Herpetological Conservation and Biology 10(Symposium):378–435.
Submitted: 7 May 2012; Accepted: 20 February 2015; Published: 21 June 2015.

Reintroduction of Kemp's Ridley (*Lepidochelys kempii*) Sea Turtle to Padre Island National Seashore, Texas and its Connection to Head-starting

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Abstract.**—Kemp's Ridley (*Lepidochelys kempii*) is the most endangered of the sea turtles. Most nesting is on the Gulf of Mexico coastline from Texas, USA, through Veracruz, Mexico, with greatest numbers near Playa de Rancho Nuevo (RN), Tamaulipas, Mexico. The Mexican government began protecting nesters, eggs, and hatchlings at RN in 1966, but annual numbers of nests continued to decline. In January 1978, the U.S. National Park Service (NPS), Fish and Wildlife Service (FWS), and National Marine Fisheries Service (NMFS), the Texas Parks and Wildlife Department (TPWD), and the Instituto Nacional de Pesca (INP) of Mexico implemented a bi-national Kemp's Ridley restoration and enhancement program (KRREP) for the NPS Padre Island National Seashore (PAIS) near Corpus Christi, Texas, and RN. Its planned goals were to reintroduce Kemp's Ridley to PAIS, which included head-starting, and to enhance protection of Kemp's Ridley nesters, eggs, and hatchlings at RN. This paper summarizes collecting, transporting, and incubating eggs, attempted imprinting of eggs and hatchlings, transporting hatchlings, tracking nesters, and documenting nestings in the wild. Through 2014, 20 Padre Island imprinted head-started turtles (n = 69 nests) and 39 RN imprinted head-started turtles (n = 64 nests) were recorded nesting in Texas (n = 125 nests) and near RN (n = 8 nests).**

Key Words.—conservation; head-start; *Lepidochelys kempii*; nesting; satellite tracking

Introduction

The endangered Kemp's Ridley Turtle (*Lepidochelys kempii*), also sometimes referred to as the Atlantic Ridley, is the most endangered species of sea turtle (Pritchard and Owens 2005). Evidence suggests that the Kemp's Ridley population is comprised of only one genetically distinct stock, and that the species has existed for 2.5–3.5 million yr (Bowen et al. 1991). Wallace et al. (2010) recently defined population segments or regional management units (RMUs) for Kemp's Ridleys; all individuals are presumed to belong to the same stock and RMU. This new RMU framework provides a strategy for organizing a unit of protection above the level of nesting populations, but below the level of species.

Most nesting occurs in the vicinity of Rancho Nuevo (RN), Tamaulipas, Mexico (Fig. 1) (Márquez-M. et al. 1982; Pritchard 2007). An estimated 40,000–42,000 adult females nested at RN on one day in 1947 (Carr 1963; Hildebrand 1963, 1982), in a synchronous nesting emergence typical of this species called an arribada (Spanish for arrival at sea). Hildebrand (1963) commented on the exploitation of eggs that was documented in the film, deemed that exploitation was a threat, and recommended implementation of conservation measures to prevent extinction of the species. The Kemp's Ridley population plummeted due to the massive egg collection and loss of juveniles and adults incidental to fisheries operations (Carr

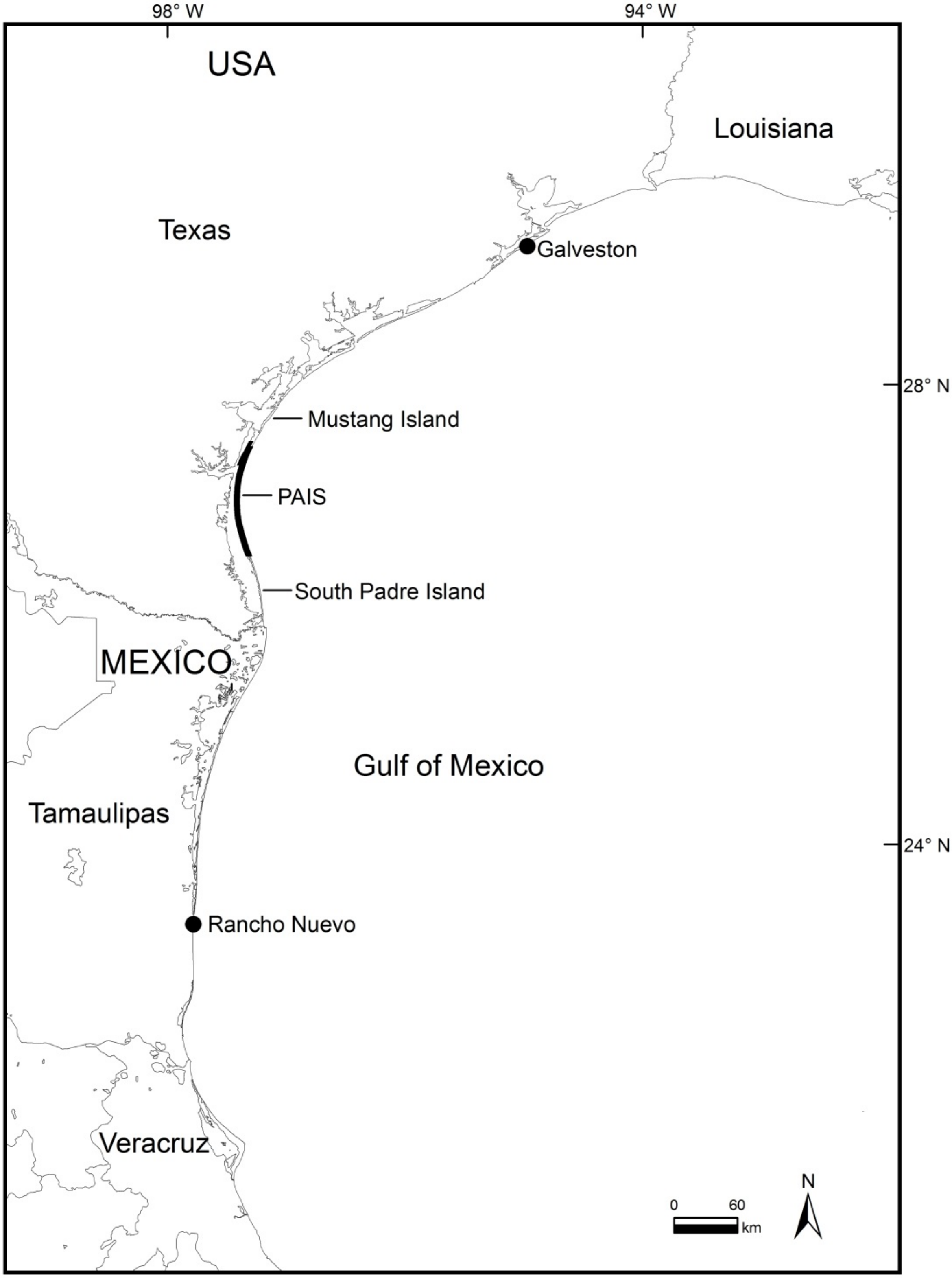

Figure 1. Map of the western Gulf of Mexico showing the locations of egg collection (Rancho Nuevo, Mexico), reintroduction (Padre Island National Seashore, Texas, USA), and head-starting (Galveston, Texas, USA) of Kemp's Ridley Turtle (*Lepidochelys kempii*). Padre Island National Seashore (PAIS) is shown as the black shaded area on North Padre Island.

1977; Magnuson et al. 1990). The Mexican Government began to protect nesting Kemp's Ridley Turtles and their eggs at the RN nesting beach in 1966 (Chavez et al. 1968). Dr. P.C.H. Pritchard and the World Wildlife Fund aided with these efforts in 1968, 1970, and 1973 (Pritchard 1969, 2007; Burchfield 2005). Despite years of efforts by Mexico's Instituto Nacional de Pesca (INP) and others, the nesting population continued to decline (Wauer 1978b; Pritchard 1997; Márquez-M. et al. 2005).

From 1963–1967, a project was undertaken to establish a nesting colony of Kemp's Ridley Turtles on South Padre Island (Fig. 1; Adams 1966, 1974; Francis 1978; Sizemore 2002; Burchfield 2005). During these years, Mr. Dearl Adams and others brought 5,098 Kemp's Ridley eggs from RN and buried them in the beach on South Padre Island. The resulting 1,227 hatchlings entered the Gulf of Mexico there.

A few years later, the National Park Service (NPS) proposed to re-establish Kemp's Ridley Sea Turtle nesting at Padre Island National Seashore (PAIS; Fig. 1; NPS 1974; Wauer 1978b, 2014; Caillouet et al. 2015). PAIS is a unit of the National Park Service System, preserves the longest stretch of barrier island beach in the USA, and is located on North Padre Island, Texas. In their 1974 Resources Management Plan, the NPS stated "The species may be endangered and should be considered for reintroduction to Padre Island which may be its only protected nesting site" (NPS 1974). Kemp's Ridley nests had been recorded at PAIS, which is within the documented historic nesting range for the species (i.e., prior to egg translocation and head-starting) extending from south Texas in the north to Veracruz, Mexico in the south (Werler 1951; Hildebrand 1963; Carr 1967; Shaver and Caillouet 1998; Burchfield 2005).

By the late-1970s, the population was reduced to a few hundred nesters and it was feared that the Kemp's Ridley would become extinct within a few years unless immediate further steps were taken (Carr 1977). The NPS contracted FWS to conduct a feasibility study for the re-establishment effort (Campbell 1977). The NPS, U.S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), Texas Parks and Wildlife Department (TPWD), and INP then came together to plan the bi-national, multi-agency Kemp's Ridley Sea Turtle Restoration and Enhancement Program (KRREP). Some of the world's most prestigious and distinguished sea turtle scientists comprised the Science Advisory Board that provided expertise to help develop the project. Personnel from multiple governmental agencies comprised the Agency Coordinating Committee that provided leadership for it. The NPS consolidated input from these entities and the feasibility study, and led preparation of a draft Action Plan (NPS et al. 1977) and final Action Plan for the KRREP (NPS et al. 1978). The goals of the KRREP were to reintroduce Kemp's Ridley to PAIS and protect nesting turtles, eggs, and hatchlings at RN (Mrosovsky 1978; Wauer 1978b; Woody 1986; Shaver 2007). The initial objective and primary focus was to reintroduce Kemp's Ridley Turtles to PAIS to form a secondary nesting colony as a safeguard for the species. Head-starting (captive rearing of hatchlings) was initiated to support the reintroduction effort, and protection efforts in Mexico were added after planning began for the KRREP. It was later alleged that translocation of eggs to PAIS for the reintroduction effort was merely the means for FWS to shunt their funds and personnel to aid with nest detection and protection efforts at RN (Taubes 1992). Undoubtedly, conservation work in Mexico was more important for the survival of the species. However, this rationale of quid pro quo (i.e., eggs in return for dollars spent in Mexico) is not supported by the planning documents (NPS 1974; NPS et al. 1977, 1978), in the sequence of events that led to the KRREP, or in early publications (Woody 1986, 1991), and approval for the reintroduction and head-starting efforts was unanimous not only from the planners, but also the Agency Coordinating Committee, and Science Advisory Board

(NPS et al. 1977, 1978). TPWD negotiated with Mexico for transfer of eggs. The NPS completed environmental compliance to conduct the work at RN and PAIS (Wauer 1978a), and required state, federal, and international permits were obtained. Throughout the years, oversight has been provided through each participating agency and the Kemp's Ridley Working Group (KRWG) (Caillouet et al. 2015).

The reintroduction effort aimed to increase Kemp's Ridley nesting at PAIS to form a viable, secondary nesting colony which could serve as a safeguard for the species, so that if a political or environmental catastrophe (e.g., hurricane, oil spill) occurred in RN, there would be an area in the USA where this species could nest and be protected (NPS et al. 1978; Wauer 1978b; Woody 1986, 1989; Shaver 2005). Based on nest site fidelity of adult females, Carr (1967) and others suggested that sea turtles might imprint to, and nest on, their natal beach. The re-establishment project attempted to imprint Kemp's Ridley Turtles to PAIS by exposing eggs to PAIS sand and hatchlings to PAIS sand and surf. It was hoped that this would cause them to later return to nest at PAIS, but the methods were unproven and it was unknown whether any of the Padre Island imprinted turtles would return to nest in south Texas. Padre Island imprinted hatchlings were transferred to the NMFS Laboratory in Galveston, Texas (hereafter referred to as NMFS Laboratory) from 1978–1988 (Table 1a, Fig. 1) for head-starting in an attempt to increase their likelihood of survival after release and enable them to be tagged for future recognition (Balazs 1979; Woody 1981; Klima and McVey 1982; Manzella et al. 1988; Caillouet et al. 1993). As recommended in the Action Plan, hatchlings were also transferred directly from RN to the NMFS Laboratory for head-starting, with the objective that these RN imprinted turtles would recruit into the population nesting in Mexico. It was thought that this might help compensate the population in Mexico for the loss of eggs used in the reintroduction effort (NPS et al. 1978). However, when the project was initiated head-starting was also considered to be unproven (Mrosovsky 1983; Dodd 1985). No head-started sea turtle had ever been documented nesting in the wild and it was unknown whether any RN imprinted or Padre Island imprinted head-starts would survive to adulthood or nest.

The KRREP was initiated to address a conservation crisis (Carr 1977). It was a restoration project to help save the world's most endangered sea turtle species from the brink of extinction. It was not intended to be a controlled experiment to test hypotheses or evaluate the utility of imprinting or head-starting as management techniques (NPS 1974; Wauer 1978b; NPS et al. 1978). After the project was initiated, head-starting of sea turtles became increasingly controversial because it is experimental, removes turtles from their natural environment, and does not reduce the threats that cause population declines (Mrosovsky 1983; Pritchard et al. 1983; Frazer 1992; Pritchard 1997; Meylan and Ehrenfeld 2000; see Caillouet et al. 2015). Because this project used unproven, experimental conservation techniques (Pritchard 1980; Klima and McVey 1982; Magnuson et al. 1990), many considered it to be an experiment that should be evaluated (Mrosovsky 1983, 2007; Wibbels et al. 1989a; Byles 1993). NMFS established two panels of scientists to review the Kemp's Ridley head-starting efforts at the NMFS Laboratory. The first panel was convened in August 1989 (Wibbels et al. 1989a) and the second in September 1994 (Eckert et al. 1994). Others also commented on and sometimes criticized the Kemp's Ridley head-start program (Mrosovsky 1983; Woody 1990, 1991; Taubes 1992; Heppell and Crowder 1994, 1998; Heppell et al. 1996, 2007; Zug et al. 1997; see Allen 1990, 1992; Shaver and Fletcher 1992; Wibbels 1992 for rebuttals). The criticisms ranged from scientific to political (Mrosovsky 2007). Some made conclusions before sufficient time had elapsed for adequately marked head-started Kemp's Ridleys to have matured and nested in the wild and before monitoring efforts at PAIS were suf-

Table 1. Summary information for Kemp's Ridley Turtle (*Lepidochelys kempii*) reintroduction, head-starting, monitoring for nesting, and release of hatchlings from nests found on the Texas coast, 1978–2014. Locations: PAIS = Padre Island National Seashore, Texas, NMFS = National Marine Fisheries Service Laboratory at Galveston, Texas, CAY = Cayman Turtle Farms, RN = Rancho Nuevo, Mexico, PI = North Padre Island, Texas, TAMUG = Texas A&M University at Galveston. (a) Year-classes of turtles head-started and tagged, (b) Years of monitoring for nesting, and (c) Numbers of turtles released, and years released.

a. Activities for head-started turtles	**Year-classes**
Eggs translocated from Mexico to PAIS for reintroduction, and resulting hatchlings transferred to NMFS for head-starting	1978–1988
Hatchlings translocated from RN to NMFS for head-starting	1989–2000[1]
Hatchlings translocated from CAY to NMFS for head-starting	1987–1988
Metal tagging of head-started turtles	1978–2000
Living tagging of head-started turtles	1983–2000[1]
Coded-wire tagging of head-started turtles	1984–1997[1]
PIT tagging of head-started turtles	1990–2000[1]
b. Monitoring for nesting	**Year**
Patrols began on PI	1986
Patrols began elsewhere on the Texas coast	1999
First confirmed PI imprinted head-started turtle recorded nesting in Texas	1996
First confirmed RN imprinted head-started turtle recorded nesting in Texas	2002
First confirmed record of nesting on the mid- and upper Texas coast	2002
Satellite tracking of nesting females by PAIS	1997–2014
Satellite tracking of nesting females by TAMUG	2005–2013
Record 117 nests documented at PAIS	2009, 2011
Record 209 nests documented in Texas	2012
c. Turtles released	**Number**
PI imprinted hatchlings released at PAIS without retrieval, 1978–1988	1,097
PI imprinted head-started turtles released, 1979–1989[2]	13,511
RN imprinted head-started turtles released, 1990–2001[2]	10,198
CAY imprinted head-started turtles released, 1988–1989	144
Hatchlings released from PI imprinted head-started turtle nests, 1996–2014	4,960
Hatchlings released from RN imprinted head-started turtle nests, 2002–2014	4,244
Hatchlings released from other nests, 1979–2014	121,643[3]

[1]Activity occurred in all or virtually all individuals in these year-classes, but also in a few from other earlier or later year-classes (see text for details).

[2]Activity occurred mostly during these years, and also to a lesser extent during other earlier or later years (see text for details).

[3]Does not include hatchlings released from 45 *in situ* nests documented in Texas from 2008–2014, or hatchlings shipped to NOAA Laboratory for head-starting or captive rearing for turtle excluder device testing during 1985 and 2013 respectively.

ficiently robust to detect them. The first head-started turtles documented nesting in the wild were located at PAIS in 1996, and were from the 1983 and 1986 year-classes. The 1983 year-class was the first one in which most turtles received living tags (Fig. 1; Table 1a), which has been the tag most useful in identifying nesters as head-started. Although monitoring for nesting by reintroduced and head-started turtles was identified as a priority and important for scientific evaluation (Wibbels et al. 1989a; Byles 1993; Williams 1993; Eckert et al. 1994; Caillouet 1998), funding to carry this out was limited (Plotkin 2007). Due to lack of funding to support PAIS monitoring during the first decade, 1996 was one of the first years that patrols were conducted seven days a week there (see ***Nesting detection***).

There were and continue to be many obstacles to determining project results. Some project methods (incubation temperature regimes, tagging, etc.) varied during different years, as improvements developed. Despite these confounding variables, some consider it the world's premier head-starting program (Meylan and Ehrenfeld 2000) and the best opportunity to date to evaluate experimental imprinting and head-starting of sea turtles (Shaver and Wibbels 2007). Shaver and Wibbels (*ibid*) reviewed data and literature summarizing results of Kemp's Ridley imprinting and head-starting through 2004. After release, head-started turtles joined the natural population and were vulnerable to the same natural and anthropogenic threats affecting wild Kemp's Ridleys (Caillouet et al. 1995a). Data collected after their release on movements, distribution, growth, diet, and nesting indicate that at least some of the head-start turtles adapted well to the Gulf of Mexico environment (Klima and McVey 1982; Wibbels 1984; McVey and Wibbels 1984; Manzella et al. 1988; Shaver 1991, 2005; Manzella and Williams 1992; Werner 1994; Werner and Landry 1994; Caillouet et al. 1995a; Landry et al. 2005; Coyne and Landry 2007; Morrealle et al. 2007; Shaver and Wibbels 2007; Seney and Landry 2008; Shaver and Rubio 2008). However, a few head-started turtles were reported displaying aberrant behavior (see Shaver and Wibbels 2007). Some head-started turtles nested in the wild, meeting a primary objective of the head-starting effort (Wibbels et al. 1989a; Byles 1993; Eckert et al. 1994; Shaver and Wibbels 2007). The return of the first Padre Island imprinted head-starts represented the first confirmed head-started sea turtle of any species nesting in the wild (Shaver 1996a, 1996b, 2005) (Table 1b). Additionally, by returning to nest at PAIS, this turtle met a primary objective of the reintroduction effort. This was the first time that a sea turtle nested on a beach that it was experimentally imprinted to (Shaver 2005). These were also the first nestings in the wild of known aged Kemp's Ridley Turtles (Shaver and Caillouet 1998).

Nesting detection efforts also aimed to protect nests to enhance recruitment and help form a viable nesting colony at PAIS (Shaver 1992, 1995a, 1996a, 2005). Eggs from most wild and head-start Kemp's Ridley nests located on the Texas coast were retrieved for protected incubation and hatchlings from about 80% of those nests were released at PAIS (Table 1c). Experimental imprinting and head-starting efforts have resulted in conservation benefits, including enhanced scientific understanding, public education, and public support. One of the most significant contributions is that the PAIS re-establishment effort initiated the bi-national KRREP which included USA aid with nest protection efforts at RN starting in 1978 (Woody 1989). Due to many years of conservation in the USA and Mexico, the Kemp's Ridley population increased exponentially from the mid-1980s through 2009 (Burchfield 2005; Heppell et al. 2005; Pritchard and Owens 2005; Crowder and Heppell 2011; NMFS et al. 2011), but annual numbers of nests documented leveled and decreased from 2010–2014 (Caillouet 2014; Plotkin and Bernardo 2014) and many more years of conservation are needed on nesting beaches and in the marine environment to ensure recovery of the species.

This paper reviews the re-establishment program (including collecting and incubating eggs, imprinting hatchlings, and transporting eggs and hatchlings) and presents updated information regarding adults in the wild (including age at maturity, documented nestings, and post-nesting movements) and factors affecting detection of nesting by head-started turtles. A companion paper by Caillouet et al. (2015) reviews experimental head-starting of Kemp's Ridleys by the NMFS (including captive rearing, tagging, releasing, analyzing tag returns, and related research) as well as its contributions to the reintroduction effort.

Materials and Methods

Egg collection and incubation.—From 1978–1988, biologists collected 22,507 Kemp's Ridley eggs in RN for experimental imprinting to PAIS (Shaver 1989, 1990; Shaver and Fletcher 1992; Shaver 2005; Shaver and Wibbels 2007). About 2,000 eggs were gathered for this project each year except during 1980 when nearly 1,000 additional eggs were collected (n = 2,976 eggs) and during 1988 when the number collected was intentionally reduced to about 1,000 to begin phase out of egg translocation (n = 1,019 eggs). Egg collection was undertaken by FWS, Florida Audubon Society under contract to the FWS, Gladys Porter Zoo (GPZ) under contract to the FWS, and other personnel working at RN. The NPS aided with collection of eggs during 1978. Biologists collected th eggs in plastic bags during egg laying, never allowed them to touch RN sand, and placed them into Styrofoam™ boxes containing PAIS sand. The Styrofoam™ boxes used had been rinsed and perforated with several holes each side, the bottom, and the lid to facilitate air exchange. The same Styrofoam™ boxes were used for egg incubation from 1978–1983, but new Styrofoam™ boxes were used each year from 1984–1988. From 1978–1983, the PAIS sand used was sent to RN moist, but from 1984–1988 the NPS dried the sand prior to shipment and biologists at RN rehydrated it immediately before placing eggs into it. The Styrofoam™ boxes containing the incubating eggs were held at RN in a concrete block incubation facility until shipment. The eggs were shipped from RN to PAIS via aircraft flights arranged by the NPS (early project years) or FWS/GPZ (later project years). Shipment varied from a few days after the eggs were laid to a few days before hatching, depending upon how closely spaced in time the nests were collected, when permits were granted to allow egg export from Mexico, or other logistical impediments such as standing water on the primitive runway at RN (Shaver and Fletcher 1992).

After arriving at PAIS, the incubation boxes were opened and a layer of cheesecloth (1978–1980) or plastic coated screen (1981–1988) and an additional layer of moist PAIS sand were placed on top. The cheesecloth and screen were used to aid with monitoring for hatching and the additional layer of sand provided more insulation for the incubating eggs. The eggs were placed into an incubation facility. The initial incubation facility was used from 1978–1982 and a larger facility was used from 1983–1988. Both facilities were screen enclosed to exclude predators and flying insects, but enable air exchange, and were outfitted with bamboo shades. Biologists opened incubation boxes once a week to check for moisture, and added distilled water as needed. Beginning at day 45 the incubation boxes were opened twice a day to check for hatching.

Incubation temperatures and sex ratios.—When the project was initiated in 1978, the pivotal temperature (i.e., the one that produces a 1:1 sex ratio) and lethal temperatures for the Kemp's Ridley were unknown. Sex ratios of hatchlings being produced during early project years were also unknown and there was concern that a male dominated sex ratio might occur due to incubation of the eggs within Styrofoam™ boxes (Mrosovsky 1983). However, no individuals could be sacrificed to determine these parameters due to the critically endangered status of the species. Efforts were initiated to gather information on incubation temperatures and sex ratios being produced, and to determine pivotal temperature, and findings were used to help improve incubation procedures.

Biologists installed temperature monitoring devices into the incubation boxes as the eggs were placed into them at RN. Beginning in 1982, incubation temperatures of eggs used for the imprinting project were measured twice daily at RN and once an hour at PAIS (Shaver et al. 1988; Shaver 2005). At both facilities, incubation box temperatures fluctuated due to changes in ambient temperature, and room temperatures were modified to mitigate for periods of very cold or hot weather.

Multiple techniques were used to determine the sex of dead individuals and older captive turtles originating from the egg imprinting effort at PAIS. Sex was identified for dead late-staged embryos and hatchlings using gonadal histology, for larger dead turtles using necropsy, and for larger live turtles using laparoscopy, serum testosterone assays, and tail length evaluations (adults only). Based on early results and sometimes small sample sizes, males predominated in the 1978, 1979, 1982, and 1984 year-classes (Shaver et al. 1988; Wibbels et al. 1989b; Caillouet 1995b; Shaver 2005; Wibbels 2007).

Beginning in 1985, biologists attempted to increase incubation temperatures during the middle third of incubation (when sex is determined) to increase the proportion of females produced. Temperatures were elevated in both the RN and PAIS incubation facilities since eggs could undergo their middle third of incubation at either location (Shaver and Wibbels 2007). Air temperatures within the RN facility were elevated by using a heater and/or keeping the facility door to the outside shut for longer periods of time than in the past, thereby trapping heat produced by the heater or ambient temperatures. Temperatures within the PAIS facility were elevated by placing plastic sheeting on the walls of the facility, under the bamboo shades. Several holes were cut into the plastic to facilitate ventilation. A heater was auto-cycled to remain on daily from 1800 to 0700 h to moderate excessive fluctuations in nocturnal temperatures. Also, to increase temperatures, warm air from the outflow of an air conditioner was allowed to come into the facility. Starting in 1986, the NPS auto-cycled the heater to remain on daily from 2300–0700 h and shunted the air conditioner outflow air outside the facility. Additionally, to better match incubation temperatures with temperatures recorded on the beach at mid-nest depth, they placed the Styrofoam^{TM} incubation boxes into larger Styrofoam^{TM} boxes and sand in between them. This increased mean incubation temperatures, reduced temperature fluctuations, and shifted the peak and minimum temperatures approximately two hours later. When temperatures reached 35.5–36.0°C, incubation box lids were removed. Lids were removed from 0600–0900 h, 2200–0900 h, or from 0100–0900 h, to decrease temperatures when they would normally be at their lowest or decreasing, respectively.

Modifications initiated in 1985 to increase incubation temperatures and the proportions of females produced were successful; females dominated in the 1985–1988 year-classes and overall 77.5% of the turtles examined from those year-classes were identified as females (Shaver et al. 1988; Wibbels 2007). Considering the 1978–1988 year-classes collectively, 59.6% of the project turtles were females, and the overall sex ratio was 1.5F:1.0M (Shaver 2005). By correlating mean middle third temperatures and percent females for all 1982–1987 year-class clutches in which 10 or more individuals were positively identified to gender and mean middle third temperatures were below 31.5° C, estimated pivotal temperature for the Kemp's Ridley was 30.2° C with 95% confidence intervals from 29.9–30.5° C (Shaver et al., 1988; Shaver 2005). All clutches from the 1982–1987 year-classes with mean temperatures exceeding 30.8°C during the middle third of the incubation period produced 100% females.

Hatching success.—Overall, 77.1% of the eggs hatched, resulting in 17,358 hatchlings, and hatching success exceeded 80% in eight of the 11 year-classes (Shaver, 1989, 2005). The NPS examined unhatched eggs from the 1980 and 1982–1988 year-classes to determine whether procedures used during the project adversely affected embryonic development and viability, and if so, to immediately develop procedures to improve incubation techniques. Excessive sand moisture and/or fungal infection from the sand or re-used incubation boxes probably contributed to the low hatching success (12.1%) and high early-stage mortality in the 1983 year-class (Shaver and Chaney 1989). High incubation temperatures in two 1985 year-class clutches (38.0–40.2°C) probably caused relatively high late stage mortality (Shaver and Chaney 1989). The overall hatching success of the 1987 year-class (64.3%) was likely reduced due to incubation temperature extremes (Shaver 1989). It is likely that sustained high incubation temperatures, above 38.0°C, prior to egg shipment to PAIS led to high late state mortality of three 1987 clutches, and all clutches from the 1987 year-class may have been adversely affected by a cold front at RN.

Hatchling imprinting and transport.—The NPS closely monitored emerging and emerged hatchlings for activity level and released most when they entered their infantile frenzy. Holding conditions varied for emerged turtles awaiting release. From 1978–1979, hatchlings were retained in their incubation boxes, but from 1980–1988 they were placed into other Styrofoam™ boxes termed transfer boxes, which contained approximately 7 cm of sand. Typically, hatchlings remained in transfer boxes about 24 hours, until they entered their frenzy and were released. However, during 1985, releases were not held on a few weekends due to logistical constraints and thus some were held longer than normal in their transfer boxes.

The NPS released hatchlings on the beach at PAIS at dawn. Hatchlings were allowed to crawl down the beach, enter the surf, and swim a distance of about 5–10 m for the imprinting process. Then hatchlings were captured using aquarium dip nets. Retrieved hatchings were counted and all from the 1983–1988 year-classes were weighed and measured. Between 1978 and 1988, 287 of these hatchlings escaped in the surf during the imprinting/recapture procedure. Additionally, 810 hatchlings that emerged from the additional 1,000 eggs received for incubation in1980 were intentionally released without capture (Shaver 2005).

From 1978–1981, recaptured hatchlings were shipped in wax coated cardboard boxes that contained a foam rubber pad on the bottom that had been soaked in water from the Gulf of Mexico. From 1982–1988, plastic containers were used instead of the cardboard boxes. Hatchlings were sometimes held for one or more days to consolidate transport to the NMFS Laboratory. Turtles were held in their shipment boxes except for the 1982, 1983, and 1985 year-classes which were held in shallow tubs of Gulf of Mexico water and the 1984 year-class which was held in tubs containing Laguna Madre (bay) water.

From 1978–1988, 381 hatchlings died at PAIS prior to release or while temporarily held at PAIS after release, but prior to shipment to the NMFS Laboratory. The highest mortality of hatchlings occurred in 1984, when they were retained at PAIS for up to 5 d to receive living tags (Hendrickson and Hendrickson 1981; Fontaine et al., 1993). In 1984, NMFS thought that the NMFS Laboratory might close and that these turtles needed to be marked immediately. During other years, hatchlings were typically held at PAIS for only 0–3 d prior to shipment and living tagging occurred at the NMFS Laboratory, not at PAIS.

Overall, 15,875 hatchlings that had been imprinted were successfully transported to the NMFS Laboratory for head-starting (Fontaine et al. 1985; Fontaine and Shaver 2005; Shaver

2005). Hatchlings were transported via NPS or U.S. Navy aircraft from 1978–1984, and NPS vehicle in 1984 (one shipment) and 1985–1988. Records linking each hatchling to the nesting turtle and nest were maintained through transfer to the NMFS Laboratory. Turtles that were subjected to the imprinting process at PAIS and then head-started, were termed the Padre Island imprinted head-starts. The objective was for them to return to PAIS to reproduce at adulthood.

From 1978–2000, biologists retrieved more than 10,000 hatchlings that emerged from nests incubated in a corral (screened beach enclosure) at RN, crawled down the beach, and temporarily entered the surf, and transported them via aircraft from RN to the NMFS Laboratory for head-starting (Fontaine and Shaver 2005; Shaver and Wibbels 2007). This included approximately 2,000 hatchlings per year from the 1989–1992 year-classes and fewer than 200 per year from the 1978–1980, 1983, and 1993–2000 year-classes. More than 90% of the head-started individuals from the 1989–2000 year-classes were females (Caillouet 1995b; Ben Higgins, pers. comm.) since most were collected from late-season nests that incubated at warmer temperatures. These turtles were termed Rancho Nuevo imprinted head-starts, and the objective was for them to return to Mexico to reproduce.

Head-starting, tagging, release.—Captive rearing, tagging, and release information is detailed in Fontaine et al. (1988b, 1989b), Caillouet (2000), Fontaine and Shaver (2005), and Caillouet et al. (2015). All head-started turtles were reared in captivity for at least 9 mo and tagged all before release. Tagging methods varied for the different year-classes, as new technology developed (Fontaine et al. 1993; Caillouet et al. 1995a, 1997). NMFS biologists used up to four types of internal and external tags to mark the turtles. All turtles received external inconel™ metal fore-flipper tags before release. These were typically placed on the trailing edge of the right fore-flipper, but occasionally the left fore-flipper was tagged, and in some cases both fore-flippers were tagged. From the 1983 year-class on, virtually all received living tags (Fig. 2), where a small light colored piece of the plastron tissue was grafted in the darker carapace on different scutes to designate different year-classes (Caillouet et al. 1986; Fontaine et al. 1988a). About a tenth of the 1980 year-class and a third of the 1982 year class also received living tags. Living tag locations for the 1982, 1983, 1984, 1985, 1987, 1989, 1990, and 1991 year-classes were re-used to designate the 1993, 1994, 1995, 1996, 1997, 1999, 1998, and 2000 year-classes, respectively (Ben Higgins, pers. comm.). NMFS biologists marked most turtles from the 1984–1997 year-classes and less than half of the turtles from the 1998 and 1999 year-classes with coded wire tags embedded in the left, right, or left and right fore-flippers (Fontaine et al. 1993; Ben Higgins, pers. comm.). Destron Fearing™ passive integrated transponder (PIT) tags were applied in the left fore-flipper to 247 Padre Island imprinted head-starts (1978, 1982, 1984, 1986–1988 year-classes) which had been held for extended time periods, a few RN imprinted head-started yearlings from the 1989 year-class, and all RN imprinted head-started yearlings from the 1990–2000 year-classes (Cail-

Figure 2. A Kemp's Ridley Turtle (*Lepidochelys kempii*) with a living tag (on left carapace scute 1) that was hatched at Padre island National Seashore in 1988, head-started and released, then found nesting in 2010. (Photographed by National Park Service).

louet et al. 1997; Fontaine et al. 1989b, 1993). NMFS biologists also applied an additional PIT tag in the right front flipper of six head-starts released from the 1998 year-class and 28 from the 2000 year-class, and in the right sub-plastron of 49 turtles from the 2000 year-class. PIT tags used for the 2000 year-class were 125 kHz, but all others were 400 kHz; none were encrypted.

Typically, head-started Kemp's Ridley Turtles were released when they were 7–15 mo old. Those head-started for longer were considered to have been overly conditioned to captive rearing (and therefore potentially atypical in behavior), and were called super head-starts (Caillouet et al. 1995b). Overall, 13,511 head-started turtles experimentally imprinted to PAIS were released into USA waters, including 13,211 released after 9–11 mo in captivity and 300 released after 2–16 y in captivity (Caillouet 1995a; Caillouet et al. 1995a; Fontaine and Shaver 2005; Shaver and Wibbels 2007; Ben Higgins, pers. comm.). Most of the Padre Island imprinted head-starts were released into the Gulf of Mexico, approximately 30 km offshore from North Padre Island and Mustang Island, Texas, with the objective of reinforcing imprinting to PAIS. However, most from the 1978 and 1979 year-classes were released off the Gulf coast of Florida, and hundreds from the 1981–1982 and 1985 year-classes were released elsewhere in Texas. Additionally, biologists released 10,198 RN imprinted head-started yearlings after 9–33 mo of head-starting. Most were released off Galveston Island, but most from the 1978 and 1979 year-classes were released off the Gulf coast of Florida, all from the 1980 year-class off Campeche, Mexico, all from the 1983 year-class off Mustang Island, and all from the 1993 year-class off Mustang Island and High Island, Texas, and Panama City, Florida.

An additional 144 head-started Kemp's Ridley Turtles were released off North Padre Island after 9–11 mo of head-starting, including 130 from the 1987 year-class and 14 from the 1988 year-class. These hatchlings had been obtained from the Cayman Turtle Farm, Ltd. (CAY), Cayman Island, British West Indies and were the progeny of Kemp's Ridleys held there for captive breeding to help preserve the species if conservation efforts in the wild failed (Wood 1982; Caillouet and Revera 1985). Balazs (1979) and Brongersma et al. (1979) had recommended retention of some Kemp's Ridleys in facilities for this purpose after the KRREP was initiated. Caillouet et al. (2015) discuss details of captive breeding that occurred. Some of the captive turtles at CAY produced viable eggs and hatchlings in the 1987 and 1988 year-classes which in turn were sent to the NMFS Laboratory for head-starting (Wood and Wood 1984, 1988, 1989; Shaver and Wibbels 2007). These were termed Cayman imprinted head-starts and there was not a clear objective of where they would later nest.

Current Study

Nesting detection.—The NPS began systematic efforts to detect and protect nesting Kemp's Ridley Turtles and their eggs on the Texas coast on North Padre Island (including PAIS) in 1986 (Shaver 1990). The 128 km of North Padre Island Gulf of Mexico shoreline includes 104 km of PAIS and 24 km north of the PAIS north boundary. Only one beach access point exists to the southernmost 96 km of PAIS, and during the nesting season most of this area is often sparsely visited by the public and has difficult driving conditions (Hildebrand 1963). Patrols were conducted only a few days a week during the first decade, but increased to 7 d a week from 1995–1997 (Shaver 2005). From 1998 onward, daily patrols repeatedly traversed the North Padre Island beachfront. This repeated coverage increased the likelihood of observing nesting females and locating their eggs. Patrols began elsewhere in Texas starting on Boca Chica Beach in 1999 and South Padre Island in 2000, which also conducted repeated daily patrols. By 2005, patrols were conducted on all Texas Gulf of Mexico beaches to some extent during the nesting season, although patrols were not conducted daily in some areas (NMFS et al. 2011).

In Texas, patrols were conducted during daylight hours from about April through mid-July. Patrollers searched the shoreline for emergent sea turtles or their tracks primarily by vehicle (four-wheel drive vehicle, all-terrain-vehicle, or utility-transport-vehicle), but sometimes on foot in developed coastal areas.

Patrollers found Kemp's Ridey nests in Texas during these searches, and from reports filed by the public or others working on the beach. NPS initiated educational programs asking the public to report nesting Kemp's Ridley Turtles at PAIS in the mid-1980s and later this was expanded coast-wide in Texas (Shaver 1990, 2005; Shaver and Miller 1999). Signs, posters, brochures, media contacts, seminars, web sites, social media, and other methods were used to alert the public.

Whenever possible, biologists examined Kemp's Ridleys found nesting in Texas for the presence of living, PIT, coded wire, and metal flipper tags that could link them to head-starting (Fontaine et al. 1993; Caillouet et al. 1997; Ben Higgins, pers. comm.) or previous nesting. Training and specialized equipment were required to check for PIT and coded wire tags. Unfortunately, biologists were only able to examine some of the nesters, since many re-entered the water before biologists arrived. Biologists marked nesting turtles that were observed with inconel™ and Biomark™ PIT tags when they did not possess them. These non-encrypted 125 kHz PIT tags were placed in the left front flipper, on the dorsal side under the scales (Balazs 1999). Biologists measured most nesters for straight-line carapace length (SLCL), from the center of the nuchal notch to the tip of the longest post-central scute. When only curved carapace length (CCL) was measured, NPS converted CCL to SLCL using the conversion equation derived for stranded Kemp's Ridley Turtles by Teas (1993).

Biologists attempted to locate nests at all locations where nesting Kemp's Ridleys or their tracks were found in Texas. They found nests at track locations by hand digging, probing with a detection stick, or using a trained dog (on North Padre Island). Sometimes tracks were so faint that after extensive searching a nest could not be found by digging or probing. A trained dog (named Ridley) aided on North Padre Island in such situations and was the first trained dog successfully used to locate Kemp's Ridley nests in Texas. When biologists could not find nests at track sites and thought that a nest could be present, they marked and monitored the sites during the incubation period to help verify whether a nest was indeed present through presence of broken eggshells, unhatched eggs, or hatchlings. Kemp's Ridley nests were classified as confirmed when either eggs or emerging hatchlings were found, and either the nesting turtles, hatchlings, or dead embryos were examined to identity species. DNA analysis was sometimes used to determine or verify species. Nests were tallied by geographic area in Texas where nesting was documented.

The annual number of nests found on the Texas coast from 2000–2014 were standardized for patrol effort and curves were fit to the data. This approach was conducted to minimize the effect of increased patrol effort over time, by standardizing the number of nests per distance patrolled and analyzing data from the last 15 y, when patrols were conducted on North Padre Island, South Padre Island, and Boca Chica Beach, which were the largest programs in Texas. Elsewhere in the USA, patrols were not conducted specifically to detect Kemp's Ridley nests. However, nesting turtles, tracks, or nests were found by nest detection and protection programs conducted for other sea turtle species or opportunistically by the public. Occasionally the public observed or recorded nesting turtles in photographs, but biologists had the opportunity to examine relatively few for tags. They confirmed nests through documentation of the nesting turtle or hatchings, or through verification of DNA from dead hatchlings or embryos.

Biologists monitored nesting Kemp's Ridleys and protected their nests for several decades at RN, and more recently at some other beaches in the states of Tamaulipas and Veracruz, Mexico

Table 2. Criteria used to classify adult female Kemp's Ridley Turtles (*Lepidochelys kempii*). [1]Head-started turtles were identified to imprinting location and year-class based on metal or PIT tag number (when present) or location of the living tag. [2]Rancho Nuevo, Mexico.

Turtle classification	Criteria
Padre Island imprinted head-started	Possessed a living, coded wire, PIT, and/or metal flipper tag that had been applied during head-starting[1]
RN[2] imprinted head-started	Possessed a living, coded wire, PIT, and/or metal flipper tag that had been applied during head-starting[1]
Uncertain wild or head-started	No tags linking turtle to head-starting, but possessed a large tag scar on right front flipper
Wild stock	No tags linking turtle to head-starting, and no large tag scar on right front flipper
Not examined	Not examined by biologists, in person or thorough photographs in which living and flipper tags could be visible

(Márquez et al. 1982, 1999, 2001, 2005; NMFS et al. 2011). Monitoring has involved repeatedly traversing the beach each day. They protected most nests found in large corrals. They dug an artificial nest cavity within the corral for each nest, placed a small screen around it, and retrieved hatchlings from there for release (Márquez-M. et al. 2005). However, since the 1970s, they have incubated some nests in Styrofoam™ boxes within incubation facilities, and in recent years they have left many on the beach to incubate *in situ*. Biologists started tagging in 1966 with monel™ flipper tags, but switched to using inconel™ flipper tags starting in 1977–1978 (Rene Márquez-M., pers. comm.). They also began applying PIT tags beginning in the mid-1980s. For many years, a large portion of the Kemp's Ridleys that nested in Mexico were examined for tags and tagged, but that percent decreased in recent years, as nesting increased. INP (and its successor agencies) led nest detection and tagging, and various agencies from Mexico, FWS, GPZ, NMFS and others have aided.

Nests in the USA, tag returns, and origin of Kemp's Ridleys nesting in Texas.—To evaluate results of experimental imprinting and head-starting, NPS gathered information on Kemp's Ridley nesting records in Texas and elsewhere in the USA, tag returns on nesting adults, and the origin of nesting Kemp's Ridleys examined (Shaver 2005). Origins of turtles recorded nesting in Texas were labeled as not examined, Padre Island imprinted head-start, RN imprinted head-start, wild stock, or uncertain wild or head-start. Because it typically takes less than an hour for a Kemp's Ridley to nest, nests are often located without biologists observing the turtle. Those that were not examined by biologists were classified as unexamined, unless there was a clear photograph of the turtle that showed a living or metal tag linking it to head-starting. We categorized turtles as head-started if they possessed a living, coded wire, PIT, and/or metal flipper tag that had been applied during head-starting (Table 2). We identified head-started turtles to imprinting location and year-class based on metal or PIT tag number (when present) or location of the living tag. We assigned turtles to the uncertain wild or head-start category when they possessed a large tag scar on the right front flipper, but no head-start tags. All head-started nesters documented through 2014 that did not possess a metal tag on their right front flipper had a large tag scar where the metal tag had been applied to them as yearlings. Large tag scars on the right front flipper have not been documented on wild stock nesters in Texas, but it is possible that they could occur from other sources and thus are not an unequivocal diagnostic of head-starting. We classified turtles that lacked head-start tags and a large tag scar on the right front flipper as being from the wild stock. We tallied the origins of nests at which nesting turtles were examined for tags by geographic area in Texas where nesting has been documented. To evaluate the relative contribution of Padre Island imprinted head-starts to the population nesting at PAIS, we calculated the annual percent of Kemp's Ridley nests recorded at PAIS at which the nesting females were examined for tags that were conclusively linked to Padre Island imprinted head-starts, for 1996 (the first year that Padre Island imprinted head-start nests were documented at PAIS) through 2014. We excluded nests from RN imprinted head-starts from these analyses.

Age and size at maturity in the wild.—Head-started turtles were identified to year-class based on living tag location, or a metal or PIT tag applied during head-starting (if present). Age was determined based on year-class identified and nesting date. The mean age and size at which head-started turtles were first documented nesting in the wild in Texas were calculated.

Incubation of eggs from nestings in Texas.—Biologists protected all Kemp's Ridley nests found at egg laying on the Texas coast from 1979–2014 to enhance recruitment. This enabled protection of the eggs and emerging hatchlings from human-related and natural threats on the beach including lighting, beach driving and raking, entanglement and entrapment in debris and ruts, high tides, predation, and other factors. This also continued the reintroduction effort at PAIS, using most of the eggs from Texas. Transfer of clutches to the PAIS incubation facility was directed by FWS and TPWD permits, and the KRWG, to reinforce objectives of the reintroduction program (NPS 1974; NPS et al. 1978). From 1979–1998, nearly all clutches discovered on the Texas coast were protected in the PAIS incubation facility, and from 1999–2014, nearly all found north of PAIS on the Texas coast and most found at PAIS were held there. Clutches were held in the incubation facility within Styrofoam^{TM} boxes using techniques developed during the experimental imprinting work from 1978–1988, modified in subsequent years, and detailed in Shaver (2005). From 2006–2014, a solid-walled, wooden incubation facility was used. This larger facility had programmable thermostats that added heat to the facility when needed during the beginning of the incubation season. Later in the incubation season, we opened the door to the screen-enclosed breezeway during the early morning hours when cooling was occasionally needed. From 1999–2014, nests from South Padre Island and Boca Chica Beach were protected in corrals there, and from 2008–2014 corrals were used to protect several of the nests found at the southern end of PAIS. During 2010, most nests that had been held in the two corrals were transferred to the incubation facility to protect them from Hurricane Alex. From 1978–2014, biologists documented a few nests that had incubated *in situ* in Texas. Two of these nests were located at egg laying and intentionally incubated *in situ* with screen protection, but the others were discovered during the incubation period or after hatching and incubated on the beach without protection. These unprotected *in situ* nests were either at sites where biologists had seen a nesting turtle or her tracks, but could not locate the nest and marked the site for later monitoring, or at sites that were unknown to biologists until sometime during the incubation period, at hatching, or after hatching. NPS quantified clutch size, hatching and emergence success, and the number of hatchlings released for clutches protected in the incubation facility and corrals, but this was often not possible for *in situ* nests due to predator or human disturbance. Biologists released most hatchlings from Texas nests on the beach at the incubation sites without marking or retrieval in the surf for head-starting. However, after release on the beach and capture in the surf, 69 hatchlings from one clutch found at PAIS in 1985 and 100 hatchlings from three clutches found on South Padre Island in 2013 were transported to the NMFS Laboratory for head-starting or captive rearing and turtle excluder device testing, respectively. Hatchlings from the incubation facility and corrals were protected during release to ensure their safe entry into the Gulf, whereas most hatchlings from *in situ* nests were not protected during release. Gonads were removed from dead late-stage embryos and hatchlings for histological sex determination (Wibbels 2003, 2007).

Post-nesting movements.—Movements of post-nesting head-start Kemp's Ridley Turtles were compared to movements of wild individuals, as indicators of the ability of head-start individuals to successfully adapt to the wild. The NPS and colleagues from Texas A&M University at Galveston (TAMUG) deployed satellite platform transmitter terminals (PTTs) to study the post-nesting movements of a subset of wild and head-started Kemp's Ridley Turtles that nested, or emerged to nest, on the Texas coast. For details regarding attachment of the PTTs, duty cycles of the PTTs, calculation of latitude and longitude, accuracy of the data, and filtering of the data using (STAT) see Coyne and Godley (2005), Seney and Landry (2008, 2011), and Shaver and Rubio (2008). Between 1997 and 2014, PAIS applied 89 PTTs on 70 turtles that nested at or near PAIS (Shaver and Rubio 2008, Shaver et al. 2013, http://www.seaturtle.org/tracking/ project numbers 96, 144, 250, 281, 495, 610, 732, 846, and 990 for PTTs deployed between 2005 and 2014). This included 57 wild turtles, 11 Padre Island imprinted head-start (including one super head-start), and two RN imprinted head-start. Among these 70 individuals monitored, one turtle received four PTTs to study movements during different tracking years (wild), three received three (two wild, one Padre Island imprinted head-start), 10 received two (six wild, four Padre Island imprinted head-start), and 56 that received one (48 wild, six Padre Island imprinted head-start, two RN imprinted head-start). Between 2005 and 2013, TAMUG applied 26 PTTs on 21 turtles, including 20 that nested, or emerged to nest, on the upper Texas coast and one that nested on South Padre Island. This included eight wild and 13 RN imprinted head-start turtles (Seney and Landry 2008, http://www.seaturtle.org/tracking/ project numbers 45, 272, 389, 617, 731, 854). Among these, one received three PTTs (RN imprinted head-start), three received two PTTs (one wild, two RN imprinted head-start) and 17 received one (seven wild, 10 RN imprinted head-start). Collectively, the PAIS and TAMUG studies deployed 115 PTTs on 65 wild (n = 79 PTTs), 11 Padre Island imprinted head-start (n = 17 PTTs), and 15 RN imprinted head-start (n = 19 PTTs). Composite plots of locations tracked for wild, Padre Island imprinted head-start, and RN imprinted head-start turtles were developed and compared.

Results

Nests in the USA, tag returns, and origin of Kemp's Ridleys nesting in Texas.——From 1979–2014, biologists documented 1,785 Kemp's Ridley nests in the USA, including 1,667 (93.4%) in Texas. Overall, the annual number of nests confirmed on the Texas coast increased from 1995–2009 and record numbers of nests were recorded during six consecutive years from 2004–2009 (Fig. 3). Although record numbers of nests were also found during 2011 (n = 199) and 2012 (n = 209), these were only slight increases

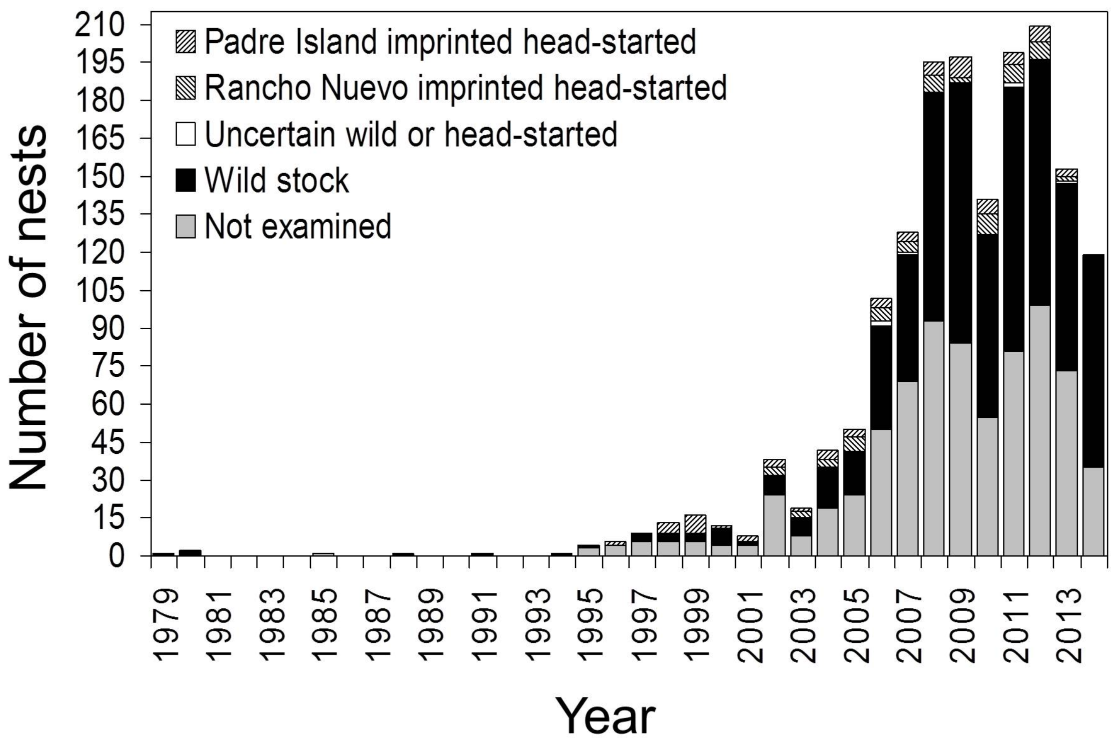

Figure 3. Number of confirmed Kemp's Ridley Turtle (*Lepidochelys kempii*) nests found on the Texas coast, 1979–2014.

from the 197 nests located in Texas during 2009, and many fewer nests were recorded during 2010 (n = 141), 2013 (n = 153), and 2014 (n = 119). The best fit to the annual number of nests found on the Texas coast from 2000–2014 standardized for patrol effort was a 3^{rd} order polynomial curve, number of nests/50,000 km patrolled = -0.0799 $\times$ year^3 + 480.97 $\times$ year^2 – 964,608 $\times$ year + (6 $\times 10^8$), r^2 = 0.903 (Fig. 4).

On 23 May 2012, a record 31 Kemp's Ridley nests were found on PAIS, of 44 documented in Texas. This was the largest number of nests recorded in a day at any area on the Texas coast, and on the Texas coast overall, through 2014. Of the 1,667 nests confirmed in Texas from 1979–2014, 1,017 were on North Padre Island, 385 on South Padre Island/Boca Chica Beach, 133 on the upper Texas coast, 56 on Mustang Island, 44 on Matagorda Island, 17 on Matagorda Peninsula, 14 on San Jose Island, and one on Corpus Christi Bay beach. More nests were located at PAIS than at any other location in the USA (Table 3). The 934 nests found at PAIS comprised 52.3% of those confirmed in the USA and 56.0% of those confirmed in Texas.

Of the 1,667 nests confirmed in Texas from 1979–2014, biologists were unable to examine nesting turtles for tags at 751 (45.1%) of the nests. Of the 916 nests at which biologists examined nesting turtles, 785 were from wild, 68 from Padre Island imprinted head-start, 57 from RN imprinted head-start, and six from uncertain wild

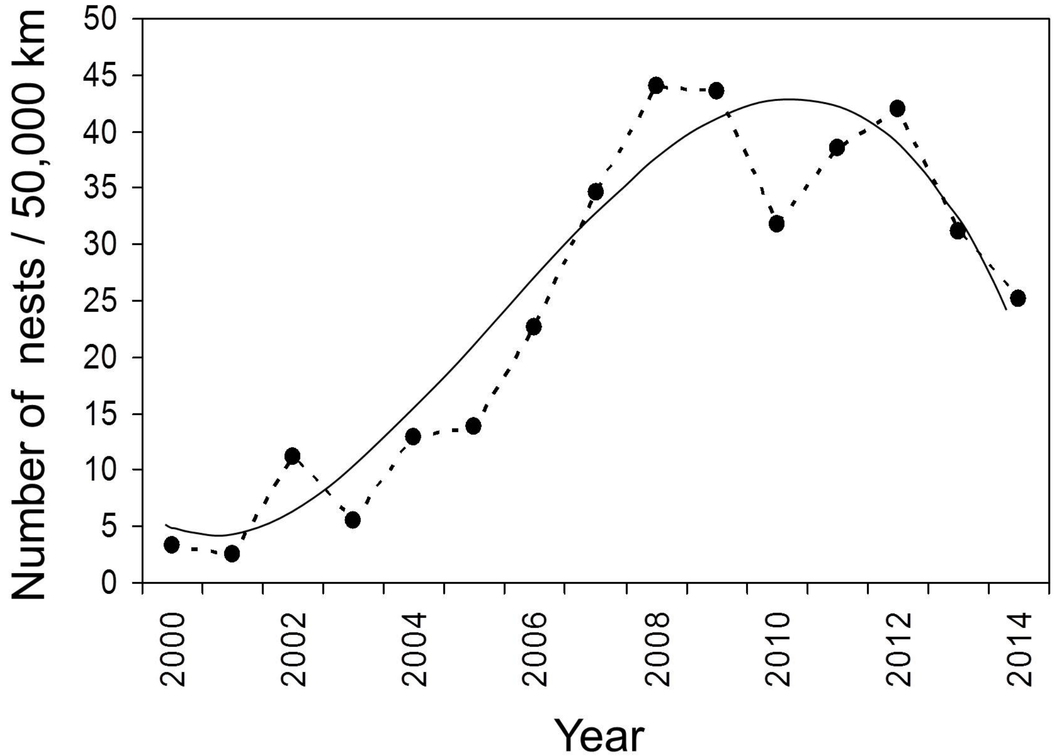

Figure 4. Number of confirmed Kemp's Ridley Turtle (*Lepidochelys kempii*) nests per 50,000 km patrolled on the Texas coast from 2000–2014 (●– – –) and the calculated 3rd 0.903.

or head-start turtles (Table 3). The 125 head-start nests documented were from 53 individuals, including 19 Padre Island imprinted (n = 68 nests) and 34 RN imprinted (n = 57 nests). In Texas, the first Padre Island imprinted head-start nest was documented nesting during 1996 and the first RN imprinted head-start nest was documented in 2002 (Fig. 3).

The first time that head-started individuals were recorded nesting in Texas, living tags were the most useful tag to identify them, but a few were identified by metal and/or PIT tags. Metal tags were present on only five of the 53 head-started individuals documented nesting. One was a super-head-started turtle from the 1986 year-class released at 3 y of age and found nesting in 1999. Of the 19 Padre Island imprinted head-start turtles found nesting, this was the only one that still possessed a metal tag. Four RN imprinted head-start turtles from the 1991, 1992, 1993, and 1995 year-classes still possessed metal tags and were at large 10–15 y ($\bar{x}$ = 12.5 y, SD = 2.1 y, n = 4) before detected nesting. Of the 34 RN imprinted head-start turtles, PIT tags were detected in nine from the 1989, 1991–1993, and 1997 year-classes. Two of the nine also possessed metal tags. Coded wire tags and tag scars on the right front flipper (when metal tags were absent) were typically used secondarily, to help corroborate that the turtle was head-started.

Origins of nests at which nesting turtles were examined for tags varied geographically in Texas.

Table 3. Number of Kemp's Ridley Turtle (*Lepidochelys kempii*) nests confirmed on the Texas coast at which nesting females were examined for tags, 1979–2014.

Location	Wild Stock	Padre Island Imprinted head-started	RN[1] imprinted Head-started	Uncertain wild or head-started
Upper Texas Coast	13	1	33	3
Matagorda Peninsula	1	0	1	–
Matagorda Island	8	0	0	3
San Jose Island	3	0	0	–
Corpus Christi Bay	0	1	0	–
Mustang Island	26	6	9	–
North Padre Island	575	60	12	–
South Padre Island/Boca Chica Beach	159	0	2	–
Total	785	68	57	6

[1]Rancho Nuevo, Mexico.

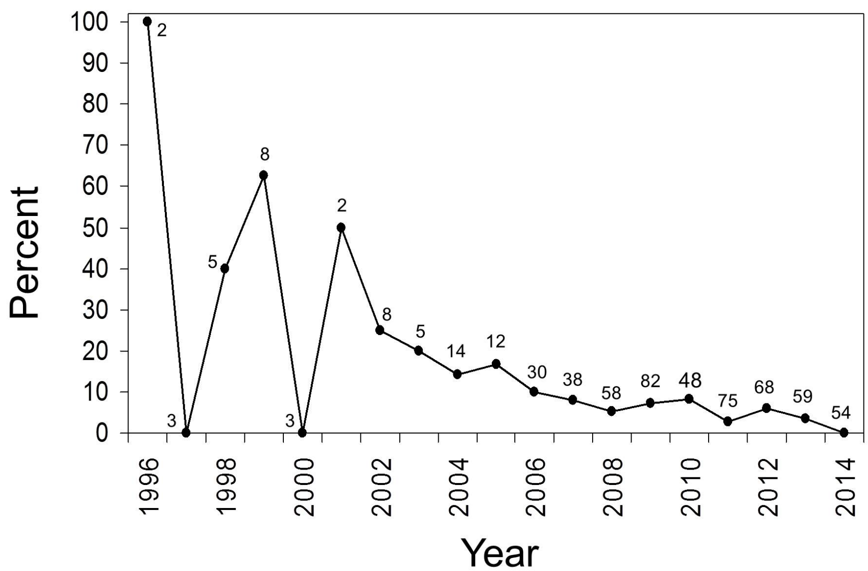

Figure 5. At Padre Island National Seashore, percentage of Kemp's Ridley Turtle (*Lepidochelys kempii*) nests at which the nesting females were examined for tags that were conclusively linked to Padre Island imprinted head-started turtles, 1996–2014. Numbers of nests at which nesting turtles were examined for tags each year are listed.

Table 4. Number of head-start Kemp's Ridley Turtle (*Lepidochelys kempii*) nests confirmed on the Texas coast, 1996–2014. [1]Texas locations include, north to south: HI = High Island, BP = Bolivar Peninsula, GI=Galveston Island, SS = Surfside Beach, BB = Bryan Beach, MATP = Matagorda Peninsula, CCB = Corpus Christi Bay, MI = Mustang Island, PI = North Padre Island, NP = North Padre Island north of Padre Island National Seashore, PAIS = Padre Island National Seashore, and SPI = South Padre Island. Other locations include: RN = Rancho Nuevo, Mexico, PC = Panama City, Florida, USA.

Year-class	Release after Head-starting (offshore)[1]	No. Individuals Nested	No. Nests	Imprint Site	Nest locations[1] (No. nests)
1983	MI	1	1	PI	PAIS (1)
1984	MI/PI	3	6	PI	MI(2), NP(1), PAIS(3)
1986	MI	6	15	PI	CCB(1), NP(2), PAIS(12)
1987	PI	6	29	PI	NP(5), PAIS(24)
1988	PI	3	17	PI	BB(1), MI(5), NP(8), PAIS(3)
1989	GI	4	10	RN	GI(6), MI(2), PAIS(2)
1990	GI	1	1	RN	MATP(1)
1991	GI	9	12	RN	BP(1), GI(3), SS(2), BB(1), NP(1), PAIS(3), SPI(1)
1992	GI	17	30	RN	BP(1), GI(16), SS(1), MI(7), PAIS(4), SPI(1)
1993	MI/HI/PC	1	2	RN	PAIS(2)
1995	GI	1	1	RN	GI(1)
1997	GI	1	1	RN	GI(1)
Total		53	125		

From 1986–2014 collectively, RN imprinted head-start nests predominated on the upper Texas coast and wild stock nests predominated in south Texas (Table 3). Kemp's Ridley nesting was documented in Texas north of Mustang Island for the first time in 2002, the same year that the first RN imprinted head-start nest was found on the upper Texas coast (Shaver 2005). At PAIS, the percent of Kemp's Ridley nests at which biologists examined the nesting females for tags (excluding turtles identified as RN imprinted head-starts), that were conclusively linked to Padre Island imprinted head-start nesters, was variable from 1996–2001 and generally decreased from 2002–2014 (Fig. 5). Of the 574 nests found at PAIS from 1996–2014, at which biologists examined the nesting turtle and it was not from a RN imprinted head-start nester, 43 (7.5%) were from Padre Island imprinted head-start nesters.

The 53 head-start turtles documented nesting on the Texas coast from 1996–2014 were from 12 different year-classes, including 1983, 1984, 1986–1993, 1995, and 1997. Nesting also varied geographically for different year-classes/imprinting locations (Padre Island or RN) (Table 4). Year-classes 1983, 1984, 1986, 1987, and 1988 were Padre Island imprinted head-start that had been released off North Padre and Mustang Islands as yearlings, and all turtles from those year-classes documented nesting in Texas through 2014 nested on those beaches with the exception of one individual that nested once on the beach of nearby Corpus Christi Bay in 2009 (which was the first record of any Kemp's Ridley nesting on a bay beach in Texas), and one individual that nested once on Bryan Beach in 2011. Year-classes 1989–1992, 1995, and 1997 were RN imprinted head-starts that had been released off Galveston Island as yearlings, and they nested over a wide distribution in Texas, including the upper Texas coast and the south Texas coast. In contrast, the two records of nesting by a RN imprinted head-start from the 1993 year-class were both at PAIS. Most turtles from this year-class (n = 158) had been released off Mustang Island as yearlings, but one was released off High Island, Texas and 29 off Panama City, Florida.

Twenty-three of the 53 head-started individuals (43.4%) were documented nesting more than once in Texas. Twenty-one of the 23 (91.3%) showed a high degree of site fidelity, nesting at the same or a nearby beach, up to 10 recorded times. However, one 1992 year-class RN imprinted head-start was first found nesting on Mustang Island in 2005 and then on Galveston Island in 2011, and another 1992 year-class RN imprinted head-start was first found nesting at PAIS in 2006 and then on Galveston Island in 2010 (n = 1 nest) and in 2012 (n = 2 nests). The former was the first record of a Kemp's Ridley (wild or head-start) not using the same or nearby beaches for nesting within Texas, although one wild turtle was later documented using two distant nesting beaches in Texas. An additional 1992 year-class RN imprinted head-start was first found nesting at PAIS in 2005 and then found nesting in Tamaulipas during 2009. This is the first and only record of a head-started turtle nesting in both countries through 2014, although nesting by wild individuals in both countries has been recorded (Shaver 2005).

In comparison, from 1991–2014, of the 402 wild individuals that biologists documented nesting in Texas, 184 (45.8%) were documented nesting more than once. Of the 184, 175 (95.1%) were recorded nesting more than once in Texas on the same or nearby beaches, one was recorded nesting on two distant Texas nesting beaches, and eight were documented nesting both in south Texas (PAIS or South Padre Island) and Tamaulipas. No wild individuals were recorded nesting both in Texas north of PAIS, and in Tamaulipas. Three of the eight first nested in south Texas (two of which were documented nesting twice in Mexico) and the other five first nested in Tamaulipas (only one nest recorded for each). The interval between nests recorded in the two countries ranged from 27 d–12 y.

A wild turtle (60.7 cm SLCL) that nested at PAIS and South Padre Island during 2009 had a PIT tag that was applied after it stranded in Barnstable, Massachusetts on 17 November 1999 (27.8 SLCL) (Peter Eliazar, pers. comm.; Christina Trapani, pers. comm.). This turtle was rehabilitated at the New England Aquarium, Columbus Zoo, and Virginia Aquarium and then released on Cape Charles, Northampton, Virginia on 3 September 2003 (54.2 cm SLCL). It was the first Kemp's Ridley Turtle documented nesting in Texas after having been tagged and released along the Atlantic coast of the USA.

In the USA outside of Texas, 118 Kemp's Ridley nests were documented and all were during 1989–2014. This included 87 from Florida (Gulf and Atlantic coasts), 15 from Alabama, 10 from North Carolina, two from Georgia, two from South Carolina, and two from Virginia (see review in Shaver 2005; NMFS et al. 2011; Matthew Godfrey, pers comm.; Jackie Isaacs, pers. comm.; Sandy MacPherson, pers. comm.; Anne Meylan, pers. comm.). Trained biologists were only able to examine a few of the nesters, but none of those were conclusively identified as Padre Island or RN imprinted head-starts.

The estimated 40,000 nests located in one day at RN in 1947 (Carr 1963; Hildebrand 1963) is used as a benchmark for this species (NMFS et al. 2011). The population declined and reached a low of only 702 nests during 1985, increased nearly annually to more than 21,000 nests during 2009, decreased to about 13,000 nests during 2010, and then ranged between about 12,000 and 21,000 nests annually from 2011–2014 (NMFS et al. 2011; Caillouet 2014; Plotkin and Bernardo 2014; Pat Buchfield, pers. comm.). Through 2014, seven head-start turtles from the 1987, and 1989–1992 year-classes were recorded nesting (n = 8 nests) at or near RN (Rene Márquez-M., pers.

comm.; Jaime Peña, pers. comm.; Wendy Teas, pers. comm.). One was a 1987 year-class Padre Island imprinted head-start that was documented in 1998. Six were RN imprinted head-starts from the 1989–1992 year-classes, and included the individual mentioned above that nested in both south Texas and near RN. The first was found nesting in 1999 and was recorded twice that year. All others were only recorded once in Mexico, between 2006 and 2009. Only one of the seven still possessed a metal tag, a 16 y old RN imprinted head-start. Through 2014, no head-start nests have been confirmed in the wild outside of Texas and Tamaulipas.

Age and size at maturity in the wild and fecundity.——The 53 head-start turtles documented nesting on the Texas coast from 1996–2014 were 10–26 y of age when first detected nesting ($\bar{x}$ = 15.5 y, SD = 3.8 y, n = 53), although we do not know if their first documented nest was actually the first of their reproductive life. One of the head-start turtles had been reared in captivity for 3 y prior to release (i.e., it was super head-started). There was no evidence from tags that any others had been held longer than the typical 7–15 mo, but PIT or metal tags necessary to determine this were often lacking when the head-start turtles were found nesting. Head-start turtles that biologists measured ranged in size from 58.1–66.6 cm SLCL when first detected nesting ($\bar{x}$ = 61.9 cm, SD = 1.9 cm, n = 46). Age and size when the turtles were first detected nesting were not correlated (Pearson Product Moment Correlation Coefficient = 0.273, P = 0.0664, n = 46).

Biologists documented individual head-start turtles nesting from 1–10 times on the Texas coast ($\bar{x}$ = 2.4, SD = 2.2, n = 53). For those recorded during more than one nesting year, the number of years between their first and last documented nest ranged from 3–11 y ($\bar{x}$ = 6.6, SD = 2.4, n = 18). Head-start nests contained 55–121 eggs ($\bar{x}$ = 97.6, SD = 11.3, n = 125 nests). Considering all 125 times that head-start turtles were recorded nesting, the maximum age recorded was 26 y. Age of the nesters and the number of eggs per clutch were positively correlated (Pearson Product Moment Correlation Coefficient = 0.185, P = 0.0394, n = 125).

Emergence success ranged from 0–100% ($\bar{x}$ = 75.3%, SD = 29.9, n = 125). No eggs hatched from the first three clutches recorded for one 1988 year-class Padre Island imprinted head-start, but emergence success from her next three recorded clutches was 95.2%, 95.3%, and 96.9%; these six nests were in a span of 8 y. Emergence success was 0% for only two other head-start nests, including one from a 1988 year class Padre Island imprinted head-start and one from a 1989 year-class RN imprinted head-start. Fourteen wild turtles produced clutches containing 60 or fewer eggs (n = 16 nests), but only one head-start clutch from a 1988 year-class Padre Island imprinted turtle contained this few eggs.

The seven head-start turtles recorded nesting at or near RN from 1998–2009 were from six different year-classes, including 1987 and 1989–1992. Excluding the individual that was first recorded nesting at PAIS and then near RN, they were 11–20 y of age when first detected nesting in Mexico ($\bar{x}$ = 15.8 y, SD = 4.4 y, n = 6). Data on SLCL, number of eggs per clutch, and hatching success were not available for these records.

Incubation of eggs from nests found in Texas.—From 1979–2014, biologists recorded 1,667 Kemp's Ridley nests in Texas, and annual emergence success for these nests ranged from 28–97% ($\bar{x}$ = 80%, SD = 14%, n = 26; Table 5). From these, 130,847 hatchlings were successfully released on Texas beaches without marking or retrieval in the surf. In addition to these, 69 hatchlings from one clutch found at PAIS in 1985 and 100 hatchlings from three clutches found on South Padre Island in 2013 were released on the beach, recaptured after release, and transported to the NMFS Laboratory for head-starting or captive rearing. Of the 1,667 nests, 1,086 incubated in an incubation facility at PAIS, 350 in a corral

TABLE 5. Number of Kemp's Ridley Turtle (*Lepidochelys kempii*) nests (wild and head-start) confirmed on the Texas coast, emergence success, and number of hatchlings released, 1979–2014 (Shaver 2005). [1]Emergence success = number of live turtles that emerged from the nest divided by the total number of eggs. Total emergence success is the mean of annual emergence success for 26 y. [2]R = weaker hatchling retained for additional care; V = hatchling from *in situ* nest killed by vehicle; W = weaker hatchling washed ashore dead; A = hatchling from *in situ* nest killed by ants; A&C = hatchling from *in situ* nest killed by ants and ghost crab; C = hatchling from *in situ* nest killed by ghost crab; T = hatchling shipped to and retained at NMFS Laboratory for head-starting or captive rearing for turtle excluder device testing. [3]Does not include *in situ* nests (10 in 2008, 11 in 2009, 1 in 2010, 5 in 2011, 5 in 2012, 11 in 2013, 2 in 2014).

Year	No. Nests	No. Eggs Intact (+ broken)	No. hatchlings Successfully released	Emergence Success[1]	No. hatchlings retained or killed on beach[2]
1979	1	67	65	97	0
1980	2	228	64	28	0
1985	1	97	0[1]	71	T(69)
1988	1	104	95	91	0
1991	1	107	100	93	0
1994	1	111	100	90	0
1995	4	335(3)	300	90	0
1996	6	590	369	63	0
1997	9	968(12)	893	92	0
1998	13	1,270(2)	800	63	R(1)
1999	16	1,681(3)	1,364	81	R(4)
2000	12	1,160	1,000	86	R(1)
2001	8	837	584	70	R(2)
2002	38	3,771(2)	2,536	68	R(4), V(14)
2003	19	1,718(7)	1,426	83	0
2004	42	3,928(6)	3,298	84	V(2)
2005	50	4,700(4)	3,402	72	R(2)
2006	102	9,717(6)	7,475	77	W(2), C(2), V(5)
2007	128	12,555(4)	10,594	84	R(4)
2008	195	17,933(25)[3]	15,819[3]	88[3]	R(9), V(8)
2009	197	17,507(11)[3]	14,506[3]	83[3]	0
2010	141	13,573(11)[3]	11,983[3]	88[3]	0
2011	199	18,870(34)[3]	16,092[3]	85[3]	A(23), A&C(1), C(2)
2012	209	20,035(32)[3]	16,577[3]	83[3]	0
2013	153	13,537(12)[3]	11,338[3]	84[3]	T(100), C(25)
2014	119	11,307(23)[3]	10,067[3]	89[3]	0
Total	1,667	156,704(197)[3]	130,847[3]	80[3]	196 T or R, 84 dead

Table 6. Method used to protect Kemp's Ridley Turtle (*Lepidochelys kempii*) nests (wild and head-start) confirmed on the Texas coast, overall percent female produced for each year, and number of hatchlings released, 1979–2014 (Shaver 2005).[1]SPI = South Padre Island, BCB = Boca Chica Beach, PAIS = Padre Island National Seashore. [2]Identified to gender by histological analysis of gonads from dead embryos and hatchlings; NA = sex ratio not yet available for 2012–2014. [3]Does not include number of hatchling shipped to NMFS Laboratory. [4]Does not include number of hatchlings produced from *in situ* nests found in 2008–2014 which could not be accurately quantified. [5]Most clutches incubated in corrals during 2010 were moved to the PAIS incubation facility during the incubation period to protect them from an approaching hurricane.

Year	No. Nests	No. nests Incubation Facility	No. nests Corral SPI/BCB[1]	No. nests Corral PAIS[1]	No. Nests *in situ*	No. individuals Identified To gender	Estimated % female	Total No. Hatchlings Released
1979	1	1	0	0	0	0	NA	65
1980	2	1	0	0	1	0	NA	64
1985	1	1	0	0	0	5	80.0	0[3]
1988	1	1	0	0	0	4	25.0	95
1991	1	1	0	0	0	0	NA	100
1994	1	1	0	0	0	10	60.0	100
1995	4	4	0	0	0	3	75.0	300
1996	6	6	0	0	0	23	65.5	369
1997	9	9	0	0	0	16	77.6	893
1998	13	13	0	0	0	127	45.6	800
1999	16	16	0	0	0	22	74.2	1,364
2000	12	11	1	0	0	47	47.8	1,000
2001	8	5	3	0	0	64	67.6	584
2002	38	28	7	0	3	208	88.0	2,536
2003	19	17	2	0	0	58	79.5	1,426
2004	42	32	9	0	1	101	84.0	3,298
2005	50	40	9	0	1	118	89.0	3,402
2006	102	77	17	0	8	610	85.0	7,475
2007	128	106	20	0	2	192	78.6	10,594
2008	195	125	49	11	10	252	71.4	15,819[4]
2009	197	126	37	23	11	121	93.7	14,506[4]
2010	141	87	32[5]	21[5]	1	224	65.2	11,983[4]
2011	199	117	38	39	5	279	63.8	16,092[4]
2012	209	102	67	35	5	NA	NA	16,577[4]
2013	153	78	37	27	11	NA	NA	11,338[3,4]
2014	119	81	22	14	2	NA	NA	10,067[4]
Total	1,667	1,086	350	170	61	2,484	70.8	130,847[3,4]

on South Padre Island or Boca Chica Beach, 170 in a corral at PAIS, and 61 *in situ* (only two of which were protected) (Table 6).

Although most of the nests held in corrals during 2010 were transferred to the incubation facility to complete incubation, their data are included in the corral tallies since the majority of their incubation period was spent in the corrals. Emergence success was not reduced due to this transfer from the corrals to the incubation facility. Mean annual emergence success for eggs held in the PAIS incubation facility was 81.8% and in corrals was 82.2%. Sixty-one *in situ* nests were documented on the Texas coast from 1979–2014, including two that were screened and left at the nest site and 59 that incubated unprotected on the beach. These 59 included 34 documented at sites where biologists had seen the nesting turtles or tracks from the nesting turtles, but could not find the nests initially, monitored the sites throughout incubation, and later located the nests. It also included 25 nests at sites that were unknown to biologists at egg laying; other beach workers or the public found and reported the nests before, during, or after emergence time. Estimated hatching success was a maximum 62% for the 26 *in situ* nests documented on the Texas coast from 1979–2008, but biologists documented some hatchlings as killed due to predation (n = 2) or beach driving (n = 31 hatchlings; Table 5); additional losses on the beach due to these and other factors were possible. Data from the 35 other *in situ* nests found from 2009–2014 are not included because most were not intact when located; biologists documented 51 hatchlings killed at these nests due to ant and/or crab predation and others could have also been killed there but disappeared before biologists arrived. Females dominated in all year-classes assessed except two, with an overall estimate of 70.8% female (Shaver 2005; Thane Wibbels, pers. comm.; Table 6). Biologists released 4,960 hatchlings from the 68 Padre Island imprinted head-start nests and 4,244 hatchlings from the 57 RN imprinted head-start nests (Table 7); hatchlings from 118 of these 120 head-start nests that hatched were released at PAIS and hatchlings from the other two were released on South Padre Island.

Post-nesting movements.——Tracking periods for the 115 PTTs deployed on turtles that emerged to nest or nested on Texas beaches between 1997 and 2014 ranged from nine to 1,492 d (Seney and Landry 2008; Shaver and Rubio 2008; Shaver et al. 2013; www.seaturtle.org/tracking/). The maximum tracking duration for these PTTs may increase since the PTT with the longest duration and eight others deployed by PAIS continue to transmit as of this writing (18 May 2015). During the nesting season, wild and head-started turtles remained within the vicinity of a nesting beach or transited up to 200 km away during the inter-nesting period (Shaver and Rubio 2008).

After they completed nesting for the season, most of the wild and head-started turtles tracked traveled northward or eastward, parallel to the coastline, with their last identified locations in the northern or eastern Gulf of Mexico (Fig. 6). Collectively, migration was documented along the Gulf of Mexico coastline from the west coast of Florida through the Yucatan Peninsula, and residency was established in various areas throughout. Some wild and head-started turtles tracked multiple times showed site fidelity to foraging sites where they had established residency previously (Shaver and Rubio 2008; Shaver et al. 2013).

Movement patterns of most of the wild and head-started Kemp's Ridley monitored were generally similar. Most used common inter-nesting residency areas, migratory pathways, and foraging areas. Most identified positions were in 20 fathoms (35.6 m) water depth or less. The most noteworthy difference between wild and head-started turtles was that all of the nine turtles that traveled southward to waters off the coast of Mexico were wild turtles; eight of these traveled to waters off Tamaulipas and one to the Yucatan Peninsula. Seven of the nine moved northward

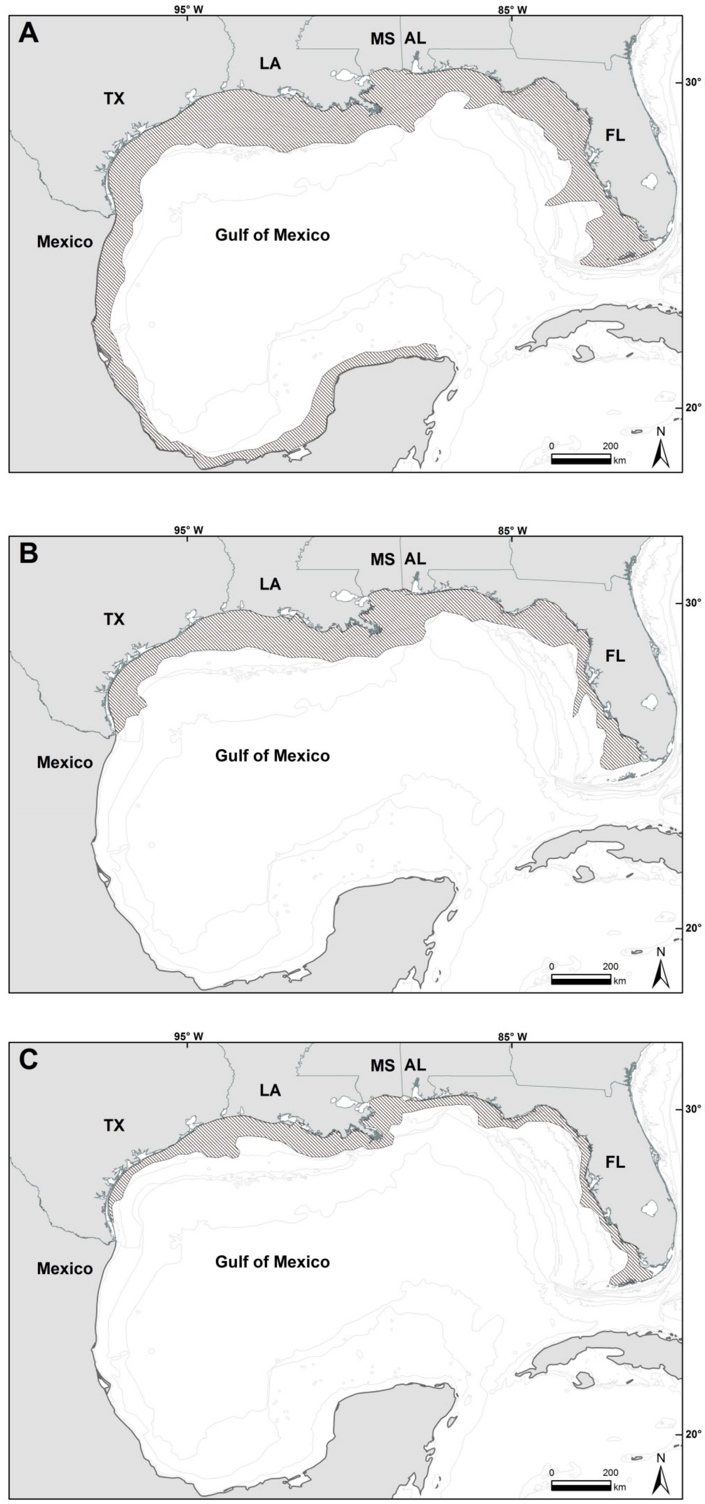

Figure 6. Generalized area use documented for adult female Kemp's Ridley Turtles (*Lepidochelys kempii*) tracked from Texas nesting beaches that were: (A) wild stock, (B) Padre Island imprinted head-start, (C) RN imprinted head-start (derived from Seney and Landry 2008; Shaver and Rubio 2008; and http://seaturtle.org/tracking/ courtesy of André Landry, Texas A&M University and Padre Island National Seashore). Most post-nesting females tracked left the nesting beach and traveled along a shallow coastal migratory corridor to feeding areas as far as Florida; movements of the three groups were generally similar.

Table 7. Number of Kemp's Ridley Turtle (*Lepidochelys kempii*) head-start (HS) nests confirmed on the Texas coast, and number of hatchlings released from those nests,1996–2014.

Year	Total No. HS Nests	Total No. Hatchlings released from HS nests	No. PI Imprinted HS nests	No. hatchlings Released from PI Imprinted HS nests	No. RN Imprinted HS nests	No. hatchlings Released from RN Imprinted HS nests
1996	2	111	2	111	0	0
1997	0	0	0	0	0	0
1998	4	239	4	239	0	0
1999	7	482	7	482	0	0
2000	1	69	1	69	0	0
2001	2	162	2	162	0	0
2002	6	253	3	128	3	125
2003	4	344	1	92	3	252
2004	7	616	4	285	3	331
2005	9	653	3	203	6	450
2006	9	491	4	313	5	178
2007	8	625	4	213	4	412
2008	12	981	5	453	7	528
2009	10	675	8	547	2	128
2010	14	1,252	6	599	8	653
2011	12	829	5	340	7	489
2012	13	988	6	419	7	569
2013	5	434	3	305	2	129
2014	0	0	0	0	0	0
Total	125	9,204	68	4,960	57	4,244

and were last located in waters off the USA and the other two were last located off Mexico. Another difference was that a higher proportion of Padre Island imprinted head-starts maintained a home range off the south Texas coast after the nesting season was completed than did turtles from the wild stock. Three of the 11 Padre Island imprinted head-starts that were tracked remained, including a 1984 year-class turtle that was resident from 9 April 1999 – 30 November 1999, a 1986 year-class turtle that was resident from 20 April 1999 – 3 October 1999 and 6 May 2010 – 24 September 2010 (two tracking periods), and a 1988 year-class turtle that was resident from 8 June 2012 – 20 August 2012. In contrast, only one of 57 wild turtles tracked by PAIS remained in south Texas after the nesting season was completed. This turtle was tracked from 1 May 2007 – 22 March 2008 and after months of being resident off south Texas briefly ventured to waters off the coast of Tamaulipas and was last located there. The only turtle tracked back to south Texas after completing winter foraging residency elsewhere was a 1987 year-class Padre Island imprinted head-start tracked from 27 April 2006–26 March 2007.

Discussion

Evaluating results of the reintroduction and head-starting aspects of the KRREP is complicated because of varying procedures used, lack of permanent tags in early head-start year-classes, incomplete efforts to detect and document nesting by turtles from this project, unclear historic nesting levels in Texas, an exponentially increasing Kemp's Ridley population through 2009, and other factors. There were two different imprinting locations, and a few head-started turtles originated as offspring from captive stock at CAY. Also, release locations of head-started turtles varied. With the passage of time, more head-started turtles have nested and longer-term data sets have become available to evaluate project results. Here we assess the effectiveness of the reintroduction and head-starting efforts based on empirical data on the age and size at maturity, nesting, and post-nesting movements of head-started Kemp's Ridley.

Age and size at maturity in the wild and fecundity.——The growth and maturation of head-started turtles following release is one indicator of how well the turtles adapted to the wild. Growth data for head-started Kemp's Ridley Turtles have been reported previously (McVey and Wibbels 1984; Fontaine et al. 1989a; Caillouet et al. 1989, 1995b; Snover et al. 2007). The size of head-started turtles measured when first detected nesting in Texas was within the range reported for nesters from the wild stock (Pritchard and Márquez-M. 1973; Márquez-M. 1990, 1994; Witzell et al. 2005; Caillouet et al. 2011). The mean age when the turtles were first detected nesting (15.5 y) was slightly higher than most model predictions for age at maturity for wild and head-started turtles. Based on a mature size of 65.0 SLCL, growth models predicted maturation of wild Kemp's Ridleys at 11–16 y or age (Zug et al. 1997), and based on a mature size of 60.0 SLCL predicted maturation of head-started Kemp's Ridleys at 11 y (Caillouet et al. 2011) and wild Kemp's ridleys at 9–13 y (Zug et al. 1997). However, nesting Kemp's Ridleys are typically only observed by biologists and checked for tags at about half the nests found in Texas, so these head-started turtles could have nested previously, when smaller and younger.

There is a slight chance that year-class and thus age were misidentified for eight turtles because their living tag locations were used to mark two different year-classes (see ***Head-starting, tagging, release***), they did not possess other head-start tags linking them to a year-class, and their first recorded nest was found when turtles from both year-classes could have been mature, given a minimum age of nesting at 10 y, which is the youngest that any head-started turtle has been found nesting. The eight include the last turtle classified as a 1984 year-class (found nesting at PAIS in 2010), last two classified as 1987 year-class (found nesting at PAIS in 2007 and 2009), last two classified as 1989 year-class (found nesting near Rancho Nuevo in 2009), one classified as 1990 year-class (found nesting on Matagorda Peninsula in 2011), and last two turtles classified as 1991 year-class (one found nesting at Bryan Beach in 2010, and one found nesting on Bolivar Peninsula in 2013). These could have been from the 1995, 1997, 1999, 1998, and 2000 year-classes, respectively, but none possessed PIT tags which had been used to mark turtles from the later year-classes. If year-class categorized for these eight turtles were adjusted, this would slightly reduce the mean age when the turtles were first documented nesting.

It is unfortunate that unique living tag locations or combinations of locations were not used to designate different year-classes and imprinting locations. In future years, when more of the turtles from these later year-classes with re-used living tag locations mature and likely nest, it will be increasingly difficult to identify year-class and imprinting location unless the turtle possesses a metal or PIT tag, and the examiner has been trained and possesses a PIT tag reader.

The fecundity of head-started turtles is a criterion that has been cited by review panels as being critical to evaluating head-starting (Wibbels et al. 1989a; Eckert et al. 1994). Based on nesting records through 2004, Shaver and Wibbels (2007) reported that the inter-nesting and remigration intervals, clutch size, and hatching success of head-started turtles were equivalent to those for wild turtles. Including records through 2013, mean clutch size for all head-started turtles that have been recorded nesting has increased from 94.1 eggs to 97.6

eggs. This increase in clutch size may indicate an increase in age of the head-start population, which would be predicted since the Padre Island imprinted turtles are aging and a reduced number of RN imprinted turtles were released from the 1993–2000 year-classes; age and the number of eggs were correlated. Mean clutch size for wild stock Kemp's Ridleys has varied since research was initiated in the 1960s, but the most current estimate is 97 eggs (NMFS et al. 2011). One super head-started turtle was documented nesting, which is noteworthy given concerns that extended time in captivity could lead to abnormal behavior after release (Caillouet et al. 1995b).

Post-nesting movements.——Movement data collected from satellite tracking suggest that many of the nesting head-started Kemp's Ridleys exhibited behaviors similar to wild turtles. Movement patterns of most of the wild and head-started Kemp's Ridleys monitored were generally comparable. Wild and head-started turtles utilized similar inter-nesting habitats, migration pathways, and foraging sites where they established residency. After they finished nesting for the season, most migrated away from the nesting beach and traveled parallel to the coastline. However, a higher proportion of the Padre Island imprinted head-starts that were tracked (27.3%) remained resident off PAIS after the nesting season was completed than did turtles from the wild stock (1.8%), and all of the turtles that ventured into waters offshore from Mexico were wild stock turtles. Only one of these wild stock turtles were tracked to the Yucatan Peninsula after nesting at PAIS, although other wild stock turtles tracked after nesting at RN also traveled there (Shaver et al. 2013). Residency was established at various sites along the Gulf coast, as far as the tip of Florida and the Yucatan Peninsula. Foraging areas used by most wild and head-started turtles were concentrated in the northern Gulf of Mexico (Shaver and Rubio 2008; Shaver et al. 2013). The continued use of these inter-nesting, migratory, and foraging sites over decades, and repeatedly by individuals, underscores the importance of these areas for preservation of this species and the need for protection efforts there.

Historical nesting in Texas.——One of the most important criteria to evaluate the reintroduction and head-starting efforts is nesting. To understand nesting trends, it is important to consider historical nesting levels. The documented historic nesting range for Kemp's Ridley in the USA is south Texas, from Mustang Island to the USA/Mexico border (Werler 1951; Carr and Caldwell 1958; Hildebrand 1963; Carr 1967; Francis 1978; Shaver 1990).

Historic Kemp's Ridley nesting levels in Texas are unclear (Shaver 2005). Hildebrand (1963), Neck (1978), and Carr et al. (1982) suggested that scattered Kemp's Ridley nesting in south Texas and a few areas in Mexico other than RN might represent remnants of larger Kemp's Ridley nesting colonies that once existed there. As Kemp's nesting increased after 1985, more nests were found in these other areas in south Texas and Tamaulipas and Veracruz, Mexico (Shaver and Caillouet 1998; Turtle Expert Working Group (TEWG) 1998; Márquez-M. et al. 1999, 2001, 2005; NMFS et al. 2011), supporting this hypothesis.

A Kemp's Ridley nest found at PAIS in 1948 was the first published record of this species nesting anywhere in the world (Werler 1951). From 1948–1976, five other Kemp's Rridley nests were documented in south Texas (Werler 1951; Hildebrand 1963; Carr 1967; Francis 1978). Based on the limited number of confirmed nesting records, Campbell (1977) and Carr et al. (1982) concluded that south Texas beaches did not appear to have supported major nesting aggregations in historical times such as was known in Mexico. This was later misinterpreted by some to mean that there was never a nesting colony at PAIS, and that the reintroduction effort aimed to create a new nesting colony (Balazs 1979; Mrosovsky

1979; Dodd and Seigel 1991). However, Carr et al. (1982) concluded that arribadas likely once occurred in Veracruz based on anecdotal reports of nesting there, and arribadas are occurring there now (Patrick Burchfield, pers. comm.), indicating a re-formation of a nesting colony. Using this rationale, there are grounds to think that arribadas could have once occurred at PAIS since arribadas are starting to form at PAIS, more turtles from the wild stock have been documented nesting at PAIS than at any other location in the USA, and there are anecdotal historical reports of more nesting than is reflected in the published literature, including anecdotal reports of possible arribadas. Some mass nesting sites for *Lepidochelys* sp. have gone undetected for decades despite efforts to find and study these animals (Plotkin 2007; Pritchard 2007).

Anecdotal historical reports of possible sea turtle nesting in Texas, not supported with photographs, observations of eggs, or complete information, cannot be categorized as confirmed nesting records, but should be considered in this context. Carr et al. (1982) relayed reports of "two small turtles nesting on the beach on a hot and strongly windy day , approximately in May 1938, when flying at low altitude to locate an automobile between Big Shell and Little Shell, on Padre Island", and a turtle seen "nesting at noon in the Barra de Corpus Christi" on an unknown date, and believed that these were Kemp's Ridley. NPS (1974) concluded that "Padre Island was once a major nesting site of the Atlantic Ridley Turtle. Accounts from old-time residents relate how they traveled by wagons along the beach, and had to wait while turtles traveled from their nests to the water ."

Three additional reports were relayed to one of the authors (DJS) during the last 15 y. (1) Billy Sandifer, a long-term PAIS fishing and birding guide, lived on the beach at PAIS from the summer of 1977 to February 1979 and spent many additional days and nights on the beach at PAIS before and after that time (Sikes 2010). He has located, identified, and reported Kemp's Ridley nesting at PAIS during the last 15 y. He stated that years ago he also saw nesting, but did not know that anyone was interested in receiving those reports or to whom he would have reported them; these observations never entered the scientific records. (2) A U.S. Army Corps of Engineers employee reported that he counted 30 turtles coming onshore to lay eggs in the vicinity of his camp at PAIS one night in the early 1970s. As nesting has increased at RN in recent years, nighttime arribadas have been documented (Jaime Peña, pers. comm.), so this could have been a Kemp's Ridley arribada even though the turtles nested at night. (3) An elderly beach visitor reported that when he was a child he and his father would visit PAIS. He said that his father would have to "dodge nesting turtles" while driving their car on the beach and that" he used to ride the turtles" on the beach, although he regretted that now.

Species is uncertain in two other anecdotal historical reports from elsewhere in Texas. In 1989, Penrose reported observing numerous "3–4 ft" (91–122 cm) long turtles laying eggs in south Texas, at the mouth of the Rio Grande, in the sandy riverbank shores (Doughty 1984). Neck (1978), Doughty (1984), and Shaver (2005) thought that these were probably Green Turtles (*Chelonia mydas*), but Hildebrand (1982) and Burchfield (2005) thought that they were probably Kemp's Ridleys. Alternatively, it is possible that they were *Apalone spinifera* (Burchfield 2005), a few of which have been reported alive on south Gulf Texas beaches in recent years. "Clusters of mammoth turtles.... basking in the hot sand" in Galveston during April or early May 1851 were likely basking Green Turtles as suggested by Doughty (1984). Green Turtles bask in remote, relatively undisturbed localities, including PAIS where small juveniles have been documented basking in recent years, and could have once basked in Galveston. It was also suggested that the turtles described in this account were "Loggerheads (*Caretta caretta*) heading ashore to nest as twilight approached" (*ibid*) or nesting Kemp's Ridleys (Burchfield 2005). Nesting Loggerheads are large (larger than 92 cm), Hildebrand (1982) concluded that large, unidentified turtles reported nesting in Texas and eggs gathered by LaSalle's expedition 300 y ago were likely Loggerheads, and three Loggerhead nests have been confirmed on the upper Texas coast in recent years (Shaver, unpublished data). In contrast, nesting Kemp's Ridleys are smaller (60–65 cm) and there were no confirmed records of Kemp's Ridleys nesting on the upper Texas coast prior to 2002, when the first RN imprinted headstarts were documented nesting.

The numbers of Kemp's Ridleys nesting at PAIS may have been reduced many years ago. A nesting colony could have been decimated by direct human exploitation, as occurred in RN. Local inhabitants (Karankawas, Mexicans, or early European settlers) may have learned to take advantage of nesting turtles and eggs that appeared on the beaches predictably when gale force onshore winds began, and during broad daylight (Burchfield 2005). Turtles that would have nested at PAIS could have been killed due to incidental capture in shrimp trawls, which was one of the most significant causes for the decline of the Kemp's Ridley population (Carr et al. 1982; Magnuson et al. 1990). Carr (1977) reported that the shrimp fleet based in Port Isabel, Texas (just south of PAIS) exerted the largest shrimping effort in the world and that shrimpers and crewmen admitted regular incidental capture when he interviewed them in 1961, but by 1977 almost none knew of the existence of the Kemp's Ridley. Dead, stranded sea turtles have been observed on south Texas beaches for decades (Rabalais and Rabalais 1980; Hildebrand 1982), but were not systematically documented until the Sea Turtle Stranding and Salvage Network (STSSN) began in the USA in 1980 (Whistler 1989; Shaver 1998b, 1999; Shaver and Teas 1999). Later, strandings were correlated with shrimp trawling on the Texas coast during the 1980s and 1990s (Caillouet et al. 1991, 1996; Lewison et al. 2003).

Several other factors could have limited the number of historical nesting records at PAIS. (1) Due to the nesting habits of the species, detection of nesting is very difficult, even for trained observers. Turtles come onto the beach and leave quickly, often without a trace (Pritchard 2007). Tracks from the nesting females are shallow, faint, and disappear quickly, especially on windy days when Kemp's Ridleys typically nest (Pritchard and Márquez-M. 1973; Márquez-M. 1990, 1994; Witzell et al. 2005; Pritchard 2007). Large amounts of seaweed (i.e., *Sargassum* sp.) sometimes wash ashore and accumulate at PAIS, and nesters do not leave a track where they crawl over the seaweed. (2) Access was difficult. For many years this area was used for private grazing and a bombing range. The first causeway to North Padre Island, built in 1927, was a one-lane wooden bridge, with troughs for automobile wheels. This bridge was replaced with a two-lane causeway in 1950. PAIS was designated as a unit of the NPS system in 1962 and dedicated in 1968. An access road was proposed for behind the dunes in the park's first General Management Plan, but was never constructed. The end of the paved road is the only vehicular access point to the southernmost 100 km of PAIS and then driving is along the beachfront. Driving conditions in Big Shell and Little Shell are so poor that historically private cars could rarely pass through (Hildebrand 1963; Carr et al. 1982), although more widespread availability of four-wheel drive vehicles has improved access in recent years. (3) Aircraft over-flights and recreational visits which could have resulted in reports were likely less frequent on nesting days, which are typically very windy. (4) Very few people would have looked for nesting until patrols began in 1986. (5) Until 1979, there was no system for the public or others working on the beach to report nesting and even later some did not know to report nesting or who to report it to. (6) Some people may have withheld nesting reports because they feared future restrictions on beach driving due to nesting; many respondents to a visitor use survey conducted at PAIS in the 1980s stated that they would be opposed to a closure of PAIS beaches to motor vehicles even if it would protect nesting sea turtles (Ditton and Gramann 1987).

Factors limiting reintroduction and head-starting returns.——Of the thousands of head-started turtles released, 53 have been documented nesting (n = 125 nests) in Texas and seven (n = 8 nests) in Mexico, one of which was also documented nesting in Texas. Several possible factors could have limited observations of nesting head-started turtles and their nests (Pritchard 1990) including: insufficient monitoring, inability to examine all the nesters, tagging and tag loss, sex ratio, mortality at sea, turtles nesting elsewhere, and age.

Thorough monitoring of beaches for head-started Kemp's Ridleys is necessary to evaluate the effectiveness of the reintroduction and head-starting efforts (Wibbels et al. 1989a; Byles 1993; Eckert et al. 1994; Shaver and Wibbels 2007). In Texas, limitations in beach monitoring (mostly due to funding and logistical constraints) may have lowered the chances of observing nesting by head-started Kemp's Ridleys, particularly from the mid-1980s to mid-1990s (Shaver and Fletcher 1992; Shaver 2005; Shaver and Wibbels 2007). Additional monitoring may have resulted in more nesters being found and more opportunities to check nesters for tags. It was not logistically possible to examine every nester for tags because Kemp's Ridleys nest relatively quickly (typically in 45 min) and often simultaneously. It was only possible to encounter and examine the nesting turtle at 54.9% of the nests recorded in Texas from 1979–2014, which is slightly higher than during a saturation tagging program conducted at RN in 1989 in which the nesting turtles were examined at 404 of 835 nests (48.4%) recorded that year (Pritchard 1990). In Mexico, examination of more of the nesting turtles also would have likely yielded additional head-start records. Of the thousands of Kemp's Ridley Turtles that were examined for tags in Mexico from 1985–2014, seven turtles (n = 8 nests) were documented as having head-start tags. However, nesters were not examined at many nest sites. Even during the saturation tagging program in 1989, nesters were not examined at 51.6% of the nests (n = 431 nests). As arribada size increased it became increasingly difficult for biologists to examine nesters for head-start tags and the observation rate likely decreased. One can assume that nesters were not examined at thousands of nests over the years. Since Kemp's Ridley nest an average of two and a half to three times during a nesting season, on average every 2 y (Witzell et al. 2005; NMFS et al. 2011), the probability increases that individual turtles were seen at least once during a nesting season or throughout the years, and thus were accounted for in the overall number of head-started individuals documented nesting, even if some of their nests were not found, or were found, but were not attributed to head-started turtles. Findings from on-going microsatellite and kinship analysis being conducted in Texas should help expand the number of nests that can be conclusively linked to some of the head-started turtles previously documented nesting there (Frey et al. 2008, 2014).

Identification of head-started turtles is problematic (Wibbels 1992; Shaver 1998a, 2005; Shaver and Wibbels 2007; Caillouet et al. 2015). Fore-flipper tag loss and difficulties in tag recognition likely limited observations of nesting by head-started Kemp's Ridleys (Shaver and Fletcher 1992; Fontaine and Shaver 2005; Shaver 2005). Turtles from the earliest year-classes (1978–1982) were released without permanent tags (i.e., living, PIT, and coded wire) and most of them would not have been identifiable at nesting due to loss of their metal tags. No nesting returns have been documented for those earlier year-classes. Thus, of the 13,211 Padre Island imprinted head-starts released from the 1978–1988 year-classes, only the 6,183 from the 1983–1988 year-classes might be identifiable at nesting. For those from later year-classes, depending on the type of permanent tag used, a trained biologist and specialized equipment were required to detect a tag. Some head-start tags are difficult to detect and turtles considered examined could have possessed head-start tags that were not recognized. For example, living tags can sometimes be confused with barnacle scars or obscured by algae and sand on the carapace. The limited number of readers available to detect PIT and coded wire tags may have reduced the chances of detecting head-started Kemp's Ridleys from their internal tags (Shaver and Wibbels 2007). If proper protocols required to detect coded wire tags are not followed, these tags might not be detected (Fontaine et al. 1993; Higgins et al. 1997). PIT tags might also be missed if compatible readers and proper scanning techniques are not employed. The PIT tag reader must be compatible with the PIT tag manufacturer and tag frequency. Most PIT tags used to mark head-starts were 400 kHz, which were one of the first PIT tags developed and have a more limited read range and longer read time than newer 125 kHz tags.

Sex ratio of most of the early year-classes may have limited nester returns (Shaver and Fletcher 1992; Shaver 2005). The early year-classes of Padre Island imprinted head-starts were male-dominated. In contrast, the 1989–2000 year-classes (RN imprinted head-starts) originated from late-season nests and over 90% of the individuals from those year-classes were females (Caillouet 1995b; Ben Higgins, pers. comm.).

Head-started nesters and nests were also limited by mortality in the marine environment. After release, head-started turtles were subjected to the same human-related and natural factors that harmed and killed wild stock turtles in the USA and Mexico (Magnuson et al. 1990; TEWG 1998). For decades, incidental capture in shrimp trawls was considered to be the largest source of human-related mortality of Kemp's Ridley sea turtles (Magnuson et al. 1990; NMFS et al. 2011). To decrease sea turtle mortality, mandatory use of Turtle Excluder Devices (TEDs) began in USA Gulf of Mexico waters in 1990 (Caillouet et al. 1996; TEWG 1998), but regulations were challenged and TEDs were not required throughout the year, inshore and offshore until 1994 (Lewison et al. 2003). The threat of shrimping was reduced, but a correlation between Gulf shrimping effort and sea turtle strandings on Texas beaches continued (Caillouet et al. 1996; Shaver 1994, 1995b, 1996c, Lewison et al. 2003). Virtually all of the head-started turtles imprinted to Padre Island were released before mandatory usage of TEDs (Caillouet et al. 2015). Caillouet et al. (1995a) reported tag returns for these turtles, estimated mortality rates, and predicted that few would survive to adulthood (i.e., at least 10 y of age). During two program reviews of head-starting, Wibbels et al. (1989a) also concluded that the shrimping-induced mortality rate of wild and head-started Kemp's Ridleys was so high that few head-started turtles were expected to reach maturity, and Eckert et al. (1994) agreed that mortality rates associated with trawling were likely high.

Annually, from 1986–2014, more adult Kemp's Ridley Turtles (SLCL > 60 cm) were found washed ashore (stranded) dead in Texas than in any other state in the USA, even though they forage in and migrate through nearshore waters of several other USA states (Renaud et al. 1996; Shaver 2005; Shaver and Rubio 2008). Strandings became elevated and concentrated on south Texas Gulf of Mexico beaches in the mid-1990s and peaked at 37 adults found stranded in 1998. Noting the large number of dead adults found stranded on south Texas beaches, the site of the reintroduction effort and of most Kemp's Ridley nests documented in the USA, several environmental groups and biologists recommended creation of a marine reserve or area closed for commercial fishing (Plotkin 1999; McDaniel et al. 2000; Shore 2000). In August 2000, TPWD passed a regulation that closed nearshore south Texas Gulf of Mexico waters to shrimp trawling during the Kemp's Ridley mating and nesting seasons (Lewison et al. 2003; Shaver 2005; Shaver and Wibbels 2007). After passage of this regulation, strandings of adult Kemp's Ridleys decreased slightly and remained stable in south Texas, despite the increasing number of Kemp's Ridleys nesting annually and likely traveling through this area to migrate between nesting beaches in Texas and Mexico and foraging grounds. This closure has likely contributed to the increase in nesting documented in Texas during the 2000s (Shaver 2005; Shaver and Wibbels 2007).

The numbers of head-started turtles nesting in Texas also may have been reduced because some of these turtles nested elsewhere in the USA, but this hypothesis is not supported by tag returns (Shaver and Wibbels 2007). From 1989–2014, 118 Kemp's Ridley nests were found in the USA outside of Texas. Bowen et al. (1994) suggested that those nesting turtles found during the late 1980s and early 1990s could have been head-started since there were no previous confirmed records of Kemp's Ridleys nesting in the USA outside of south Texas. Those nesters examined directly or through photographs did not possess any observable head-start tags, although some could have been from the earliest year-classes that were released without living tags. However, the 118 nests were not concentrated around sites where head-started yearlings were released in the late 1970s (e.g., Homosassa and Florida Bay, Florida). The largest number were found in Escambia County, in the Florida Panhandle (n = 28 nests), which is distant from the release sites and a relatively low area for Loggerhead nesting. Through 2014, no head-start nests have been confirmed in the wild outside of Texas and Tamaulipas.

Age of the turtles may have limited the numbers of head-start nests that have been documented, especially when early reviews occurred. As stated above, these reviews occurred before sufficient time had elapsed for adequately marked head-started Kemp's Ridleys to have matured and nested in the wild and before monitoring efforts at PAIS were sufficiently robust to detect them. Some of the RN imprinted head-starts from the latest year-classes may not be mature yet.

To date, more nests have been documented from Padre Island imprinted head-starts than from RN imprinted head-starts. However, more RN imprinted head-started individuals have been documented and nearly all of the factors listed above increase the likelihood that nests from RN imprinted head-starts will ultimately outnumber nests from Padre Island imprinted head-starts. Overall, RN imprinted head-starts are younger than Padre Island imprinted head-starts, more of them are still maturing and recruiting into the nesting population, and a higher percent of them are females. There may be a higher survival rate for RN imprinted head-starts since all Padre Island imprinted head-starts were released prior to mandatory use of TEDs, whereas most of the RN imprinted head-starts were released after. And, as a group, more RN imprinted head-starts were tagged with permanent tags. All received living tags and many received PIT tags, whereas only some of the Padre Island imprinted head-starts received living tags and few received PIT tags.

Distribution and trends in nesting.——The preponderance of Kemp's Ridley nests that have been documented in the USA since 1979 (93.4%) have been in Texas. From 2000–2009, Kemp's Ridley nesting increased exponentially on the Texas coast and in Mexico (Heppell et al. 2007; Crowder and Heppell 2011; NMFS et al. 2011; Caillouet et al. 2014), but annual numbers of nests found leveled and decreased from 2010–2014 (Fig. 3). The numbers of nests recorded in Texas could have been influenced by changes in intensity of monitoring and public education (Shaver 2005, Shaver and Wibbels 2007), but these trends were also found when the annual number of nests found was standardized for patrol effort. The numbers of nests documented in Texas represent minimum estimates of nesting. It can be difficult to locate Kemp's Ridley nests, especially in remote areas and during high winds. Nests could have been missed, as evidenced by the 25 *in situ* nests that were unknown to biologists at egg laying and were opportunistically found later by patrollers, others working on the beach, or the public. There were possibly other nests that failed to hatch or hatched in remote areas that were never enumerated.

Most of the 1,667 nests confirmed in Texas from 1979–2014 (87.5%) were within the documented historic nesting range for the species in the USA, which extends from Mustang Island southward to the USA/Mexico border, excluding Corpus Christi Bay. Nests were documented on the Texas coast north of Mustang Island starting in 2002, when the first RN imprinted head-starts were found nesting. The remaining 12.5% of nests, which were outside the documented historic nesting range, were on the shoreline of Corpus Christi Bay and about 2/3 of the Texas Gulf of Mexico coastline, extending from San Jose Island to the Texas/Louisiana border.

During 1979–2014, 52.4% of the USA nests were at PAIS. Even dating back to the historical records, the largest numbers of Kemp's Ridley nests found in the USA were found at PAIS (Shaver and Caillouet 1998, Shaver 2005). Little Shell and Big Shell, now preserved within the boundaries of PAIS, were specifically mentioned as nesting areas in historical accounts (Carr and Caldwell 1958; Carr 1967; Hildebrand 1963). Carr et al. (1982) thought that these areas might be preferred as nesting sites over others because of characteristics of sediment and coastal currents, or that turtles survived in these areas due to limited human activity there. Ogren (1989) and Putman et al. (2010) concluded that currents off the Texas coast would not be conducive for development of a Kemp's Ridley nesting colony. However, Putman et al. (2010) considered the Texas coast as one nesting zone and there are variations in shelf width and current patterns along the hundreds of miles of Texas coastline, with a deeper water approach offshore from Little Shell and Big Shell. One of the authors (DJS) has observed that hatchlings are swept into the Gulf of Mexico more rapidly in Little and Big Shell than at some other areas of PAIS. Putman et al. (2013) predicted successful dispersal of hatchlings from locations where they were released at PAIS, Tamaulipas, and Veracruz during 2009, 2010, and 2011. PAIS is the only location on the Texas coast where nests from all five sea turtle species occurring in the Gulf of Mexico have been found. More nests from the other four species have been found at PAIS than in the rest of the state combined. PAIS is the only location in Texas where Hawksbill (*Eretmochelys imbricata*) and Leatherback (*Dermochelys coriacea*) nests have been recorded, and is one of only two locations (i.e., North and South Padre Islands) in Texas where Green Turtles nests have been documented. Most of the Green Turtle and all of the Leatherback nests were in Little Shell and Big Shell (Hildebrand 1963, 1982; Shaver 2000). Relatively few nests from these other four species have been recorded, but there has been less effort to search for nesting before and after the Kemp's Ridley nesting patrol season in Texas (April through mid-July), when some of these other species nest.

Origins of nesting turtles in Texas.——Based on tag returns through 2014, Kemp's Ridleys currently nesting in Texas have been a mixture of Padre Island imprinted head-started turtles, RN imprinted head-started turtles, and turtles from the wild stock, which predominated. Turtles that were identified as wild stock could be head-started turtles that had lost their tags and thus were no longer identifiable as head-started. They could also be survivors or descendants from: (1) *in situ* nests on the Texas coast; (2) nests protected in the incubation facility or corrals on the Texas coast (including 63 turtles from a nest laid at PAIS in 1985 that were head-started and released, and offspring from known head-start nests); (3) hatchlings from the PAIS reintroduction project that escaped into the Gulf of Mexico off PAIS during release from 1978–1988 (n = 287) or were intentionally released there in 1980 (n = 810); (4) hatchlings from a reintroduction project that transported eggs from RN to South

Padre Island, that were released into the Gulf of Mexico off South Padre Island from 1963–1967 (n = 1,227) (Francis 1978; Burchfield 2005); (5) nests elsewhere in the USA; or (6) nests in Mexico. Although any of these are possible, based on the numbers of turtles released it is most probable that the turtles classified as wild stock nesters in Texas have originated from the millions released in Mexico over the years. However, Kemp's ridley is a native nester in south Texas and it is also likely that offspring from Texas *in situ* nests throughout time, as well as hatchlings released from the incubation facility and corrals in Texas since 1979 have survived and nested. With an average of 12 yr to maturity (NMFS et al. 2011), females released from the incubation facility starting in 1979 would have matured and started nesting as early as 1991. Those released from head-start nests would have a multiplicative impact over the years (Caillouet et al. 2015), but since they were not marked their contributions will be difficult to track. Research is on-going to link nests of unknown maternity to known nesting wild and head-started turtles in Texas using microsatellite and kinship analysis (Frey et al. 2008, 2014). Nests are being successfully matched to known genetic stock of mothers, and incorporation of these findings will expand the number of nests that can be conclusively linked to some of the head-started and wild turtles previously documented. Continuation of this on-going analysis will help to quantify the contribution of offspring from head-started and wild turtles to the overall population increase. Genetic fingerprinting can represent a very important tag to investigate a variety of questions.

At least one of the wild stock nesters successfully recruited into the Texas nesting population from a distant developmental habitat on the Atlantic coast; this turtle was found stranded in Massachusetts, rehabilitated and released, and documented at a typical nesting size (60.7 cm SLCL). A few such events have previously been recorded on the nesting beach in Tamaulipas, but this is the first one documented nesting in Texas of the more than 1,000 juvenile Kemp's Ridleys that have been tagged and released after stranding and rehabilitation, or in-water capture on the Atlantic coast of the USA. This nest record also provides more evidence that Kemp's Ridley Turtles occurring along the Atlantic coast of the USA may not be waifs and lost to the population, as was once hypothesized.

The origins of turtles nesting varied geographically along the Texas coast, based on those that were examined for tags from 1986–2014 (Shaver 2005). From 1986–2014 collectively, RN imprinted head-start nests predominated on the upper Texas coast, which is outside the documented historic nesting range, and wild stock nests predominated in south Texas, which is within the documented historic nesting range. At PAIS, the majority of nesters examined were from the wild stock. Padre Island imprinted head-starts produced a portion of the nests at PAIS, but a decreasing proportion over time; a few RN imprinted head-starts were also found nesting there.

There is a slight chance that imprinting location was categorized incorrectly for seven head-start turtles that did not possess PIT or metal tags. Living tag locations on these turtles had been used for turtles from two different year-classes or imprinting locations. Included are three turtles mentioned above (see ***Age and size at maturity in the wild and fecundity***) that had living tag locations used for two year-classes that were imprinted to different locations. The three were documented nesting at PAIS one, two, and three times, and categorized as Padre Island imprinted head-starts from the 1984 and 1987 year-classes, but could have been RN imprinted head-starts from the 1995 and 1997 year-classes. However, none possessed PIT tags which had been used to mark the later year-classes. The other four turtles were from year-classes with more than one imprinting location within those year-classes. The single representative of the 1983 year-class was recorded nesting once and categorized as a Padre Island imprinted head-start, although it is slightly possible that it was a RN imprinted head-start since both Padre Island imprinted head-starts (n = 172) and RN imprinted head-starts (n = 18) were released from that year-class. Also, the three head-starts from the 1988 year-class recorded nesting were categorized as Padre Island imprinted head-starts, but there is a slight chance that they originated at CAY since both Padre Island imprinted head-starts (n = 794) and CAY imprinted head-starts (n = 14) were released from that year-class. Among these three was the only Padre Island imprinted head-start documented nesting on the upper Texas coast, and this was its only recorded nest in Texas. The other two head-starts from the 1988 year-class were documented nesting at or near PAIS six and 10 times. Due to these nesting patterns, perhaps the upper Texas coast nester was CAY imprinted, but the two south Texas nesters were Padre Island imprinted. Head-started turtles released from the 1987 year-class included both Padre Island imprinted (n = 1,100) and CAY imprinted (n = 130), but turtles from CAY did not receive living tags, thus the 1987 year-class turtles recorded nesting must have been correctly categorized as Padre Island imprinted (Anonymous 1999). Even if the imprinting locations categorized for some of these seven turtles were changed, this would not substantially alter conclusions of the geographic distribution analyses just described or implications for re-introduction and head-starting described below.

Nesting locations in relation to imprinting, rearing, and release sites.——Head-started turtles were documented nesting at several locations. It is recognized that tag returns are not an unbiased means to draw conclusions regarding distribution of nesting (Mrosovsky 2007). However, identifying potential factors influencing the distribution of these head-start nests could provide insight into homing of these animals and guidance for others that might attempt to undertake sea turtle reintroduction projects in the future. Isolating potential causes for nest distribution is complicated by variations in imprinting locations and release sites (including sometimes within a year-class), and the same factors that limited detection of nestings by head-started turtles (see ***Factors limiting reintroduction and head-starting returns***).

Imprinting activities were not planned as an experiment to test the imprinting hypothesis, but aimed to imprint the turtles to PAIS (for the Padre Island imprinted turtles) or RN (for the RN imprinted turtles) before they were head-started, and results can be evaluated indirectly in relation to the imprinting hypothesis (Caillouet et al. 2015). Natal homing is widely recognized as being important in nesting beach selection (Meylan et al. 1990a) and may be accomplished through imprinting (Owens et al. 1982) and orientation and navigation in relation to inclination angle and total intensity of the earth's magnetic field (Putman and Lohmann 2008; Lohmann et al. 2013) or influences of surface circulation (Putman et al. 2010). Sea turtles developing in the egg, entering the surf for the first time, and/or swimming away from the nesting beach may imprint on one of the elements of the magnetic field at their natal beach and use this information to return to that area to reproduce years later. Orientation in relation to the earth's magnetic field through magnetic imprinting may help turtles get to the general area offshore from their natal beach and then they could use other local cues to fine tune home to the specific site (Putman and Lohmann 2008). Magnetic imprinting of hatchlings and homing related to surface circulation may have occurred for some turtles that successfully returned to nest at their imprinting sites. However, since head-started turtles were not allowed to swim away from their imprinting sites as hatchlings, magnetic imprinting and natal homing could have been disrupted for some (Zug et al. 1997) and they may have used these or other cues to return to their rearing and/or release locations. Alternatively, navigation to the nesting beach may have been influenced by social facilitation (Hendrickson 1958), quasi random wandering (Mrosovsky

2007), and/or other factors. None of these factors alone seems to explain the distribution of nests found, and multiple factors may have been influential.

Some head-started turtles may have been successfully imprinted to their imprinting sites. If magnetic imprinting and navigation are more powerful forces than surface circulation at yearling release in determining nesting sites to which head-started Kemp's Ridleys returned as adults, then most turtles should have returned to their imprinting sites. Initial evidence supporting that Padre Island imprinted head-started turtles may have been successfully experimentally imprinted was gathered for 4 mo old hatchlings during multiple choice laboratory studies conducted in the early 1980s (Grassman et al. 1984; Owens et al. 1986; Grassman 1993). Returns of Padre Island imprinted head-starts do not verify that imprinting occurs in sea turtles, but some of these data are consistent with the imprinting hypothesis (Shaver and Wibbels 2007); 95.7% of the documented nests (n = 66 of 69 nests) for Padre Island imprinted head-starts were at or near their imprinting site. However, only 10.9% of the nests (n = 7 of 64 nests) documented for RN imprinted head-starts were at or near RN. Of the two imprinting groups combined, 53.4% of the nests (n = 55 of 133 nests) were documented at PAIS, which is not surprising since 56.4% of the head-started Kemp's Ridley yearlings released were imprinted to PAIS. However, the fact that 43.6% of the head-started Kemp's Ridley yearlings released were imprinted to Mexico but only 6.0% of the head-start nests (n = 8 of 133 nests) were documented at RN suggests that efforts to search for, detect, and document head-started Kemp's Ridleys at RN have not been comparable to those at PAIS, forces that might have guided them toward RN were exceedingly weak, or both. It is possible that many more RN imprinted head-starts returned to Mexico to nest, but this cannot be ascertained and we are left only with existing records to draw inferences from the data.

Release site may have influenced nesting location for some of the head-started turtles. Scott et al. (2014) concluded that adult sea turtle migrations are directly influenced by their past experiences as hatchlings drifting in ocean currents. If surface circulation to which the head-started yearlings were exposed at release was a more powerful force in determining the nesting sites to which they returned as adults, then they should have nested near their release sites. All release sites for the turtles documented were distant from RN. Padre Island imprinted head-starts that were documented nesting had all been released offshore from North Padre Island or Mustang Island as yearlings and all of their recorded nests were on North Padre or Mustang Island except one on the shores of a nearby bay, one on the upper Texas coast, and one at RN. Considering all year-classes of RN imprinted head-starts collectively, there were three clusters of nesting, including at or in the vicinity of Galveston Island (n = 35 nests), PAIS (n = 23 nests), and RN (n = 7 nests). The 1993 year-class was the only RN imprinted head-start year-class (after adequate marking in 1983) in which some of the individuals were released off North Padre or Mustang Island, and in which all nests were recorded at PAIS. This could provide evidence that release site was influential for some. However, the sample size of returns was low for that year-class (n = 2 nests). All other RN imprinted head-start year-classes after 1983 were released off Galveston. The slightly higher numbers of RN imprinted head-starts nesting at and near Galveston could indicate a return to release locations there. Additionally, all nests documented from the 1995 and 1997 year-classes were on Galveston Island, but the sample size was low (n = 1 nest) for each year-class. However, several nests from RN imprinted head-starts were distant from their release sites. Magnetic navigation and the influence of surface circulation at release sites may act synergistically.

Mrosovsky (2007) proposed that Padre Island imprinted head-started turtles may have returned to nest at and near PAIS as a result of range expansion and quasi random wandering, rather than through imprinting. He suggested that head-started turtles released at or near PAIS might disperse upon entering the seas, but if movements were not in any particular direction, more might find themselves in the general vicinity of PAIS when they reach maturity and may nest on the nearest available shore. The nests found at and near PAIS from the Padre Island imprinted head-starts and the 1993 year-class RN imprinted head-starts released off North Padre and Mustang Island would be consistent with this hypothesis, but would not be a range expansion since PAIS is within the documented historic nesting range of the species. The nests at the Galveston nesting cluster from RN imprinted head-starts released off Galveston would also be consistent, but in this case it would be an expansion of nesting range beyond the documented historic records. However, the three Padre Island imprinted head-start nests and 28 RN imprinted head-start nests in the USA and Mexico that were not at the release sites (23.3% of all head-start nests) would not be consistent with the hypothesis. This wandering could have occurred for turtles from early year-classes released near Florida, but the nests in Florida are distributed widely on the Gulf and Atlantic coasts and not in the proximity of the release sites.

Some RN imprinted head-starts could have returned to nest near where they were reared. All head-started turtles were reared in Galveston and 35 nests were found in that vicinity. However, despite also being reared in Galveston, only one Padre Island imprinted head-start was documented nesting at or near Galveston.

Another factor such as social facilitation may have also been influential. Hendrickson (1958) proposed social facilitation as a mechanism influencing orientation of females to the nesting beach, whereby neophyte turtles follow experienced turtles to the nesting beach, and after a favorable nesting experience, fix on that site for future nestings. Although this hypothesis has been largely dismissed for sea turtles (Meylan et al. 1990a), this behavior may occur in Kemp's Ridley which nests in arribadas, or when other navigation mechanisms have been disrupted such as could be the case for the head-started turtles, and may not be restricted to inexperienced females. Two Padre Island imprinted head-start nests and 28 RN imprinted head-start nests were not at the rearing or release sites, including one Padre Island imprinted head-start nest on the shoreline of Corpus Christi Bay, 21 RN imprinted head-start nests at the PAIS nesting cluster, and eight head-start nests (one Padre Island imprinted and seven RN imprinted) at the RN nesting cluster. Of these, only the seven RN imprinted head-start nests at the RN nesting cluster were at their imprinting location. Nesting on the shoreline of Corpus Christi Bay could have been the result of an error in navigation since Corpus Christi Bay is directly inland from release site offshore from Mustang Island. However, the PAIS and RN nesting clusters are also the epicenters for nesting by wild turtles in the USA and Mexico. Homing abilities of these head-started turtles may have been disrupted due to varied imprinting, rearing, and release sites, and in the absence of homing ability these turtles followed other turtles to the nesting epicenters. For that matter, some of the head-started turtles that returned to their imprinting, rearing, or release sites could have also been drawn into their nesting locations by following other turtles nesting there. Additionally, since nesting had not been confirmed on the upper Texas coast until 2002 when RN imprinted head-start turtles started nesting there, wild turtles may have been drawn into nesting at and near Galveston by head-started turtles nesting there.

Site fidelity recorded for wild and head-started turtles documented nesting in Texas was similar, which could indicate that similar forces may have influenced the distribution of their subsequent nest sites. Head-started turtles exhibited fidelity to nesting on the Texas coast, with individuals recorded nesting up to 10 times. From 1979–2014, 43.4% of head-started and 45.8% of wild turtles were documented nesting more than once. In Texas, the longest nesting record for a head-started turtle was 11 yr and for a wild turtle was 13 yr. Additionally, nest site fidelity for the recaptured turtles was similar and high, with 91.3% of head-started and 95.1% of wild turtles returning to the same or nearby Texas beaches for subsequent nesting. The three head-starts that were documented nesting on different nesting beaches were 1992 year-class RN imprinted head-starts, which were released off Galveston. One of the three nested in south Texas and then Tamaulipas (near the imprinting location). This is similar to the eight wild individuals recorded nesting in different areas, which were south Texas and Tamaulipas. The other two head-started turtles nested in south Texas and then on Galveston Island (near the rearing and release locations), and included the first individual recorded using distant nesting beaches within Texas. There are several examples of individual female sea turtles nesting on widely separated beaches (see Mrosovsky 2007). For both head-stared and wild Kemp's Ridleys, instances of low site fidelity could be due to nesting habits of the species. Sometimes Kemp's Ridley Turtles travel long distances during the inter-nesting interval (Shaver and Rubio 2008). They typically nest during specific weather conditions and wait for those conditions to develop. Occasionally, when appropriate weather conditions arise, perhaps in the presence of other turtles, they may come into nest where they are and it is a different location than where they nested previously. Mrosovsky (2007) used examples of individuals nesting on multiple beaches to support his hypothesis of random wandering and conclusion that choice of nest site is not ineluctably determined by experiences at an early stage of development. However, just because site fidelity occasionally does not occur, this does not mean that imprinting never occurs.

With more years of data collection, nesting patterns and factors affecting nest distribution may become more evident. Padre Island imprinted head-starts are aging and it is uncertain how many more will nest in the future. However, since RN imprinted head-starts are mostly female, and those in the later year classes are still maturing, more nesting records are likely for them in the future.

Success of reintroduction effort.——The reintroduction effort should be evaluated separately from head-starting. The reintroduction effort was the original intent of the project planners and head-starting was introduced to support the reintroduction effort. Head-starting continued for 12 years after egg shipment from RN to PAIS ended in 1988.

The reintroduction effort has shown signs of success. A nesting colony is being formed at PAIS, which was the initial and primary goal of the KRREP. In 2009 and 2011, 117 Kemp's Ridley nests were documented at PAIS which is 16.7% of what the Kemp's Ridley annual nest count had been reduced to at its lowest recorded point in 1985. Nesting increased exponentially through 2009 and that increase would have been less had the reintroduction effort not occurred. Nesting by Padre Island and RN imprinted head-starts contributed to the increase in nesting that occurred at PAIS. The Padre Island imprinted head-starts were intended to return to PAIS, and 62.3% of their documented nests (n = 43 of 69 nests) have been there. From 2003–2014, fewer than 20% of the nests found annually at which the nester was examined (and was not RN imprinted head-start) were linked to Padre Island imprinted head-starts. Wild stock turtle nests predominated. Confirmed Padre Island imprinted head-starts produced a decreasing portion of the documented nests at PAIS over time.

The 43 Padre Island imprinted head-start nests documented at PAIS is a minimum estimate of the contribution of these nesters to the population nesting there. Additional nesting by Padre Island imprinted head-starts must have occurred, but is difficult to quantify because nesting turtles were not examined at nearly half the nests, some nesters examined could have been misclassified as wild, and some nests may have been missed. Additionally, hatchlings produced from head-start nests are not being marked.

How much the reintroduction project elevated nesting is also difficult to quantify because the baseline historic nesting levels at PAIS are uncertain and nesting numbers increased rapidly in Texas and Mexico through 2009. Arribadas are beginning to form at PAIS, and perhaps are being restored there, as they are at a few beaches in Mexico other than RN where they likely occurred historically (Carr et al. 1982). This reintroduction effort will remain difficult to evaluate due to the confounding factors (Dodd 1985; Godfrey and Pendrono 2002; Mrosovsky 2007). Dodd and Seigel (1991) define success of a repatriation project as establishment or enhancement of a viable, self-sustaining population, although determining this for a population can be difficult (Burke 1991). Monitoring to detect and protect nesting by Kemp's Ridley Turtles and evaluate results of the re-introduction effort should continue at PAIS and on other beaches in Texas and Mexico.

Although only 62.3% of the nests documented from Padre Island imprinted head-starts were at PAIS, another 33.3% (n = 23 of 69 nests) were on nearby beaches north of PAIS, and close enough to PAIS that wild and head-started individuals often use both areas for nesting. Some nests were only a few km from the northern beach boundary of PAIS; the imprinting site for these turtles was at the northern part of PAIS. However, three nests recorded were clearly outside the intended target. One of the nests was near RN, which did not contribute to the reintroduction effort at PAIS, but was at the nesting epicenter in Mexico. The second nest was on the shoreline of Corpus Christi Bay and was the first Kemp's Ridley recorded nesting on a bay shoreline in Texas. Had eggs been left to incubated *in situ* and successfully hatched, fewer hatchlings would have likely survived due to increased predation in the calmer, clearer bay waters and difficulty of exit from the bay and into Gulf of Mexico currents that are important for hatchling dispersal (Putman et al. 2010). The third nest was located near Galveston. Many more RN imprinted head-start nests were recorded away from their intended site at RN, but these will be discussed below (see ***Success of head-starting effort***) since the reintroduction effort did not aim for them to become part of the PAIS nesting colony, although some have.

Success has also been achieved in other ways. The Action Plan for the reintroduction project (NPS et al. 1978) initiated USA participation in Kemp's Ridley recovery efforts on the nesting beach in Mexico. The bi-national work at RN continues and has been vital to restoration efforts for this imperiled species.

A great deal was learned about the basic biology of Kemp's Ridley Turtles during the KR-REP (Plotkin 2007). The reintroduction effort provided new and important information and technologies, particularly regarding incubation temperatures and sex ratios which could not easily be studied in any other way at the time due to permitting and logistical considerations. The reintroduction effort served as a platform to educate the public about the plight of Kemp's Ridley at a time when the population was diminishing and reached its lowest nesting level of 702 nests, recorded in 1985 (Phillips 1989; Allen 1990, 1992). PAIS is visited by people from across the USA and around the world. Through the years, the public has had an opportunity to learn about recovery efforts for this endangered species first-hand during visits to PAIS or through educational products and extensive media coverage that the effort at PAIS has received (Caillouet 2006). Through the 1980s and early 1990s, public education about Kemp's Ridley Turtles was particularly important as controversial TED regulations were developed and implemented (Weber 1995). Use of TEDs in shrimp trawls increased survival of Kemp's Ridleys (TEWG 1998; Lewison et al. 2003; Heppell et al. 2007).

The reintroduction effort was an important factor that led TPWD to close south Texas nearshore waters to shrimp trawling during the entire Kemp's Ridley mating and nesting seasons starting in 2000. Prior to this regulation, strandings of adult Kemp's Ridleys were elevated in this area. Agencies and the public were concerned and supported this closure to help protect the secondary nesting colony (Plotkin 1999; Shore 2000). After the closure was instituted, Lewison et al. (2003) estimated that it would likely reduce mortality of adult Kemp's Ridleys by up to 39% and protect the secondary Kemp's Ridley nesting beach to safeguard the population should a catastrophe affect the primary nesting beach in Rancho Nuevo, Mexico. The closure likely benefitted turtles nesting in south Texas (Shaver 2005) and the overall Kemp's Ridley population since many Kemp's Ridleys migrate travel through those waters when transiting between nesting and foraging sites (Renaud et al. 1996; Shaver et al. 2005; Shaver and Rubio 2008; Shaver et al. 2013).

The cost-effectiveness of the reintroduction and head-start efforts eventually came under question (Woody 1991; Taubes 1992; Anonymous 1993; see Shaver and Fletcher 1992; Wibbels 1992 for rebuttals). However, conducting a cost-effectiveness or risk analysis to evaluate the reintroduction effort (Burke 1991) would also be difficult because many agencies participated and no compilation of costs was called for in the initial planning (NPS et al. 1978; Caillouet et al. 2015). NPS, FWS, NMFS, TPWD, INP, and other agencies expended funds for various aspects of this work, but these activities were often interwoven with other activities conducted for this and other species. NPS activities to incubate the eggs and transfer the hatchlings to Galveston cost a few thousand dollars each year from 1978–1988 (Shaver and Fletcher 1992), in comparison to much higher costs to head-start these turtles annually. In retrospect, the reintroduction effort would have been less expensive and perhaps less controversial without head-starting, but results would never have been known since the technology for mass tagging of Kemp's Ridley hatchlings had not been developed yet (Pritchard 1979; Higgins et al. 1997).

NPS et al. (1978) recommended imprinting Kemp's Ridley hatchlings to RN as well as to PAIS. In hindsight, had all the head-started turtles been imprinted to PAIS and released offshore from North Padre Island, more may have returned to nest at PAIS and fewer would likely have nested at unintended sites, thereby increasing the success of the reintroduction efforts. It would have likely reduced the scatter of nesting, thereby making detection and quantification of results easier. It would have also reduced confounding variables that complicate evaluation of the reintroduction and head-starting efforts (see ***Success of head-starting effort***.).

A nesting colony is growing at PAIS, aided in part by the reintroduction effort. Results from this project indicate that transplanting eggs and releasing hatchlings on beaches where the intent is to reintroduce or bolster a nesting colony can be at least modestly successful. However, these techniques remain experimental and should only be under undertaken after careful evaluation (Godfrey and Pendrono 2002).

Incubation of eggs from nests found in Texas.——All Kemp's Ridley nests found at egg laying on the Texas coast from 1979–2014 were protected to enhance recruitment, similar to the protocol in place and used at RN for more than four decades. Those procedures of protecting virtually all eggs in corrals and all hatchlings during release substantially increased their survival rate, which saved Kemp's Ridley from extinction and contributed to the exponential increases in nesting documented through 2009 (Heppell et al. 2005, 2007; Heppell 1997; Márquez-M. et al. 2005; NMFS et al. 2011). Most nests found in Texas have been protected at PAIS to continue the reintroduction effort. Protection of eggs within the incubation facility and corrals in south Texas has resulted in high hatching success. Emergence success for eggs held in the incubation facility and corrals (i.e., approximately 81%), was at least 20% higher than for *in situ* nests documented in Texas. Additionally, hatchlings were protected during release from the incubation facility and corrals, whereas hatchlings emerging from *in situ* nests were not and several died before entering the surf. At RN, an estimated 87% of the hatchlings that emerged from *in situ* nests that were not lost to erosion during 2009–2012 made it to the water (Bevan et al. 2014). From 1979–2011, eggs from the Texas coast produced an estimated 70.8% female, which is between the estimated 64% female produced from the nesting beach in Mexico during 1998–2006 and the estimated 76% female produced from corrals in Mexico during 1998–2006 (Wibbels 2007; Thane Wibbels, pers. comm.). Of the 130,847 hatchlings released from 1,667 Kemp's Ridley nests found in Texas during 1979–2014, 9,204 were from 125 nests confirmed from head-started turtles. Hatchlings from 118 of the 120 nests that hatched were released at PAIS. The other two head-start nests were found and protected on South Padre Island, and the hatchlings were released there.

Currently, under permitting from FWS and TPWD, eggs from nests found on Texas beaches north of PAIS are transferred to the PAIS incubation facility and hatchlings are released at PAIS to bolster the nesting population there. The need for a secondary nesting colony (NPS et al. 1978; Woody 1986, 1991; Dodd 1985) has not ended (Caillouet 2005, 2006). Threats continue and the Kemp's Ridley population is still endangered (NMFS et al. 2011). Kemp's Ridley is the only sea turtle species with one RMU (Wallace et al. 2010), which increases their vulnerability to species extinction.

Success of head-starting effort.——Caillouet et al. (2015) and Shaver and Wibbels (2007) review in detail panel evaluations and critiques of the Kemp's Ridley head-starting project, and address their criticisms and recommendations. Here, we use project results to assess the success of head-starting efforts. The 133 nests documented worldwide from head-started turtles (Padre Island and RN) indicate some success of the Kemp's Ridley head-starting effort. These records demonstrated that head-started turtles are able to join wild populations, find their way to nesting beaches, and produce viable offspring, which is a condition that Eckert et al. (1994) stated must be met for head-starting to be considered successful. The reintroduction effort was successful in meeting its original objective of reestablishing a nesting colony of Kemp's Ridley Turtles. Identification of Padre Island imprinted turtles at nesting was possible only because they had been tagged during head-starting.

Kemp's Ridley nesting increased exponentially in Texas through 2009. Documented nesting by some head-started Kemp's Ridley Turtles contributed to the increase, but their relative contribution to this increase is difficult to ascertain (see ***Factors limiting reintroduction and headstarting returns***). The fecundity rate of headstarted turtles has been as high as the fecundity rate of wild turtles, meeting another criterion established by Eckert et al. (1994). Offspring from head-start nests have been released, joined the population, and should have a multiplicative effect over time. However, they have not been tagged and thus are indistinguishable from wild turtles without genetic analyses. The Blue Ribbon Panel suggested an Ultimate Criterion for evaluating success of head-starting was that the proportion of nesting head-started females should increase relative to the proportion of nesting wild females (Wibbels et al. 1989a). However, Eckert et al. (1994) noted the Ultimate Criteria was based on an assumption of continued decline in the population. When the population increased, the proportion represented by headstarted nesters would decline, especially when they were no longer being produced through head-starting. Indeed, the percent of nests documented at PAIS that were from Padre Island imprinted head-starts declined.

One of four milestones that the Natural Research Council's Committee on Sea Turtle Conservation (Magnuson et al. 1990) listed for headstarting to be considered a conservation practice is that some head-started turtles must nest on natural beaches (Meylan and Ehrenfeld 2000). The term natural beaches was not defined, but likely meant beaches where the species would occur naturally. Bowen et al. (1994) suggested that Kemp's Ridleys that nested on the Atlantic USA coast during the late 1980s and early 1990s could have been head-started turtles since there were no previous confirmed records of Kemp's Ridleys nesting in the USA outside of south Texas. Although it could not be substantiated that they were head-started, they voiced concern that if they were head-started, nesting there could have been the result of aberrant behavior, and/or a negative, unintended consequence of head-starting. Of all 133 Kemp's Ridley head-start nests documented, 36 were in unintended areas outside the two imprinting sites and documented historic nesting range of the species. This includes the nest from a Padre Island imprinted head-start on Corpus Christi Beach, which was the first Kemp's Ridley nest recorded on a Texas bay beach.

Nesting on bay beaches would likely reduce contributions of offspring to the population (see ***Success of reintroduction effort***). It also includes 35 nests that were on the upper Texas coast (n = 34 nests) and Matagorda Peninsula (n=1 nest), north of the documented historic nesting range. One might argue that these 35 nests were the result of natural dispersion and nesting range extension of the growing population. However, 34 of these nests are from RN imprinted head-start turtles and nesting had not been historically documented in these areas until 2002, when the first RN imprinted head-start nests were confirmed. Additionally, only one of the 35 nests was from a Padre Island imprinted head-start and relatively few nests from wild turtles (n = 14 nests from 11 wild turtles) have been documented on the upper Texas coast. The intent was for RN imprinted head-starts to return to Mexico to breed, and some have. Thus, nesting of RN imprinted head-starts on the upper Texas coast has been an unintended consequence of head-starting, and at least initially, a human-induced extension of the documented historic nesting range. Wild turtles were first recorded nesting on the upper Texas coast in 2005, a few years after head-started turtles, and could have been drawn into the area to nest by the head-started turtles (see ***Nesting locations in relation to imprinting, rearing, and release sites***). The upper Texas coast is generally more developed and prone to erosion than are the intended imprinting and nesting locations for the head-started turtles at RN and PAIS.

The bi-national program, including reintroduction, head-starting, and Rancho Nuevo operations, was proposed for 11 y, during 1978–1988 (NPS et al. 1978). Head-starting of Padre Island imprinted turtles was to support the reintroduction experiment and of RN imprinted turtles to help compensate for the eggs translocated to PAIS. FWS terminated PAIS imprinting using the justification that the 11 y had passed. However, both head-starting and the work at Rancho Nuevo continued, although the 11 y had also passed for them. We believe that termination of the Padre Island imprinting effort after 1988 was premature. The Blue Ribbon Panel (Wibbels et al. 1989a) concurred with this decision to terminate Padre Island imprinting, stating that it added many extra variables and had the potential to interfere with the effectiveness of head-starting. However, had Padre Island imprinting continued for the 1989–2000 year-classes and the yearlings been released offshore from PAIS, this would have reduced confounding variables that complicate evaluation of head-starting, and likely concentrated nesting by the head-started turtles at the intended imprinting and nesting locations (PAIS and RN), rather than at other areas. The reintroduction effort would have been more successful with the addition of more Padre Island imprinted head-starts, particularly since many of the factors that limited nesting and documentation of nesting by Padre Island imprinted head-starts improved by through time (see ***Factors limiting reintroduction and head-starting returns***).

When evaluating the successfulness of Kemp's Ridley head-starting efforts, the large amounts related research and public education efforts that were conducted should also be considered. Important information and technologies were developed during head-starting, particularly regarding the husbandry of captive sea turtles (Meylan and Ehrenfeld 2000; see Caillouet et al. 2015). The high profile of head-starting enhanced public awareness of the plight of Kemp's Ridley, and the need to conserve all sea turtles. Thousands of school children and adults were educated at the NMFS Laboratory, and Help Endangered Animals Ridley Turtles (HEART) used this visibility to mobilize children and their parents in the cause of sea turtle conservation in Texas and nationally (Caillouet 2006). These individuals vocally supported development of TED regulations, which were controversial, but very beneficial to sea turtle conservation. Some of the head-started turtles were used for TED testing prior to or during their release.

More years of data collection will be necessary to evaluate the long-term success of Kemp's Ridley head-starting efforts. Some head-started individuals are continuing to nest and some may not have matured yet. Efforts must be made to locate, examine, and collect data from Kemp's Ridleys that nest in Texas and Mexico. Even then, full project results will likely never be known due to the myriad of confounding variables and logistical limitations. The demonstration that head-started turtles can reproduce has tempered some judgments against head-starting (Mrosovsky 2007). However, head-starting remains experimental, should not be substituted for protection of sea turtles in their natural habitat, and is not recommended except in extremely rare cases as a last resort, with oversight and animal care standards in place (Meylan ane Ehrenfeld 2000; Mrosovsky 2007; Pritchard 2007; Shaver and Wibbels 2007; see Caillouet et al. 2015).

Acknowledgments.—We thank all of those that contributed to the planning, oversight, and conduct of reintroduction and head-starting of Kemp's Ridley Turtles and associated activities including public education and research. The KRREP was planned before we started working with Kemp's Ridley Turtles. We extend our profound appreciation to Robert Whistler, Roland Wauer, and Henry Hildebrand, who proposed the program during the 1970s. We thank them and the others that helped form and begin the KRREP including Howard (Duke) Campbell, Archie Carr, John Dennis, Hal Irby, Clyde Jones, Edward Klima, Rene Márquez-M. James McVey, Peter Pritchard, Jack Woody, and other members of the Scientific Advisory Board and Agency Coordinating Committee (see Caillouet et al. 2015). We also thank Dearl Adams, Bob Hessling, Keith Hoyt, Ila Loetscher, and others that translocated Kemp's Ridley eggs to South Padre Island during the 1960s, which also helped pave the way for the KRREP. The Mexican government is thanked for donating eggs and hatchlings gathered at RN by Patrick Burchfield, Rene Márquez-M., Peter Pritchard, Roland Wauer, and their staffs from 1978–2000. CITES permitted the importation of eggs and hatchlings into the USA.

Various components of the work were funded and permitted by NPS, NMFS, FWS, TPWD, and INP (and its successor agencies including CONANP and SEMARNAT). Bryan Arroyo, Richard Byles, Kelsey Gocke, Mike Ray, Tom Shearer, Catherine Yeargan, and others aided with FWS and TPWD permitting and support. Work by PAIS personnel was authorized under FWS Permit TE840727-3, TPWD Scientific Permit SPR-0190-122, and NPS Institutional Animal Care Protocols NPS IACUC 2011-15.

Animal Rehabilitation Keep (ARK), City of Corpus Christi, Friends of Aransas and Matagorda Island National Wildlife Refuges (FAMI), Gladys Porter Zoo, HEART/Sea Turtle Restoration Project, National Fish and Wildlife Foundation, National Park Foundation, Natural Resource Damage Assessment (NRDA), Norcross Wildlife Foundation, Sea Turtle, Inc., Shell Oil Company Foundation, Texas General Land Office, TAMUG, Texas Master Naturalists, Unilever HPC-USA, U.S. Geological Survey, University of Alabama at Birmingham, University of Charleston, University of Texas, and others provided assistance or funding for activities in Texas.

Milford Fletcher, Edward Klima, Rene Márquez-M., Peter Pritchard, Jack Woody, and the KRWG provided continuous oversight, guidance, and direction. We thank the many NPS administrators that supported the reintroduction effort at PAIS, and hundreds of NPS employees and volunteers that aided with sea turtle conservation, research, and public education over the years. The U.S. Navy transported hatchlings by aircraft from Corpus Christi to Galveston. We thank Roger Zimmerman, Edward Klima, James McVey, and other NMFS employees that supported and aided with head-starting and associated research. We thank numerous people that assisted with efforts to find, document, and protect nesters, stranded adults, and nests in the USA and Mexico. Carole Allen, Tony Amos, Darrell Echols, Jeff George, Lucia Guillen, Leo Gustafson, Ben Higgins, Don Hockaday, Lyndsey Howell, Christi Hughes, Ashley Inslee, Curtis Jones, Shane Kasson, Shanna Kethan, André Landry, Jody Mays, Sonny Perez, Keith Ramos, Kimberly Reich, Cynthia Rubio, Jeffrey Rupert, Jennifer Sanchez, Erin Seney, Tom Shearer, Jeanine Stewart, Chad Stinson, and others helped lead monitoring and data collection efforts on various Texas beaches. Hundreds of participants of monitoring projects and the STSSN assisted. Allan Chaney, Michael Coyne, Peter Dutton, John Hendrickson, Dave Owens, Thane Wibbels, and others aided with related research efforts.

Special thanks to Andrea Cannon, Ben Higgins, Lyndsey Howell, Christi Hughes, Shanna Kethan, André Landry, Tasha Metz, Kimberly Reich, and Erin Seney who provided nesting data from the upper Texas coast or satellite tracking data for turtles that nested there. Beth Brost, Patrick Burchfield, Russell Burke, R. Bruce Bury, Sandra Cashes, Ken Dodd, Peter Eliazar, Timothy Fontaine, Matthew Godfrey, Gary Hopkins, Jackie Isaccs, Edward Klima, Sandy MacPherson, Anne Meylan, Nicholas Mrosovsky, Mark Nicholas, David Owens, Lorna Patrick, Jaime Peña, Jeremy Phillips, Peter Pritchard, Nathan Putman, Dickie Revera, Michael Rikard, John Stiner, Wendy Teas, Christina Trapani, Roland Wauer, Robert Whistler, Thane Wibbels, Jack Woody, and others provided data, information, literature, and suggestions that aided with the development of our manuscript. We thank Carole Allen, Andrew Guthrie, Ila Loetscher, Mary Ann Tous, and Ted Williams for their long-term support of Kemp's Ridley conservation and public education efforts. Cynthia Rubio and Jennifer Shelby Walker assisted with preparation of graphics for this manuscript. The senior author thanks Stephen Kurtz for training her dog Ridley to aid with nest detection and for his patience and support during long hours of field work and preparation of this manuscript.

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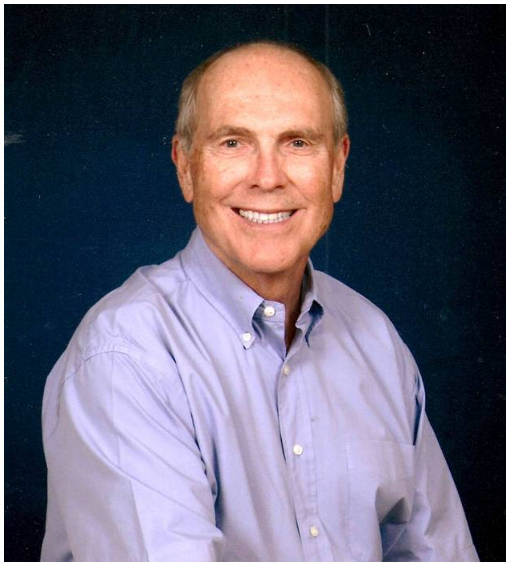
Donna J. Shaver received her B.S. in Wildlife Biology (1981) from Cornell University, M.S. in Biology (1984) from Texas A&I University, and Ph.D. (2000) in Zoology from Texas A&M University in College Station, Texas. Her doctoral research focused on the distribution, residency, and seasonal movements of the Green Sea Turtle in Texas. Dr. Shaver has worked with sea turtles since 1980. She worked with the National Park Service at Padre Island National Seashore from 1980–1993. From 1993–2003, she was Director of the U.S. Geological Survey Padre Island Field Research Station. Since 2003, she has been Chief of the Division of Sea Turtle Science and Recovery for the National Park Service at Padre Island National Seashore. Dr. Shaver is the Texas Coordinator of the U.S. Sea Turtle Stranding and Salvage Network. She is a member of the Kemp's Ridley Sea Turtle Recovery Team, KRWG, and IUCN Species Survival Committee Marine Turtle Specialist Group. Dr. Shaver oversees a variety of sea turtle research and conservation projects conducted in Texas, collaborates with other researchers in the U.S. and Mexico, and provides training and leadership to biologists and volunteers working with sea turtles in Texas and Mexico. Her largest and most long-term effort has been the Kemp's Ridley Sea Turtle Restoration and Enhancement Project at Padre Island National Seashore. She has conducted research on unhatched Kemp's Ridley eggs, sex ratios and incubation temperatures for Kemp's Ridley, sea turtle nesting and strandings in Texas, Kemp's Ridley foraging ecology, and movements and habitat use by adult Kemp's Ridley and juvenile Green turtles. Her work has been recognized with awards from several organizations including most recently the U.S. Fish and Wildlife Service 2013 Endangered Species Recovery Champion Award for Agency Partner, and Harte's Heroes 2014 Legends of the Gulf Award. To date, she has authored or co-authored more than 110 publications and reports dealing with sea turtles. She has been interviewed by numerous media outlets, was featured as ABC World News Tonight's Person of the Week on July 29, 2005, and was named the Corpus Christi Caller Times Newspaper 2011 Newsmaker of the Year on January 1, 2012. http://www.gulfbase.org/person/view.php?uid=dshaver. Photographed by National Park Service.



Charles W. Caillouet, Jr. has a B.S. in Forestry (1959) and M.S. in Game (Wildlife) Management (1960) from Louisiana State University, and Ph.D. in Fishery Biology (1964; minors Statistics and Physiology) from Iowa State University. His doctoral research focused on the relationship between forced exercise and blood lactic acid in Channel Catfish (*Ictalurus punctatus*). During 1964–1967, while an Assistant Professor at University of Southwestern Louisiana (now University of Louisiana Lafayette), he investigated abundance and distribution of postlarval Brown Shrimp (*Farfantepenaeus aztecus*) and White Shrimp (*Litopenaeus setiferus*) in Vermilion Bay, Louisiana. During 1967–1972, as Associate Professor at Rosenstiel School of Marine and Atmospheric Science, University of Miami, he helped establish a commercial marine fisheries statistics collection program for Puerto Rico's Department of Agriculture, conducted statistical analyses and evaluation of sport fishery catch rates in Everglades National Park, and directed and conducted Sea Grant aquaculture research on Pink Shrimp (*F. duorarum*). He was to first to induce maturation in female pink shrimp by eyestalk ablation. As Supervisory Fishery Biologist (Research) and Chief of various divisions and branches at the Galveston Laboratory during 1972–1998, he supervised and conducted research related to biology, population dynamics, and aquaculture of Penaeid shrimp, and head-starting Kemp's Ridley; he also managed environmental impact studies related to petroleum exploration and production, and Strategic Petroleum Reserve salt dome brine disposal. In October 1985, he and Dr. André Landry chaired the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, at Texas A&M University Galveston. In 1988, Dr. Caillouet assisted in drafting IUCN guidelines for use by CITES in reviewing and evaluating sea turtle ranching proposals. In November 1995, he and his staff received a U.S. Department of Commerce Bronze Medal Award for superior federal service related to sea turtle research and related activities. He served on the TEWG (1998), and peer reviewed the draft 5-Yr Review for Kemp's Ridley (NMFS 2007). In 2004, he participated in Stakeholders meetings associated with development of NMFS et al. (2011), peer reviewed an early draft, and commented on a later draft during the public comment period. To date, Dr. Caillouet has authored or coauthored 136 publications and reports. He is an Emeritus Member/Fellow of the American Institute of Fishery Research Biologists, and a member of the IUCN/SCC Marine Turtle Specialist Group. Following retirement in June 1998, he remained engaged in Kemp's Ridley and Penaeid shrimp research as a volunteer. http://www.gulfbase.org/person/view.php?uid=ccaillouet. Photographed by Olan Mills.