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BIOLOGY OF TEXAS SEA TURTLES

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Donna Shaver is the Chief of the Division of Sea Turtle Science and Recovery at Padre Island National Seashore and the Texas Coordinator of the U.S. Sea Turtle Stranding and Salvage Network. She received the Lifetime Achievement Award from the International Sea Turtle Society in 2018, the 2013 U.S. Fish and Wildlife Service Endangered Species Recovery Champion Award for Agency Partner in 2014, the Corpus Christi Caller Times 2011 Newsmaker of the Year in 2012, and she was the ABC World News Tonight's Person of the Week on July 29, 2005. She has studied Texas sea turtles since 1980 and is well known for her leadership role in the recovery of the critically endangered Kemp's ridley sea turtle. Her studies describing sea turtle migratory and foraging habitat use, as well as nesting and stranding trends, have led to increased protections for sea turtles in Texas and beyond.

With over 400 scientific publications and presentations, Shaver is distinguished as one of the top sea turtle biologists in the USA and was named the 2021 Texas Distinguished Scientist at the annual meeting of the Texas Academy of Science. Shaver oversees a variety of sea turtle research and conservation projects conducted in Texas, collaborates with other researchers in the USA and Mexico, and provides training and leadership to hundreds of biologists and volunteers working with sea turtles in Texas.

It is a tremendous honor to receive the Distinguished Texas Scientist Award from the Texas Academy of Science (TAS). I thank the Academy for this honor, and I am grateful for, and humbled by, this recognition. I proudly share this award with the thousands of people that have aided with the sea turtle research, conservation, and public education efforts that I have participated in since 1980 and led since 1986.

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My career began at Padre Island National Seashore (PAIS), Texas, in 1980, working with the high-profile, multi-agency, Bi-National Kemp's Ridley Sea Turtle *(Lepidochelys kempii)* Restoration and Enhancement Program aimed at saving the world's most critically endangered sea turtle species from extinction. The National Park Service formed a 20-member advisory team of leading sea turtle biologists and agency officials in the 1970s, who signed an Action Plan establishing this program in 1978. After working with this program and learning the role of human activities in causing the dire plight of this endangered species, I decided to dedicate my career to helping save this species from extinction. Recovery actions for this and four other species of threatened and endangered sea turtles occurring in Texas have required long-term commitment to conservation and research, as well as collaboration and cooperation among our many partners and assistance by the public. Our partners have included volunteers and staff members with the National Park Service (NPS) and U.S. Geological Survey (USGS) at PAIS, and many other organizations in Texas and elsewhere in the USA and Mexico. I have gained unique expertise and knowledge through my four decades of work and integrated it into these efforts and associated training and leadership I led for participants in the Texas sea turtle nesting and stranding programs. Through our combined efforts we have aimed to increase sea turtle nesting, save stranded sea turtles, and gather data vital to informing management and protection of these species in Texas coastal waters and on Texas Gulf of Mexico beaches.

The enduring and primary focus of my work has been recovery of the Kemp's ridley sea turtle. Part of the Bi-National Kemp's Ridley Sea Turtle Restoration and Enhancement Program has been an effort to form a secondary nesting colony of this species at PAIS as a safeguard against extinction in the event of a political or environmental catastrophe at their primary nesting beach in Mexico (Shaver & Caillouet 2015) by using the experimental processes of imprinting and head-starting. When this program was initiated it was a conservation emergency, and the experimental imprinting and head-starting procedures used to form the secondary nesting colony were unproven. In 1986, I began the program to detect Kemp's ridley nesting on the

Texas coast to determine results of the experimental imprinting and head-starting efforts and continued the program to form this secondary nesting colony through protection of nests and protected release of hatchlings, associated research and public education (Figure 1). Additionally, I have conducted a significant amount of work with the threatened green sea turtle (*Chelonia mydas*); the primary sea turtle species found foraging and stranded (washed ashore, alive or dead due to cold-stunning and other factors) in Texas. I carry out these activities, and more, as the Texas Coordinator of the Sea Turtle Stranding and Salvage Network (STSSN), and as the State Coordinator for nesting in Texas.

The documented historic nesting range of the Kemp's ridley is from South Texas, USA to Veracruz, Mexico, with the epicenter of nesting near the village of Rancho Nuevo, in Tamaulipas, Mexico. This nesting epicenter was originally unknown, and biologists searched for years to try to locate where the Kemp's ridley nested (Wibbels & Bevan 2016). The first published record of Kemp's ridley turtles nesting anywhere in the world was a turtle found nesting in

Figure 1. Shaver releases Kemp's ridley (*Lepidochelys kempii*) hatchlings at a public event at Padre Island National Seashore.

1950 on North Padre Island, at a location within the area designated as PAIS in 1968. PAIS is 104 km long and preserves the longest stretch of undeveloped barrier island beach in the USA. This record was 12 years before Dr. Henry Hildebrand of Corpus Christi, Texas published a film made by Andres Herrera that showed an estimated 40,000 Kemp's ridley turtles nesting on one day in 1947 at Rancho Nuevo, Mexico. By the time scientists found and visited the beach in the early 1960s, drastic declines in nesting were noted (Wibbels & Bevan 2016).

Efforts to protect nesting females on the beach in Rancho Nuevo began in 1966, but the population continued to decline. In 1978, the USA joined into the on-going protection program for nesting turtles and nests at Rancho Nuevo as another part of the Bi-National Kemp's Ridley Sea Turtle Restoration and Enhancement Program. In 1985, a low of only 702 nests recorded worldwide was reached, but in 1986 the number of nests found increased, providing the first evidence of initial population recovery (Gallaway et al. 2016).

PAIS was chosen as the location to form a secondary nesting colony of Kemp's ridley turtles due to both documentation of these turtles nesting there previously and the protected status of PAIS as a unit of the National Park Service (NPS). From 1979–1989, 22,507 Kemp's ridley eggs (approximately 2,000 eggs/year) were collected at Rancho Nuevo, packed in PAIS sand and shipped to PAIS for protected incubation. Resulting hatchlings were released on the beach and allowed to crawl into the surf and swim for a few yards in the Gulf of Mexico surf. It was hoped that that the exposure to PAIS sand and surf would cause the hatchlings to become imprinted to PAIS and thereby return there to nest when they reached adulthood in 10–15 years. Hatchlings were scooped from the surf and taken to the National Marine Fisheries (NMFS) Laboratory in Galveston, Texas to be reared in captivity for nine to 11 months (a process called head-starting) to increase rates of survival and enable tagging for future recognition. Most of these turtles (n=13,211) were released offshore into Gulf of Mexico waters. During a subsequent stage of this project (1989–2000), hatchlings were brought directly from Mexico for rearing at the NMFS Laboratory. In total, 10,198 hatchlings that emerged from nests in

Rancho Nuevo were allowed to crawl down the beach and enter the surf before they were captured and transported to the NMFS Laboratory. They were reared at the NMFS Laboratory for nine to 11 months and then were released in Gulf of Mexico waters off Texas (Shaver & Caillouet 2015). It was thought that these turtles would return to Mexico to nest in greater numbers than if released as hatchlings, and therefore would help compensate the Mexico population for the loss of the eggs to the PAIS population.

In 1986, I began to lead efforts to locate nesting sea turtles at PAIS. This was necessary to determine the results of the experimental imprinting and head-starting efforts, document nesting by turtles from this work and from the wild stock, protect all nesting Kemp's ridley turtles and eggs at PAIS, and aid in formation of the secondary nesting colony. Since locating nesting Kemp's ridley turtles and their nests is complicated by the nesting habits of this species, and the large, remote area that our program is responsible for covering, I devised a two-pronged approach to find and protect nesting sea turtles. The first approach, through beach patrols to search for nesting turtles and their tracks, and the second with public education, aimed at seeking reports from, and assistance by, the beachgoing public. Nests are often found by the public and others working and recreating on the beach. Since this species nests mostly during the day, we receive many of these reports. We provide training and public education to encourage these public reports, and in turn, this has helped local communities be a part of the program, which they have embraced and supported.

Ours were the first systematic patrols to detect Kemp's ridley nesting in Texas. I aided others that established the four other nesting programs in Texas. With help of the other projects, systematic nesting patrols are now conducted on nearly all Texas Gulf beaches, to some extent, during the Kemp's ridley nesting season (1 April–15 July; Shaver et. al 2016a). As Texas Coordinator of the STSSN, my staff and I provide training, leadership, and guidance to all the Texas sea turtle projects, and we maintain the records for nesting turtles, nests, and stranded sea turtles recorded in Texas.

We attempt to locate nesting females and nests to document and protect them. Patrols and nest relocation are the primary mitigation measures used to protect nesting Kemp's ridley turtles and nests in Texas from beach driving and multiple other threats. Most Texas beaches are open to beach driving through the Texas Open Beaches Act, which is part of the Texas Constitution, and nesting is often in the soft sand of the beach vehicular roadway.

Eggs from Texas sea turtle nests are relocated for protected care to the PAIS incubation facility or one of two fenced beach corrals in south Texas. Eggs are closely cared for and achieve a high hatching and emergence success (Shaver et al. 2020a). Protected care enables protected release of hatchlings, as they crawl down the beach and into the surf. Sea turtle nest management in Texas has been patterned after procedures used in Mexico and is in accordance with the Kemp's Ridley Recovery Plan (NMFS 2011) and requirements of the Threatened and Endangered Species permits issued by the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department (TPWD; TE840727; SPR-0190-122). There are many threats to nests, hatchlings, and nesting females; some are human related, and others are natural (Shaver et al. 2020a). Examples include predators, beach driving, high tides and inundation, and marine debris. In recent years, the severity of some of these threats has increased substantially at PAIS. Specifically, sea level rise and nuisance coastal flooding have become prominent threats at PAIS (Culver et al. 2020). Texas beaches are being inundated with increased frequency each year, reducing beach habitat, and increasing direct threats to sea turtles and nests left *in situ* through higher inundation risk and vehicle drive over as visitors look for a clear roadway along the narrowing beach.

Nests from five sea turtle species have been recorded in Texas but the only location where all five were documented was at PAIS. Kemp's ridley is by far our most frequent nester at PAIS and elsewhere in Texas (Figure 2). Far fewer Kemp's ridley nests are found in Texas than in Mexico (approximately 100:1), but the annual numbers of nests found in both areas have trended similarly in recent years and are highly correlated (Shaver et al. 2016a). Nesting

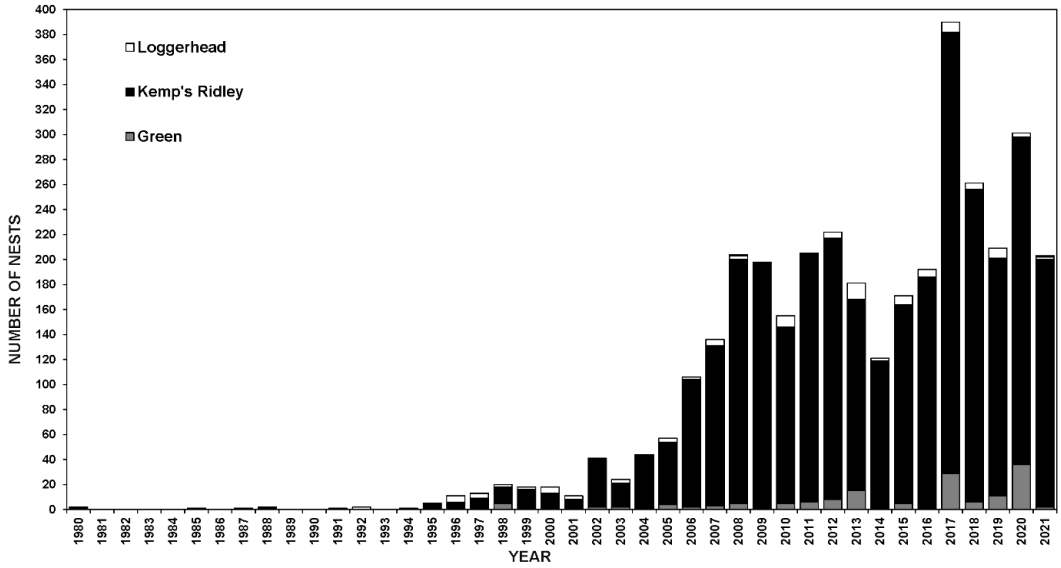

Figure 2. Annual nest counts of loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and green sea turtles (*Chelonia mydas*) found on the Texas coast from 1980–2021. Not included are two leatherback (*Dermochelys coriacea*) sea turtle nests, found in 2008 and 2021, and one hawksbill (*Eretmochelys imbricata*) sea turtle nest found in 1998.

increased for Kemp's ridley turtles worldwide from 1995 through 2009 but dropped in 2010 (Shaver et al. 2016a; Shaver et al. 2021). For several years, recovery efforts were showing promising signs of success, with 15–19% increases in annual nest numbers recorded. Population modeling reported in the Kemp's ridley recovery plan predicted continued exponential increases in nesting, if protection of turtles in the marine environment and on the nesting beaches continued. However, exponential increases in nesting ended in 2010, prompting renewed and continued concern about the recovery status of the species. There have been some increases in nesting since 2010, but the trends are troubling and do not compare to the large increases in previous years.

The largest number of Kemp's ridley nests recorded in Texas was in 2017, when 353 nests were found, including 219 at PAIS. The 353 nests found in Texas during 2017 was nearly half of what the worldwide nest count was reduced to when the Kemp's ridley population was at the lowest point in 1985 (702 nests). With more years of work, hopefully nesting will continue to increase and reach 702 nests annually in Texas,

which could serve as a stock to rebuild the population if a disaster occurs at the primary nesting beach in Mexico. We are also documenting an increase in green turtle nesting in Texas as well, with a record number of nests (n=36) in 2020. However, Texas green sea turtle nesting increases are at a much lower level than has been seen in other areas outside of Texas, prompting concerns about their recovery (Shaver et al 2020b).

Over the years, many related research projects have been conducted with our partners. More than half of Kemp's ridley nests documented in the USA yearly are at PAIS. Being the epicenter of Kemp's ridley nesting in the USA has provided us access to largest concentration of Kemp's ridley nesters and nests in the USA. We have had an obligation under the Kemp's Ridley Recovery Plan to aid by undertaking unique data collection opportunities and partner with outside experts. We have gathered data critically needed by managers and stakeholders to understand population demographics and possible reasons for the recent fluctuations in Kemp's ridley nest numbers, and to aid with recovery efforts. Effective management must be based on sound science.

To date, I have conducted the largest and longest duration satellite tracking study on adult female Kemp's ridley turtles, worldwide. From this dataset, a wealth of information has been gained. For example, in Shaver et al. (2016b) we used State Spaced Modeling to define the migratory corridor for post-nesting Kemp's ridley turtles in the Gulf of Mexico, tracked from three anchors of the documented historic nesting range, PAIS (north), Rancho Nuevo (epicenter), and Veracruz (south). When Kemp's ridley females have completed nesting for the season, most females leave waters off the nesting beaches and travel parallel to the coastline; some migrate to the north and some south. We further determined that a high proportion of the large numbers of migrating females from the main nesting beaches in Mexico migrate northward through USA nearshore waters (Gredzens & Shaver 2020). Thus, we concluded that near-shore waters of the entire Gulf of Mexico coastline, in the USA and Mexico, must be considered important migratory habitat for this species.

The data from my work at PAIS constitutes the longest continuous mark-recapture program for nesting Kemp's ridley turtles. Due to the large number of nests found in Mexico in recent years, it was no longer feasible to tag large numbers of females for a mark-recapture program, limiting the usefulness of the technique there. Through analysis of tag returns in Texas nesting Kemp's ridley turtles from 2005–2020, we determined the percentage of apparent neophytes (i.e., those documented nesting without evidence of prior tagging) has been declining since 2005, although there was a slight increase in that percentage during the last few years. Additionally, there was an overall increase in remigration interval (i.e., the time between nesting years). The remigration interval increased from 2.0 years as described in the Kemp's Ridley Recovery Plan to 3.5 years for the 6-year period 2015–2020 (Shaver et al. 2016a). The changes in demographic trends documented by our work helped provide clues as to the cause of the end of exponentially increasing nesting documented prior to 2010. Additionally, the first confirmed Kemp's ridley returnee from the PAIS imprinted hatchlings was found at PAIS in 1996, and the first Mexico imprinted Kemp's ridley, in 2002 on the upper Texas coast. This was the first evidence that the long-term imprinting experiment was working, and many more have been documented since (Shaver & Caillouet 2016).

As the state lead of the STSSN in Texas, I provide leadership and guidance to NPS staff and many other partners in our activities to document, rescue, and rehabilitate stranded sea turtles in the state. Live turtles are rescued and brought to rehabilitation where there is excellent chance of success if the turtles are located quickly enough. Some dead individuals are also salvaged for necropsy and study. The green sea turtle has become our most frequently stranding species (Figures 3 & 4). The number of stranded sea turtles recorded in Texas has surged since 2010 due to the increase in green sea turtle strandings. Cold stunning has accounted for more than 75% of the green sea turtles found stranded in Texas. The largest cold stunning event recorded in the USA, since the formation of the STSSN in 1980, was recorded this winter in Texas associated with the severe cold weather that began on 11

February 2021, with the stranding of 13,323 green sea turtles and three loggerhead turtles (*Caretta caretta*), most of which were documented in south Texas.

Throughout my career, publishing has been a significant challenge. It was only prioritized by my employer for only a quarter of my career, when I was a Research Grade Scientist for the NPS and USGS, and as a result many years of scientific priority were lost due to competing urgent needs that had to be addressed including, protecting nesters and eggs of the world's most endangered sea turtle species from being destroyed at their most important nesting beach in the USA, raising funding for this research, aiding TPWD with revision of their shrimp fishery management plan to help reduce deaths of adult Kemp's ridley turtles offshore from PAIS, aiding with preparation of an environmental assessment to seasonally reduce the speed limit on the PAIS Gulf beach, aiding the U.S. Department of the Interior as the Kemp's ridley species expert assigned to serve as Principal Investigator of the Natural Resources Damage Assessment study to determine impacts of the Deepwater Horizon Oil spill to Kemp's ridleys and eggs, represent sea turtle needs for stranding and nesting in Texas for the same study, and working to save from discontinuation, the decades long, multi-species sea turtle preservation actions started by the NPS and steadfastly supported by them until recently, that I devoted my entire career to.

Despite these immense challenges, publishing our results has been a personal priority and obligation for me (Figure 5). I was the senior or junior author on 85 (75%) of the 114 peer reviewed publications about sea turtles in Texas (excluding thesis and doctoral dissertations, experimental research, and grey literature) since 1967 and other institutions authored the other 29 (25%) (Figure 5). During the remainder of my career, I hope to pass along the information I have learned through more publications, training, and inspiration of the next generation to take over this work and carry it on. Public education is critical to the success of efforts to conserve and recover

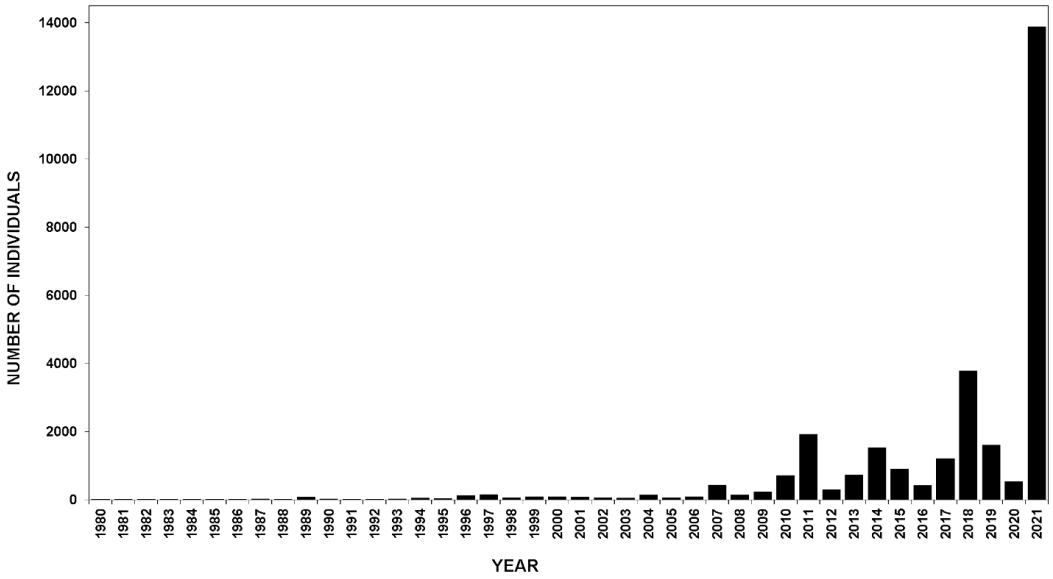

Figure 3. Number of stranded green sea turtles (*Chelonia mydas*) found on the Texas coast from 1980 to 31 August 2021. Includes hatchlings and post-hatchlings (less than 10.0 cm straight carapace length).

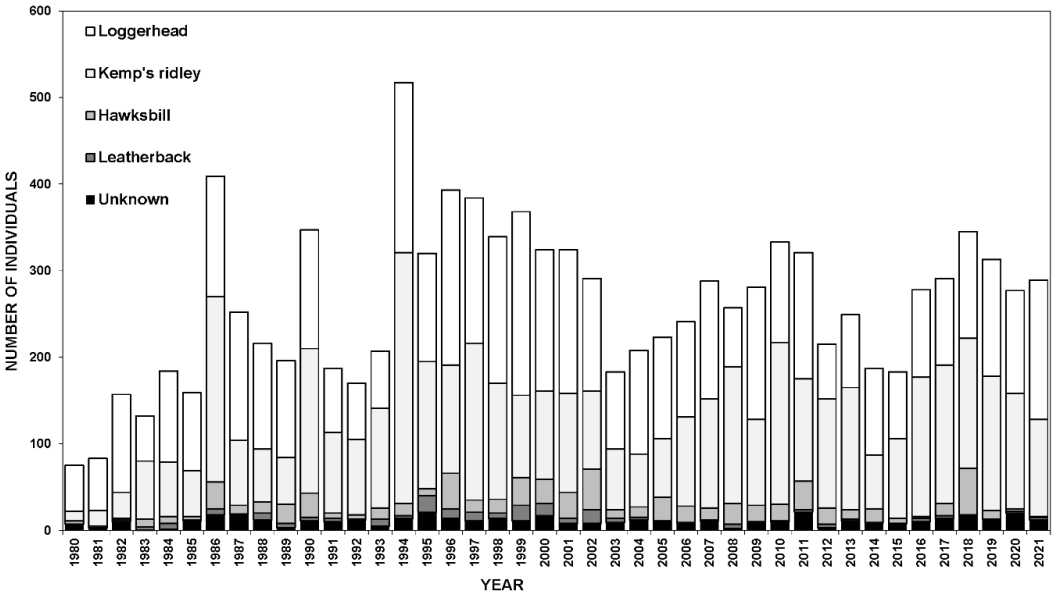

Figure 4. Number of stranded loggerhead (*Caretta caretta),* Kemp's ridley (*Lepidochelys kempii*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), and unknown species sea turtles found on the Texas coast from 1980 to 31 August 2021. Includes hatchlings and post-hatchlings (less than 10.0 cm straight carapace length).

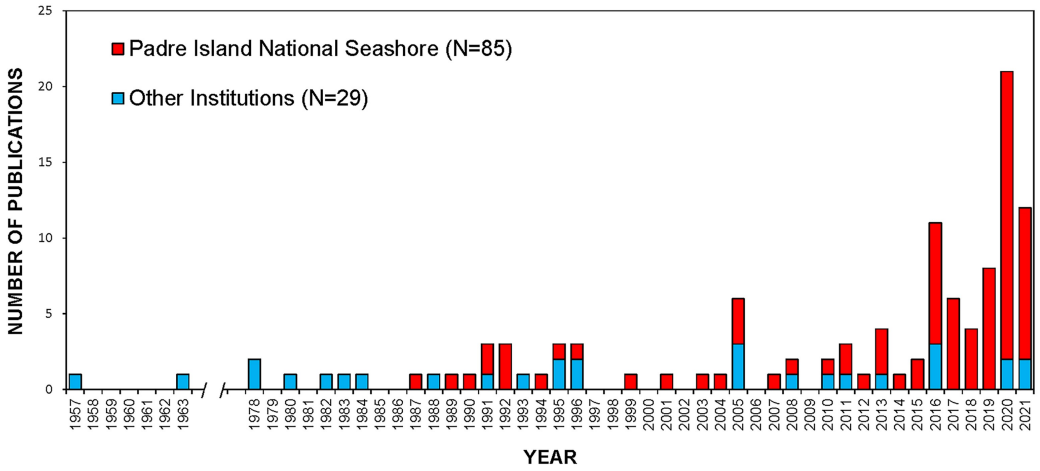

Figure 5. Peer-reviewed scientific publications on Texas sea turtles produced by and including authors from Padre Island National Seashore (red) and those solely from other institutions (blue), 1957–2021. These values exclude thesis and doctoral dissertations, experimental research, and grey literature regarding Texas sea turtles.

sea turtles in Texas, as humans and sea turtles share our Texas waters and beaches. We strive to strike a balance between visitor access and threatened and endangered species conservation, but this can only be done through public education and cooperation. Public releases of sea turtles (Figure 1) provide a great educational opportunity and through these events, along with other educational tools such as media interviews and social media, we encourage the local community to be involved in our work.

In conclusion, I am proud to be able to provide educational opportunities and inspiration to the next generation of scientists through my work. You never know who you will inspire or what they will become. My program serves as an important training ground for biologists that are beginning their career. Many have gone on to become professors, program leads, agency officials, and countless other professions in science. Many have written to tell me how important working with a strong female role model and woman-run program was to them, and how important this work was in their development. I would also like to encourage everyone to invest in volunteers. Without volunteers, our work would not be possible. Volunteering allows people to take ownership of the things they love, to protect our natural resources, and to make a difference. Volunteers provide thousands of

hours of assistance every year and pass on their knowledge and inspiration to others in the community about the work we do. Lastly, never lose hope. It took over a decade to see the first signs of success of my work, but it was worth it. Without hope and determination, we might have lost the Kemp's ridley. Instead, we have been seeing a promising recovery of this, and other, species at PAIS, and are helping to ensure that future generations are able to enjoy and admire these wonderful creatures. Invest in education, youth, and volunteers today; they will pay for themselves and ensure our natural resources remain viable for generations to come.

LITERATURE CITED

Culver, M. F., J. C. Gibeaut, D. J. Shaver, P. E. Tissot & M. Starek. 2020. Using lidar data to assess the relationship between beach geomorphology and Kemp's ridley (*Lepidochelys kempii*) nest site selection along Padre Island, TX, USA. Front. Mar. Sci. 7:214.

Gredzens, C. & D. J. Shaver. 2020. Satellite tracking can inform population-level dispersal to foraging grounds of post-nesting Kemp's ridley sea turtles. Front. Mar. Sci. 7:559. https://doi.org/10.3389/fmars.2020.00559. (Accessed 5 Dec 2021).

NMFS (National Marine Fisheries Service). 2011. Binational recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*), 2nd revision. National Marine Fisheries Service, Silver Spring, MD.

Shaver, D. J. & C. W. Caillouet, Jr. 2015. Reintroduction of Kemp's ridley (*Lepidochelys kempii*) sea turtle to PAIS, Texas and its connection to head-starting. Herpetological Conservation and Biology 10 (Symposium):378–435.

Shaver, D. J., C. Rubio, J. Shelby Walker, J. George, A. F. Amos, K. Reich, C. Jones & T. Shearer. 2016a. Kemp's ridley sea turtle (*Lepidochelys kempii*) nesting on the Texas coast: Geographic, temporal, and demographic trends through 2014. Gulf Mex. Sci. 33(2):158–178. https://doi.org/10.18785/goms.3302.04. (Accessed 5 December 2021).

Shaver, D. J., K. M. Hart, I. Fujisaki, C. Rubio, A. R. Sartain-Iverson, J. Pena, D. Gomez Gamez, R. de Jesus Gonzales Diaz Miron, P. M. Burchfield, H. J. Martinez & J. Ortiz. 2016b. Migratory corridors of adult female Kemp's ridley turtles in the Gulf of Mexico. Bio. Con. 194(2016):158–167. https://doi.org/10.1016/j.biocon.2015.12.014. (Accessed 5 December 2021).

Shaver, D. J., H. R. Frandsen, J. Shelby Walker, J. A. George & C. Gredzens. 2020a. Threats to Kemp's ridley sea turtle (*Lepidochelys kempii* Garman, 1880) nests incubating *in situ* on the Texas coast. Herp. Notes 13:907–923.

Shaver, D. J., H. R. Frandsen, J. A. George & C. Gredzens. 2020b. Green Turtle (*Chelonia mydas*) nesting underscores the importance of protected areas in the northwestern Gulf of Mexico. Front. Mar. Sci. 7:673. https://doi.org/10.3389/fmars. 2020.00673. (Accessed 5 December 2021).

Shaver, D. J., C. Gredzens, J. Shelby Walker, C. A. J. Godard-Codding, J. E. Yacabucci, A. Frey, P. H. Dutton & C. J. Schmitt. 2021. Embryo deformities and nesting trends in Kemp's ridley sea turtles *Lepidochelys kempii* before and after the Deepwater Horizon oil spill. End. Sp. Res. 44:277–289. https://doi.org/10.3354/esr01107. (Accessed 5 December 2021).

Wibbels, T., & E. Bevan. 2016. A historical perspective of the biology and conservation of the Kemp's ridley sea turtle. Gulf of Mexico Science 2:129–137.