety and Health Administration (MSHA).

Lakeshore housing development – an off-river site, usually managed by a homeowners association, with at least one house on the property that an individual or family occupies for all or part of the year.

Transition site – an off-river site that is no longer managed by a sand and gravel mining company or regulated by the Mine Safety and Health Administration (MSHA) and does not have homeowners in residence on the property; transition sites are primarily managed by the real estate developer rather than a sand and gravel mining company or a homeowners association.

Survival Definitions

Annual survival probability – the probability that an animal alive during one time period (i.e., year) will still be alive the next equivalent time period (van der Toorn 1997).

Daily survival probability – the probability that a nest intact or animal alive one day will still be intact or alive the next day (van der Toorn 1997).

Recapture probability – the probability that a previously marked animal will be re-sighted or captured during a session (Lettink and Armstrong 2003).

Seasonal survival probability – the probability that a nest or animal will survive the entire incubation period (nests), incubation and chick-rearing period (adults), or pre-fledging period (chicks); it is estimated by extending the daily survival probability over the appropriate number of days.

Age Definitions

Adult – life stage after completing first migration cycle (winter-spring); a bird is in adult plumage one year of age or older and capable of breeding.

After hatch year – a bird in at least its second calendar year of life (Pyle 1997).

Chick – life stage from hatching to when a bird is capable of flight (plover: hatch day to 27 days post-hatch; tern: hatch day to 20 days post-hatch).

Fledgling – Brief period when a juvenile bird is capable of short flights but is still dependent on parental care.

Hatch year – a bird in first-basic plumage during its first calendar year of life (Pyle 1997).

Juvenile – a bird in juvenal plumage, before the first prebasic molt (Pyle 1997).

INTRODUCTION

The lower Platte River and its major tributaries provide important nesting and migratory stopover habitat for two bird species of special conservation concern: the state and federally endangered Interior Least Tern (*Sternula antillarum athalassos*) and threatened Piping Plover (*Charadrius melodus*). The Tern and Plover Conservation Partnership (TPCP), based at the University of Nebraska-Lincoln School of Natural Resources, and Nongame Bird Program (NBP), based at the Nebraska Game and Parks Commission (NGPC), work cooperatively on tern and plover monitoring, research, management, and outreach activities in Nebraska. The TPCP and NBP focus monitoring and research efforts along the Lower Platte, Loup, and Elkhorn rivers in the eastern part of the state. We also work on tern and plover issues across the state, including Lake McConaughy, and the region.

FOCUS ANIMALS

The Interior Least Tern is the smallest of the terns found in North America. The species was first described in 1847 from a type specimen collected in Guadeloupe, West Indies (American Ornithologists' Union 1998). Meriwether Lewis and William Clark recorded their first observation of an Interior Least Tern on 5 August 1804 along the Missouri River, near present day Omaha, Nebraska while on their 1803–1805 “Voyage of Discovery” across North America. The species was placed on the Endangered Species List on 27 June 1985 (50 Federal Register 21784–21792), and a Recovery Plan was issued in September 1990. As a result of their listing status, Interior Least Terns are protected by the Federal Endangered Species Act (1973) and the Nebraska Nongame and Endangered Species Conservation Act (Neb. Rev. Stat. § 37-801-11). A review of the species' population status has recently been completed by the USFWS (P. Hatfield, pers. comm.) and on-going monitoring plans are being developed (J. Bart, pers. comm.).

The Piping Plover is a small, migratory shorebird; the common name reflects the plaintive whistling sound they produce as one of their primary vocalizations. The species was first described in 1824 from a type specimen collected in New Jersey (American Ornithologists' Union 1998). Meriwether Lewis and William Clark saw Piping Plovers, and recorded their observations, in what was to become the state of Nebraska, during their 1803–1805 “Voyage of Discovery” across North America. The species was placed on the Endangered Species List on 10 January 1986 (50 Federal Register 50726–50734), and the Northern Great Plains Recovery Plan (which covers Nebraska) was issued in May 1988. The listing status of this species is managed under the auspices of the Federal Endangered Species Act (1973) and the Nebraska Nongame and Endangered Species Conservation Act (Neb. Rev. Stat. § 37-801-11). Critical habitat for the Northern Great Plains breeding population was designated in Montana, Nebraska, South Dakota, and Minnesota on 11 September 2002 (67 Federal Register 57637). The United States District Court vacated the portion of critical habitat located in Nebraska on 13 October 2005; to date, it has not been reinstated. A review of the species' population status was completed in 2009 and a revised recovery plan is nearing completion (C. Aron, pers. comm.).

Interior Least Terns and Piping Plovers are an integral part of the fauna of Nebraska. Terns and plovers were described by all of the major expeditions that passed through the region (e.g., Lewis and Clark, John James Audubon, Stephen Long, Duke Paul Wilhelm, Governor Kemble Warren, and Ferdinand Hayden), but they were known by Native Americans well before that. Historically, terns and plovers flourished on sparsely-vegetated midstream sandbars of the Platte, Missouri, Loup, Elkhorn, and Niobrara rivers. However, much of this natural habitat has been lost due to broad-scale alterations of natural river systems. The amount of suitable sandbar habitat has been reduced by the presence of invasive plant species, construction of dams and reservoirs, river channelization, bank stabilization,

hydropower generation, and water diversion. Terns and plovers frequently nest on human-created habitats that occur outside of the river channel. These habitats are created by industrial and commercial activities such as sand and gravel (aggregate) mining, dredging, and construction operations. This change in nesting habitat from exclusively river sandbars to a combination of on-river and off-river habitats is the result of the decrease in available river nesting habitat and the increase in available human-created off-river nesting habitat.

Interior Least Terns and Piping Plovers are migratory birds that spend significant portions of the year in different parts of the Western Hemisphere. They are only in their nesting areas about four months of the year. The other eight months are spent on migration and on their overwintering areas. Piping Plovers spend the winter along the Gulf of Mexico, southern Atlantic Coast, in the Bahamas, and on other Caribbean Islands. These habitats are characterized by wide sandy beaches and a combination of sand flats, mudflats, tide pools, marshes, lagoons, and large inlets. Interior Least Terns spend the winter well off-shore and along coasts, bays, estuaries, and river mouths near Central and South America. Loss of overwintering habitat contributed to the decline of both species. The principal threats to tern and plover overwintering habitat include habitat loss and degradation, increased coastal residential and industrial development, and stochastic events (e.g., global sea level rise, oil spills, water pollution, and hurricanes).

FOCUS AREA

We define our study area as the lower Platte River system in eastern Nebraska, including the Loup and Elkhorn rivers and numerous off-river sites (Fig. 1, Table 1). We concentrate our monitoring and research efforts in our primary study area, which includes the lower Platte and Loup rivers from the Loup Public Power District Diversion to the Missouri-Platte River confluence; throughout the remainder of this report our primary study area is referred to as the lower Platte River (Fig. 2). The TPCP concentrates its monitoring and research efforts on off-river nesting habitats along our primary study area. Additional off-river monitoring also occurs at off-river sites along the North Loup, Middle Loup, and Elkhorn rivers. These off-river habitats include lakeshore housing developments, active and inactive sand and gravel mines, and transition sites. The NBP concentrates its monitoring and research efforts on river sandbars along the lower Platte River proper which does not include the Loup or Elkhorn rivers. We define the lower Platte River proper as the 103 river miles lying between the Loup-Platte River confluence (near Columbus, Platte County) and the Missouri-Platte River confluence (near Plattsmouth, Cass County). The lower Platte River passes through eight counties (Platte, Colfax, Butler, Dodge, Saunders, Douglas, Sarpy, and Cass) and four Natural Resources Districts (Lower Platte South, Lower Platte North, Papio-Missouri, and Lower Loup).



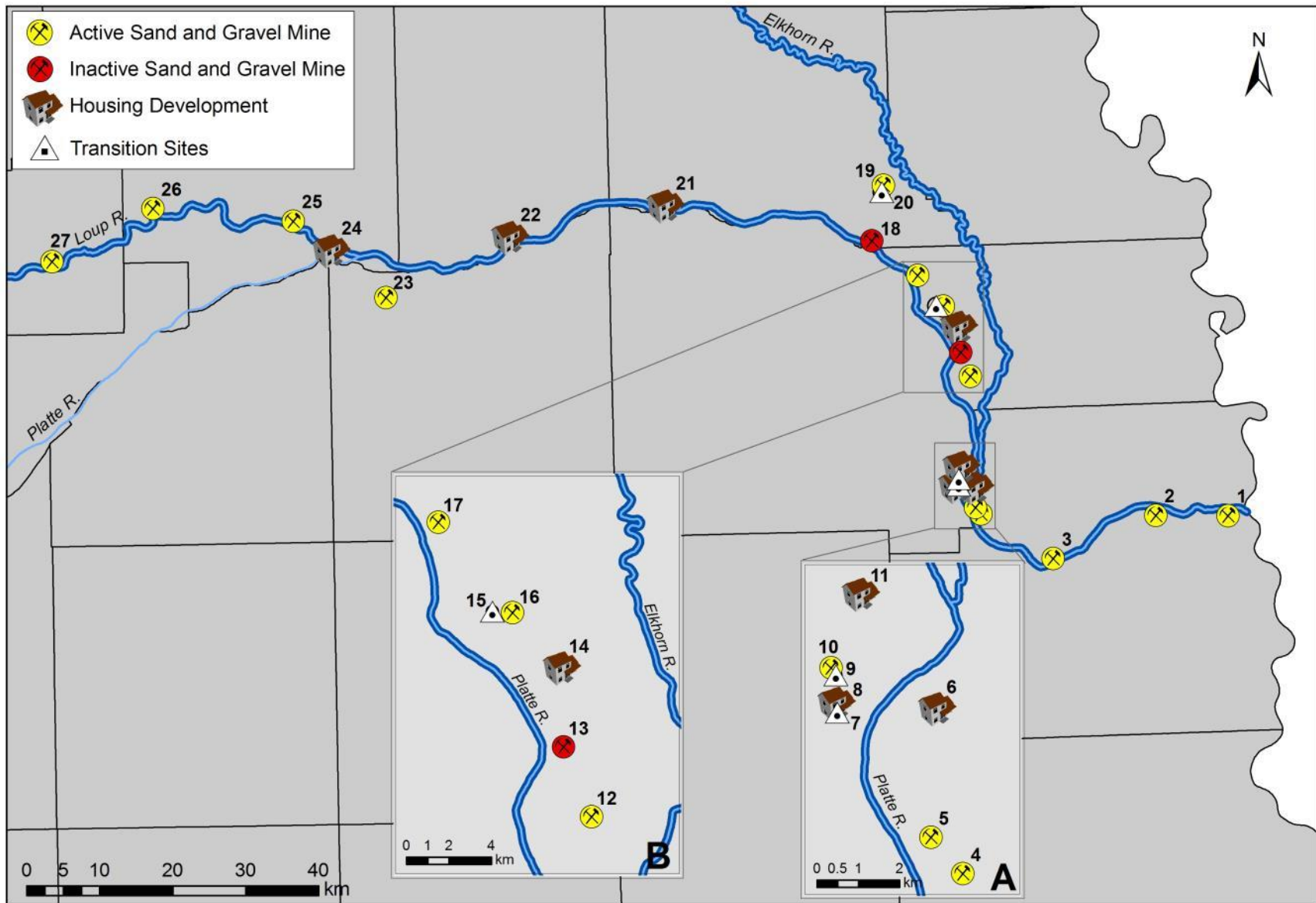


Figure 1. Our study area is highlighted in dark blue. Locations of off-river Interior Least Tern and Piping Plover nesting areas within our study area are marked. Off-river sites can be matched to numbers in Table 1.

2016 Interior Least Tern and Piping Plover Report for the lower Platte River, Nebraska

Table 1. Off-river tern and plover nesting sites; site numbers correspond with Figure 1.

#	Site Name	River	Owner	Site Type	County	2016 Nesting
1	Oreapolis #8	Platte	Lyman Richey	Active Mine	Cass	Yes
2	New Cullom #3	Platte	Central Sand and Gravel	Active Mine	Cass	No
3	Louisville Lakes	Platte	Western Sand and Gravel	Active Mine	Sarpy	Yes
4	Linoma Beach #50	Platte	Lyman Richey	Active Mine	Sarpy	No
5	Linoma Beach #51	Platte	Lyman Richey	Active Mine	Sarpy	No
6	Melia	Platte	Private Lake	Housing	Sarpy	Yes
7	Sandy Pointe	Platte	Sandy Pointe Development	Transition	Saunders	Yes
8	Lake Allure (South)	Platte	Homeowners' Association	Housing	Saunders	Yes
9	Lake Allure (North)	Platte	Lake Allure Development	Transition	Saunders	Yes
10	Sand Creek	Platte	Western Sand and Gravel	Active Mine	Saunders	Yes
11	Big Sandy	Platte	Homeowners' Association	Housing	Saunders	No
12	OMG-Graske Pit	Platte	Old Castle Materials Group	Active Mine	Douglas	Yes
13	Waterloo #40	Platte	Lyman Richey	Inactive Mine	Douglas	No
14	Mallard Landing	Platte	Homeowners' Association	Housing	Douglas	No
15	Bluewater	Platte	Bluewater Dev. Corporation	Transition	Douglas	Yes
16	Valley #7	Platte	Lyman Richey	Active Mine	Douglas	Yes
17	KMG	Platte	Mallard Sand and Gravel	Active Mine	Dodge	Yes
18	Western Fremont	Platte	Western Sand and Gravel	Inactive Mine	Dodge	Yes
19	NE Fremont North	Platte	Lyman Richey	Active Mine	Dodge	Yes
20	Ritz Lake	Platte	Homeowners' Association	Transition	Dodge	Yes
21	Riverview Shores	Platte	Homeowners' Association	Housing	Dodge	Yes
22	Socorro Lake	Platte	Homeowners' Association	Housing	Colfax	Yes
23	Bellwood #73	Platte	Central Sand and Gravel	Active Mine	Butler	Yes
24	Whitetail Lake	Platte	Homeowners' Association	Housing	Platte	Yes
25	Columbus #71	Loup	Central Sand and Gravel	Active Mine	Platte	Yes
26	Genoa North #95	Loup	Central Sand and Gravel	Active Mine	Platte	Yes
27	LPPD-Loup Diversion	Loup	Preferred Rocks - LPPD	Active Mine	Nance	Yes

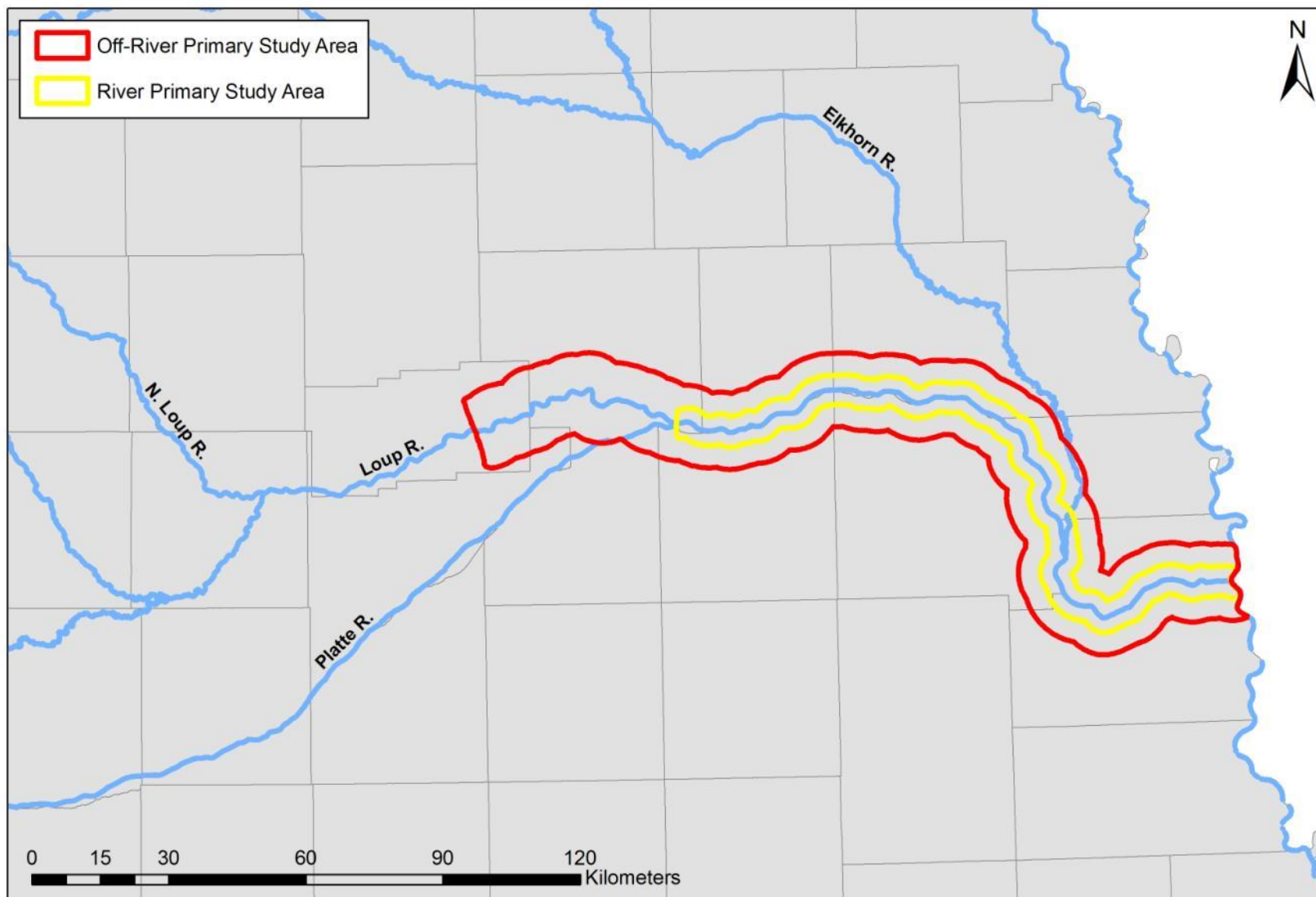


Figure 2. Our primary study area – the red box outlines the area where the TPCP concentrates its off-river monitoring and research efforts, and the yellow box outlines the area where the NBP concentrates its on-river monitoring and research efforts.

2016 OFF-RIVER CONDITIONS

Overall, conditions at off-river sites were similar to previous years. Similar to what was observed in 2015, we had a number of sites (4) transitioning from sand and gravel mines to lakeshore housing developments in 2016. Prior to the 2015 nesting season, memoranda of understanding (MOU) between the NGPC, TPCP, United States Fish and Wildlife Service (USFWS) and four housing developments were executed. In 2016, we continued to work closely with the developers and workers at these transition sites throughout the nesting season to avoid take and minimize human disturbance. In 2016, several sand and gravel mining companies modified their operations, relocated dredges, and moved slurry pipes. At established lakeshore housing developments the pace of home construction continued to increase in 2016.

2016 LOWER PLATTE RIVER CONDITIONS

The amount of suitable sandbar nesting habitat on the lower Platte River varies from year to year. Daily and seasonal fluctuations in the volume of water flowing in the river caused by annual rainfall, ice and snow accumulation, ground water levels, and river channel morphology influence sandbar development and maintenance. General flow conditions on the lower Platte River are monitored by the United States Geological Survey (USGS) stream gages (<http://waterdata.usgs.gov/ne/nwis/rt>). In addition to the USGS data, we monitored flow conditions by visual inspection of the river at bridge crossings and by direct inspection of the river via kayak.

In 2016, condition and availability of sandbar nesting habitat was affected by high water levels. In 2016, water levels peaked at 18,100 cfs at the North Bend gage (USGS 06796000 Platte River) on 2 May and 48,600 cfs at the Louisville gage (USGS 06805500 Platte River) on 12 May (Figs. 3–4). The majority of sandbars were inundated until early June. The lower reach of the river (between the confluence of the Elkhorn River and the confluence of the Missouri River) had a second peak (47,700 cfs at the Louisville gage) in water levels on 12 June which inundated nearly all exposed sandbars.



An off-river nesting site in Dodge County, NE, transitioning from a sand and gravel mine and into a lakeshore housing development.

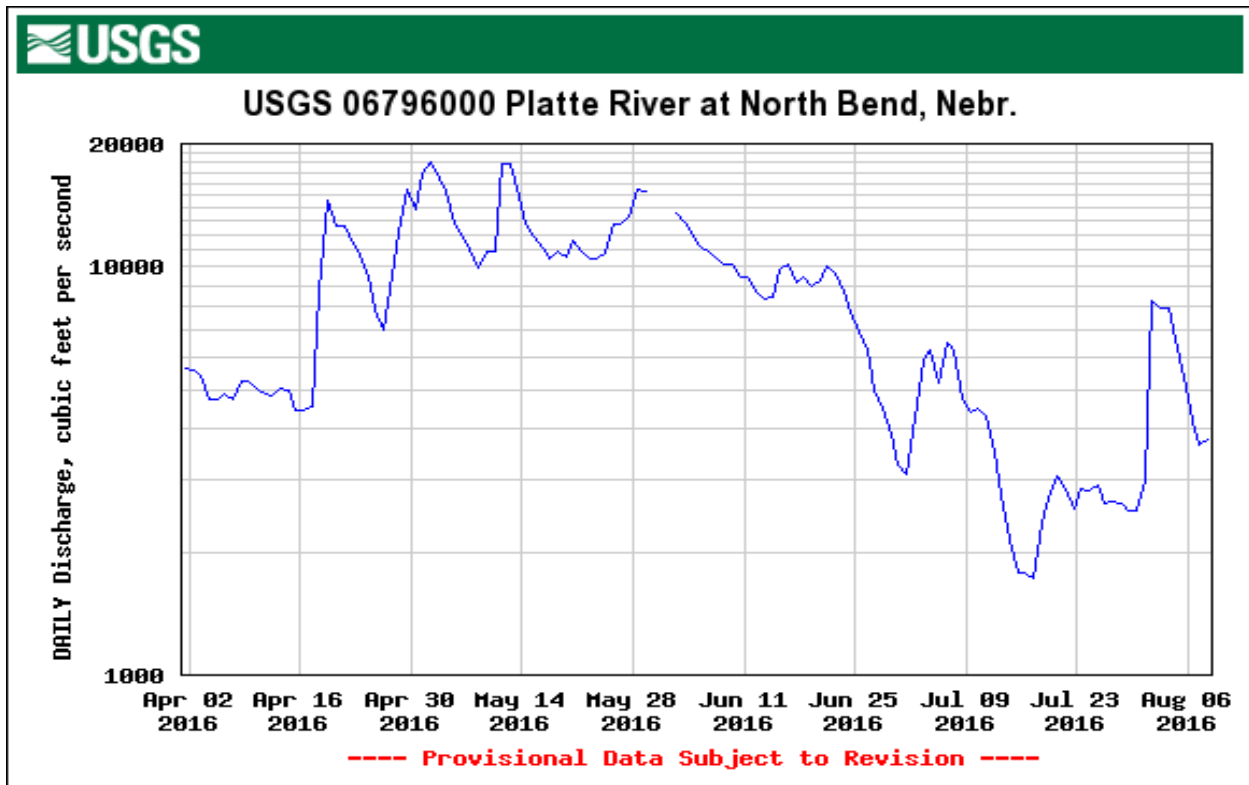


Figure 3. Daily water discharge (cubic feet per second; cfs) measured at the North Bend, Dodge County, USGS gage from 1 April 2016 through 8 August 2016.

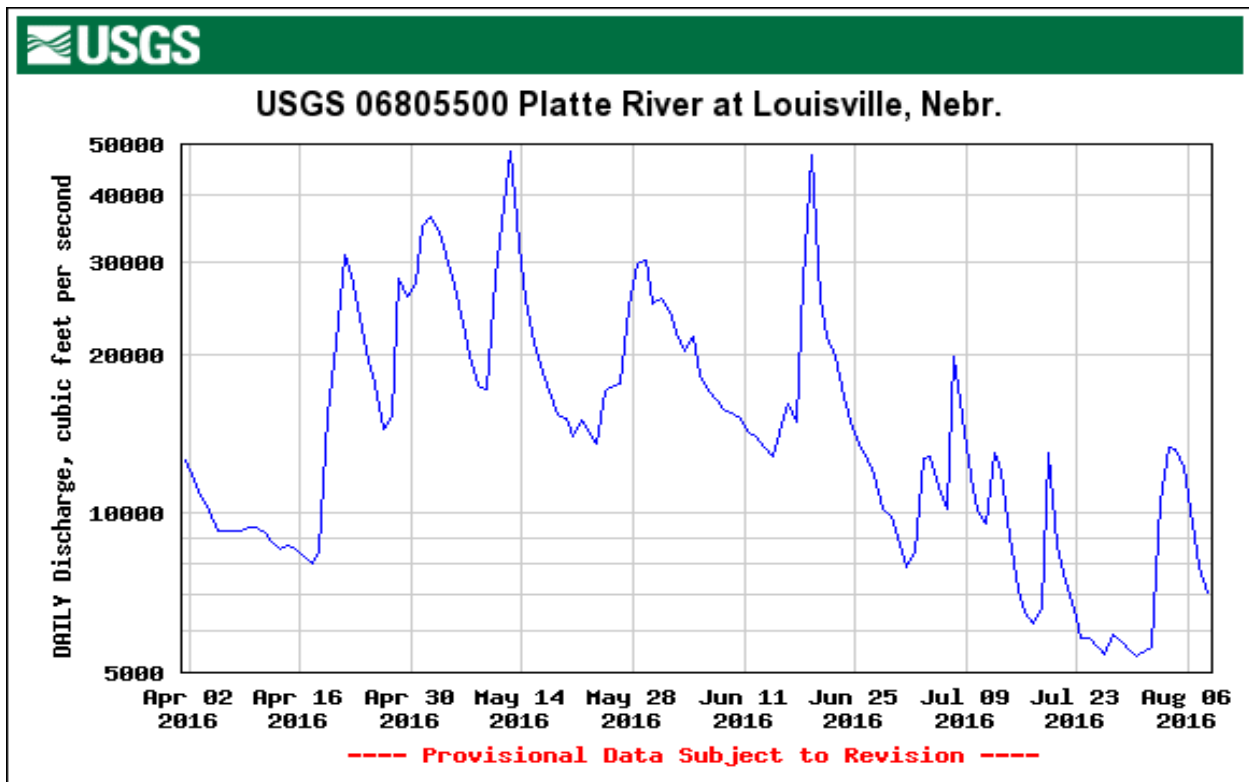


Figure 4. Daily water discharge (cubic feet per second; cfs) measured at the Louisville, Cass County, USGS gage from 1 April 2016 through 8 August 2016.

COLOR BANDING SCHEMES

Piping Plovers and Interior Least Terns are banded across their ranges. Piping Plovers have longer legs than Interior Least Terns which makes it much easier to mark them with color bands. Along the lower Platte River we place a combination of six bands on Piping Plovers and one or two bands on Interior Least Terns. Piping Plovers receive a metal USGS band on one of their upper legs, a colored flag on the opposite upper leg, and a two color bands on each of their lower legs (Fig. 5). Research groups place different colored flags on Piping Plovers to indicate where they were originally banded (Fig. 6). Along the Platte River light blue flags are used. Interior Least Terns always receive a metal USGS band on their lower right leg (we also placed a blue alpha-numeric color band the lower left leg of a few terns banded in 2015 and 2016) (Fig. 5).



Figure 5. Piping Plover chick (left) and Interior Least Tern chick (right).

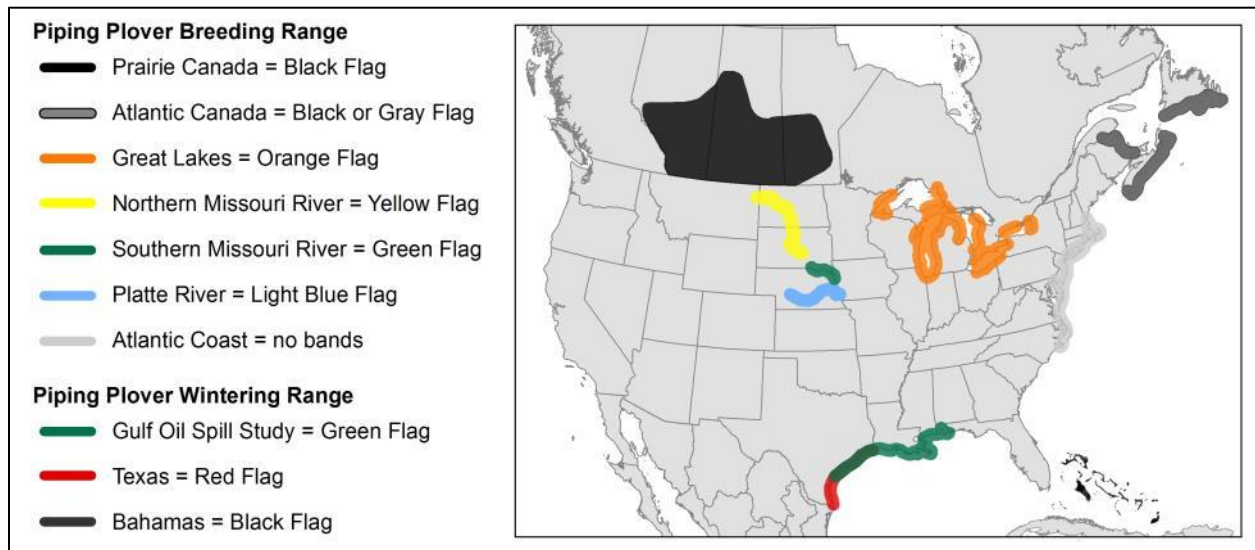


Figure 6. Piping Plover research groups place different colored flags on Piping Plovers to indicate where they were originally banded.

MONITORING

MONITORING REGIONAL MOVEMENTS OF BANDED PIPING PLOVERS AND INTERIOR LEAST TERNS

Piping Plover Breeding Season Observations

This was the ninth year we captured and color-banded Piping Plovers along the lower Platte River. To date, we have banded 685 plovers; 146 adults and 539 chicks (Table 2). The majority of plovers (680) color-banded in our primary study area were captured at off-river sites; however, we banded five plover chicks with metal USGS bands only on river sandbars in 2009. Since 2008, we observed plovers in our primary study area that were originally banded in locations throughout the Great Plains and US Gulf Coast. In 2015, we observed plovers that were originally banded along the lower Platte River, the central Platte River, the Missouri River between South Sioux City, NE and Yankton, SD, the Missouri River north of Yankton, SD, and the US Gulf Coast. Plovers banded along the central Platte River and the Missouri River north of Yankton, SD are banded by USGS biologists (E. Roche, pers. comm.). Plovers banded along the Missouri River between South Sioux City, NE and Yankton, SD and some plovers banded along the US Gulf Coast are banded by the Virginia Tech University Shorebird Program (D. Catlin, J. Fraser, K. Hunt, M. Friedrich, pers. comm.). Some plovers banded along the US Gulf Coast in Texas are banded by biologists with the Coastal Bend Bays and Estuaries Program (CBBEP; D. Newstead, pers. comm.).

In 2016, we observed 74 previously banded Piping Plovers in our primary study area. We observed 60 light blue-flagged plovers originally banded along the lower Platte River, two blue-flagged plovers originally banded along the central Platte River, eight green-flagged plovers originally banded along the Niobrara River and Missouri River south of Yankton, SD, two green-flagged plovers banded along the US Gulf Coast, and two red-flagged plovers banded near Galveston Island, Texas.

Over the last nine years, a number of Piping Plovers originally banded along the lower Platte River have been re-sighted nesting in other locations across the Great Plains (Table 3). Of the 541 plovers banded on the lower Platte River prior to 2016, 189 (35%) have been re-sighted during the breeding season at least one year after they were banded; 154 returned to nest along the lower Platte River, four have been observed on the central Platte River, 25 have been observed on the Missouri River, five have been observed on the Niobrara River, and one has been observed in the alkali lakes region of North Dakota. A majority (57%) of lower Platte River plovers that returned to the lower Platte River to nest were originally banded as adults. A majority (80%) of lower Platte River plovers reported outside of the lower Platte River study area during the nesting season were originally banded as chicks. Overall, 72% of the lower Platte River plovers banded as adults and 23% of the lower Platte River plovers banded as chicks have been re-sighted at least once during a breeding season at least one year after they were banded.

In 2016, 10 lower Platte River plovers were observed outside of the lower Platte River study area during the nesting season. Five plovers were observed on the Missouri and Niobrara rivers in northeast Nebraska and southeast South Dakota, four were observed along the central Platte River, and 1 was observed on an alkali lake near Moffit, North Dakota. This is our first report of a lower Platte River plover observed north of the Nebraska-South Dakota border. Nine of these plovers were originally banded as chicks and one was originally banded as an adult.

Table 2. Number of Piping Plovers banded along the lower Platte River each year.

Year	Adults	Chicks	TOTAL
2008	19	12	31
2009	18	23	41
2010	9	48	57
2011	15	31	46
2012	11	73	84
2013	15	58	73
2014	27	72	99
2015	17	93	110
2016	15	129	144
TOTAL	146	539	685

Table 3. Number of Piping Plovers previously banded along the lower Platte River and re-sighted during the breeding season at least one year after they were originally banded.

Age Banded	lower Platte River	central Platte River	Missouri River	Niobrara River	North Dakota Alkali Lakes	TOTAL
Adults	87	1	6	0	0	94
Chicks	67	3	19	5	1	95
TOTAL	154	4	25	5	1	189

Interior Least Tern Breeding Season Observations

This was our second year capturing and banding adult Interior Least Tern and our ninth year capturing and banding Interior Least Tern chicks in our primary study area along the lower Platte River. To date, we have banded 1314 terns; 27 adults and 1287 chicks (Table 4). All of the adult terns and the majority of the tern chicks (944) were banded at off-river sites.

In 2016, we captured nine adult terns; two of the nine birds captured were originally banded along the lower Platte River prior to the 2016 nesting season. Both of these birds were originally banded at off-river sites; one was banded in 2008 and the other was banded in 2012. We also recovered a dead adult tern at an off-river site near Genoa, Nance County, originally banded as a chick in 2013 at an off-river site along the central Platte River near Alda, Hall County.

We have received three reports of our Interior Least Terns nesting outside of the lower Platte River. Two terns were observed nesting along the Missouri River in 2012 and one was observed nesting along the central Platte River in 2015 and 2016.

Table 4. Number of Interior Least Terns banded on the lower Platte River each year.

Year	Adults	Chicks	TOTAL
2008	0	168	168
2009	0	199	199
2010	0	118	118
2011	0	120	120
2012	0	76	76
2013	0	93	93
2014	0	190	190
2015	20	202	222
2016	7	121	128
TOTAL	27	1287	1314

Piping Plover Non-Breeding Season Observations

Winter Range

Every year a number of Piping Plovers banded along the lower Platte River are observed in wintering areas during the non-breeding season (Fig. 7). As of 10 September 2016, we received eight reports of lower Platte River plovers in their winter range following the 2016 breeding season; all observed along the US Gulf Coast. The first two lower Platte River plovers reported in their winter range following the 2016 breeding season were observed along the coast of Texas on 21 July 2016. Both of these plovers were banded along the lower Platte River as adults in 2014 and were observed nesting along the lower Platte River again in 2016. Four of the eight lower Platte River plovers reported in wintering areas following the 2016 breeding season were originally banded along the lower Platte River in 2016. One was banded as an adult in 2016 and three were banded as chicks in 2016. The first young bird to arrive on the US Gulf Coast was banded as a 7-day old chick at a housing development in Dodge County, Nebraska, on 13 June 2016. On 6 August 2016, this plover was reported over 800 miles away near Galveston, TX.

Over the course of this study, 85 plovers originally banded in our primary study area have been re-sighted in their winter range during the nonbreeding season, with several birds observed more than once. Of the 85 plovers, 37 were originally banded as adults and 48 were originally banded as chicks. Winter sightings of lower Platte River plovers extend from the southern tip of Texas to the Florida Keys and north along the US Atlantic Coast to South Carolina. Lower Platte River plovers have been reported in seven states and 30 counties along the coast (Table 5). The majority of winter re-sightings have occurred along the US Gulf Coast. The first reports of lower Platte River plovers along the US Atlantic Coast occurred during the winter of 2012–2013. To date, seven lower Platte River Plovers have been observed wintering along the US Atlantic Coast.

Since 2008, we have received a total of 351 reports of lower Platte River plovers observed during the non-breeding seasons (2008–2016), with most reports provided by resident and visiting birders and recreational wildlife photographers.

Two green-flagged plovers and two red-flagged plovers observed along the lower Platte River in 2016 were originally banded along the US Gulf Coast. The green-flagged plovers were banded as a part of a BP-Deepwater Horizon Oil Spill (NRDA) recovery study conducted by the Virginia Tech Shorebird Program (D. Catlin, pers. comm.). A total of seven plovers banded as a part of this oil spill study have been observed along the lower Platte River.

Table 5. States where lower Platte River plovers have been observed overwintering.

State	Number of LPR Plovers reported	Percent of total
Alabama	2	2%
Florida	21	24%
Georgia	1	1%
Louisiana	9	10%
Mississippi	5	6%
South Carolina	2	2%
Texas	49	55%

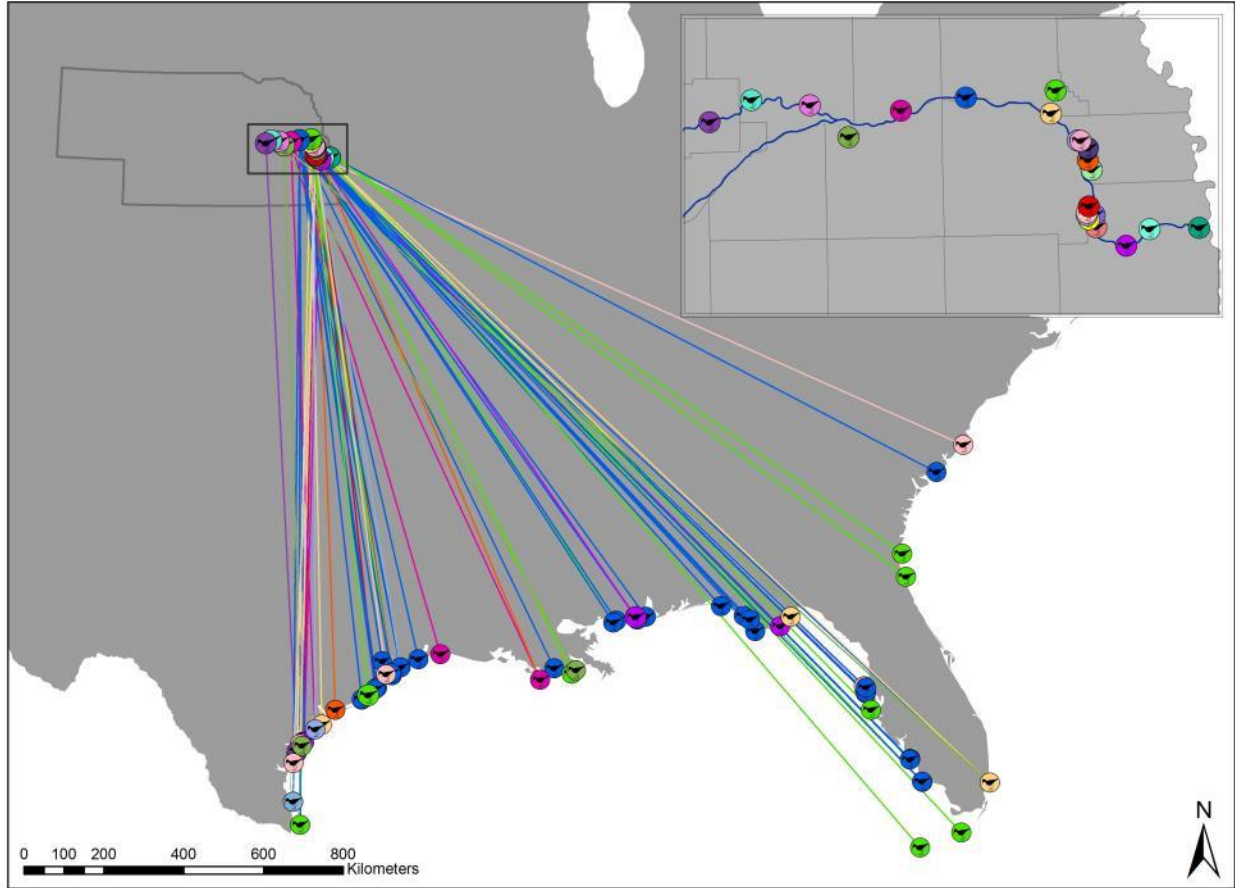


Figure 7. Locations where light blue-flagged plovers, originally banded in our primary study area, have been observed during the non-breeding season on the US Gulf and Atlantic coasts from 2008 to 2016. Each colored marker in Nebraska represents a nesting site where plovers have been banded and each marker on the coast shows the location where an individual light blue-flagged plover has been re-sighted during the winter.



Migration Period

Over the last nine years we received three reports of lower Platte River plovers in the interior of the United States, but outside of their breeding range, during migration. All of these reports occurred during spring migration. The first report was of a plover banded as a chick in June 2012 in Dodge County, Nebraska. This plover was observed at Lake Tyler in northeast Texas on 2 May–3 May 2013 and a couple weeks later, on 21 May, this bird was reported nesting on a Missouri River sandbar in northeast Nebraska. The second report occurred during the spring of 2014. This report was of a plover originally banded as an adult in Saunders County, Nebraska, in June 2013. We do not know where this bird spent the winter but, on 20–24 April 2014, it was observed at Coralville Reservoir, Iowa. On 20 May 2014, this bird was observed nesting at the same site it was banded the previous year. The third report occurred during the spring of 2016. This report was of a plover banded as a 1-day old chick in Dodge County, NE in June 2012. On 5 May 2016 this plover was reported at Stillhouse Hollow Lake, Bell County, TX which is about 200 miles from the coast. This plover was observed nesting in Nebraska in June 2016.

In early fall 2016 (16 August) we recovered a dead juvenile Piping Plover inside an airplane hangar in Lincoln, Nebraska. The bird was reported to us by Duncan Aviation staff. The site where the bird was found did not possess typical Piping Plover habitat (Fig. 8). This plover flew into the airplane hangar and appeared to have died due to a collision. This plover was banded as a 3-day old chick on 28 June 2016 in Dodge County, NE, about 50 miles north of where its carcass was recovered.

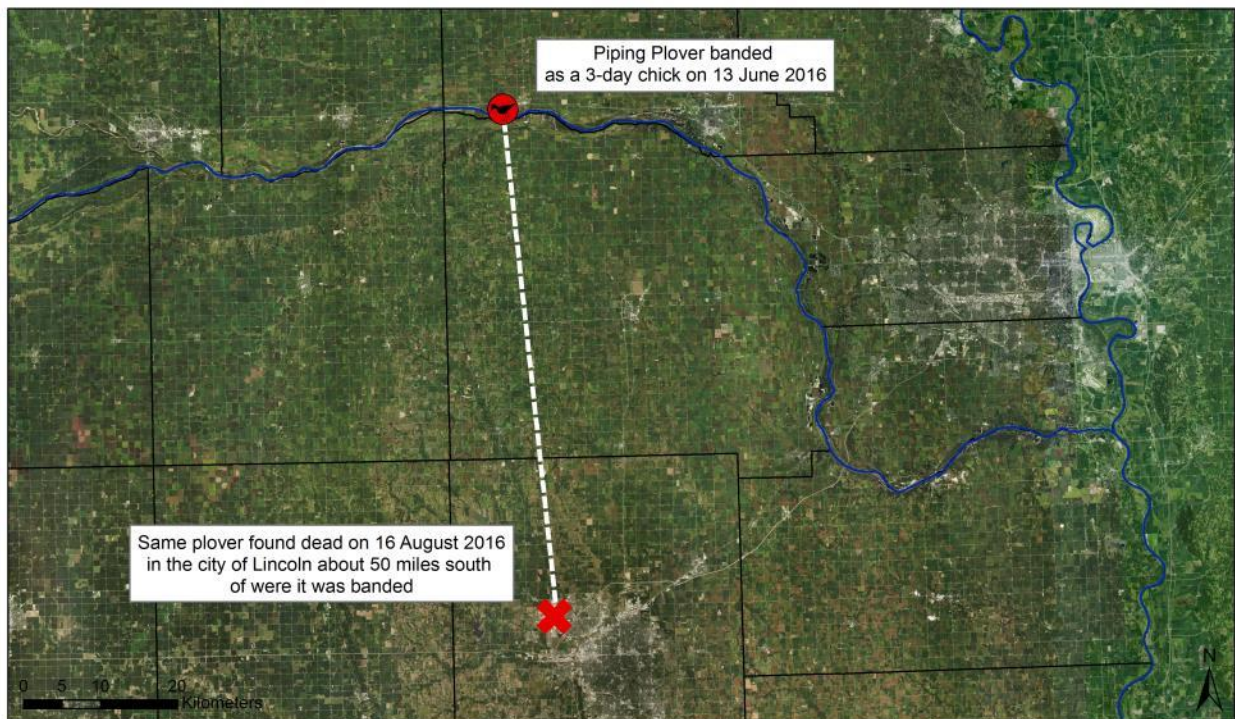


Figure 8. Lower Platte River plover banded in Dodge County, NE, on 13 June 2016 and recovered dead in Lincoln, Lancaster County, NE, on 16 August 2016.

Interior Least Tern Non-Breeding Season Observations

Five Interior Least Terns originally banded along the lower Platte River have been observed in Texas during the nonbreeding season.

MONITORING NESTS AND CHICKS

Methods: Off-River Habitat

We began conducting Interior Least Tern and Piping Plover surveys at each off-river site in late April 2016. We surveyed each site every five to seven days (some sites were visited more frequently than this when we were working to re-sight and band chicks). We searched for terns and plovers and their nests or evidence of nest scrapes. Each nest was assigned a unique identification number. We recorded nest locations using a handheld GPS unit (Garmin Oregon 550t, Garmin Ltd., Olathe, KS, USA). We recorded the number of eggs in each nest and “floated” the eggs in water to determine the nest initiation date (Hays and LeCroy 1972). A majority of the nests were located one to ten days after the first egg was laid. Using the egg floating data, we calculated the eggs’ expected hatch date, assuming a 28-day incubation period for plovers and a 21-day incubation period for terns. We located nests throughout the season. All nests at off-river sites were visited every five to seven days. During each subsequent nest visit, we counted the number of terns and plovers present, located new nests, checked known nests, and searched for and banded tern and plover chicks. We only “floated” eggs on the day the nest was first found. We determined the status of each tern and plover nest based on the following criteria:

Confirmed Successful: ‘pipped’ eggs or newly-hatched chick(s) observed in or in the immediate vicinity (< 1 meter) of the nest cup

Likely Successful: empty, but intact nest cup located on or after the expected hatch date; nest cup may contain small pieces of eggshell

Confirmed Failed: nest cup and/or eggs found destroyed or abandoned

Likely Failed: nest not relocated on repeat visits prior to expected hatch date

Undetermined: nest not re-checked prior to hatch date or not enough evidence to determine nest fate

At some off-river sites, Interior Least Terns and Piping Plovers placed their nests in areas not accessible to us for safety reasons. Some areas of active mine sites present possible cave-in hazards and we work with the mining companies to avoid these areas. In these cases, we only recorded the number of nests, eggs, adults, chicks, fledglings and juveniles that were visible from a distance.

We recorded the total number of active nests and the total number of terns and plovers of each age class. The age classes we used were:

Adults: birds approximately one year or older, in adult plumage, and capable of breeding

Chicks: plovers – hatch day to 27 days post-hatch; terns – hatch day to 20 days post hatch

Fledglings: birds capable of flight but still dependent on parents

Juveniles: birds capable of sustained flight and independent from parents but not in adult plumage (within the first year of life)

We recorded any notable observations including weather conditions, bird injuries, and evidence of disturbance caused by humans, dogs, cats, vehicles, natural predators, or recent severe weather events. We recorded the band combinations of all terns and plovers observed and recaptured with leg bands.

Results: Off-River Habitat

In 2016, we located 72 Piping Plover nests and 272 Interior Least Tern nests at off-river sites in our primary study area (Table 6). These nests were distributed across 21 sites, four sites along the Loup River and 17 sites along the lower Platte River (Figs. 9–10). This included four lakeshore housing developments, four transition sites, and 13 sand and gravel mines. In 2016, 68% of plover nests and 26% of tern nests were confirmed successful, while 13% of plover nests and 29% of tern nest were confirmed failed (Tables 7–8). We observed 142 plover chicks and 124 tern chicks on off-river sites (Table 6).

Table 6. The number of Interior Least Tern and Piping Plover nests and chicks observed at each off-river site along the lower Platte River 2016.

Off-River Site	Habitat	Piping Plover		Interior Least Tern	
		# Nests	# Chicks	# Nests	# Chicks
Genoa - LPPD Diversion	Mine	3	4	19	1
Genoa North #95	Mine	8	11	16	3
Columbus #71	Mine	4	7	11	7
Whitetail Lake	Housing	0	0	8	0
Bellwood #73	Mine	1	3	13	8
Socorro Lake	Housing	0	0	0	0
Riverview Shores	Housing	5	14	10	6
Ritz Lake	Transition	8	22	37	23
NE Fremont (North)	Mine	0	0	1	2
Western Fremont	Mine	0	0	5	2
KMG	Mine	2	0	22	18
Valley #7	Mine	5	5	31	1
Bluewater	Transition	10	21	2	0
Mallard Landing	Housing	0	0	0	0
Waterloo #40	Mine	0	0	0	0
OMG Graske Pit	Mine	3	6	6	0
G Plant	Mine	0	0	11	0
Sand Creek	Mine	4	8	11	9
Lake Allure (North)	Transition	8	23	22	12
Lake Allure (South)	Housing	2	4	0	0
Sandy Pointe	Transition	2	7	24	16
Big Sandy	Housing	0	0	0	0
Melia	Housing	1	3	2	0
Linoma Beach #50	Mine	0	0	0	0
Linoma Beach #51	Mine	0	0	0	0
Louisville Lakes	Mine	5	4	17	14
New Cullom #3	Mine	0	0	0	0
Oreapolis #8	Mine	1	0	4	2
TOTAL		72	142	272	124

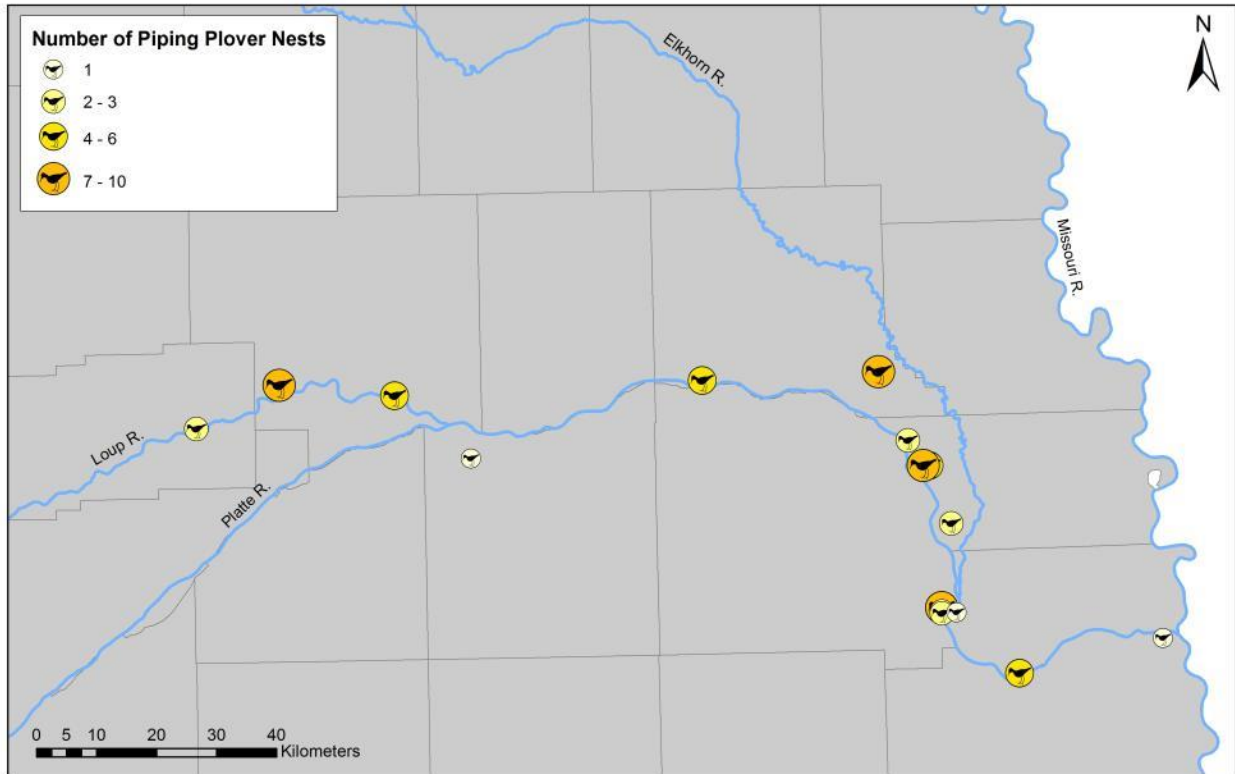


Figure 9. Location of off-river Piping Plover nesting sites in our primary study area in 2016.

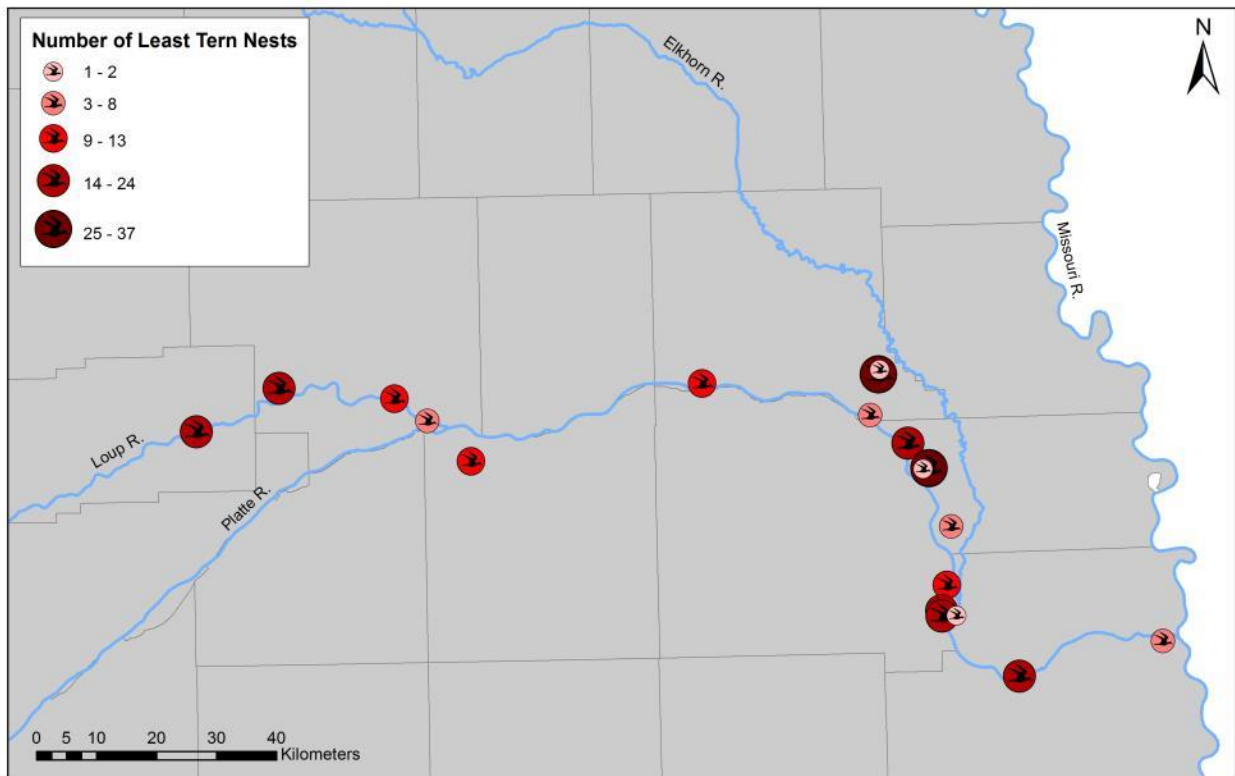


Figure 10. Location of off-river Interior Least Tern nesting sites in our primary study area in 2016.

Table 7. The fate of Piping Plover nests on off-river sites along the lower Platte River in 2016.

Nest Fate	Mines		Housing		Transition		Total	
	#	%	#	%	#	%	#	%
Confirmed Hatched	20	28%	7	10%	22	31%	49	68%
Likely Hatched	4	6%	0	0%	3	4%	7	10%
Confirmed Failed	7	10%	0	0%	2	3%	9	13%
Likely Failed	0	0%	1	1%	0	0%	1	1%
Undetermined	5	7%	0	0%	1	1%	6	8%
TOTAL	36	50%	8	11%	28	39%	72	100%

Table 8. The fate of Interior Least Tern nests on off-river sites along the lower Platte River in 2016.

Nest Fate	Mines		Housing		Transition		Total	
	#	%	#	%	#	%	#	%
Confirmed Hatched	39	14%	10	4%	21	8%	70	26%
Likely Hatched	29	11%	8	3%	10	4%	47	17%
Confirmed Failed	66	24%	4	1%	8	3%	78	29%
Likely Failed	0	0%	0	0%	0	0%	0	0%
Undetermined	44	16%	11	4%	22	8%	77	28%
TOTAL	178	65%	33	12%	61	22%	272	100%



Alisa Halpin (left) and Courtney Everhart (right) banding a newly hatched Interior Least Tern chick at a transition site in Dodge County, NE.

Methods: On-River Habitat

Access to river sandbars differs from access to off-river sites, so we take a different approach to monitoring terns and plovers nesting on midstream river sandbars. We monitored river conditions for the presence of sandbar habitat early in the nesting season. In 2016, we surveyed the lower 41 miles of the river via kayak and cooperated with the USFWS to survey the upper 54 miles of the river via airboat.

We visually scanned for the presence of terns and plovers and behaviors suggestive of nesting or breeding. When a colony was located, we surveyed the sandbar for nests. Once nests were found, we used the same nest monitoring method as for off-river nests. We recorded nest locations using a handheld GPS unit and recorded the number of eggs in the nests. We “floated” the eggs to determine the nest initiation date (Hays and LeCroy 1972).

Results: On-River Habitat

Kayak surveys were conducted by the NBP in mid-June. Kayak surveys were conducted from river mile 41 near Venice, Douglas County, to river mile 0 near Plattsmouth, Cass County. This portion of the lower Platte River (river mile 41 – river mile 0) was only surveyed once (mid-June) during the nesting season. Airboat surveys were conducted by the USFWS in mid-June and mid-July. Airboat surveys were conducted from river mile 103 near Columbus, Platte County, to river mile 49 near Leshara, Saunders County. This portion of the lower Platte River was surveyed twice (mid-June and mid-July) during the nesting season.

In 2016, we recorded a total of 33 Interior Least Tern nests on 13 lower Platte River sandbars between Columbus and Plattsmouth (Fig. 11, Table 9). We did not observe any Piping Plover nests on river sandbars in 2016. We were unable to confirm nest fates on river sandbars in 2016.

Table 9. The location of Interior Least Tern and Piping Plover nesting colonies and the number of nests observed in each colony on lower Platte River sandbars in 2016.

River Sandbar	River Mile	Piping Plover # Nests	Interior Least Tern # Nests
RM 3	3.00	0	1
RM 7 – Cullom	7.00	0	4
RM 12.3 – E. Cedar Creek	12.30	0	6
RM 24.4 – Interstate South	24.40	0	3
RM 64.5	64.50	0	1
RM 65.25	65.25	0	2
RM 65.5	65.5	0	2
RM 69	69.00	0	1
RM 70	70.00	0	1
RM 71.5	71.50	0	1
RM 83	83.00	0	1
RM 88	88.00	0	4
RM 96.75	96.75	0	6
TOTAL		0	33

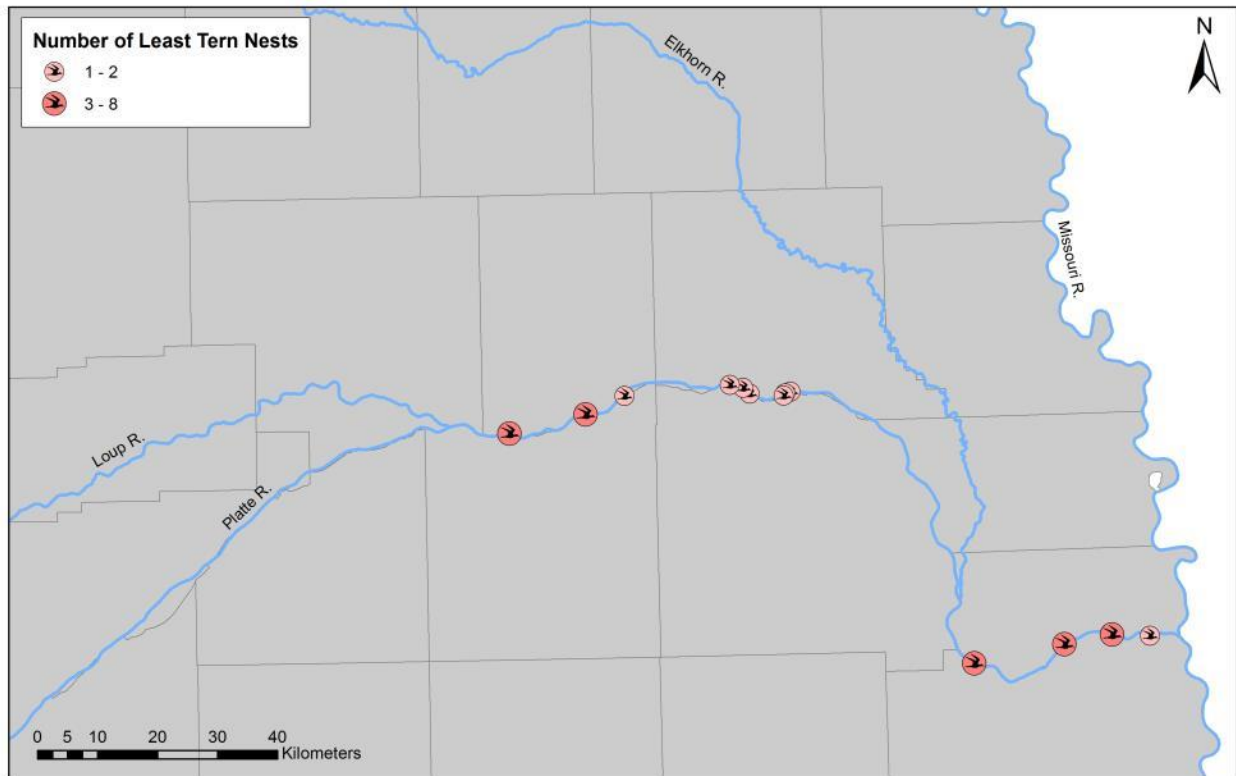


Figure 11. Location of Interior Least Tern colonies on river sandbars along the lower Platte River in 2016.

RESEARCH

ESTIMATING SURVIVAL RATES

Accurately estimating demographic parameters, such as daily and seasonal survival probabilities for individual birds and nests, leads to a better understanding of Interior Least Tern and Piping Plover population dynamics. This allows us to develop and implement more effective management strategies for these two species. We constructed scatterplots of tern and plover chick growth (based on body mass) from hatching to fledging. We estimated nest, adult, and chick survival by using capture-mark-recapture and statistical modeling techniques (Program MARK; <http://www.cnr.colostate.edu/~gwhite/mark/mark.htm>).

Methods

Banding and Re-sighting

We conducted all bird capture and banding under the authorization of the USGS Bird Banding Laboratory (Patuxent Wildlife Research Center; <http://www.pwrc.usgs.gov/bbl>) and the USFWS through an inter-agency agreement with the NGPC (MBB holds Federal Master Bird Bander Permit # 23545 with Threatened and Endangered Species endorsements and Nebraska Educational and Scientific Permit # 241; the TPCP holds Federal Threatened and Endangered Species handling permit #TE 070027-1; JGJ holds Federal Master Bird Bander Permit #20259 with Threatened and Endangered Species endorsements). Color-band combinations were coordinated prior to the beginning of the field season with the Bird Banding Laboratory and others with an interest in tern and plover research.

At off-river sites, we captured and banded adult Piping plovers and Interior Least Terns during incubation. The capture, handling, and banding protocols used for plovers were the same as those used in previous years. This year was the second year we captured, handled, and banded adult terns and placed HD video cameras at tern and plover nests to determine band combinations without re-capturing and handling the birds. We followed protocols developed and used by USGS biologists on the central Platte and Missouri rivers (E. Roche, C. Dovichin, pers. comm.). The HD video cameras were provided by USGS biologists Erin Roche, Collin Dovichin, Dustin Toy, and Megan Ring.

Adult Piping plovers were captured using a simple box trap placed over the nest (Fig. 12). This method is effective and minimizes risk of injury to the adult and eggs. Box traps have no moving parts; the bird walks through the door, settles on its nest, and is captured. Adult terns were captured using a remote control triggered bow net trap that was placed around the nest (Fig. 13). The adult tern settles on its nest, a net is triggered using a remote control, the net goes over the adult and nest, and the adult is captured. The a remote control triggered bow net trap was made and provided to us by USGS biologists Erin Roche, Collin Dovichin, Dustin Toy, and Megan Ring. We captured plover and tern chicks by picking them up from the sand or from their nests.

We exercise great caution when handling and banding birds. We do not capture or band birds during extreme weather (cold, windy, rainy, or when inclement weather was forecast) or when the temperature was above 85° F (30° C). Birds are observed after banding and on subsequent visits to determine if there are any behavioral changes or signs of injury. As part of our protocol, we are to suspend all banding activities if problems or injuries were observed at any time. We did not observe any problems or injuries to birds as a result of monitoring, capture, handling, or banding in 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 or 2016.



Figure 12. Wire box trap placed over a Piping Plover nest showing the bird approaching the trap (A), entering through the open “door” (B), and settling on the nest (C).



Figure 13. Remote control triggered bow net trap placed over an Interior Least Tern nest showing the bird approaching the trap (A), settling down on the nest (B), and a biologist getting the tern out of the trap after the net was triggered over the bird and nests (C).

In 2016, we banded each Piping Plover, adult and chick, with an individually numbered metal USGS band (size 1A) on one of the upper legs. We placed a light blue flag on the opposite upper leg; the light blue flag indicates that this bird was banded in Nebraska along the Platte River. We place a unique combination of color bands (yellow, green, black, gray) on the lower legs of each plover we band. We place two color bands on the lower right leg and two color bands on the lower left leg. The unique color band combination indicates each bird's individual identity (Fig. 14).

We measured the mass of each Piping Plover adult by placing the bird in a cloth bag and suspending it from a Pesola scale ($\pm 0.3\%$ accuracy). We measured the following morphological characters for adult plovers: length of the left and right flattened wing chord (wrist to the distal end of the outermost primary feather), length of the left, right, and middle tail feathers, length of the left and right tarsus (unfeathered leg above the hallux), length of the culmen (exposed midline ridge of the beak), width of the beak at the nostrils, and length of the total skull (distal end of the beak to the posterior end of the skull). All measurements were taken by one individual (LRD) to minimize measurement error. We measured the left and right sides of each bird so bilateral symmetry could be calculated. Symmetry is a commonly used measure of an individual bird's "quality." The symmetry of skeletal parts and feathers reflects an individual's nutrition and health during development; this gives us a metric to assess the "quality" of birds produced at different nesting habitats (on-river versus off-river) and in different years. Symmetry also gives us a way to assess the quality of overwintering habitat for birds; better foraging habitat provides better overwintering survival, nutrition, and health for nesting birds.

We banded each Interior Least Tern adult and chick with an individually numbered metal USGS band (size 1A) on their lower right leg. We also placed a blue alpha-numeric band the lower left leg for adult terns (Fig. 14). We measured each chick's body mass using a digital scale (Ohaus SP401, Parsippany, NJ, USA) that was accurate to ± 0.1 gram. Scales were calibrated using a standardized weight to ensure accuracy. We did not take any morphological measurements of tern or plover chicks.

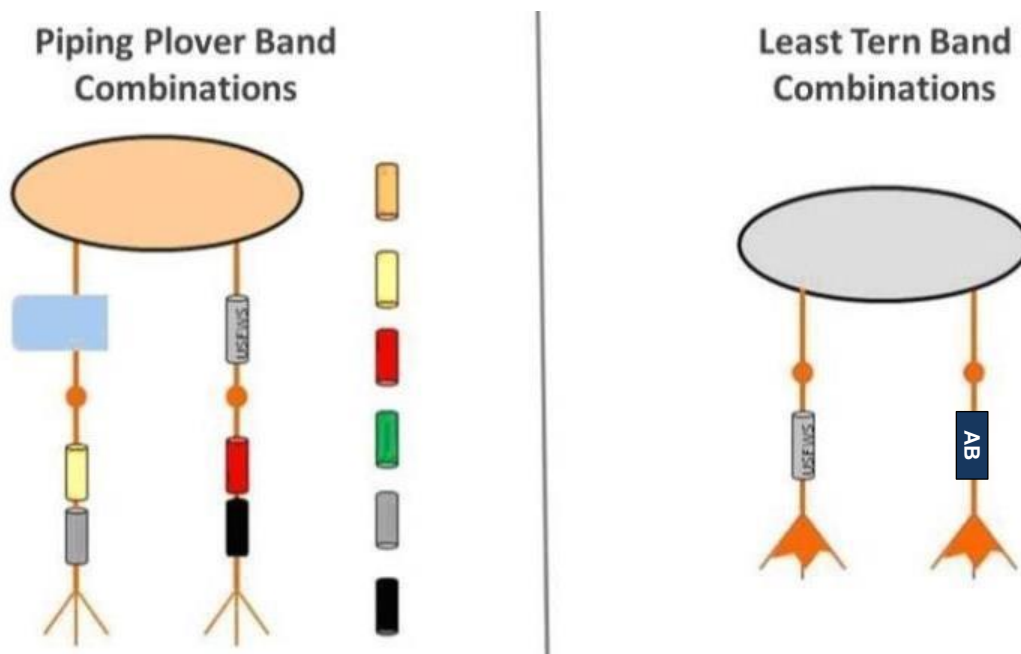


Figure 14. Diagram illustrating the banding scheme used on Piping Plovers and Interior Least Terns banded along the lower Platte River. The flags, color bands, and metal bands may be on either leg and plover color combinations vary.

Daily and Seasonal Survival Analyses

We monitored Piping Plover and Interior Least Tern nests throughout the nesting season (see Monitoring section for details). We used nest monitoring data to calculate daily and seasonal nest survival probabilities. We attempted to re-sight banded terns and plovers every five to seven days. We weighed birds when we recaptured them. We used this capture-mark-recapture dataset to calculate daily and seasonal survival probabilities for each individual.

We estimated survival probabilities using the software program MARK (White and Burnham 1999). We used the general methods of Lebreton et al. (1992), Burnham and Anderson (2002), and Dinsmore and Dinsmore (2007). We assessed model fit for each analysis using the Akaike's Information Criterion (AIC); the model with the lowest AIC value was considered the model that best fit the data.

Nest Survival Analysis

We used data from nest monitoring (see Monitoring section) to estimate nest survival. We estimated nest survival probabilities using the nest survival utility in Program MARK. We constructed encounter histories by summarizing the day each nest was found (k), the last day the nest was found active (l), the last day the nest was checked for activity (m), and the fate of the nest (f). Due to small sample sizes we did not include any covariates in our model and assumed constant survival across the season. We provide both daily survival probability and seasonal survival probability. Seasonal survival is the probability a nest will survive the 21- or 28-day incubation period and it is estimated by extending the daily survival probability to the appropriate number of incubation days.

Within Year Individual Survival Analysis

We constructed individual encounter histories for all terns and plovers captured, recaptured or observed at off-river sites. We used this data to determine the probability of adults and chicks surviving the 2016 nesting season. We provide both daily survival probability and seasonal survival probability for adults and chicks. Adult plovers included in this analysis were originally color-banded along the lower Platte River, central Platte River, Missouri River, or the US Gulf Coast. Tern and plover chicks included in this analysis were produced and banded in our primary study area. We did not include any covariates in the models. We attempted to fit models with varying degrees of time-dependence to the data, but the model that included constant survival and constant recapture probabilities $\{\phi(c), p(c)\}$ was always the best-fitting model based on AIC; this is most likely due to our relatively small sample sizes.

Annual Survival Analysis

We constructed individual encounter histories for all plovers captured, recaptured, or observed in our primary study area from 2008 through 2016. We used this data to determine the probability of Piping Plovers surviving from one year to the next. We do not have sufficient numbers of re-sightings of Interior Least Terns to consider them in this type of analysis.

Growth Scatterplots

Our growth scatterplots for 2016 included only tern and plover chicks produced at off-river sites. We weighed chicks every time they were encountered. In cases where the chick was banded while still in or very close to the nest, we 'age' them based on the nest's known hatching date. If chicks were banded after they left the nest, we estimated their age using an age-based time series of photographs.

Statistical Analysis

All statistical analyses were performed using Program R 3.1.3 (R Development Core Team 2014). Due to small sample sizes, we used nonparametric statistical tests; statistical significance was set at $P < 0.05$. Means (± 1 SE) are reported.

Results

Banding and Re-sighting

In 2016, we banded 144 Piping Plovers and 128 Interior Least Terns; all banding occurred at off-river sites. We captured and banded 15 adult plovers and 129 plover chicks. Most plover chicks (73%) were less than one week old when banded. We re-sighted 60 plovers that were originally banded along the lower Platte River in previous years, eight that were originally banded along the Missouri River south of Yankton, SD, two that were originally banded along the central Platte River, and four originally banded along the U.S. Gulf Coast.

We banded seven tern adults and 121 tern chicks. Most tern chicks (87%) were less than one week old when banded. We recaptured two adult terns originally banded along the lower Platte River as chicks prior to the 2016 nesting season; one was banded in 2008 and the other was banded in 2012.



An adult Interior Least Tern captured and banded at an off-river site along the lower Platte River in 2016.

Daily and Seasonal Survival

Piping Plover Nest Survival

We estimated Piping Plover nest survival from 71 nests located at off-river sites (8 at lakeshore housing developments, 35 at sand and gravel mines, and 28 at transition sites). We did not include one plover nest in which nest fate was undetermined. In 2016, all off-river plover nests had a daily survival probability of 0.99 ± 0.00 and a seasonal survival probability of 0.75 ± 0.06 . Plover nests at lakeshore housing developments had a daily survival probability of 1.00 ± 0.00 and a seasonal survival probability of 1.00 ± 0.00 . Plover nests at sand and gravel mines had a daily survival probability of 0.98 ± 0.01 and a seasonal survival probability of 0.57 ± 0.10 . Plover nests at transition sites had a daily survival probability of 1.00 ± 0.00 and a seasonal survival probability was 0.90 ± 0.07 (Fig. 15).

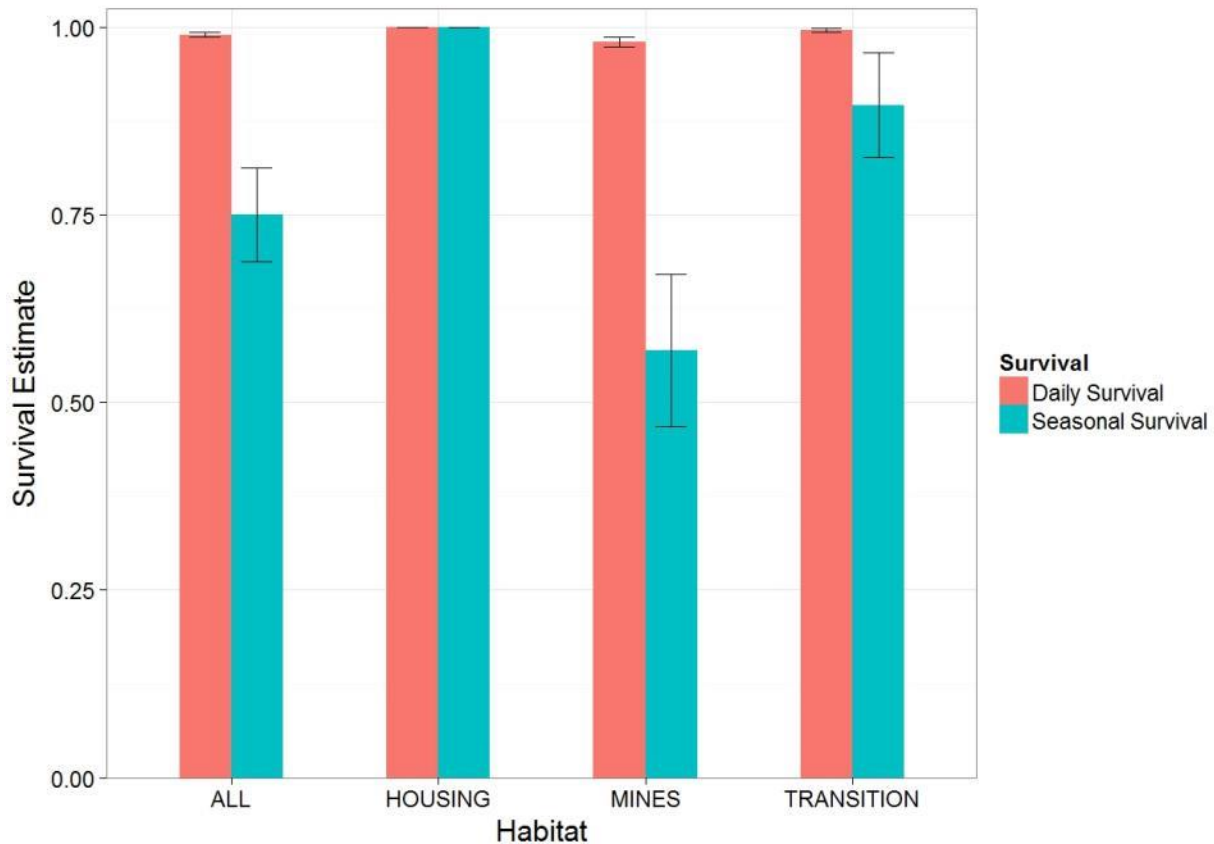


Figure 15. Daily and seasonal survival probabilities of Piping Plover nests at all off-river sites, lakeshore housing developments, sand and gravel mines, and transitions sites in 2016.



In 2016, we placed protective exclosures around 46 of the 71 off-river Piping Plover nests. Nests with protective exclosures had a daily survival probability of 0.99 ± 0.00 and a seasonal survival probability of 0.80 ± 0.07 ; while nests without protective exclosures had a daily survival probability of 0.98 ± 0.01 and a seasonal survival probability of 0.61 ± 0.14 (Fig. 16).

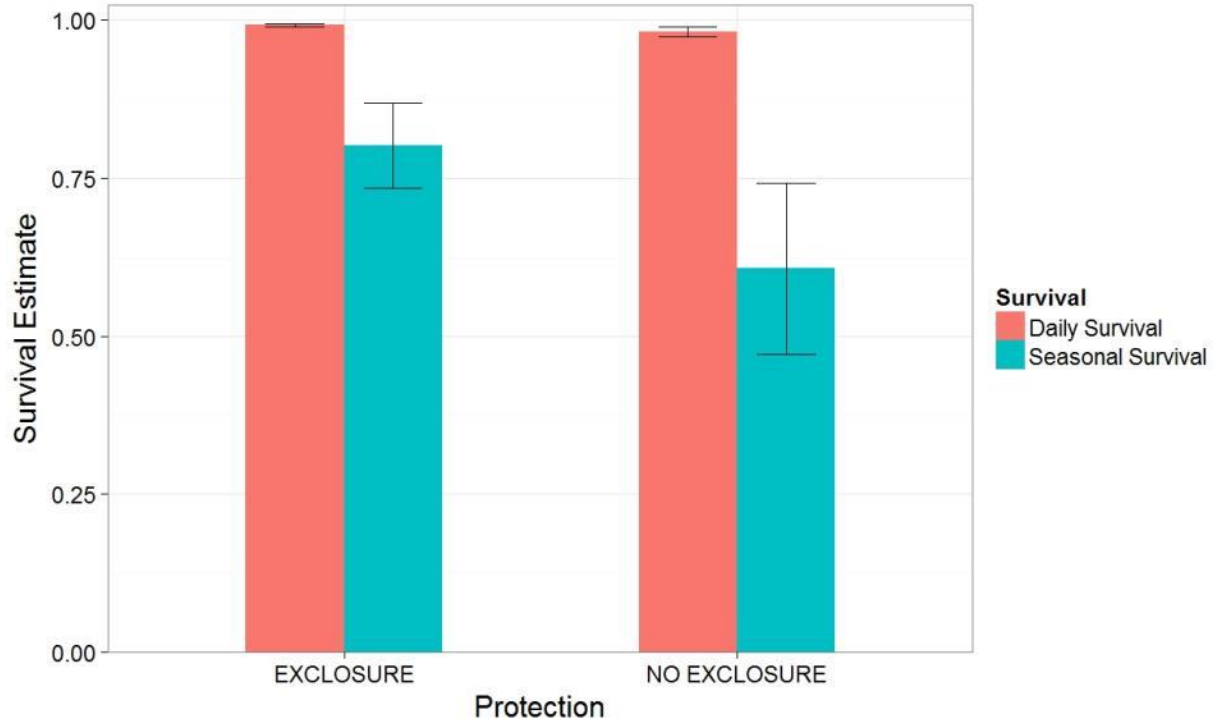


Figure 16. Daily and seasonal survival probabilities of Piping Plover nests at off-river sites with protective exclosures and those without protective exclosures in 2016.



Interior Least Tern Nest Survival

We estimated Interior Least Tern nest survival from 268 nests at off-river sites (33 at lakeshore housing developments, 175 at sand and gravel mines, and 60 at transition sites). We did not include four tern nests in which nest fate was undetermined. In 2016, the daily survival probability of off-river tern nests was 0.95 ± 0.00 and the seasonal survival probability was 0.35 ± 0.03 . Tern nests at lakeshore housing developments had a daily survival probability of 0.97 ± 0.01 and a seasonal survival probability of 0.49 ± 0.09 . Tern nests at sand and gravel mines had a daily survival probability 0.94 ± 0.01 and a seasonal survival probability of 0.30 ± 0.04 . Tern nests at transition sites had a daily survival probability 0.96 ± 0.01 and a seasonal survival probability of 0.45 ± 0.07 (Fig. 17). In 2016, we did not estimate nest survival for tern nests on river sandbars.

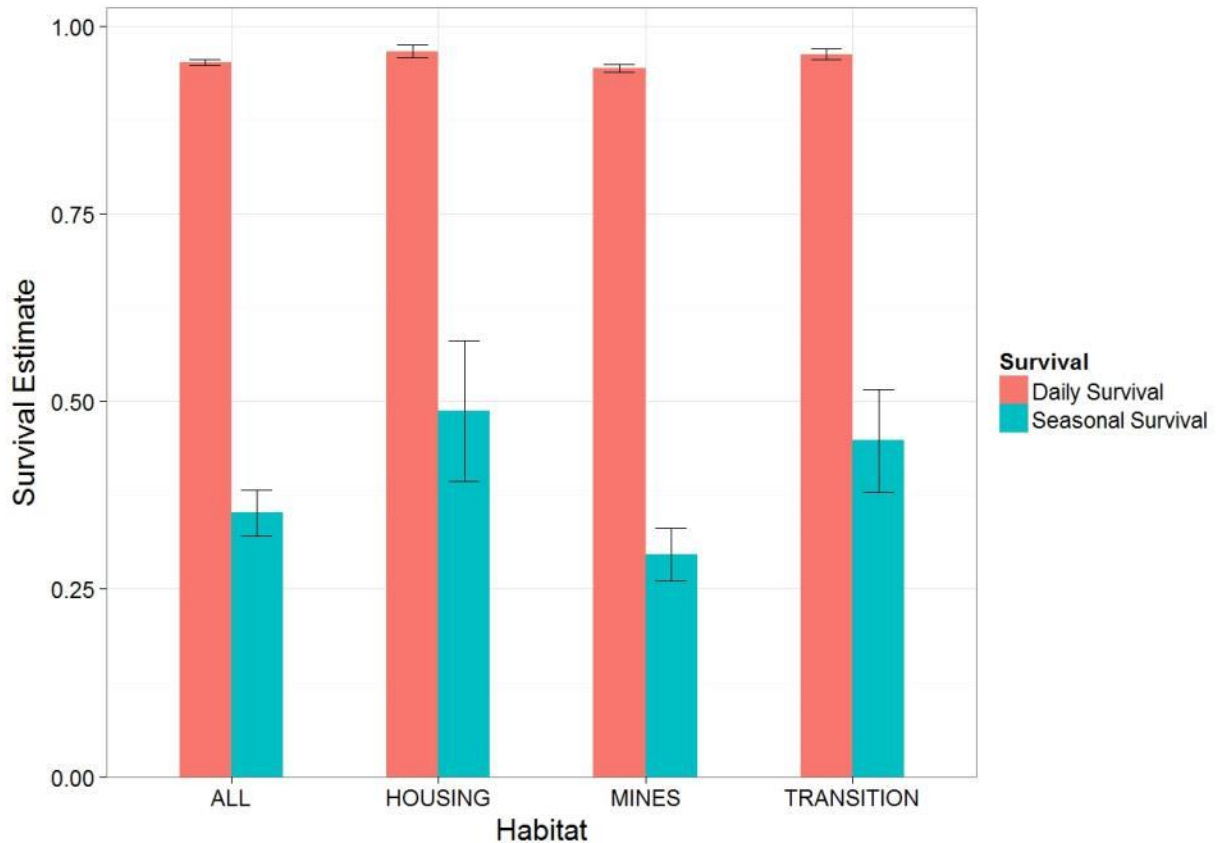


Figure 17. Daily and seasonal survival probabilities of Interior Least Tern nests at off-river sites in 2016.



Within Year Individual Survival

In 2016, the daily survival probability for adult plovers nesting at off-river sites was 0.98 ± 0.00 and the seasonal survival probability was 0.62 ± 0.05 . The daily survival probability for plover chicks reared at off-river sites was 0.93 ± 0.01 and the seasonal survival probability was 0.13 ± 0.04 . The daily survival probability for adult terns nesting at off-river sites was 0.98 ± 0.02 and the seasonal survival probability was 0.60 ± 0.30 . The daily survival probability for tern chicks reared on off-river sites was 0.92 ± 0.02 and the seasonal survival probability was 0.19 ± 0.09 (Figs. 18 - 20).

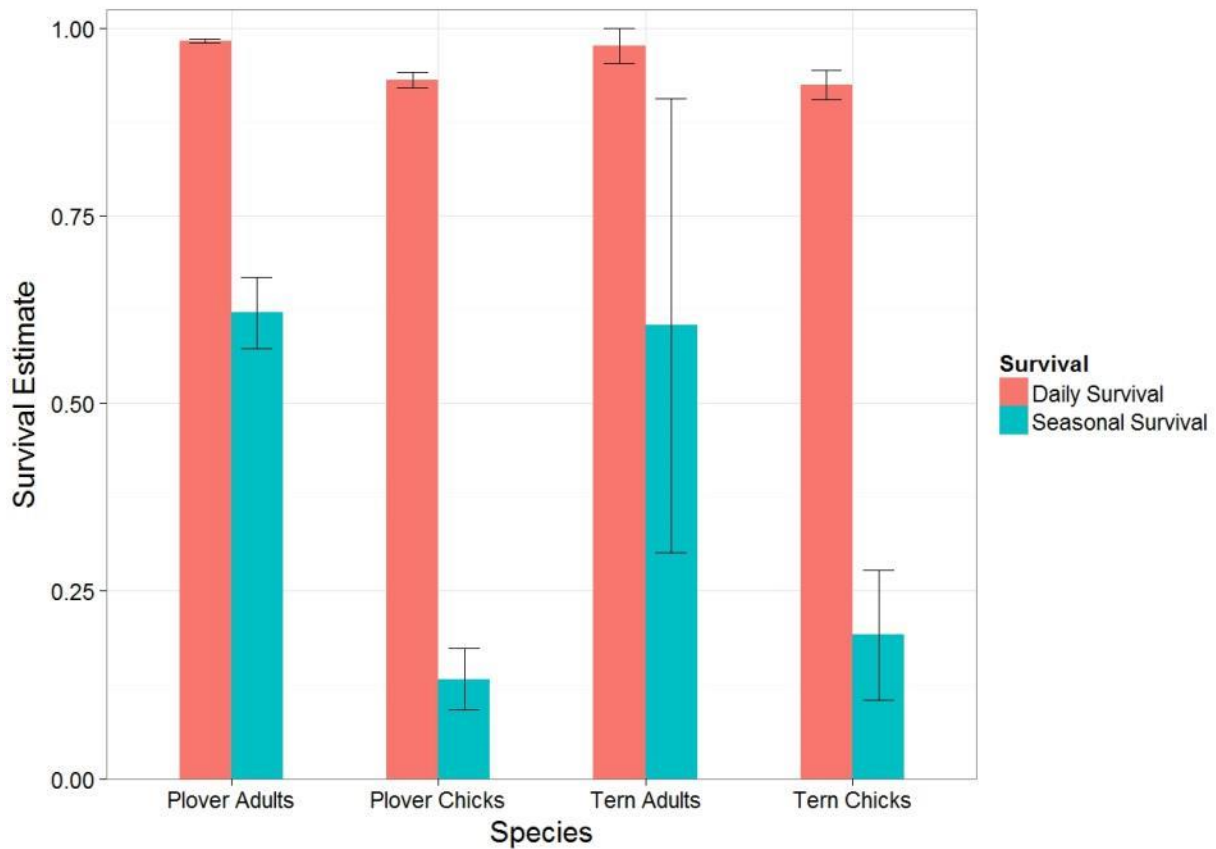


Figure 18. Piping Plover and Interior Least Tern within year daily and seasonal survival probabilities at off-river sites in 2016.



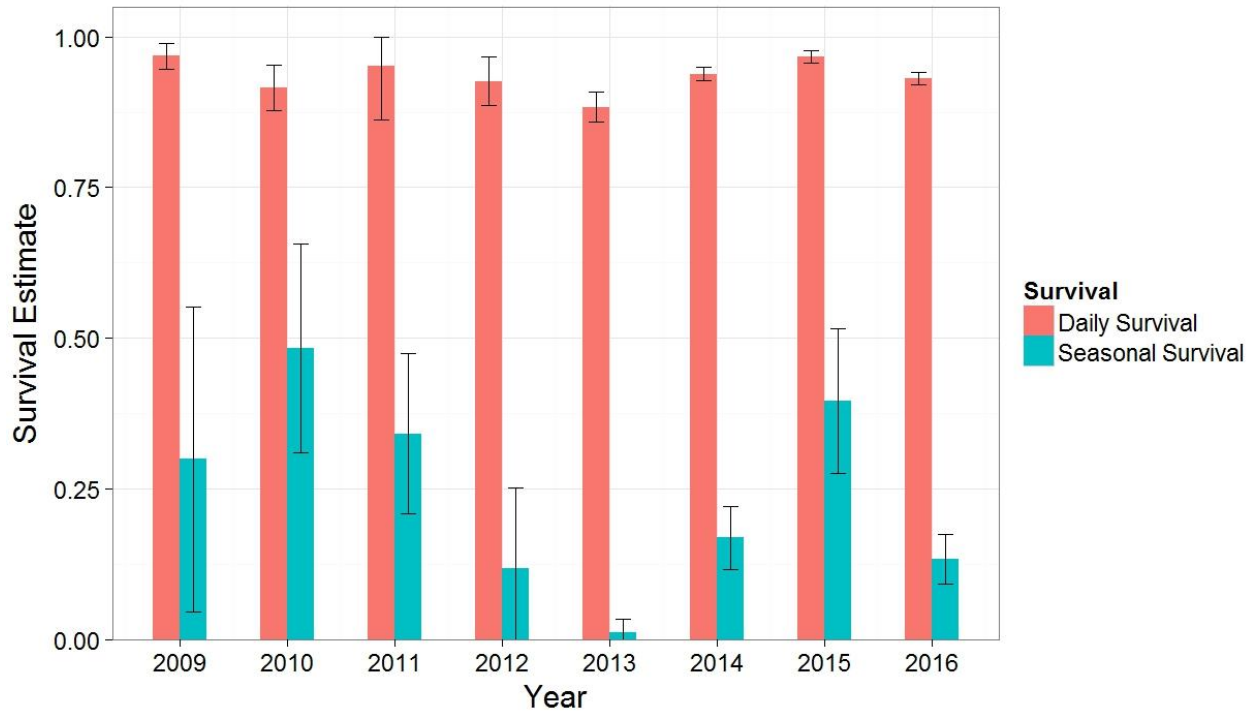


Figure 19. Piping Plover chick daily and seasonal survival at off-river sites each year.

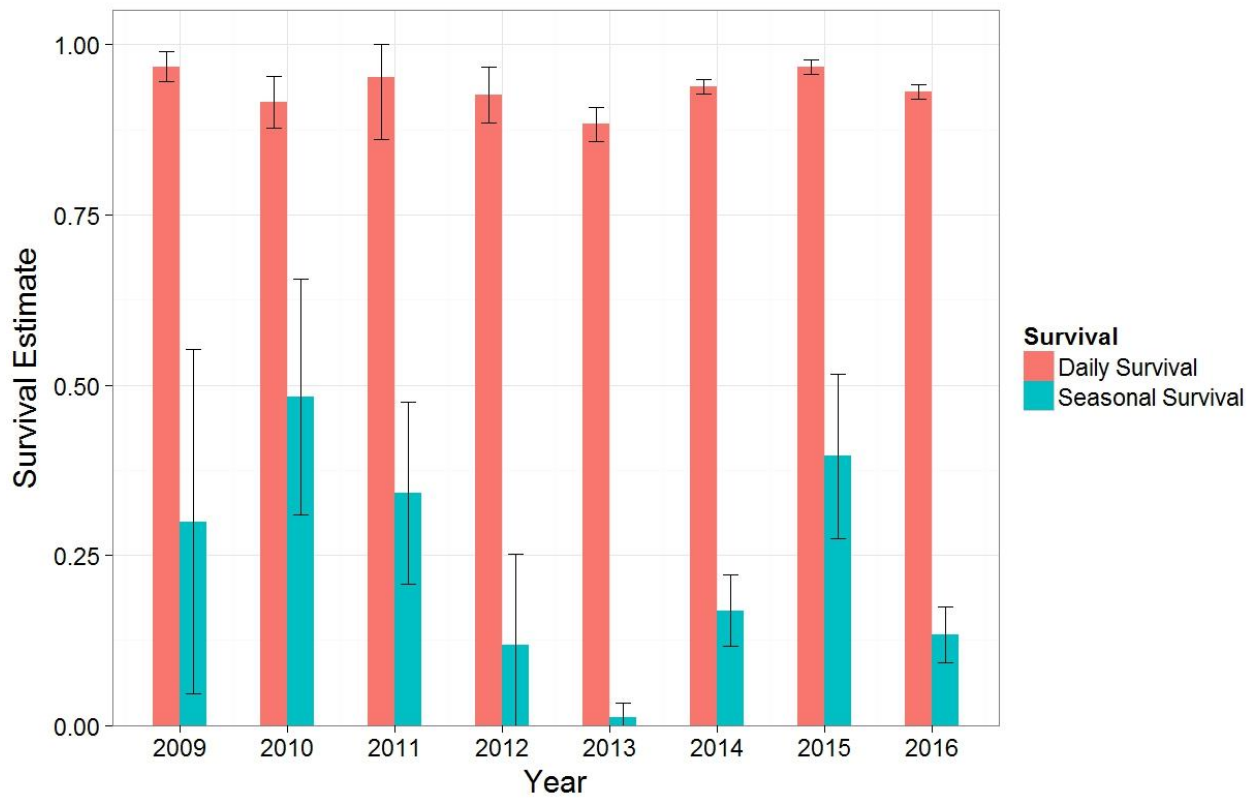


Figure 20. Interior Least Tern chick daily and seasonal survival at off-river sites each year.

Annual Survival

We estimated annual survival probabilities for plovers banded along the lower Platte River as adults and chicks from 2008 to 2016. The annual survival probability for adult plovers originally banded as adults along the lower Platte River, 2008 to 2016, was 0.71 ± 0.03 and the annual recapture probability was 0.78 ± 0.04 . The annual survival probability for adult plovers originally banded as chicks over their subsequent migration-winter cycles was 0.71 ± 0.05 and the recapture probability was 0.48 ± 0.06 . The annual survival probability for juvenile plovers originally banded as chicks over their first migration-winter cycle (hatch year) was 0.35 ± 0.08 and the recapture probability was 0.43 ± 0.06 (Fig. 21). These estimates do not distinguish between mortality and dispersal to breeding areas separate from their natal areas (e.g., away from our study area), so they are likely biased low.

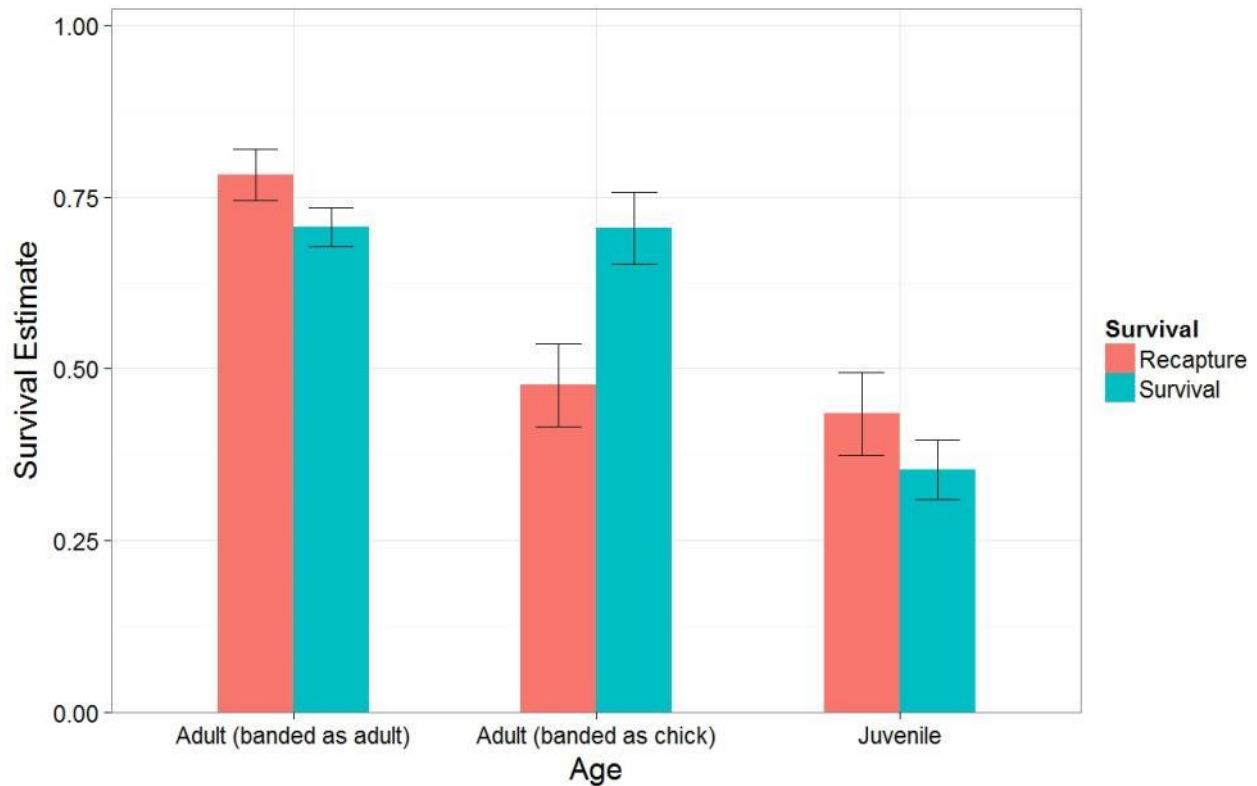


Figure 21. Annual survival and recapture probabilities for Piping Plovers originally banded as adults and chicks along the lower Platte River from 2008 to 2016.



Growth Scatterplots

We created scatterplots of Piping Plover and Interior Least Tern chick growth, based on body mass, from hatching to fledging. Scatterplots were created from 129 plover chicks and 121 tern chicks banded on off-river sites in 2016 (Figs. 22–23).

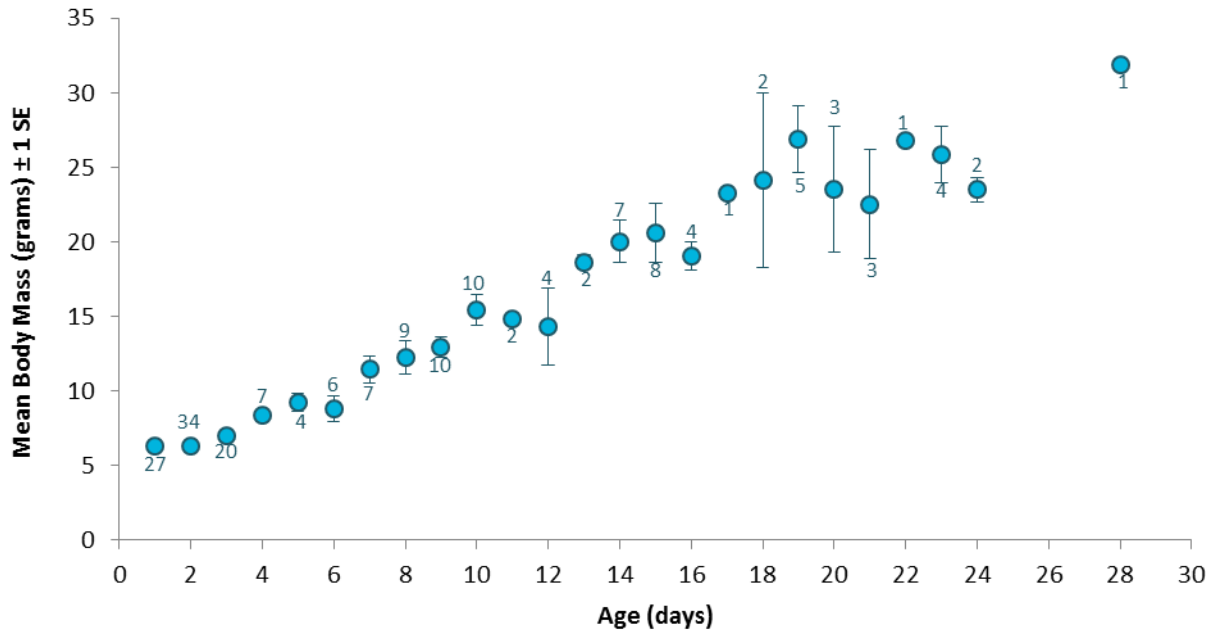


Figure 22. Scatterplot of Piping Plover chick growth from hatching to fledging at off-river sites in 2016. The graph shows the data represented as mean body mass, standard error, and sample size (number in each age class).

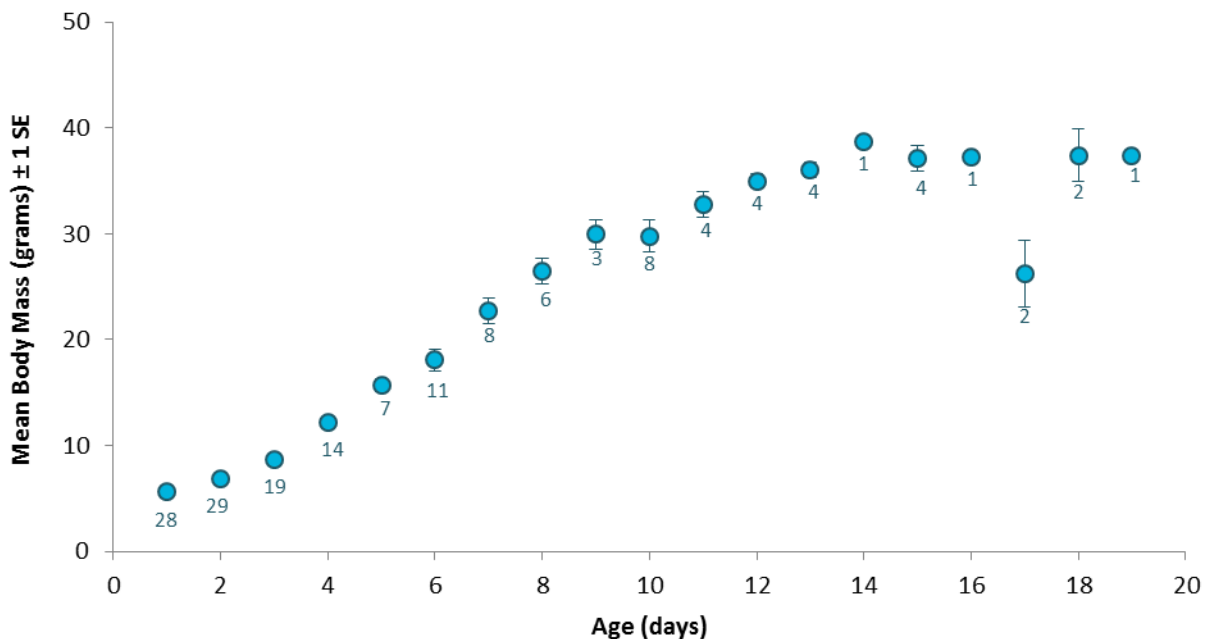


Figure 23. Scatterplot of Interior Least Tern chick growth from hatching to fledging at off-river sites in 2016. The graph shows the data represented as mean body mass, standard error, and sample size (number in each age class).

MANAGEMENT

The TPCP uses a voluntary, proactive approach to reduce human-bird conflicts and avoid the need for law enforcement actions in Interior Least Tern and Piping Plover management.

Before terns and plovers return to Nebraska in the spring and the field season begins, TPCP personnel meet with the production crews and property managers of the aggregate (sand and gravel) mines in our focus area. We discuss production plans for the upcoming season, safety regulations, and site access. We pay particular attention to concerns mine personnel have regarding on-site activities of the TPCP and changes to federal MSHA (Mine Safety and Health Administration) policy as it applies to non-mine personnel. We also meet with real estate developers and homeowners' associations at the lakeshore housing developments. At these meetings, we discuss the construction plans for the area and site access. We pay particular attention to property owners' concerns regarding on-site activities of the TPCP.

The result of these meetings is a set of site-specific management and monitoring plans; an equally valuable result is the TPCP becoming better acquainted with the people living and working at these sites. This makes our management efforts easier to implement and more effective as the nesting season progresses. We maintain close contact with these individuals throughout the season, so we can quickly respond to any on-site changes that develop.

Mine Safety and Health Administration (MSHA)

Every year, all TPCP personnel receive MSHA training and certification for scientific (non-miner) workers. In 2016, our training was again provided by Tim Zuehlke, a MSHA certified trainer, and included mine safety, Red Cross First Aid, CPR and AED training. Copies of TPCP personnel certification cards are provided to the mining companies for their records.

Protecting Interior Least Tern and Piping Plover Nests

To protect tern and plover nesting areas, we erect "Keep Out" signs around the perimeter of all off-river nesting areas; these signs were designed in 2008 by the TPCP and have been widely adopted for use across Nebraska and other parts of the northern Great Plains. In areas where human foot or vehicle traffic is to be expected, 'psychological' barriers are added. These barriers consist of black or orange cord tied between the "Keep Out" sign posts with red-silver Mylar™ streamers attached to the cord to make it more visible.

Based on conversations with mine personnel and homeowners' associations before the nesting season begins, we mark off the areas where it would be safest for terns and plovers not to nest. At mines, these are areas that are going to be dredged during the nesting season or where heavy equipment will be operating. At housing developments, these are areas where buildings are to be constructed or utilities are to be installed. We know that terns and plovers avoid nesting in areas where the 1) substrate is disturbed by raking, 2) vegetation is present, 3) substrate particle size is unattractive to the birds or 4) areas are physically disturbed in some other way (J. Marcus, J. Dinan, R. Johnson, E. Blakenship, and J. Lackey 2007. *Waterbirds* 30: 251–258). In addition to planting vegetation, resurfacing the sand, and raking the substrate, we often opt for a physical method of discouraging birds from nesting in an area. Before the birds arrive, we put up grids of three-foot-tall fiberglass poles with 16-foot-long streamers of red-silver Mylar™ flagging attached to them. The poles are set 16 feet apart. When the streamers blow in the wind, they make a crackling sound and sweep the ground, which discourages the birds from attempting to nest in the area.

We use protective wire mesh nest enclosures around plover nests, but not tern nests because of the birds' behavior around their nests—plovers walk up to their nests while terns fly up to their nests. These enclosures help to protect plover nests from both human disturbance and natural predation. For terns, we place protective boundaries around tern nesting colonies that were in areas with human activity. We do this by roping off the nesting areas using rope (with red-silver Mylar™ strips are tied to it to make the rope more visible), signs, and 3-foot tall rebar poles. These roped off areas only help to protect tern nests from human disturbance; they do not reduce natural predation.

Lake McConaughy Piping Plover Human Dimensions Study

In 2016, we completed the fourth season of a research project initiated in 2013 aimed at improving our understanding of interactions between human recreation and nesting Piping Plovers on the beaches of Lake McConaughy in Keith County. During the first three seasons, we conducted personal interview surveys of people using the beaches and observed Piping Plovers and their nests during incubation to evaluate bird response to human disturbance. During this last season, we only conducted personal interview surveys. The personal interview surveys addressed recreationists' knowledge of wildlife protection laws and beach use regulations and their opinions of the birds. The nest and brood observations addressed the birds' responses to human-caused disturbances. We changed the personal interview survey questions every year letting us address a broader set of issues.

International Piping Plover Census

Every five years, a survey of all Piping Plover habitat is conducted to estimate the current Piping Plover population size (total number of individuals). The survey is coordinated by Elise Elliott-Smith and Susan Haig (Oregon State University USGS Cooperative Research Unit) and employs sophisticated statistical techniques to develop robust estimates. The survey results are used to evaluate progress toward species recovery and direct/redirect resources so that recovery proceeds apace. In Nebraska, surveys took place at tern and plover nesting habitat throughout the state. The TPCP in cooperation with the NGPC and USFWS surveyed the lower Platte River study area.



A Piping Plover nest with a wire mesh enclosure around it and keep out sign nearby.

OUTREACH

Essential to our mission to protect Interior Least Terns and Piping Plovers is our outreach program. The TPCP is an important member of Nebraska’s conservation and environmental education community. We are frequently called upon to give presentations and lectures, assist with symposia, workshops and festivals, participate in workgroups, and serve on committees. While the majority of our outreach efforts are focused on terns and plovers nesting along Nebraska’s lower Platte River, we appreciate that we play a broader role in improving environmental literacy locally, regionally, and nationally. We take advantage of opportunities to reach as many different constituencies as possible with our message of common-sense conservation. The number of adults and children we are able to reach across the state has grown substantially over the past few years (Figs. 24-25). The TPCP continues to be one of the go-to programs in Nebraska’s environmental education community. We have evolved from being an organization that needed to seek out events to participate in to one that receives a stream of requests for participation. It is gratifying for us to meet people who know what the TPCP does and who commend us for our work.

Platte River Time-Lapse Project (<http://plattebasintimelapse.com>)

We are pleased work with Michael Forsberg, Michael Farrell, Peter Stegen, Valerie Cuppens, and Nebraska Educational Television as they developed a tern and plover educational curriculum suitable for upper level elementary-middle school students and teachers. The material is currently available at: <http://plattebasintimelapse.com/learn/terns-and-plovers>.

On-Line Activities

The internet and social media continue to be important tools in expanding our outreach program. Our website (<http://ternandplover.unl.edu>) is frequently updated with information about the Partnership. Our YouTube videos, “Respect the Signs, Respect the Birds”, “Plover at Nest” and “Points about Plovers” continue to generate interest in the TPCP.



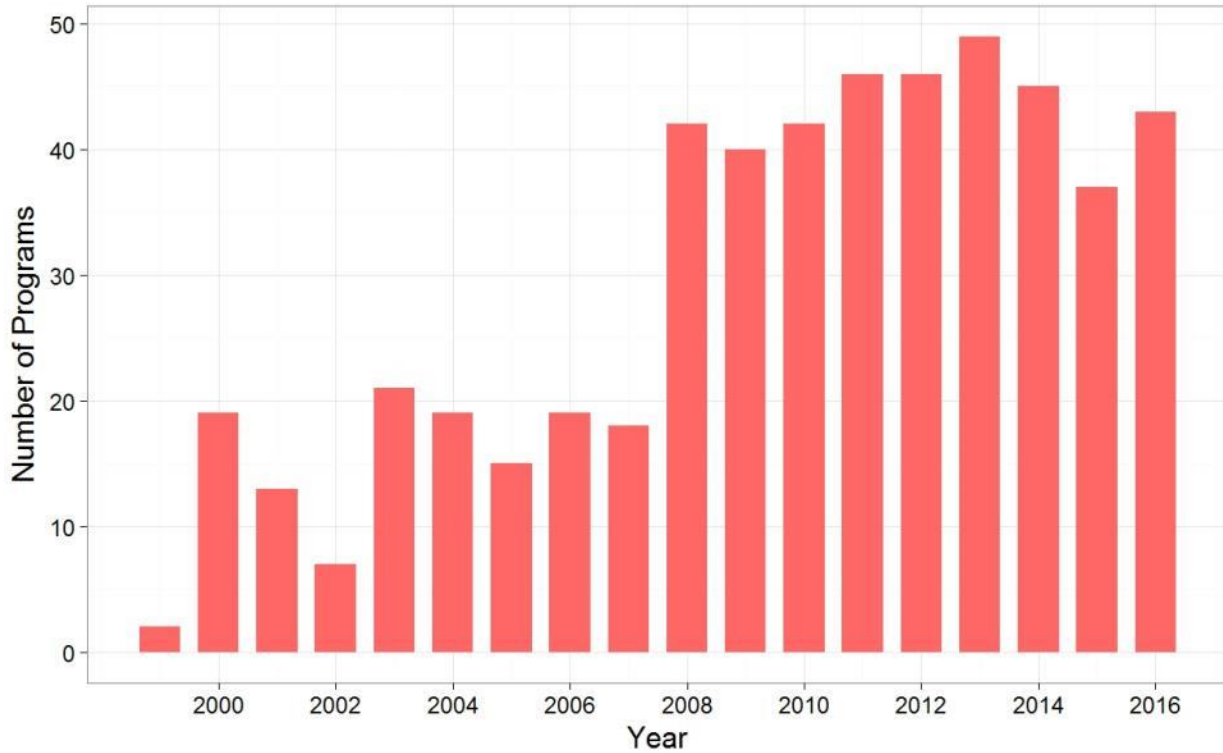


Figure 24. Number of programs delivered by the TPCP from 1999 through 2016 (this only includes scheduled programs; we frequently deliver impromptu presentations).

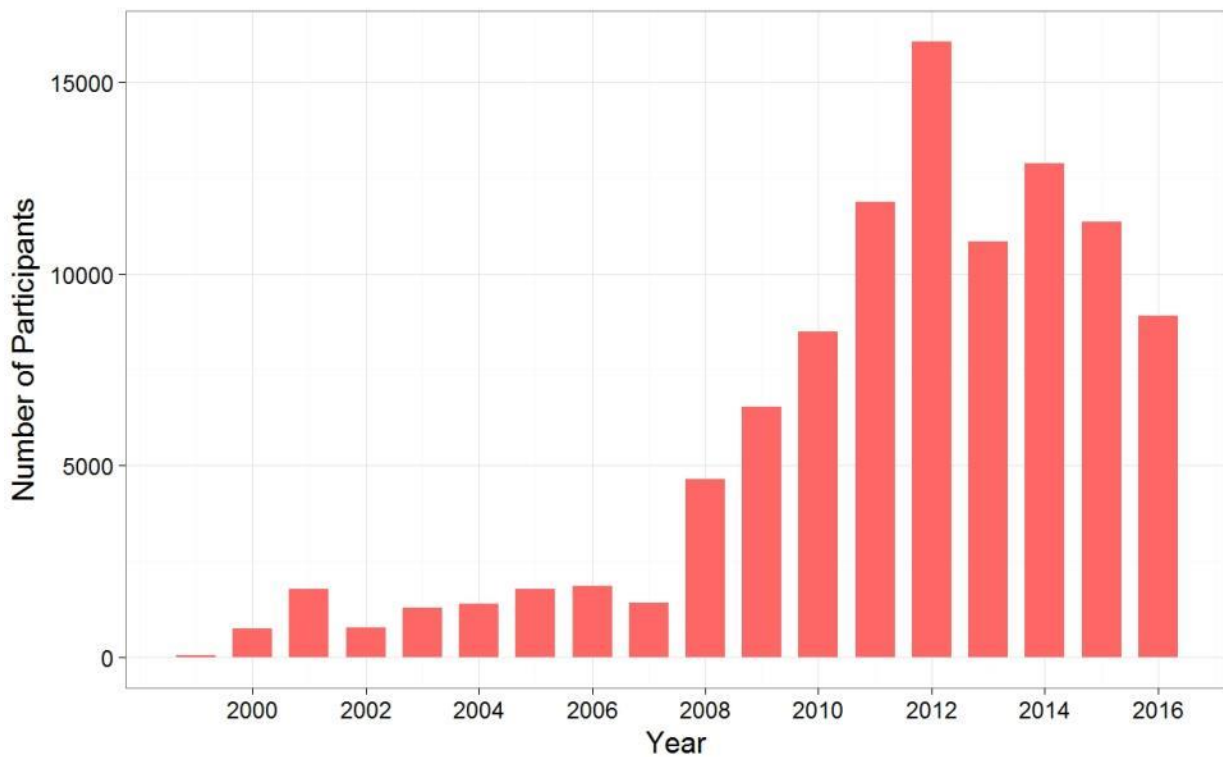


Figure 25. Number of participants in TPCP programs from 1999 through 2016 (this only includes scheduled programs; we frequently deliver impromptu presentations).

Programs for the General Public

Dimensions School Family Nature Night, Lincoln, NE
Durham-Smithsonian Museum Teacher's Night Out, Omaha, NE
EarthWellness Festival, Lincoln, NE
Eastridge Elementary School Family Nature Night, Lincoln, NE
Fremont Eco-Fair, Fremont, NE
Huntington Elementary School Family Nature Night, Lincoln, NE
Iowa Western Community College, Council Bluffs, IA
Irving Middle School Chimney Swift Club, Lincoln, NE
Kooser Elementary School Family Nature Night, Lincoln, NE
Lower Platte River Corridor Alliance Water Quality Open, South Bend, NE
Nebraska Audubon's Nebraska Crane Festival, Kearney, NE
Nebraska Audubon's Crane Festival, Wild Experience Room, Kearney, NE
The Messengers documentary film, Lincoln NE
Wahoo Bird Club, Wahoo, NE

Homeowners' Associations

Big Sandy, Bluewater, Lake Allure, Lake Socorro, Mallard Landing, Riverview Shores, Sandy Pointe, and Ritz Lake

University of Nebraska-Based Education Programs

SNR Department Seminar
UNL Big Red Summer Camp
UNL Women's Club (International)
UNO Biology Department Seminar

Education-Curriculum Development Activities

Informal Educators of Lincoln Network
Iowa Western Community College Environmental Studies
Lincoln Public Schools STEM
Nebraska Association of Teachers of Science
University of Nebraska School of Natural Resources

Conferences with Presentations

2016, NAOC (North American Ornithology Conference), Washington, DC
2016, USFWS/NGPC/Congressional Delegation Coordination Meeting, Grand Island, Nebraska
2016, Society for Range Management, Corpus Christi, Texas
2016, Iowa Western Community College, Council Bluffs, Iowa
2016, Water Leaders Academy, Kearney, Nebraska
2016, Nebraska Chapter of the Wildlife Society, Kearney, Nebraska
2016, Audubon's Nebraska Crane Festival, Kearney, Nebraska
2016, Nebraska Natural Legacy Conference, Broken Bow, Nebraska

Mine Site Visit and Presentation

2016, USFWS Federal Aid Administrators, Ashland, Nebraska

Professional Committees and Workgroups

Lower Platte River Weed Management Area
Nebraska Environmental Trust Technical Advisory Committee
PACE (Planning, Aggregate, Community, Environment)

Featured in the Media

2016, "Piping Plovers: the perils of the first migration", Nebraska Game and Parks Commission's Nongame Bird, 16 August

2016, "Piping Plovers: the first migration", Nebraska Game and Parks Commission's Nongame Bird, 12 August (republished by Gulf Coast Bird Observatory, Lake Jackson, Texas)

2016, "Can prairie chickens share the prairie with wind turbines?" Center for Grassland Studies newsletter, with Larkin A. Powell (<http://grassland.unl.edu/documents/CGS%20Winter-Spring%202016%20web.pdf>), Spring

2016, "Cranes, Electric Cars, and the Climate Implications of a Changing Arctic in the Central U.S., Week 10: Nebraska", with Eric Hunt, Martha Shulski, Michael Forsberg, and Donald Wilhite, Our Arctic Nation blog post, (<https://medium.com/our-arctic-nation/week-10-nebraska-a7f135e92d13#.4ol4j5o8u>)

2016, "Citizen scientists 'tern' the tide for rare birds", Nebraska Life, July

2016, "Where have all the terns gone?" LPRCA newsletter, Spring

2016, "They're not bats", Irving Middle School Chimney Swift Club, Lincoln Public Schools educational brochure, Spring

Grants and Fundraising

Toward adaptive Management: evaluating Piping Plover management at Lake McConaughy, Nebraska State Wildlife Grant, Nebraska Game and Parks Commission, awarded 2013–2016

Publications

Ziegler, S.L., D.H. Catlin, M.B. Brown, J.D. Fraser, L.R. Dinan, K.L. Hunt, J.G. Jorgensen, and S.M. Karpanty. in review. Interacting effects of climate change and anthropogenic modification on a disturbance-dependent species in a large riverine system. *Ecosphere*.

Powell, L.A., M.B. Brown, J.A. Smith, J.O. Harrison, and C.E. Whalen. in revision. Modeling the spatial effects of disturbance: a constructive critique to provide evidence of ecological thresholds. *Wildlife Biology*.

- Jorgensen, J.G., and M.B. Brown. 2016. Recreationists' perception of inconvenience and their acceptance capacity for Piping Plovers (*Charadrius melodus*) on a public beach, Nebraska, USA. *Wader Study* 123: 59-68.
- Jorgensen, J.G., L.R. Dinan, and M.B. Brown. 2016. Flight initiation distances of nesting Piping Plovers (*Charadrius melodus*) in response to human disturbance. *Avian Conservation and Ecology* <http://dx.doi.org/10.5751/ACE-00826-110105> [11:5].
- Catlin, D.H., M.B. Brown, L. Dinan, J.D. Fraser, K.L. Hunt, J. G. Jorgensen, and S.L. Zeigler. 2016. Metapopulation viability of an endangered shorebird depends on man-made habitats: piping plovers and prairie rivers. *Movement Ecology* DOI: 10.1186/s40462-016-0072-y.
- Hunt, K. L., Dinan, L. R., Friedrich, M. J., M.B. Brown, Jorgensen, J. G., Catlin, D. H., and Fraser, J. D. 2015. Double brooding of Piping Plovers (*Charadrius melodus*) in the Northern Great Plains. *Waterbirds*. 38: 321-329.
- Jorgensen, J.G. and M.B. Brown. 2015. Evaluating recreationists' awareness and attitudes toward Piping Plovers (*Charadrius melodus*) at Lake McConaughy, Nebraska, USA. *Human Dimensions of Wildlife* 20: 367-380.
- Brown, M.B., J.G. Jorgensen and L. R. Dinan. 2015. 2015 Interior Least Tern and Piping Plover monitoring, research, management, and outreach report for the lower Platte River, Nebraska. Joint report of the Tern and Plover Conservation Partnership and the Nebraska Game and Parks Commission Non-game Bird Program, Lincoln, NE.

Reviewers for Professional Publications and Organizations

Auk (American Ornithologists' Union)
Frontiers in Ecology and the Environment
Nebraska Environmental Trust
Nebraska Game and Parks Commission
United States Fish and Wildlife Service
Wilson Journal of Ornithology (Wilson Ornithological Society)

Miscellaneous

Hold UNL IACUC#1261 research approval certificate

Hold UNL IRB#20130213371EX research approval certificate

Hold NGPC Scientific and Educational permit # 905. Authorized to trap, net, band, release, and salvage endangered Least Tern, threatened Piping Plover, and incidental species

Hold USFWS Master Bander permit # 23545, with authorization to trap, use mist nets, and band all species except waterfowl, eagles and all endangered/threatened species except Interior Least Terns and Piping Plovers

Hold USFWS Threatened and Endangered Species permit # TE070027-0. Authorized to handle endangered Interior Least Terns and threatened Piping Plovers; reauthorized through 2018

University of Nebraska Teaching and Mentoring

Organizer, “Being a better mentor: a workshop for mentors and mentors-to-be”, presented by Association for Women in Science (AWIS), University of Nebraska, Lincoln, NE

Mentor, Lincoln Public Schools, Lincoln, NE, job shadowing program

NRES 208 Introduction to Applied Climate Science (presentation; E. Walter-Shea)

WMNS/NRES/AGRI 385 Women, Gender and Science (presentation)

NRES 386 Vertebrate Zoology

NRES 399 Independent Research

NRES 433/833 Wildlife Management Techniques (with Larkin Powell)

NRES 497 Career Experiences

NRES 498/898 Ornithology Laboratory (with EJ Raynor)



LITERATURE CITED

- American Ornithologists' Union. 1998. Check-list of North American Birds, 7th edition. American Ornithologists' Union, Washington, DC.
- Annear, T., I. Chisholm, H. Beecher, A. Locke, P. Aarrestad, C. Coomer, C. Estes, J. Hunt, R. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. Mayes, G. Smith, R. Wentworth, and C. Stalnaker. 2004. Instream Flows for Riverine Resource Stewardship. Revised edition. The Instream Flow Council, Cheyenne, WY.
- Brown, M.B. and J.G. Jorgensen. 2010. 2010 Interior Least Tern and Piping Plover monitoring, research, management, and outreach report for the lower Platte River, Nebraska. Joint report of the Tern and Plover Conservation Partnership and the Nebraska Game and Parks Commission.
- Burnham, K.P. and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd edition. Springer, New York, NY.
- Dinsmore, S.J. and J.J. Dinsmore. 2007. Modeling avian nest survival in program MARK. *Studies in Avian Biology* 34: 73–83.
- Hays, H. and M. LeCroy. 1972. Field criteria for determining incubation stage in eggs of the Common Tern. *Wilson Bulletin* 83: 425–429.
- Lebreton, J.D., K.P. Burnham, J. Clobert, and D.R. Anderson. 1992. Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs* 62: 67–118.
- Lettink, M. and D.P. Armstrong. 2003. An introduction to using mark-recapture analysis for monitoring threatened species. Department of Conservation Technical Series 28A: 5–32.
- Marcus, J.F., J.J. Dinan, R.J. Johnson, E.E. Blankenship, and J.L. Lackey. 2007. Directing nest site selection of Least Terns and Piping Plovers. *Waterbirds* 30: 251–258.
- Pyle, P. 1997. Identification guide to North American Birds. Slate Creek Press, Bolinas, CA.
- Rabbe, M. 2014. USFWS Interior Least Tern and Piping Plover nesting survey results from 2014 for the Lower Platte River, Leshara to Columbus, Nebraska. U.S. Fish and Wildlife Service Grand Island Field Office Report.
- R Development Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. Accessed at: <http://www.R-project.org>

White, G.C. and K.P. Burnham. 1999. Program MARK: survival estimates from populations of marked animals. *Bird Study* 46: S120–S139.

Van der Toorn. 1997. A survival guide to survival rates. *Marine Mammals: Public Display and Research* 3: 27–28.