EARTHSPAN
2023 PEREGRINE FALCON MIGRATION STUDIES AT SOUTH PADRE ISLAND, TEXAS

In partnership with:

The Peregrine Fund

December 27, 2023

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CONDUCTED UNDER

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Additionally, we appreciate permitting assistance from the LANWR, the USGS Bird Banding Lab, and Texas Parks and Wildlife Department. We thank Jeff Johnson, Matthew Carling, and Elizabeth Wommack of the University of Wyoming's Robert and Carol Berry Biodiversity Conservation Center for support of our sample archive and shared genetic insights. We appreciate the logistical assistance of Doyle Wells and the staff of the Island Adventure Park, and Steve Mercer of Coastal Transplants. We are grateful for the insights and assistance of Cristin Howard, Lynn and Gary Tate, the South Padre Island Birding and Nature Center, Thomas deMaar, Wendy Knight of Sea Turtle Inc., and Joe Watson. As always, our warm thanks go out to Vicki and Pete Moore, Willard Heck, James Weaver, Steve Shepard, Richard Moore, Kelly McDowell, Ed Moody, Kathy Cunningham, Matt Reidy, Raul Andrade, Kathy Maechtle, and the Glady Porter Zoo. In addition, we thank the members of NAFA and the Texas Hawking Association, including Bruce and Evelyn Haak, Steve Duffy, Jimmy Walker, Bob Smith, Patrick Johnson, Russell Davidson, and Bill Hones for all their help. As always, we are grateful for the tireless interest, efforts and insights of Earthspan Founder Mark Fuller, Earthspan Treasurer Jim Dayton, and all of those involved with our collaborative studies, including Joe Barnes, Chris DeSorbo, and Arnaud Van Wettere. We appreciate the hoods and supplies provided by David Frank at Western Sporting. Finally, thanks are due to many South Padre Island and Valley residents, and those not mentioned, who in so many ways foster the monitoring of peregrine falcons that migrate along the Texas Gulf Coast. Altogether, this group represents a wealth of expertise, collaboration and dedication, without which the surveys could not continue.

The interest, assistance and enthusiasm of survey visitors including Henry Taylor, Nancyellen Brennan, Sally Jeffords, Renee Lockett, Richard Moore, Jay and Chrissy Kleberg, Fred, Jessie and Elsa Sheckells were encouraging and informative to our long-standing collaborative research and monitoring efforts at Padre Island.

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EXECUTIVE SUMMARY

As part of a continuing research program of Peregrine Falcon (*Falco peregrinus*) migration studies in partnership with The Peregrine Fund (TPF); we conducted spring and fall Padre Island Peregrine Falcon Surveys (PIPFS) on South Padre Island (SPI), Texas. We monitor the health and dynamics of Peregrine Falcons that migrate along the Texas Gulf Coast and concentrate on South Padre Island. This report is focused on our productive 47th annual, 2023 field efforts.

During the spring migration period, we surveyed the South Padre Island Unit of Laguna Atascosa National Wildlife Refuge from 09 April through 03 May, conducting 261 survey hours in the field over 25 survey days. We recorded 268 peregrine falcon observations and captured 29 peregrines, including 5 seasonal recaptures. Among the new captures, 20 (83.33%) peregrines were first banded this season and 4 (16.67%) were previously banded Padre Returns from our 2012-2022 surveys. Adult peregrines comprised 84% of age-determined sightings (n=191) and 71% of new captures. The minimum average area stopover duration among recaptures was 3 days, ranging from a few hours to 5 days. Our seasonal sighting rate of 10.27 peregrine observations per 10 survey hours is close to the lower bounds of our 44-year mean of 15.96 (± 6.31 sd).

During the fall migration period we conducted 479 survey hours in the field over 31 days, from 25 September through 26 October. We recorded 545 peregrine falcon sightings on South Padre Island and captured 137 peregrines, including 71 seasonal re-sightings and 17 recaptures. Among new captures, 118 (98%) were first banded this season and 2 (2%) were previously banded Padre Returns marked during the 2022-2023 migrations at Padre Island. Adults comprised 23% of age-determined sightings (n=413) and 7 % of new captures. The minimum average stopover duration of seasonal recaptures during the fall season is 4 days, ranging from 1 hour to 9 days. Capture totals are average among recent years, but the seasonal sighting rate of new peregrine observations per 10 survey hours 9.89 is well below our 46-year fall Survey mean of 15.71 (± 5.56 sd).

Blood, feather and cloacal swab samples were collected from 144 individual peregrines. These contribute to our collaborative mercury monitoring efforts with Joe Barnes (FWS) and Chris DeSorbo (Biodiversity Research Institute, or BRI), and Highly Pathogenic Avian Influenza (HPAI) serology studies with Arnaud Van Wettere of the Utah Veterinary Diagnostic Laboratory (UTVDL). In addition, Survey sampling will assist a new effort by Ericka Griggs from the Wildlife Pathogens Lab at the University of Vermont in collaboration with BRI. This initiative seeks to establish baseline infection status and prevalence of avian malaria and other haemosporidian parasites in peregrines and other raptors among different geographic regions of the Arctic. We conducted four constructive outreach field tours this year with the help of Geoff Pampush, Paul Juergens, Brian Mutch, Pete and Vicki Moore and Richard Moore. Lastly, we continue towards incorporating survey data into the Global Raptor Data Bank to enhance the utility and security of our long-standing survey datasets.

Our surveys and associated collaborative studies have been quite productive, although the continued decreasing trends among counts and captures since 2016 is of growing concern. Vacillations among survey metrics are common, likely weather-related variations in migration data. Parallel decreases in migrant volume among seasons at SPI, however, are concerning. Inquiries to better assess these patterns in our data and through breeding area studies could be helpful to interpreting developing patterns and perhaps lead to better understanding of the potential factors at play on migratory peregrines.

Our long-term research at Padre Island addresses issues of concern to people, peregrines and Neotropical migrants in a changing world. Understanding the migratory peregrines' population health and dynamics provides broad-scale insights into the habitat conditions of avian populations throughout this predator's range. Survey data provide evidence of the tundra peregrine's recovery and the corresponding decline in organochlorine contaminant loads. The U.S. Fish and Wildlife Service used our data in removing F.p. *tundrius* and F.p. *anatum* from the List of Endangered Species, and also in developing management strategies for the harvest of juvenile migrant peregrines for falconry. Our research, while focused on peregrines, serves to benefit society and avian conservation.

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Cover painting – Larry Haines- www.spiartist.com

INTRODUCTION

In 1890, Griscom and Crosby (1925) identified the South Texas Gulf Coast as an autumnal focal point for the later-categorized high latitude, North American migratory Peregrine Falcons (*Falco peregrinus tundrius* and *F.p. anatum*). During the era of DDT-induced peregrine population declines, diverse efforts were undertaken to study, monitor and augment the species. James H. Enderson (1969) advocated coastal surveys as population indices to monitor remote migratory peregrine populations. For decades, Padre Island, one of the largest fall migratory stopover sites and only known spring staging area for tundra peregrine falcons, has been a center for population monitoring activity and related migration research by falconers and scientists alike. Our studies of peregrine migration ecology at Padre Island and contaminant/pathogen monitoring efforts here are well documented. We have demonstrated the importance of the South Texas Gulf Coast as migratory and winter habitats to peregrines and associated species, resulting in the conservation of some habitats. Yet much still remains to be learned.

Colonel R.L. Meredith initiated autumnal beachfront migration surveys on Padre Island from the 1940s through 1965. Surveys were further developed, in addition to studies of peregrine migration ecology by J.H. Enderson, W.G. Hunt, C.M. White, R.R. Rogers, and D.J. Slowe in the 1960s (Enderson 1963, Hunt 1966, Enderson 1969, Hunt *et al*. 1975). Padre Island was identified as a spring migration concentration point and staging area for northward migrants, the only known location of this type in the Western Hemisphere (Ward *et al*. 1978, Hunt *et al*. 1980). Drs. F.P. Ward and K.E. Riddle expanded surveys to incorporate both the spring and autumn migration periods (Riddle *et al*.1977-1985). Thus, the Padre Island Peregrine Falcon Survey was established as a counterpart in the Central Flyway to the standardized study Ward had begun within the Atlantic Flyway at Assateague Island, MD/VA in 1970 (Ward and Berry 1972, Ward et al. 1988). Earthspan principals W.S. Seegar, T.L. Maechtle, and M.A. Yates, with the addition of G.E. Doney in 2006, steer current migration surveys, biomonitoring efforts and related migratory peregrine research through Earthspan, and in collaboration with The Peregrine Fund (Seegar *et al*. 2003).

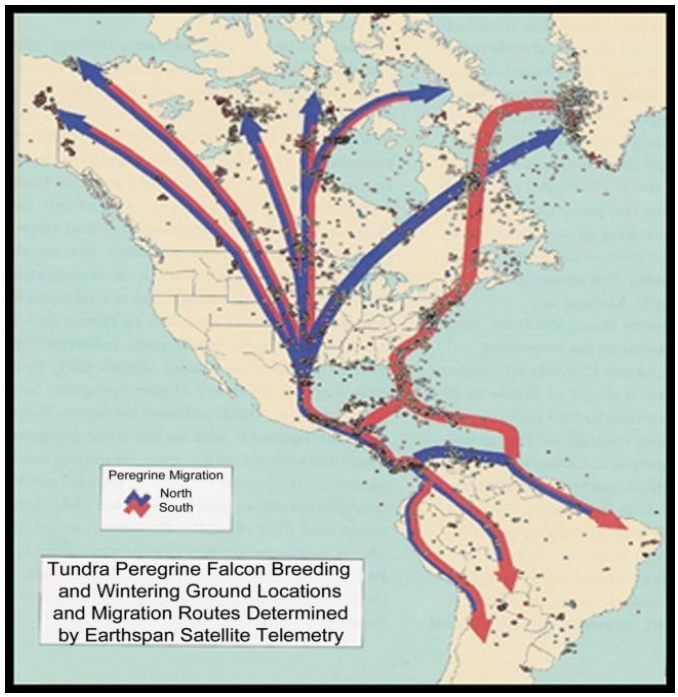

Figure 1. Migratory Range of Tundra Peregrine Falcons

Through the decades, associated studies of Padre migrants have addressed aspects of migratory peregrine natural history. These include migratory and foraging behavior (Hunt 1966, Hunt *et al*. 1975), spring migratory behavior (Hunt *et al*. 1980), and habitat selection of spring migrants (Hunt and Ward 1988). Recent investigations have also documented the importance of Padre Island as Peregrine Falcon winter habitat (Enderson *et al*. 1995, Juergens 2003). Building on the Yates *et al.* (1988) band return analyses, our role in the development and application of satellite telemetry has greatly advanced the study of migratory peregrines (Fuller *et al*. 1998, McGrady et al. 2002, Seegar *et al.* 2003, Fuller *et al.* 2006).

Four decades of our banding, telemetry and recapture efforts at Padre Island, including those of breeding area studies, have defined the annual range of migratory, high latitude peregrines. These include the

highlighted migratory routes in Figure 1, to and from breeding/winter ranges and the Mid-Atlantic States/Gulf Coast of the USA, and south throughout Latin America. Migratory peregrines are proven sentinels of environmental conditions due to their high trophic standing, extensive migrations, and catholic avian diet. The Padre Survey permits broad-scale, range wide sampling of this remote nesting sentinel species to monitor environmental contaminants and the spread of infectious diseases that pose human health and conservation concern in the Western Hemisphere. Biomonitoring of Padre migrants by Henny *et. al.*(1982, 1988, 1996, and 2009) illustrated broad scale declines of organochlorine (OC) contaminant burdens during the corresponding recovery period of Arctic peregrine populations. Dusek *et al*. (2005) documented increases in West Nile virus (WNV) seroprevalence from 2001-2004, following its introduction and spread across North America. Monitoring circulating polycyclic aromatic hydrocarbons (PAHs) from 2009-2011 addressed the potential scope of impacts of the 2010 Deepwater Horizon oil spill on migratory peregrines (Seegar *et al.* 2015). Present biomonitoring includes mercury (Hg) exposure and Avian Influenza (Redig & Goyal 2012). In addition, field surveys archive biannual sample allotments for retrospective analyses of new or emergent concerns.

As Jim Enderson envisioned in 1969, the ability to quantitatively link migration monitoring with wintering and breeding season population dynamics is still developing. A critical step is the partitioning of Padre migrants into their regional breeding populations (Longmire *et al*. 1991, Longmire 1988, Morizot 1988, Parrish *et al.*1983). Known origin (breeding/natal) of migrants will permit investigations of the dynamics of migratory population structure change over time, regional migration strategies, and the influence of continental weather patterns on migration. Dr. J. Johnson and colleagues (2010) addressed temporal changes and similarities in the genetic population structure of Padre migrants and American regional populations. Developments in genetic and stable isotope techniques hold the most promise for advances in these topics. All are relevant issues of interest to migration monitoring and refining our biomonitoring capabilities.

While the peregrine is one of the most studied birds in the world (White *et al*. 2002, 2020), much remains to be learned about their migration and winter ecology, population dynamics, role as an infectious disease host and environmental contaminant sentinel, and how a changing climate may affect them. Long-term studies provide a foundation to assess change and its causes. The health and dynamics of the tundra peregrine population is fundamental to the very nature and stability of the biologically diverse populations of birds that constitute their prey on a hemispheric scale. Therefore, understanding tundra peregrine population dynamics allows for critical insights into avian populations throughout this predator's range. For all these topics of interest, Padre Island and our survey are important for the wealth of knowledge we have been able to amass on high latitude peregrines that frequent our study area during migration.

OBJECTIVES

To monitor the health and further understanding of the dynamics and migration ecology of tundra and high latitude peregrines, the Padre Island Peregrine Falcon Survey addresses both short and long-term objectives. Short-term objectives include: 1) monitoring contaminant loads to assess population health and the general habitat conditions of the geographically broad areas they utilize; and 2) monitoring the spread of infectious diseases (such as Avian Influenza and WNV) that pose both avian and human health and conservation concern. Long-term objectives include: 1) monitoring population trends and migration phenology through band returns and sightings; 2) maintaining a banded population and temporal tissue archive for future applications; 3) sampling blood from captured individuals for DNA level genetic analyses to identify the regional make-up of the Padre migrants; and 4) identifying migratory pathways, breeding areas, and critical wintering areas for Padre migrants through band returns and locations of radio marked falcons tracked by satellite and cellular technologies.

STUDY AREA AND METHODS

Our study area includes the northern 40 km of undeveloped land on South Padre Island, from the north end of Highway 100 to the Mansfield Channel (Fig. 2). Much of this property is currently a part of Laguna Atascosa National Wildlife Refuge. Hunt and Ward (1988) describe the study area. Survey efforts concentrate on the island's wind tidal flats, west of the dune barrier. Due to inundation, the landmass or amount of exposed and accessible wind tidal flats available to survey and as peregrine habitat can vary daily with tides, wind direction and rainfall. During autumn, we also monitor the beach front and hurricane washes due to seasonal habitat use of these areas.

The Padre Survey is conducted during the peak of each spring and autumn migration. A team of 2-3 researchers surveys the study area using all-terrain vehicles (ATVs) from dawn to dusk, as weather conditions permit. Peregrine sightings are noted according to time, species, age, sex, location and activity.

A capture attempt is made when peregrines are found in areas conducive to trapping and are not identified by color marking as duplicates. Ward and Berry (1972) describe capture methods. Captured peregrines are processed and released at the capture site, usually within 15 minutes. Processing includes: 1) marking of unbanded individuals with U.S. Geological Survey (USGS) bands or recording band information for previously banded falcons; 2) individual sex and age determination by USGS Bird Banding Laboratory (BBL) guidelines; 3) collection of a 2ml blood sample (1.5 for males) from the brachiocephalic vein for contaminant, infectious disease, and genetic analyses; 4) collection of feather samples for contaminant and natal origin studies; 6) collection of morphologic measurements; and 7) color marking falcons' feathers (red temporary dye) in the fall to subsequently identify previously captured falcons and accrue information on staging time and turnover on the Island. When the study plan and funding so dictate, we also outfit a few individuals with satellite or cellular-received transmitters. The backpack attachment of Teflon ribbon or neoprene is individually fitted on each falcon, and the package weight conforms to BBL guidelines.

Figure 2. South Padre Island Study Area

Samples collected are processed for storage daily at the field station. Sighting and banding data are entered in a database for analyses, reporting and access to recapture information. Therein, we have adopted the BBL methods of describing age and sex among sighted and captured peregrines, as well as subsequent encounters with those individuals. All banding information is reported to the BBL after each season. Band recovery data are accrued throughout the year from the BBL and collaborators, and then compiled in our database.

The spring survey was conducted by Bill Seegar, Mike Yates and Gregg Doney; the fall survey by Robert McGuire Nick Todd, Samuel Voss, Hana Weaver, and Gregg Doney. Outreach field tours were organized and assisted with the help of Geoff Pampush, Paul Juergens, Brian Mutch, Pete and Vicki Moore, and Richard Moore.

RESULTS AND DISCUSSION

Spring 2023 Survey-

During spring migration, we surveyed the South Padre Island Unit of Laguna Atascosa National Wildlife Refuge from 09 April through 03 May, conducting 261 survey hours in the field over 25 survey days. We recorded 268 peregrine falcon observations and captured 29 peregrines, including 5 seasonal recaptures. Among the new captures, 20 (83.33%) peregrines were first banded this season and 4 (16.67%) were previously banded Padre Returns from the 2012-2022 surveys. Adult peregrines comprised 84% of age-determined sightings (n=191) and 71% of new captures. The minimum average area stopover duration among recaptures was 3 days, ranging from a few hours to 5 days. Our seasonal sighting rate of 10.27 peregrine observations per 10 survey hours is low among recent years, and very close to the lower bounds of our 44-year mean of 15.96 (SD 6.31).

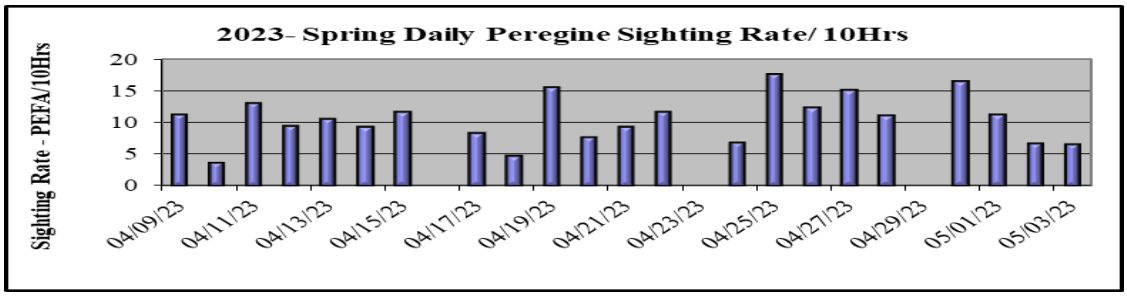

Figure 3. Spring daily sighting rate (peregrines observed per 10 survey hours).

A slow but steady turnover of peregrines of mixed age classes was found on the island during the first survey week, during a period of light northern winds and a few unsettled thunderstorms. The wind tidal flats were wet, but drained quickly from the dry winter in south Texas. The migration increased in a relatively cyclic pattern as 3 strong northern fronts with heavy rain and high winds passed on 16, 23 and 29 April. Between fronts east to southeast winds cleared and dried the wind-tidal flats and brought increasing numbers of peregrine migrants during the latter half of the season. Peregrine responsiveness varied daily, with intermittent recaptures that suggested little migration turnover on the island. During our last survey afternoon on 03 May, a few days of generally eastern winds had opened the light sand layer west of the black algal mat. Thousands of peeps and small to mid-sized waders foraged there well into the rarely seen and exposed grass beds of the Laguna Madre. With square miles of open sand flats, peregrines were still understandably resting at the Laguna's edge.

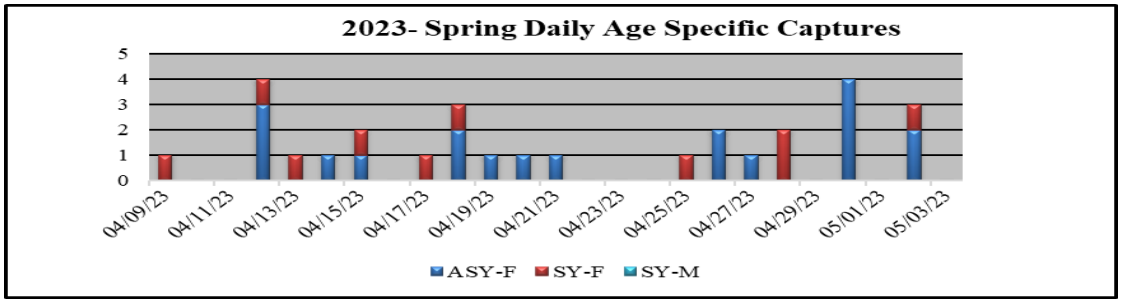

Figure 4. Spring age/sex specific daily captures.

Four Padre Returns spanning both migration periods were captured this season and are discussed in the following section. We thoroughly enjoyed the enthusiasm and encouragement during our survey field

visits with Henry Taylor and Nancyellen Brennan. The steadfast assistance in the field and throughout the year from Brian Mutch, Paul Juergens, and The Peregrine Fund was also greatly appreciated.

Fall 2023 Survey –

During the fall migration we conducted 479 survey hours in the field over 31 days, from 25 September through 26 October. We recorded 545 peregrine falcon sightings on South Padre Island and captured 137 peregrines, including 71 seasonal re-sightings and 17 recaptures. Among new captures, 118 (98%) peregrines were first banded this season and 2 (2%) were previously banded Padre Returns, marked during the 2022-2023 migrations at Padre Island. Adults comprised 23% of age-determined sightings (n=413) and 7% of new captures. The minimum average stopover duration of seasonal recaptures during the fall season is 4 days, ranging from > 1 hour to 9 days. Our seasonal sighting rate of new peregrine sightings per 10 survey hours was 9.89, which is quite low among recent years and well below our 46-year fall Survey mean of 15.71 (SD 5.56).

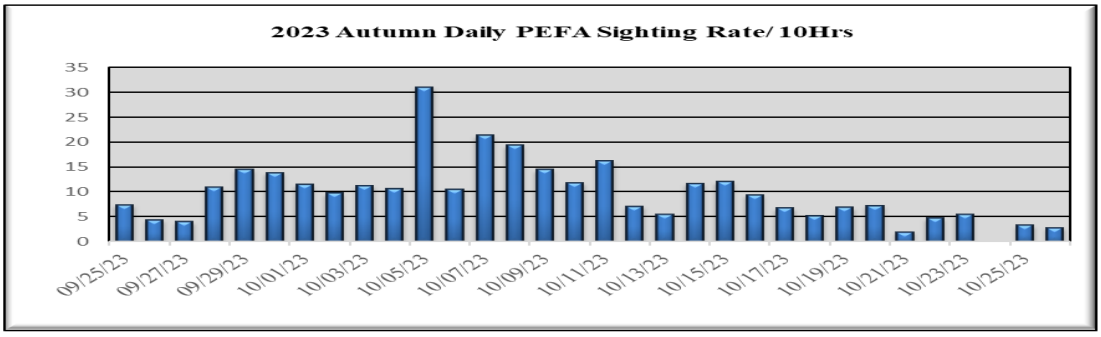

Figure 5. Fall daily sighting rate (new peregrines seen per 10 survey hours).

The hot, dry summer was evident in south Texas, during our travels and opening days of the fall Survey. Following setup, we found a few, primarily-hatch year peregrines on the island during our first few survey days on 25-27 September. The wind-tidal flats were dry and wide open from the north to south ends. Ground temperatures and southeastern winds were hot. The bulk of the peregrine migration passed SPI in a condensed period from 28-September – 11 October This coincided with favorable northern winds and occasionally the Trade Winds spanning the Gulf, which can assist southbound migrants significantly. Access to the wind-tidal flats grew progressively more limited during this period from occasional rain and tidal events. The survey team's fortitude persevered. Then the flats were completely inundated to the dunes on the evening of 10 October from heavy rain and northwest winds.

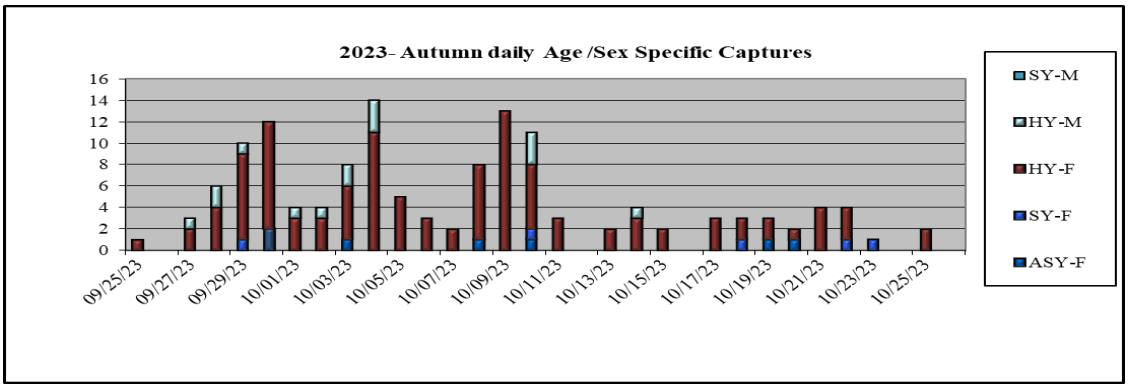

Figure 6. Fall age/sex specific daily captures.

Peregrine numbers decreased as surveys focused on small accessible areas 11-13 October as the wind settled. Much of the flats were inaccessible. Heavy clouds and an approaching northern front limited, but

gave us a brief view of, the Ring of Fire during the solar eclipse on 14 October. A small pulse of flighty new peregrine migrants arrived through 16 October, with very strong north winds (25-35 mph). Surveys were primarily limited to the dune areas with wind weights, but the flats were soon cleared of standing water. The peregrine migration was obviously waning, yet swallow and shorebird migrants were abundant as calm winds and settled weather ensued 17-21 October. Surveys could again cover much of the Island and diligence yielded new captures. The adult component of the migration also increased, when two previously banded Padre Returns were captured. Strong southeast winds mounted 22-26 October, precluding surveys on the 24th, when few peregrines were found on the Island. White pelican sightings near the Mansfield Channel again aligned with the tail-end of the core peregrine migration season. We began closing the fall Survey.

We greatly appreciate the insights, interests and enthusiasm of the four groups of Survey visitors this season. The opportunity to share the Survey's knowledge, wonders, and the unique importance of the affinity of migratory peregrines to South Padre Island habitats with broad associated interests is critical. The migration and weather aligned quite well this season. The timing of a tour by Geoff Pampush and Sally Jeffords on the evening of 02 October was perfectly aligned with an influx of hatch-year peregrine migrants. Diego Johnson and Nick Todd found a lull to explore the flats, finding a few peregrines during the high winds of 07 October. Richard Moore and Renee Lockett joined us on one of our peak mornings of the flight (09 October), a visit and insights we thoroughly enjoyed. The opportunity to meet Jay and Chrissy Kleberg on the SPI beach during their Chasing the Tide trek of the seven Texas barrier islands was a treat. The visits of Fred, Jessie and Elsa Sheckells on 21 October were perfectly aligned with conditions that produced a few late season birds.

In total, our 2023 field seasons were quite productive related to our captures, banding, sampling and associated studies. During the spring season, the migration was spread throughout the season. During fall migration the bulk of peregrine migrants passed in the early part of the migration. These types of vacillations among survey metrics are common, likely weather-related variations that can affect Survey results. However, the parallel declines of migrant volume or numbers in Survey count and capture metrics among seasons since 2016 are concerning (See Figure 6, Pg 8). Recent breeding area declines of peregrine and other falcon species add to concerns, like the Yukon River AK (Ambrose pers. comm.) and NM (Johnson *et. al*. 2023). Inquiries to better assess the declining patterns in our migration data and breeding area studies could lead to a better understanding of the scale and scope of potential factors currently at play on migratory peregrines among our sites. These may include environmental factors, pathogens (HPAI), contaminants, phenology, and distributions, etc.

Banding and Sampling Information

Bird banding is a primary tool utilized by our surveys and administered by the USGS Bird Banding Lab to identify individuals and learn of annual distributions, demographics and life history traits. Seven previously banded peregrines were encountered this year, either as Padre Returns (n=6) captured this year and banded at Padre during previous surveys, or as foreign band encounters (n=1). Each provides pertinent information about the fidelity of migratory routes, habitat use, and migration phenology for these long-distance migrants, and clearly illustrates the hemispheric importance of Padre Island habitats to migratory peregrines.

During the spring 2023 season four previously banded Padre Returns were captured. These include two second-year peregrines originally banded during the fall of 2022 by Gregg Doney and Hana Weaver. These were recaptured, respectively, by Mike Yates and Gregg Doney. A 9-year-old peregrine was captured by Bill Seegar, which was banded as a hatch-year by Kyle Fedden during the fall of 2014. Gregg Doney captured a 12-year-old peregrine, first banded by Catherine Wightman as a second-year in the fall of 2012. During the fall migration, two peregrines captured were each also captured during the spring

2023 Survey. Sam Voss captured a falcon banded by Mike Yates last spring. The second was the third capture of a falcon in roughly a single year. Gregg Doney banded a hatch-year falcon during the fall 2022 survey. Mike Yates captured her last spring, and Gregg captured her again this fall. A band encounter report from the BBL noted a hatch-year peregrine first banded by Robert McGuire during the fall survey as captured in November in Mexico due to an injury. We await the details.

Blood, feather and cloacal swab samples were collected from 144 individual peregrines this year, which contribute to our collaborative mercury monitoring efforts with Joe Barnes (US Fish and Wildlife Service) and Chris DeSorbo (BRI), and HPAI serology studies with Arnaud Van Wettere of UTVDL. In addition, Survey fall sampling will assist a new effort by Ericka Griggs from the Wildlife Pathogens Lab at University of Vermont in collaboration with BRI. This initiative seeks to establish baseline infection status and prevalence of avian malaria and other haemosporidian parasites in peregrines and other raptors, among different geographic regions of the Arctic.

In total, during our 47-year survey efforts on Padre Island (1977–2023), we have conducted 36,720 hours of field surveys, recorded 53,718 Peregrine Falcon observations, and captured/marked/sampled 10,779 peregrines. Padre Survey efforts, collectively included with the Assateague Island Peregrine Falcon Survey include 16,707 peregrine banding records. Our collective efforts provide metrics and support associated studies on the health, dynamics and movements of high latitude North American peregrines migrating along the Texas Gulf Coast and Mid-Atlantic coastlines. Through sampling, this provides snapshots of habitat conditions throughout their annual range. We send sincere gratitude to all involved in the peregrine survey effort and our supporters, directly and indirectly, historically and during the past nearly five decades.

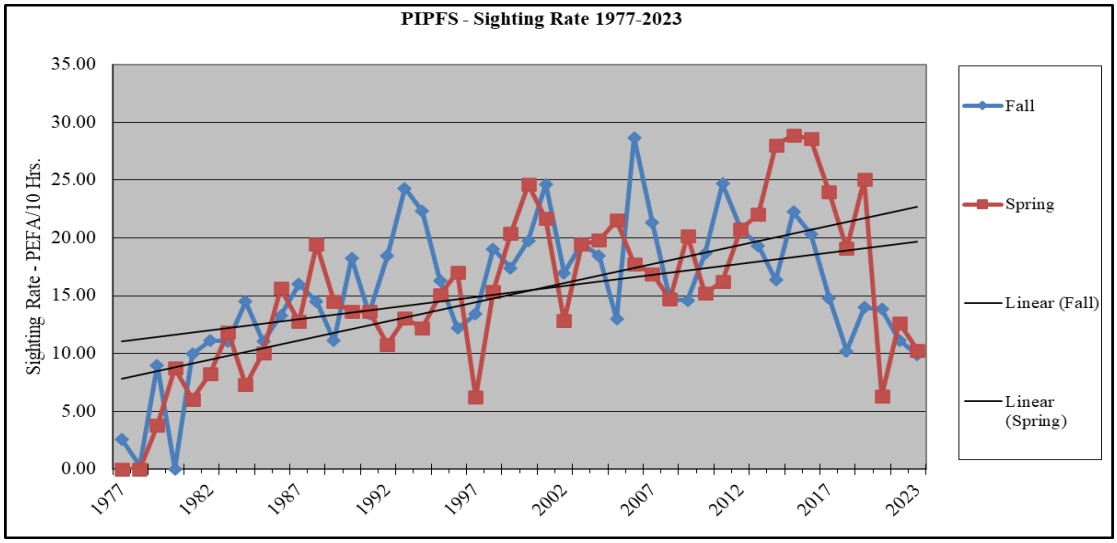

Figure 7 –Padre Survey sighting rate trends over time.

COLLABORATIVE STUDIES AND RECENT PUBLICATIONS

Contaminants Monitoring

In an ongoing collaboration with Joe Barnes of the U.S. Fish and Wildlife Service, we have continued to sample feathers for mercury contaminant analyses at Assateague and Padre Islands. This work draws from research by Barnes and Gerstenberger (2015) looking at mercury in feathers of a non-migratory population of peregrines in southern Nevada, and in their avian prey. Peregrine mercury levels are correlated with that of their prey, in order to use peregrines as an indicator species of broader environmental contamination. AMAP (2011) has highlighted concerns about increasing mercury levels in the Arctic, primarily from anthropogenic sources and augmented by melting of permafrost. Ambrose et al. (2000) identified mercury as a contaminant of concern specifically for peregrines breeding in Alaska due to trends in egg burdens and the general increasing trends in Arctic biota. Climate warming may remobilize and increase methylization of mercury, thus increasing ecosystem and human exposure. Our initial publication of mercury exposure in peregrine migrants was published (Barnes et al. 2019) in the Journal of Raptor Research. The abstract can be found in Appendix II. Our current effort incorporates molt patterns (Hunt et al. 1975, White et al. 2013) into a new feather sampling regime and with the collaboration of Chris DeSorbo (BRI) including blood and feather analyses; we seek insights on the geography of annual mercury exposure and that of individual adult peregrines over time.

During the 2023 surveys, we collected peregrine blood and feathers at the Assateague and Padre Island Surveys, focusing on adult migrant sampling due to their limited sampling availability at other sites. We also maintain sampling a seasonal juvenile cohort to assess trends and annual variability of mercury exposure in the Arctic.

In collaboration with The Peregrine Fund and the Center for Environmental Sciences and Engineering at the University of Connecticut, blood analyses of migrant peregrines collected during the Assateague Island (MD) and Padre Island surveys quantified temporal and spatial trends of polycyclic aromatic hydrocarbon (toxic components of crude oil) exposure in migrant peregrines from 2009 through2011 (Seegar *et al.* 2015). Please see the abstract in Appendix II. A method development poster of this study (Perkins et al. 2011) was presented at the SETAC North America 32nd Annual Meeting in Boston, MA. In addition, Tom Maechtle gave a presentation of this work at the 2014 Raptor Research Foundation Conference in Corpus Christi, Texas. The samples we collected at Assateague and Padre Islands (along with those previously archived) comprised an invaluable resource in demonstrating the utility of non-lethal blood sampling to assess effects of contaminants. Results showed a marked increase in both the levels of PAHs present and their composition (a transition to crude oil-based compounds) in the year following the 2010 Deepwater Horizon oil spill, followed by a return to near baseline components.

Henny *et al*. (1999) reported that organochlorine (OC) residues in plasma of Peregrine Falcons decreased significantly in spring migrants at Padre Island between collections obtained during 1978-80 and those collected in 1994. Henny noted that decreases in OC pesticide residues coincided with increased peregrine populations throughout the Arctic and other regions of North America. The update of this study conducted with 2004 samples (Henny *et al.* 2009) reported further dramatic declines (96-97%) in tundra peregrine OC contaminant loads at Padre Island during the later sampling period. This is a significant conservation milestone of the past century, though Henny suggests vigilance since the indoor use of DDT has been reauthorized in Africa. While the decreased use of persistent OCs has been an important factor in restoring peregrine populations, it heralds a change in agricultural processes that may now employ less persistent but more toxic chemicals. Henny (2009) also elucidates the large-scale utility of Padre Survey biomonitoring for emergent persistent organic pollutants (POPs) in the Americas. Polybrominated diphenyl ether (PBDE) flame retardants have dramatically increased in wildlife and humans and are of

developing concern worldwide. By utilizing our sample archive and future sampling, a broad scale inquiry of PBDE contaminant burdens in Padre migrants is warranted.

Avian Disease Monitoring

We initiated a collaboration in December 2022 with Arnaud Van Wettere (DVM, MS, PhD, DACVP) At the School of Veterinary Medicine, Utah State University. Entitled Prevalence of Avian Influenza A Virus Antibodies in Migrating North American Peregrine Falcons, it is summarized thus:
An outbreak of highly pathogenic avian influenza (HPAI) virus H5N1 started in the fall of 2021. The scale of this outbreak is unprecedented; it is the largest and most prolonged to date in the USA. Raptors are known to be particularly susceptible to HPAI, with most succumbing within a few days post infection. Given that peregrine falcons often prey on bird species known to carry the virus asymptomatically (e.g., waterfowl, gulls, shorebirds), they are at a higher risk of exposure to the virus than most raptor species. While a small number of wild peregrine falcons and falconry birds that succumbed to HPAI virus infection have been found during this outbreak, data on how many falcons survive infection is lacking. Studies during past outbreaks have shown that very few falcons (<0.1%) have antibodies to avian influenza virus. However, past HPAI outbreaks occurred in the fall and/or winter and disappeared in early summer with the return of warm temperatures. Therefore, exposure to the virus of peregrine falcons that migrate to Central and South America for the winter was likely limited. As this outbreak started in the fall of 2021 but persisted during the summer and fall 2022, peregrine falcons are more likely to have been exposed to HPAI virus than in past outbreaks. The goal of this study is to detect evidence of exposure to avian influenza virus. The presence of antibodies to avian influenza virus will be evaluated in the plasma of peregrine falcons captured during the fall and spring of 2021 and 2022 to determine how many peregrine falcons have developed an immune response against the virus. Determining the prevalence of antibodies against avian influenza virus will provide documentation of exposure to the virus in migrant peregrine falcons and indicate whether some falcons survived infection.

The UTVDL tested 442 peregrine samples and 6 tested positive for influenza A antibodies. For spring and fall 2021 which is the period before the HPAI outbreak started, the combined number of positives is 1 out of 237 birds (0.42%, similar to past studies). For Spring 2022, Fall 2022, and Spring 2023 (the outbreak period) the combined number of positive birds is 4/204 (1.96%). A single individual sampled in both 2021 and 2022 accounted for two of the positives, so was removed from the 2022-23 results. The number of birds with antibodies remains very low, but higher than reported in past surveys. The percentage of peregrines with antibodies in past studies in the US was 1/472 (0.2%) in 2006 to 2010, and 2/299 (0.67%) in 2001 to 2004, and 2 of 109 falcons (1.83%) during the large outbreak of 2014 to 2015. The encouraging news is that AI exposure is not invariably fatal to peregrines, although most succumb rapidly. We also infer that serology metrics in peregrines do relate to the scale of outbreaks, which has grown considerably at present. This autumn we also collected cloacal swabs from captured peregrines for analyses.

In a 2015 survey collaboration with Dr. Tom Gidlewski and Meredith Grady from the USDA APHIS National Wildlife Research Center, we contributed blood and cloacal swab samples from our Assateague and Padre Island surveys for analyses in their Highly Pathogenic Avian Influenza (HPAI) in Raptors of the US project. This effort contributes to the conservation of raptors, knowledge of the epidemiology of HPAI, heightened national surveillance efforts, and understanding of potential impacts on populations. The recent spread of HPAI viruses into North America and their tendency to reassort generates concerns and questions on the risks to agriculture, zoologic collections, wildlife and, potentially, human populations. As researchers have pointed out, robust, targeted surveillance programs among wild birds and poultry, modeling of the movements of HPAI-infected wild birds, and experimental research studies

will provide the knowledge required for intelligent policy and management decisions (Hall *et al.* 2015). The USDA completed its first round of testing with 274 serum samples collected in 2015 from all species of raptors (including 109 peregrine samples we collected at Assateague and Padre Islands). Samples were analyzed using the IDEXX Multi-S ELISA to detect influenza A antibodies. Two peregrines (and two other raptors) tested positive for influenza A antibodies of the overall 459 raptor samples analyzed, including one positive peregrine from each of the Assateague Island and Padre Island surveys. Among migratory peregrines 1.83% were seropositive. Please see page 19 in Appendix II for details.

In collaboration with Dr. Pat Redig of the Raptor Center at the University of Minnesota, peregrine plasma and cloacal swabs we collected from 2006-2009 were analyzed to detect exposure to Highly Pathogenic Avian Influenza H5N1.Consistent with wild bird monitoring throughout North America, the test results for the presence of Avian Influenza (H5N1) in all those samples were negative. Dr. Redig related in February 2009 that they have "... tested all cloacal swabs with a matrix pcr (m-PCR) and all of the blood samples with a competitive ELISA for influenza - neither test has yielded evidence of virus parts (m-pcr) or antibodies (ELISA) in these samples." To date H5N1 has not been detected in North America, but in late 2014 H5N2 was documented among wild ducks and H5N8 among domestic fowl in the Pacific Northwest. Captive Gyrfalcons and peregrines that had been fed falconry-captured ducks died of H5N8.

A research note (Redig and Goyal, 2012) was published indicating that among raptors, Bald Eagles do show exposure to influenza A viruses, and there is limited serologic prevalence of influenza A virus antibodies in migratory peregrines and other raptors. See the abstract for details in Appendix II.

Migration Phenology

In collaboration with Dr. Brad Fedy and Julie Galloway at the University of Waterloo, during her undergraduate thesis Galloway investigated whether the peak fall migration timing (in 1985-1989 and 2006-2013) of peregrines at SPI has changed. Migration timing was analyzed in conjunction with a suite of climate-related covariates, including local temperature, the North Atlantic Oscillation index (NAO), and the El Niño–Southern Oscillation index. Lastly, the study investigated migration timing in relation to several other variables that could influence Peregrine Falcon migration, including the predator-prey relationship between peregrines and shorebirds, and age and sex effects on migratory patterns and behavior. Prior to analyses, a database was created to store digitized data from scanned hard-copy Padre Island Peregrine Falcon Survey datasheets.

In this preliminary study, there was some evidence to suggest that migratory timing was correlated with the local-scale temperature and larger-level climate of South Padre Island. For instance, the study suggests that peak migration dates were later in years where the maximum temperature was high for the five-day period preceding peak arrival. However, additional data and a longer time frame are necessary to confirm this trend. The North Atlantic Oscillation index and mean Peregrine Falcon migration were correlated and suggested that migration timing was advanced in years where conditions were cold and wet along the migration route, and delayed in years where conditions were hot and dry.

Genetic Analyses

In collaboration with Drs. Sandra Talbot (USGS) and Jeff Johnson (The Peregrine Fund) we provide red blood cell samples for continued genetic analyses. Dr. Talbot is completing DNA level analyses of peregrine samples acquired at Assateague and Padre Islands. Talbot is utilizing samples collected from past surveys and investigating methods that will help us: 1) describe the composition of the migratory population using a molecular probe that will identify birds to population of natal origin; 2) assess the relative contribution of various breeding populations to the migratory populations at Assateague and Padre; 3) examine how changes in weather patterns and migratory patterns influence the size of the

migratory populations; and 4) possibly draw conclusions about changes in the size of breeding populations. Johnson and Dr. David Mindell presented a conference poster assessing the temporal genetic stability of migrating Peregrine Falcons sampled at Padre Island, TX between the years 1985-2007 (Johnson *et al.* 2007). Further analyses were published in Johnson *et al.* (2010).

Stable Isotope Research

We maintain feather collections from juvenile falcons at Padre for future stable isotope analyses to continue research initiated by Dr. Nancy Clum of the Wildlife Conservation Society. Dr. Clum's research assesses the feasibility of using stable isotopes as a means of identifying natal origins of migrant birds. If successful, this technique may allow us to: 1) evaluate the relative importance of different breeding habitats to populations of Arctic peregrines; 2) identify the dominant trophic position of Arctic peregrines; and 3) identify any temporal patterns of migration related to breeding habitat. Isotope data will be combined with data on plumage and morphological variation, which have also been suggested to vary geographically among peregrine populations. In addition, future comparative analyses of isotopic signatures of Gulf and East Coast HY falcons have potential to reveal the effects of continental weather patterns on juvenile tundra peregrines.

Population Monitoring

We provided the chapter on migration studies (Seegar *et al*. 2003) in Return of the Peregrine, the Peregrine Fund book documenting the species' recovery. Our studies at Padre and Assateague Islands formed the basis of that chapter. Mike Yates developed a presentation, delivered by Tom Maechtle at the 2014 raptor Research Foundation Conference in Corpus Christi Texas, updating the summary of our long-term standardized studies of migrating Tundra Peregrine Falcons on the East and Gulf Coasts of the US. Please see the abstract in Appendix II on page 14.

Satellite Telemetry

Advances in the miniaturization of satellite-received transmitters have only recently allowed the tracking of medium sized raptors such as Peregrine Falcons. Seegar and Yates first equipped migrating peregrines with 30-gram Platform Transmitter Terminals (PTTs) at Assateague Island, MD/VA in 1993. After the successful deployment and tracking of these first two individuals, we radio marked seven adult female Peregrine Falcons at Padre Island in the spring of 1994. In the spring of 1996, we radio marked the first migrant male peregrines at Padre Island with 20-gram PTTs. To date 20 Peregrine Falcons (two males, 18 females) have been radio marked with PTTs at Padre Island. Three Second Year peregrines were outfitted with new cellular GPS/GSM transmitters (~24g, North Star Science and Technology, LLC) during the 2012 spring survey. Satellite tracking data sets from Padre and Assateague migrants, as well as those we have tracked from Alaska, Canada, Mexico, Greenland and Russia were consolidated. They have been archived at MoveBank (https://www.movebank.org/) so we may better address research questions in collaboration with other users of that repository.

Dr. Michael McGrady is analyzing data collected from these instrumented birds. Building on the Yates *et al*. (1988) collation of band return data, this information has identified important areas in the Western Hemisphere for the conservation of peregrines and their prey.

Dr. Mark Fuller presented analyses of our satellite tracking results, including peregrines tagged on Padre Island, during the Raptor Migration, Ecology and Conservation in the New World Symposium, held in conjunction with the North American Ornithological Conference, Veracruz, Mexico, in October 2006. This analysis examined peregrine migration strategies, migratory corridors, wintering areas, staging areas and the influence of weather patterns on peregrine migration. Please refer to the Fuller *et al*. (2006)

abstract in Appendix II.

Satellite telemetry has spurred many of the recent advances in migration research. An applied example of its value was demonstrated in Swainson's Hawks (*Buteo swainsoni*). From concerns generated by declining demographics in nest monitoring surveys, Earthspan was part of a multi-agency effort to monitor Swainson's Hawk populations throughout the year using satellite-received telemetry. Use of this technology led researchers to areas in Argentina, where large numbers of Swainson's Hawks were found dead. Subsequent investigations determined that secondary poisoning due to contact with the insecticide Monochrotophos caused the mortalities. This chemical was used to protect crops from grasshoppers, a primary food source for Swainson's Hawks wintering in Argentina. Winter use areas were delimited through the satellite tracking of radio marked Swainson's Hawks. Once the cause of mortality was discovered, researchers working with government representatives and environmental groups were able to convince the product's manufacturer to voluntarily withdraw its use from the region. They replaced farmers' stocks with a reportedly less toxic product for controlling insect pests. This case demonstrates the utility of tracking migrants with the aid of satellite telemetry to monitor environmental health. Field evaluations would have been more difficult and costly without the location estimates for Swainson's Hawk wintering areas provided by satellite tracking. Most significantly, the needless mortality of Swainson's Hawks was quickly curtailed. Besides conserving Swainson's Hawks, this proactive management saved an untold amount of multi-agency resources.

The situation described above indicates the need for continued and more extensive field evaluations of highly toxic, but less persistent (therefore more difficult to detect) chemicals. It also illustrates the advantages of proactive monitoring, as embodied by our PIPFS efforts. The threat of poisoning for Neotropical migrants continues to be a problem in Latin America, where organophosphates appear to have largely replaced the use of persistent organochlorines.

CONCLUSIONS AND RECOMMENDATIONS

Data from the Padre survey continue to suggest full recovery of Arctic populations of Peregrine Falcons. This conclusion is supported by reports of researchers observing increased production in most Arctic regions of North America (Cade *et al*. 1988, Cade and Burnham 2003). To some extent, the variability in our seasonal sighting rate (Figure 6), and capture metrics are likely due to the effects of local and continental scale environmental factors, which warrants further study. However, the current declines from 2016 onward raise concerns, since similar patterns are also emerging among some breeding area studies (Yukon River-[Ambrose, pers.comm.], NM [Johnson *et.al.* 2023], and anecdotal accounts). Some migration peregrine counts do illustrate recent declining numbers. Should a larger scale pattern of decline emerge, inquiries which might account for environmental variability of peregrine migrants and identify pertinent new stressors (such as HPAI) may be prudent.

The recovery of the peregrine is one of the few success stories for an Endangered Species. Continued monitoring furthers our understanding of peregrine population dynamics. While we supported delisting the Arctic subspecies from the List of Threatened and Endangered Species in 1994, we continue to recognize its importance as a sentinel species of environmental conditions that affect a myriad of other avian species. Through the integration of several technologies, (e.g., tracking of peregrines by satellite, analyses of genetic make-up and investigation of contaminant burdens and emerging pathogens) the Padre Island Peregrine Falcon Survey can be used to monitor the environmental health of a large geographic area. This includes diverse habitats used by peregrines, as revealed by satellite derived location estimates and band returns. These habitats are shared by a wide variety of avian species and can serve to identify areas where further local monitoring is warranted (particularly in Latin America).

We recommend that the Padre Island Peregrine Falcon Survey continue, as data from our research will: 1) provide information on evolving population dynamics and migratory patterns; 2) provide samples to monitor for present and future infectious diseases and contaminants, and define genetic composition of the Padre population; 3) maintain our temporal tissue archive for future applications; and 4) help identify key migration and over-wintering habitat of Neotropical migrants in the Gulf Coast region, Central and South America.

Additionally, we recommend that winter use areas revealed by band returns and satellite received location estimates be investigated to evaluate their importance to Peregrine Falcons, other Neotropical migrants, and resident species. Pending sufficient funding, we plan to continue autumn and spring surveys. Our surveys will be conducted using similar methods and number of personnel as deployed throughout the Survey's history, incorporating new protocols to address developing concerns. These include emergent persistent organic pollutants, zoonotic diseases, and the impacts of climate change on this Neotropical migrant.

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APPENDIX – I
Padre Island Peregrine Falcon Survey Totals 1977-2023

Year	Season	Survey Hours	Sighting Rate # s./10h	Peregrines Sighted	Peregrines Captured	Vehicles used
1977	Autumn	467	2.59	121	31	Trucks/beachfront
1978	Autumn	384	0.31	118	33	TBF(12) & PTS (21)
1979	Spring	154	3.77	58	8	TBF (8) & PTS (0)
1979	Autumn	420	8.98	377	89	TBF (41) PTS (24) ATV (24)
1980	Spring	542	8.73	473	54	TBF-PTS-ATV
1980	Autumn	0	0.00	0	0	Hurricane Allen
1981	Spring	448	6.05	271	32	ATV&TBF
1981	Autumn	602	9.95	599	152	ATV&TBF
1982	Spring	950	8.22	781	92	ATV&TBF
1982	Autumn	734	11.10	815	155	ATV&TBF
1983	Spring	1150	11.86	1364	149	ATV&TBF
1983	Autumn	986	11.08	1092	283	ATV&TBF
1984	Spring	1240	7.31	906	88	ATV&TBF
1984	Autumn	809	14.47	1171	196	ATV&TBF& PTS
1985	Spring	895	10.06	900	152	ATV&TBF
1985	Autumn	409	11.02	451	128	ATV
1986	Spring	597	15.63	933	102	ATV
1986	Autumn	632	13.29	840	216	ATV
1987	Spring	828	12.75	1056	140	ATV
1987	Autumn	433	15.98	692	188	ATV
1988	Spring	770	19.44	1497	209	ATV
1988	Autumn	656	14.53	953	296	ATV/begin using dye in fall.
1989	Spring	864	14.51	1,254	127	ATV
1989	Autumn	701	11.10	778	248	ATV
1990	Spring	817	13.61	1112	129	ATV
1990	Autumn	735	18.24	1341	298	ATV&TBF
1991	Spring	670	13.64	914	114	ATV
1991	Autumn	580	13.45	780	250	ATV&TBF
1992	Spring	578	10.80	624	89	ATV
1992	Autumn	114	18.42	210	64	ATV&TBF
1993	Spring	618	13.06	807	127	ATV
1993	Autumn	995	24.28	2,416	694	ATV&TBF
1994	Spring	319	12.23	390	83	ATV/hovercraft
1994	Autumn	276	22.32	616	118	ATV/TBF-SPI only
1995	Spring	139	15.04	209	43	ATV/SPI only
1995	Autumn	192	16.30	313	84	ATV/TBF-SPI only/hurricanes
1996	Spring	54	17.04	92	19	ATV/SPI only
1996	Autumn	397	12.19	484	198	ATV/TBF-SPI only
1997	Spring	87	6.21	54	16	ATV/SPI only
1997	Autumn	328	13.41	440	183	ATV/TBF-SPI only
1998	Spring	164	15.37	252	44	ATV/SPI only
1998	Autumn	605	19.04	1152	309	ATV/SPI only
1999	Spring	160	20.38	326	78	ATV/SPI only
1999	Autumn	512	17.40	891	275	ATV/SPI only
2000	Spring	195	24.62	480	80	ATV/SPI only
2000	Autumn	400	19.75	790	151	ATV/SPI only

APPENDIX – I (cont.)
Padre Island Peregrine Falcon Survey Totals 1977-2023

Year	Season	Survey Hours	Sighting Rate # s./10h	Peregrines Sighted	Peregrines Captured	Vehicles used
2001	Spring	251	21.67	544	105	ATV/SPI only
2001	Autumn	290	24.66	715	186	ATV/SPI only
2002	Spring	309	12.82	396	49	ATV/SPI only
2002	Autumn	197	16.95	334	68	ATV/SPI only
2003	Spring	162	19.44	315	37	ATV/SPI only
2003	Autumn	302	19.50	589	171	ATV/SPI only
2004	Spring	159	19.81	315	52	ATV/SPI only
2004	Autumn	263	18.48	486	103	ATV/SPI only
2005	Spring	106	21.51	228	34	ATV/SPI only
2005	Autumn	262	12.98	340	117	ATV/SPI only
2006	Spring	111	17.75	197	17	ATV/SPI only
2006	Autumn	359	28.66	1029	200	ATV/SPI only
2007	Spring	112	16.88	189	30	ATV/SPI only
2007	Autumn	258	21.32	550	92	ATV/SPI only
2008	Spring	154	14.68	226	40	ATV/SPI only
2008	Autumn	318	14.65	466	133	ATV/SPI only
2009	Spring	166	20.18	335	60	ATV/SPI only
2009	Autumn	387	14.60	565	144	ATV/SPI only
2010	Spring	104	15.19	158	42	ATV/SPI only
2010	Autumn	401	18.20	730	180	ATV/TBF-SPI only
2011	Spring	178	16.24	289	33	ATV/SPI only
2011	Autumn	371	24.69	916	202	ATV/TBF-SPI only
2012	Spring	145	20.76	301	37	ATV/SPI only
2012	Autumn	480	20.79	998	228	ATV/TBF-SPI only
2013	Spring	145	22.01	319	42	ATV/SPI only
2013	Autumn	532	19.32	1028	212	ATV/TBF-SPI only
2014	Spring	196	28.01	549	51	ATV/SPI only
2014	Autumn	358	16.34	585	114	ATV/TBF-SPI only
2015	Spring	143	28.88	413	52	ATV/SPI only
2015	Autumn	356	22.23	793	151	ATV/TBF-SPI only
2016	Spring	169	28.58	483	58	ATV/SPI only
2016	Autumn	345	20.35	702	180	ATV/SPI only
2017	Spring	191	23.96	457	36	ATV/SPI only
2017	Autumn	429	14.80	635	131	ATV/SPI only
2018	Spring	243	19.09	464	56	ATV/SPI only
2018	Autumn	434	10.21	443	74	ATV/SPI only
2019	Spring	230	25.04	576	51	ATV/SPI only
2019	Autumn	395	13.97	552	95	ATV/SPI only
2021	Spring	199	6.33	126	19	ATV/SPI only
2021	Autumn	416	13.85	576	158	ATV/SPI only
2022	Spring	252	12.62	319	26	ATV/SPI only
2022	Autumn	496	11.13	552	150	ATV/SPI only
2023	Spring	261	10.27	268	29	ATV/SPI only
2023	Autumn	479	9.89	474	120	ATV/SPI only
Totals		**36,720**		**53,718**	**10,779**	

Codes:
ATV – All terrain vehicles, TBF- Trucks on beach front, PTS – Permanent trapping station

APPENDIX – II
Abstracts of Recent Publications and Presentations

Oliphant, L.W, M.A. Yates, G.E. Doney. 2019. Determining Your Passage Peregrine's "Size" From Migration Data. Hawk Chalk-LVIII (3):38-41. Published by the North American Falconers Association.

Background: Falconers want their birds to enthusiastically pursue wild quarry with the strength and stamina of a wild bird, while still remaining responsive to the falconer. In earlier times assessing the condition of a bird was accomplished by paying close attention to its behavior, feeling the keel, or palpating fat deposits. Although modern falconers still utilize these subjective methods, the use of accurate scales to determine a bird's weight is now the most common method of assessment. We ask other falconers what weight their bird flies at. The assumption is that at some particular 'flying weight' their bird is in 'optimum condition'. This is a big assumption.

Methodology/Summary: In a creative applied and informative publication designed by Dr. Lynn Oliphant, professor emeritus from the University of Saskatchewan, also collaborating with and the Cape May Raptor Banding Project; this effort serves as a guide to assist falconers in determining a relative flying weight for a new immature peregrine. We utilized a large sample of morphology data collected during the Assateague and Padre surveys and at Cape May, to explore the relationship between weight and "body size" as reflected by a wing cord measurement. Using simple linear regression and based on a wing chord measurement, we provide simple predictive equations for East and Gulf Coast birds, which estimate the average weight of wild-trapped immature peregrine for comparison. Variation between the East and Gulf Coast peregrine weights and relative comparisons with a freshly trapped passage bird are discussed.

Barnes, J.G., G.E. Doney, M.A. Yates, W.S. Seegar, S.L. Gerstenberger.2019. A Broadscale Assessment of Mercury Contamination in Peregrine Falcons across the Northern Latitudes of North America. Journal of Raptor Research53(1):1-13.

ABSTRACT.—We document concentrations of total mercury (THg) in feathers of Peregrine Falcons (*Falco peregrinus*; hereafter peregrines) collected during autumn migration at South Padre Island, Texas and Assateague Island, Maryland from 2009–2015. We detected THg in all sampled fourth primary (p4; range = 0.44–37.46 μg/g) and axillary feathers (range = 0.09–62.68 μg/g). We found no significant difference in THg concentrations between hatch-year (HY) peregrines by study site. Mean THg concentrations were greater in after-hatch-year peregrines in both feather types than in HY peregrines, but concentrations in p4 feathers of second-year peregrines (mean = 14.9 μg/g) were significantly greater than after-second-year individuals (mean = 8.5 μg/g). Pooling samples from HY birds across both sites and all years, we found no significant differences between the concentrations in the axillaries of females (mean = 2.4 μg/g) vs. males (mean = 2.2 μg/g), nor between the two feather types. The concentration associated with toxic effects in peregrines is unknown; however, peregrines have recently experienced broad population expansion across the presumed breeding area of the birds we sampled, and the THg concentrations we measured were lower than those in an apparently healthy breeding population in the southwestern USA. We documented widespread THg exposure in peregrines migrating from the northern latitudes of North America, but additional research is needed to assess trends in mercury exposure in the face of increasing global anthropogenic release of mercury into the environment and the release of long-term sequestered mercury in melting permafrost from climate change.

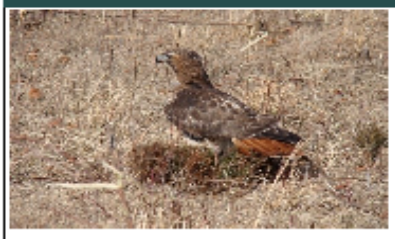
Deliberto, Thomas. 2018. Investigating Exposure of Raptors to Avian Influenza. Program Activity Report - National Wildlife Disease Program, US Department of Agriculture. 15 August 2018.

National Wildlife Disease Program

15 August 2018

PROGRAM ACTIVITY REPORT (PAR)

Investigating Exposure of Raptors to Avian Influenza



Red-tailed hawk. *Photo courtesy of USDA Wildlife Services.*

Avian influenza is a Type A influenza virus that has been documented in more than 100 bird species, but some species of waterfowl, shorebirds, and gulls are considered the primary reservoirs. Certain strains of avian influenza are termed highly pathogenic avian influenza viruses (HPAIV) because they cause high morbidity and mortality rates in poultry.

During 2014-2015, Eurasian HPAIV H5N8, and Eurasian/North American HPAIV H5N2 and H5N1 resulted in significant mortality of poultry and some species of wild birds. In particular, 7 wild raptors were found dead and tested positive for HPAIV after being submitted for diagnostic testing. Three falconry birds also tested positive for HPAIV.

In response, the National Wildlife Disease Program (NWDP) developed a project to explore how HPAIV might be affecting raptors. The main objective was to survey live raptors for antibodies in blood serum to influenza A virus and, more specifically, to Eurasian H5 HPAIV. Oropharyngeal and cloacal swabs were also collected from raptors to determine if birds were actively shedding influenza virus at the time of sampling.

Raptors were sampled in 13 states from 2014 to 2017. Samples were submitted to the USDA Wildlife Services' National Wildlife Research Center and Colorado State University Veterinary Diagnostic Laboratory in Fort Collins, CO, for initial testing. Non-negative samples requiring further testing were sent to the USDA National Veterinary Services Laboratory in Ames, IA.

Overall, 459 serum and 522 swab samples were collected from a total of 588 birds. All swab samples were negative for type A influenza via RRT-PCR. Only four serum samples tested positive by ELISA for antibodies to influenza A. Of those, none were identified as known HPAIV subtypes, suggesting that the birds were likely exposed to native North American wild bird influenza viruses.

The survey did not find evidence for widespread exposure of raptors to Type A influenza. Furthermore, no evidence of exposure to the Eurasian HPAIV strains was documented. Given that this work occurred simultaneous to the Eurasian HPAIV outbreaks, during which raptors were confirmed with HPAIV, it is likely that infection with Eurasian H5 HPAIVs in raptors resulted in mortality rather than morbidity and recovery.

Species	n
Red-tailed Hawk	227
Peregrine Falcon	127
Black Vulture	62
Northern Goshawk	32
Great-horned Owl	27
American Kestrel	22
Barred Owl	14
Turkey Vulture	14
Red-shouldered Hawk	13
Cooper's Hawk	10
Bald Eagle	9
Golden Eagle	6
Broad-winged Hawk	4
American Crow	3
Swainson's Hawk	3
Eastern Screech Owl	2
Northern Harrier	2
Osprey	2
Rough-legged Hawk	2
Barn Owl	1
Ferruginous Hawk	1
Merlin	1
Prairie Falcon	1
Sharp-shinned Hawk	1
TOTAL	586

Willard Heck sampling a peregrine falcon on Padre Island in Texas. *Photo courtesy of Kate Davis with Earthspan, Inc.*

Collaborators:
Earthspan, Inc.
Hawk Ridge Bird Observatory
HawkWatch International
Cape Fear Raptor Center
Rocky Mountain Raptor Program
Colorado State University
National Veterinary Services Laboratory
USDA/APHIS Wildlife Services

For more information, please contact Tom Deliberto.

USDA United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services

The original artwork on this page was created by Erika Kampe and Sarah Goff

Seegar, W.S., M.A. Yates, G.E. Doney, T.C.M. Seegar, J. P. Jenny, C. Perkins, M. Giovanni. 2015. Migrating Tundra Peregrine Falcons (*Falco peregrinus tundrius*) accumulate polycyclic aromatic hydrocarbons along the Gulf of Mexico following the Deepwater Horizon oil spill. Ecotoxicology24(5): 1102-1111.

Monitoring internal crude oil exposure can assist the understanding of associated risks and impacts, as well as the effectiveness of restoration efforts. Under the auspices of a long-term monitoring program of Tundra Peregrine Falcons (*Falco peregrinus tundrius*) at Assateague (Maryland) and South Padre Islands (Texas), we measured the 16 parent (unsubstituted) polycyclic aromatic hydrocarbons (PAHs), priority pollutants identified by the United States Environmental Protection Agency and components of crude oil, in peripheral blood cells of migrating Peregrine Falcons from 2009 to 2011. The study was designed to assess the spatial and temporal trends of crude oil exposure associated with the 2010 Deepwater Horizon (DWH) oil spill which started 20 April 2010 and was capped on 15 July of that year. Basal PAH blood distributions were determined from pre-DWH oil spill (2009) and unaffected reference area sampling. This sentinel species, a predator of shorebirds and seabirds during migration, was potentially exposed to residual oil from the spill in the northern Gulf of Mexico. Results demonstrate an increased incidence (frequency of PAH detection and blood concentrations) of PAH contamination in 2010 fall migrants sampled along the Texas Gulf Coast, declining to near basal levels in 2011. Kaplan–Meier peak mean PAH blood concentration estimates varied with age (Juveniles-16.28 ± 1.25, Adults-5.41 ± 1.10 ng/g, wet weight) and PAHs detected, likely attributed to the discussed tundra peregrine natural history traits. Increased incidence of fluorene, pyrene and anthracene, with the presence of alkylated PAHs in peregrine blood suggests an additional crude oil source after DWH oil spill. The analyses of PAHs in Peregrine Falcon blood provide a convenient repeatable method, in conjunction with ongoing banding efforts, to monitoring crude oil contamination in this avian predator.

Yates, M.A., W.S. Seegar, T.L. Maechtle, G.E. Doney. 2014. Long-term standardized studies of migrating Tundra Peregrine Falcons (*Falco peregrinus tundrius*) on the East and Gulf Coasts of the U.S. 2014 Raptor Research Foundation Conference in Corpus Christi, TX. 30 September 2014.

Range-wide DDT-related declines among Peregrine Falcon populations led to endangered species status in the U.S. in 1970. Standardized autumn studies of migrating Tundra Peregrine Falcons were begun at two well-documented focal points of migration (Assateague Island, MD/VA, 1970, and Padre Island, TX, 1977). Padre Island was identified as the only known vernal migration concentration point in the Western Hemisphere, and spring studies were added there in 1979. To date we have expended >50,000 man-hours in sighting ~64,000 Tundra Peregrines and capturing 14,639. Our long-term database on this subspecies since 1970 is unparalleled. At Assateague it can also be directly related to data collected during 1938-1969 by falconer/naturalists, effectively providing a continuous database of >seven decades at this migration focal point. Our data document the recovery of migratory peregrine populations after the 1972 U.S ban of DDT, and we plan to continue these monitoring efforts. We have tracked 58 peregrines from these study sites and coastal Mexico by satellite-received telemetry, defining migratory routes and areas of critical use by subjects and their associated prey species. We have archived thousands of blood samples from Tundra Peregrines; these apex predators are an established bioindicator of environmental health. Samples can be analyzed to provide current and retrospective insights into known and emerging chemical and biological threats to the environment and to our living world. We documented the decline and virtual disappearance of DDE in Tundra Peregrine blood. We have also utilized samples in genetic and natal origin studies, as well as the investigation of West Nile Virus, Avian Influenza, and PAH contamination resulting from the 2010 Deepwater Horizon Gulf of Mexico oil spill. These important studies will continue indefinitely into the future.

Maechtle, T.L., W.S. Seegar, M.A. Yates, G.E. Doney, T.C.M. Seegar, J. P. Jenny, C. Perkins, M. Giovanni. 2014. Migrating Tundra Peregrine Falcons (*Falco peregrines tundrius*) accumulate polycyclic aromatic hydrocarbons along the Gulf of Mexico following the Deepwater Horizon oil spill. 2014 Raptor Research Foundation Conference in Corpus Christi, TX. 30 September, 2014.

Monitoring internal crude oil exposure can assist the understanding of associated risks and impacts, as well as the effectiveness of restoration efforts. Under the auspices of a long-term monitoring program of Tundra Peregrine Falcons (*Falco peregrinus tundrius*) at Assateague (Maryland) and South Padre Islands (Texas), we measured circulating parent polycyclic aromatic hydrocarbons (PAHs), components of crude oil, in peripheral blood cells of migrating Peregrine Falcons from 2009-2011. The study was designed to assess the spatial and temporal trends of crude oil exposure associated with the 2010 Deepwater Horizon oil spill (DWH). This sentinel species, a predator of shorebirds and seabirds during migration, was potentially exposed to residual oil from the spill in the northern Gulf of Mexico. Results demonstrate an increased incidence of PAH contamination in 2010 fall migrants sampled along the Texas Gulf Coast, declining to near basal levels in 2011. Kaplan-Meier peak mean ∑PAH blood concentration estimates varied with age (Juveniles-16.28 ±1.25, Adults-5.41 ±1.10 ng/g, wet weight) and PAHs detected, likely attributed to the discussed tundra peregrine natural history traits. Diagnostic sourcing ratios are not possible due to the few PAH analytes detected. Yet increased incidences of fluorene, pyrene and anthracene, with the presence of other PAHs in peregrine blood suggest an additional crude oil source after DWH. Continued monitoring is recommended until parent PAH profiles return to basal constituents and to include alkyl PAH analyses. The analyses of PAHs in Peregrine Falcon blood provide a convenient repeatable method, with little disturbance to birds, for monitoring crude oil contamination in coastal environments and their avian prey base.

Redig, P. T. and S. M. Goyal. 2012. Serologic evidence of exposure of raptors to influenza A virus. Avian Diseases, 56(2):411-413.

SUMMARY. Serum or plasma samples from raptors that prey or scavenge upon aquatic birds were tested by a commercially available blocking enzyme-linked immunosorbent assay for the evidence of antibodies to influenza A virus. Samples were taken from birds (n=616) admitted to two rehabilitation centers in the United States. In addition, samples from 472 migrating peregrine falcons (Falco peregrinus) trapped on autumnal and vernal migrations for banding purposes were also tested. Only bald eagles were notably seropositive (22/406). One each of peregrine falcon, great horned owl (Bubo virginianus), and Cooper's hawk (Accipiter cooperi) from a total of 472, 81, and 100, respectively, were also positive. None of the turkey vultures (n=21) or black vultures (n=8) was positive. No clinical signs referable to avian influenza were seen in any bird at the time of capture. These data indicate that, among raptors, bald eagles do have exposure to influenza A viruses.

Perkins, C., A. Provatas, W. Seegar, M. Yates, D. Evers, and P. Jenny. 2011. Analysis of PAHs 9500 from MC-252 in whole blood and RBCs from live-captured birds using ultra performance liquid chromatography (UPLC): Method development and assessment. SETAC North America 32nd Annual Meeting in Boston, MA. Nov. 15, 2011.

The explosion of the Deepwater Horizon oil platform on April 20, 2010, resulted in an unprecedented release of crude oil in the Gulf of Mexico. Much of the oil and the dispersants used impacted salt marshes and beaches around the Gulf, with numerous species of birds documented as being exposed. While the use of dispersants in an oil spill response involves tradeoffs between effects to the shoreline and effects to pelagic and deep-sea environments, relatively little is known on the effects that the oil-associated polycyclic aromatic hydrocarbons (PAHs) have upon the health of avian

populations. Circulating blood-borne, parent PAHs can provide a direct link for exposure assessment and reconstruction since they are not as affected by differences in metabolism and excretion. There are a couple of challenges in analyzing whole blood and red blood cells (RBCs) from live-captured birds that make quantitation more difficult; minimal sample volume (0.1- 0.5 ml) can be obtained without being detrimental and the target analytes are less abundant by volume in circulating RBCs in contrast to whole blood. We developed a novel method for the analysis of 16 PAHs utilizing ultra-performance liquid chromatography coupled to photodiode array, fluorescence, and tandem mass spectrometry detectors. This rigorous method obtained good recoveries of standard reference material (60-95%), matrix spikes (60-95%), calibration verifications (90-95%), and surrogates (85%) while obtaining good sensitivity of at least 5ng/g for PAHs and for Dispersants. This method was developed in support of an ongoing study examining uptake and exposure in migrating Peregrine Falcons and other birds.

Johnson, J.A., S.L. Talbot, G.K. Sage, K.K. Burnham, J.W. Brown, T.L. Maechtle, W.S. Seegar, M.A. Yates, B. Anderson, D.P. Mindell. 2010. The Use of Genetics for the Management of a Recovering Population: Temporal Assessment of Migratory Peregrine Falcons in North America. PLoS ONE 5(11): e14042. doi: 10.1371/journal.pone.0014042

Background: Our ability to monitor populations or species that were once threatened or endangered and in the process of recovery is enhanced by using genetic methods to assess overall population stability and size over time. This can be accomplished most directly by obtaining genetic measures from temporally spaced samples that reflect the overall stability of the population as given by changes in genetic diversity levels (allelic richness and heterozygosity), degree of population differentiation (FST and DEST), and effective population size (Ne). The primary goal of any recovery effort is to produce a long- term self-sustaining population, and these genetic measures provide a metric by which we can gauge our progress and help make important management decisions.

Methodology/Principal Findings: The Peregrine Falcon in North America (Falco peregrinus tundrius and anatum) was delisted in 1994 and 1999, respectively, and its abundance will be monitored by the species Recovery Team every three years until 2015. Although the United States Fish and Wildlife Service makes a distinction between tundrius and anatum subspecies, our genetic results based on eleven microsatellite loci suggest limited differentiation that can be attributed to an isolation by distance relationship and warrant no delineation of these two subspecies in its northern latitudinal distribution from Alaska through Canada into Greenland. Using temporal samples collected at Padre Island, Texas during migration (seven temporal time periods between (1985–2007), no significant differences in genetic diversity or significant population differentiation in allele frequencies between time periods were observed and were indistinguishable from those obtained from tundrius/anatum breeding locations throughout their northern distribution. Estimates of harmonic mean Ne were variable and imprecise, but always greater than 500 when employing multiple temporal genetic methods.

Conclusions/Significance: These results, including those from simulations to assess the power of each method to estimate Ne, suggest a stable or growing population, which is consistent with ongoing field-based monitoring surveys. Therefore, historic and continuing efforts to prevent the extinction of the Peregrine Falcon in North America appear successful with no indication of recent decline, at least from the northern latitude range-wide perspective. The results also further highlight the importance of archiving samples and their use for continual assessment of population recovery and long-term viability.

Henny, C.J., M.A. Yates, W.S. Seegar. 2009. Dramatic Declines of DDE and Other Organochlorines in Spring Migrant Peregrine Falcons from Padre Island, Texas, 1978–2004. J. Raptor Res. 43(1):37-42.

Peregrine Falcons (Falco peregrinus) captured in the spring at Padre Island, Texas, nest across the arctic and subarctic from Alaska to Greenland and winter throughout Latin America. Padre Island, located immediately north of the Mexican border, is the peregrines' first landfall in the U.S.A. after spending about 6 mo in Latin America. Blood plasma was collected from spring migrants at Padre Island between 1978 and 2004 to monitor trends in organochlorine (OC) pesticides and their metabolites. Geometric mean concentrations of p, p9-DDE (mg/g, ww) decreased throughout the study: 1978–1979 (0.879), 1980 (0.617), 1984 (0.551), 1994 (0.406) and 2004 (0.013). Most other OC pesticides, with detection limits used during the earlier portion of this study, were no longer detected during the last two sampling periods. The reduced concentrations of OC pesticides suggest that other pesticides (including carbamates, organophosphates and pyrethroids) are likely being used as replacements. These replacement compounds are not as persistent and cannot be readily evaluated at migration sites like Padre Island. However, concentrations of flame retardants (polybrominated diphenyl ethers; PBDEs) have recently increased in bird eggs in many regions and have been reported in blood plasma. Concentrations of PBDEs in peregrine plasma could be evaluated at Padre Island for assessment of trends in the Americas.

Johnson, J.A. and D. P. Mindell 2007. Temporal population genetic stability of Peregrine Falcons migrating through Padre Island, Texas. Poster presentation at throne Hundred and Twenty-Fifth Stated Meeting of the American Ornithologists' Union**,** University of Wyoming, Laramie, WY. August 2007.

Temporal samples were collected from Peregrine Falcons during both fall and spring migration at Padre Island, TX. Three temporal periods (1985 - 1986, 1988 - 1989, and 2006 - 2007) were analyzed using 11 microsatellite loci. No significant differences in genetic diversity (number of alleles and heterozygosity) were observed within a migration period or between years, and no significant differences in allele frequencies were identified across temporal periods. Estimates of variance effective population size (Ne) were also quite high. Assuming panmixia across breeding territories in North America for migrant Peregrine Falcons, these genetic results indicate that the population is doing well due to extensive efforts to prevent extinction following their precipitous decline in the mid-20th Century.

Fuller, M.R., W.S. Seegar, L. Schueck, G. Young., K. Thorup, A. Hedenstrom. Peregrine Falcon Migration in the Western Hemisphere. Presentation at the Raptor Migration, Ecology and Conservation in the New World Symposium, held in conjunction with the North American Ornithological Conference, Veracruz, Mexico. October 2006.

We radio marked adult female Arctic Peregrine Falcons (*Falco peregrinus tundrius*) at nests in West Greenland, the northern Ungava Peninsula and Rankin Inlet, Canada, and on Assateague and Padre Islands, USA. During southward migration, falcons leaving Greenland often paused before crossing the Davis Strait. Some individuals stopped for 4 or more days during migration, but we found no consistent stopover strategy. Analyses of meteorological data from Canada and the USA during sample southward migrations suggest that peregrines are affected more by the winds on the morning of migration than by winds the morning after, and that tailwinds affect the likelihood of migration and the migration distance. Some falcons migrated near coastlines, but others made water crossings of more than 1,000km. However, detours from direct routes occurred commonly. Generally, the movement patterns are described best by geographical courses, and in no cases do the tracks indicate the use of constant geomagnetic courses. At least five Peregrine Falcons made a loop migration, southward along the eastern seaboard to Central and South America, then north into southern Canada via the central USA. Average migration rates varied from 142 to 282 km per day among bands of latitude. The average southward migration was 162 km/day and northward was 149 km/day.

Dusek, R. J., E. K. Hofmeister, W. S. Seegar, M. A. Yates, T. L. Maechtle, and B. J. Dayton. 2005. Prevalence of West Nile Virus in Peregrine Falcons. Poster presentation, Proceedings of the Raptor Research Foundation annual meeting, Green Bay, WI.

Since West Nile Virus (WNV) was discovered in New York City, New York in 1999, it has quickly spread throughout the continental United States, much of Canada, central America and the Caribbean. Yearly outbreaks of this disease have continued into 2005 causing mortality in tens of thousands of wild birds and likely will never disappear from the western hemisphere. Morbidity and mortality from WNV have been reported quite commonly in raptors, especially in Ohio in 2002 and then again in Colorado in 2003, but little is known about the impact or prevalence of this disease in this group of birds. In 2001 we initiated a study to determine the prevalence of specific WNV neutralizing antibody in Peregrine Falcons during migration at Assateague Island, Maryland and Virginia (fall only), and South Padre Island, Texas (spring and fall). Peregrine Falcons have been monitored through observation and banding for 35 and 28 years respectively at these two locations. From fall of 2001 through the spring of 2005 more than 650 blood samples have been tested by PRNT for WNV antibody. Prevalence of antibody has increased from 2.0% in fall 2001 to 14.7% in spring of 2005. During 1999-2004 capture success and observations have declined when compared against the 10-yr average 1988-1998 at Assateague Island, however, this decline cannot be directly attributed to WNV based on our data. Results from this study reflect the increasing prevalence of WNV throughout North America. Based on our data continued monitoring and research are warranted.

APPENDIX – III - Band Information - 2023

Previously Banded Padre Returns:

Band #	Date	Age	Sex	Captured By	First Banded By	Age	Date	Comments
1947-56036	9-Apr-2023	SY	F	M. Yates	G. Doney	HY	9-Oct-2022	4/25-Myates-recap
1947-56060	25-Apr-2023	SY	F	G. Doney	H. Weaver	HY	19-Oct-2022	
1947-24544	30-Apr-2023	ASY	F	W. Seegar	K. Fedden	HY	16-Oct-2014	
1687-26021	2-May-2023	ASY	F	G. Doney	C. Wightman	SY	17-Oct-2012	
1947-56036	18-Oct-2023	SY	F	G. Doney	G. Doney	HY	9-Oct-2022	3rd capture at SPI, 4/9 MYates, 10/23-SVoss-recap
1947-44793	22-Oct-2023	SY	F	S. Voss	M. Yates	SY	12-Apr-2023	

Foreign Captures & Recoveries:

Band #	Band Date	Age	Sex	First Banded	Location	Captured/ Reported By	Date	Age	Location	Status	Comments	Report Method
2447-04547	10/8/2023	HY	F	R. McGuire	SPI	BBL	11/5/2023	HY	Mexico	Captivity	Due to striking a wire (etc).	BBL-RTB

Status Codes:

RTRN – Padre Returns, FCAP – Foreign capture of falcon banded at Padre, FRTR – Capture of a falcon banded elsewhere, RCOV – Band recovery – found dead