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Head-Starting the Kemp's Ridley Sea Turtle, *Lepidochelys kempii*, at the NMFS Galveston Laboratory, 1978–1992: A Review

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ABSTRACT. – We review the Kemp's ridley sea turtle head-start experiment at the National Marine Fisheries Service (NMFS) Galveston Laboratory which was part of an international effort to save this endangered species from 1978 through 1992. During the 15 years of this experiment 22,596 tagged yearling turtles were released into the Gulf of Mexico, of which 878 were recaptured either dead or alive. Through 2000, ten adult head-started Kemp's ridleys have returned and nested; nine at North Padre Island and Mustang Island, Texas (near where they had been experimentally imprinted) and one at the primary nesting beach on the east coast of Mexico near Rancho Nuevo.

KEY WORDS. – Reptilia; Testudines; Cheloniidae; *Lepidochelys kempii*; sea turtle; management; conservation; head-start; review; USA

The Kemp's ridley, *Lepidochelys kempii*, was listed by the U.S. Fish and Wildlife Service as an Endangered species throughout its range in 1970 (Ross et al., 1989; Magnuson et al., 1990; Kemp's Ridley Recovery Team, 1992) and its status has remained unchanged to this date; it is considered Critically Endangered by the IUCN. The Kemp's ridley population declined from 1947 when an estimated 42,000 females nested in one day (Hildebrand, 1963) until 1985 when there was a nesting population of only approximately 500 (Pena et al., 2001). The decline of this species, due primarily to human activities, could be attributed to collection of eggs, fishing for juveniles and adults, killing adults for meat and other products, direct take for subsistence use, and fisheries by-catch (Pritchard, 1980; Ross et al., 1989). In addition to these sources of mortality, Kemp's ridleys have been subject to high levels of incidental take by shrimp trawlers which is believed to have delayed recovery (Caillouet et al., 1991). During the nesting season of 2000 there were 6277 nests recorded at nesting beaches in Tamaulipas and Veracruz, Mexico, including the primary nesting beach located near Rancho Nuevo (Pena et al., 2001). The Kemp's ridley has been reported to nest sporadically from Veracruz, Mexico, to Padre Island, Texas (Márquez et al., 1989), and occasional nesting has been recorded for Florida and the Carolinas. Threats to the nesting beach in Mexico are presently few, but potentially serious. Human population growth and increasing developmental pressure plus human encroachment and access along the entire nesting area is of primary concern and may result in increased threats to the nesting beach.

Since 1977, a bi-national Kemp's Ridley Recovery Program has been directed by the Kemp's Ridley Working Group, including participation by the U.S. Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Instituto Nacional de la Pesca of Mexico, Texas Parks and Wildlife Department, and the Gladys Porter Zoo, Brownsville, Texas. Initially, the program had three main objectives: (1) protect the primary nesting beach at Rancho Nuevo from poachers and predators; (2) establish a second nesting colony at the Padre Island National Seashore (PINS), near Corpus Christi, Texas, by relocating a small percentage of the eggs from Rancho Nuevo; and (3) experimentally head-starting those hatchlings at the NMFS Galveston Laboratory from PINS in an effort to increase the first-year survival which was estimated to be very low in the wild.

Head-starting of Kemp's ridleys was a subsidiary and experimental part of the Kemp's Ridley Recovery Program (Klima and McVey, 1981; Woody, 1986, 1989). Its main purposes were: (1) to increase survival by captive-rearing turtles during the critical first year of life; (2) to establish a nesting colony on Padre Island, Texas, through imprinting (Klima and McVey, 1981; Woody, 1986, 1989; Shaver, 1989, 1990); (3) to develop sea turtle captive-rearing practices (Fontaine et al., 1985, 1989; Leong et al., 1989); and, (4) to study growth and survival in captivity and in the Gulf of Mexico following reintroduction of tagged head-start turtles (Caillouet and Koi, 1985; Caillouet et al., 1986a, 1989, 1993, 1995b). Head-start, in this context, is the practice of rearing hatchling turtles in captivity to a size that may protect them from the high rates of natural predation that would have otherwise occurred in their early months in the natural environment. Our project involved collecting eggs at Rancho Nuevo, incubating them at Rancho Nuevo or Padre Island, Texas (Shaver, 1989, 1990, 2005), exposing the hatchlings to either of these two beaches in an attempt to imprint them, captive-rearing (9–11 months) and tagging the turtles in Galveston and releasing the turtles into the Gulf of Mexico. Of the 25,676 hatchlings received alive from the 1978–92 year-classes, 22,596 (86.7%) were successfully reared, tagged, and released into the Gulf of Mexico at sizes comparable to late-pelagic or early post-pelagic stages in wild Kemp's ridleys (Ogren, 1989). Captive-rearing ended with release of the 1992 year-class but the search continues in south Texas, Mexico, and throughout the range of the Kemp's ridley for head-started turtles washed ashore or nesting (Eckert et al., 1992; Byles, 1993; Williams, 1993; Shaver, 2004).

Likely, prior to the implementation of turtle excluder devices (TEDs), the commercial shrimp fleet killed an untold number of sea turtles each year. Even after implementation of TEDs in the 1990s a correlation has continued between shrimp trawling and sea turtle strandings (Caillouet et al., 1996; Shaver, 1998). Besides shrimp trawls, sea turtles have been taken in pound nets, trawls, gill nets, hook and line, crab traps, and long lines (Manzella et al., 1988a). In addition to their use in the head-start experiment and TED certification procedures, Kemp's ridleys at the Galveston Laboratory have been the subjects of research on physiology (reproductive, respiratory, metabolic, fitness, anesthetic, and submergence), chemical imprinting, tagging, sex determination, temperature-sex relationship, and diseases (Caillouet et al., 1995a).

This paper presents a review of the captive rearing of Kemp's ridley sea turtles at the NMFS Galveston Laboratory during head-starting (1978 through 1992) and continuing efforts to locate, identify, and document adult nesters on beaches in south Texas and Mexico.

METHODS

All Kemp's ridley eggs and hatchlings used in this experiment were obtained at the Rancho Nuevo, Mexico, nesting beach. From 1978 through 1988, 2000 eggs were collected each year from the nesting beach, placed in PINS sand and then transported either by truck or U.S. Coast Guard helicopter to PINS where they were incubated and the resulting hatchlings allowed to crawl down the beach into the surf where they were re-collected and transported by aircraft or automobile helicopter to the sea turtle facilities at the NMFS Galveston Laboratory (Shaver et al., 1988; Shaver, 1989, 2004). In later years, 1989 through 1992, 2000 hatchlings were taken annually from the Rancho Nuevo nesting beach and transported by aircraft directly to the Galveston Laboratory sea turtle captive rearing facilities. The head-start experiment was terminated at the completion of the 1992 year-class rearing season.

The building at the NMFS Galveston Laboratory housing the turtle rearing tanks was constructed of metal framing and its concrete floor was slightly sloped toward drain troughs covered with fiberglass grates (Fig. 1). Incoming seawater flowed through PVC pipes laid in the same troughs that carry waste seawater from the turtle barn and into the City of Galveston domestic sewerage system. Each fiberglass rearing tank was equipped with a seawater supply pipe and an elevated standpipe that maintained the seawater level. The turtles were reared in isolation from each other to prevent incidents of biting, injury, and infections that arise when they are reared in groups (Fontaine et al., 1989; Leong et al., 1989). As hatchlings, the turtles were isolated in small plastic pots placed in groups of four within a plastic crate (Fig. 2). After 60 days, the pots were removed, and hatchlings were redistributed, one per crate (Fig. 3). The crates were bolted together with nylon fasteners into groups of 10 to facilitate handling. Each crate was lined on its four inside walls with high-impact styrene sheeting to prevent both dispersion of food and contact between turtles in adjacent crates. The bottom of each crate was fitted with vinyl-coated wire mesh to allow turtle excrement and uneaten food to sink to the bottom of the rearing tank. The crates were supported by a rack constructed of PVC pipe. When the ridleys were 9–11 months old, they were tagged and released into the Gulf of Mexico or adjacent bays (Caillouet et al., 1987; Fontaine et al., 1993).

If kept beyond one year of age, turtles became too large for the plastic crates and were redistributed into larger vinyl coated wire mesh cages within the rearing tanks (Fig. 4). The wall of each cage was lined with high-impact styrene sheeting, and the bottom was made of vinyl-coated wire mesh. Cages, in groups of two, were supported by galvanized wire hangers or plastic cable ties attached to wooden poles laid across the rearing tank.

While isolation rearing was somewhat confining, the turtles exhibited high survival rate and good health. Except for ridleys used in TED certification in the past, and turtles reared for more than one year in captivity (in some cases, to sexual maturity), captive-reared Kemp's ridleys have not been semi-wild conditioned before release into the wild (Klima and McVey, 1981; Fontaine et al., 1989; Caillouet et al., 1995a). However, an experimental exercise regimen was shown to improve swimming performance in captive-reared ridleys (Stabenau et al., 1992).

The turtles were fed floating feed pellets manufactured by Purina Mills, Inc. (Fontaine et al., 1989; Caillouet et al., 1989). Each turtle received a daily ration based on a percentage of the average body weight of a sample of turtles of the same age. Feeding of newly hatched sea turtles was postponed for up to nine days, to allow time for yolk sac absorption (Fontaine and Williams, 1997). The daily ration for hatchlings was about 2% of the average body weight per turtle and was reduced gradually to about 1% by the time the turtles were one year old. Each turtle was individually fed a daily ration divided into two equal portions, one in the morning and one in the afternoon.

Seawater was filtered through well points buried in the sand off the beach at Galveston as it was pumped from the Gulf of Mexico (Fontaine et al., 1989). It flowed into a concrete-lined sump, where particulate matter was allowed to settle, and then pumped into insulated fiberglass reservoirs. It received no further filtration or chemical treatment, but was heated during winter with thermostat-controlled electric immersion heaters placed in some of the reservoirs. Heated and unheated seawater was mixed to the appropriate temperature before being pumped into the rearing tanks, and the temperature was maintained thereafter by controlling the air temperature within the rearing building, using forced-air heaters during winter and exhaust fans during summer. The

Figure 1. The sea turtle holding tanks within the NMFS Galveston Laboratory sea turtle research facility. The building, of metal frame construction, is 18.3 m (60 ft) wide and 30.5 m (100 ft) long providing a working research area of 557 m^2 (6000 ft^2). Temperature is maintained in the winter with large natural gas blower heaters and in the summer with large blower fans. Unfiltered seawater, pumped from the Gulf of Mexico, is heated and maintained at 28°C in 37,850 liter (10,000 gal) insulated storage tanks. The tanks, constructed of fiberglass, are 5.5 m (18 ft) long, 1.8 m (6 ft) in width, and 0.6 m (2 ft) in depth. Approximately 3028 liters (800 gal) of sea water is maintained in each tank. The water within the tanks is drained and the tanks cleaned three times a week.

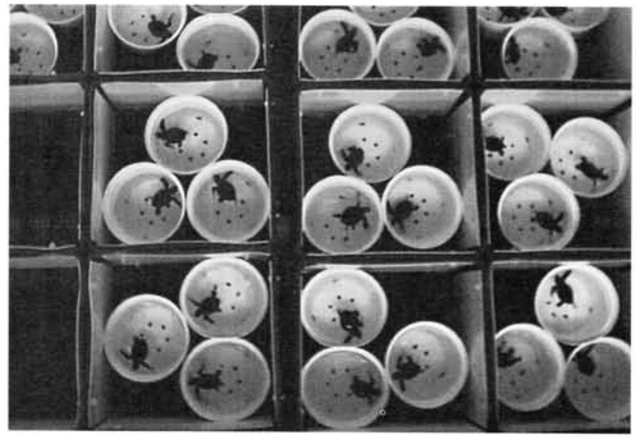

Figure 2. For the first month in the facility, the hatchlings are kept in small plastic flower pots. This method allows for close observation and care for each of the turtles. The flower pots are drilled with holes in the bottom to allow for good water exchange and elimination of uneaten food and waste.

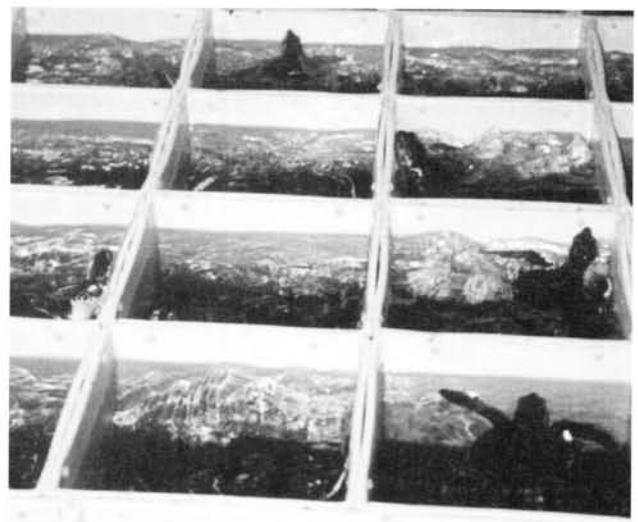

Figure 3. Plastic crates within a sea turtle rearing tank. The turtles remain in this rearing posture for 1 year at which time they are either released into the Gulf of Mexico or placed in larger wire cages (see Fig. 4) for longer growing periods (up to 3 years).

Figure 4. Vinyl-wire cages lined with high-impact styrene plastic. These cages allow captive rearing of sea turtles for up to 3 years of age.

temperature of the seawater in the rearing tanks ranged from 23 to 31°C (73 to 88°F), with a mean near 27°C, and the salinity ranged from 20–39 ppt, with a mean near 31 ppt. Three times per week, rearing tanks were drained and scrubbed to remove uneaten food and turtle waste, then refilled with clean seawater. Once per month, each tank was scrubbed with a high-pressure sprayer to remove algae and other materials adhering to the sides and bottom.

Keeping seawater clean and warm was of major importance to successful rearing and disease prevention in sea turtles. Various fungal infections, both external and internal, that eventually lead to death, occurred if the turtles were reared at temperatures below 20°C (Fontaine et al., 1989; Leong et al., 1989). Whether this situation resulted from detrimental effects of cooler temperatures on the immune system, encouragement of growth of fungi by lower temperatures, or other factors, is not known. Additional diseases and treatments have been described for Kemp's ridleys and loggerheads reared at the Galveston Laboratory (Leong et al., 1989; Robertson and Cannon, 1997). Sick or injured turtles were removed from the rearing building and treated in a separate facility used for quarantine, to avoid exposing healthy turtles to diseases.

Tagging Methods

Most head-started ridleys released into the wild were tagged in four distinct ways: (1) external, metal, fore-flipper tag; (2) external, living tag (plastron to carapace tissue graft); (3) internal, magnetized, coded wire tag; and, (4) internal, passive integrated transponder (PIT) tag (Table 1). The metal fore-flipper tag, the most widely used sea turtle tag, probably is not retained to adulthood (Henwood,

Table 1. Release dates and number of turtles released, for each year-class of NMFS Galveston Laboratory head-started Kemp's ridley sea turtles, 1978–92.

Year-class	Wire-tagged (left)	Wire-tagged (right)	Living-tagged	PIT-tagged	Flipper-tagged	Total
1978	9		1	8	2018	2028
1979					1363	1370
1980			180		1723	1723
1981					1639	1639
1982	12	12	436	12	1324	1336
1983			183		190	190
1984		1041	1041	23	1017	1041
1985	1533		1533		1533	1533
1986	1726		1492	97	1629	1726.
1987	1280		1265	5	1230	1280
1988	910		870	102	808	910
1989	1914		1447	69	1845	1914
1990	1979		1979	1979	1979	1979
1991	1944		1944	1944	1944	1944
1992	1963		1963	1963	1963	1963
Total	13,270	1053	14,334	6202	22,205	22,576

1986). External living tags, internal wire tags, and internal PIT tags show promise as lifetime tags, but require special expertise, equipment, or both, for detection (Fontaine et al., 1989b).

Fore-Flipper Tag. — All head-started ridleys were tagged with metal (inconel or monel) fore-flipper tags before release (Fontaine et al., 1985, 1989a, b; Manzella et al., 1988b). Tags were usually placed on the trailing edge of the right fore-flipper, but left fore-flippers have been tagged occasionally, and in some cases both fore-flippers have been tagged. Fore-flipper tags were Hasco Style, Number 681, manufactured by National Band and Tag Company, Newport, Kentucky. Each tag was engraved on one side with the message "NMFS LAB, VIR. KEY, MIAMI, FL. 33149" and on the other side with a five or six character identification alphanumeric code consisting of letters, numbers, or both.

Living Tag. — Starting with the 1984 year-class, all head-started ridleys were living-tagged before release. The living tag was formed by transplanting a piece of lighter colored plastron tissue into a scute on the darker carapace to create a light mark on an otherwise dark background. Each year, the living tag was applied to a different carapace scute to distinguish year-classes (Caillouet et al., 1986a; Fontaine et al., 1988a).

Wire Tag. — All head-started ridleys were tagged with magnetized wire tags, beginning with the 1981 year-class, in either the right or left fore-flipper before release (Manzella et al., 1988b). All were magnetized before being implanted, but un-magnetized wire tags may be used and magnetized later.

Passive Integrated Transponder (PIT) Tag. — Beginning with the 1990 year-class, all head-started ridleys were tagged with PIT tags placed into the latero-ventral muscle of the left axilla before release. The PIT tag is a tiny microprocessor capable of transmitting (we used either 450 or 120 MHz) a 10-character alphanumeric identification code when scanned by a detector. A turtle can be scanned for the presence of a PIT tag by holding the portable detecting device as close to the skin as possible without touching. Both dorsal and ventral surfaces should be scanned. Several passes should be made with the scanner over the area in question. A PIT tag sometimes will not respond to the scanner on the first pass, so several scans may be needed.

The PIT tag cannot be seen because it is internal. It costs considerably more than flipper tags and wire tags. The portable electronic detecting devices also are expensive. Nevertheless, PIT tags are excellent lifetime tags for sea turtles.

Recovery Efforts

Wild and head-started sea turtles found washed ashore in the U.S. have been documented in conjunction with the Sea Turtle Stranding and Salvage Network (STSSN) (Shaver, 1998). The STSSN also documented individuals reported as being captured incidental to various fisheries operations. A few head-started ridleys have also been documented stranded or incidentally captured in areas outside the U.S.

Efforts to detect nesting by head-started and wild ridley turtles on North Padre Island began in 1986 and those efforts later expanded to additional areas in south Texas (Shaver, 1990, 2005). Nesting turtles and nests have been documented and protected at Rancho Nuevo, Mexico, since 1966, with efforts expanding to additional areas in the states of Tamaulipas and Veracruz during later years (Pena et al., 2001; Márquez et al., 2001). Only a portion of nesting turtles were observed in Mexico and south Texas, but those that were seen by biologists were examined for the various tags used to mark head-started turtles (Shaver, 2005). Efforts to detect and document head-started individuals stranded or nesting will be continued.

RESULTS

Survival and Growth in Captivity. — The survival rate during head-starting for the 1978–92 year-classes combined was 87% (Caillouet et al., 1987) and in the later years was over 90%. Kemp's ridleys readily fed upon the commercial pellets and grew well during the experiment (Table 2). Under the controlled conditions of captive rearing, Kemp's ridleys can grow to an average weight of 1.26 kg and an average straight-carapace length of 19.5 cm in one year (Caillouet et al., 1987).

Release and Recovery. — The NMFS Galveston Laboratory tagged and released 22,596 (Table 3) head-started ridley sea turtles, of which 878 have been recovered (3.9%) through 2000. Tag recoveries of head-started Kemp's ridleys were widely distributed but centered around the western Gulf of Mexico where most of the turtles were released close to the area of the experimental imprinting site (Padre Island National Seashore, Corpus Christi, Texas). Recaptures reported within 60 days after release were usually relatively close to the release site and turtles at large for over 60 days appeared to be distributed in the same pattern and area as historical records for wild Kemp's ridleys. One exception

Table 2. Estimates of individual weight adjusted for bias and straight carapace length (SCL) for head-started Kemp's ridleys for each year-class and combined year-classes (from Caillouet et al., 1997).

	1 Year		1.22 Years	
Year-class	weight (kg)	SCL (cm)	weight (kg)	SCL (cm)
1978	1.11	18.6	1.83	22.1
1979	1.34	19.9	2.25	23.7
1980	1.52	20.7	2.47	24.5
1981	0.86	17.1	1.48	20.5
1982	1.17	19.0	1.97	22.6
1983	0.56	14.7	0.83	16.9
1984	0.80	16.6	1.27	19.5
1978	2.52	24.6	5.20	31.6
1979	1.86	22.2	3.10	26.5
1980	2.29	23.8	4.51	30.1
1981	1.10	18.6	1.92	22.5
1982	0.64	15.4	1.06	18.3
1983	0.94	17.6	1.66	21.4
1991	0.62	15.3	0.96	17.7
1992	1.22	19.2	2.35	24.0
Combined	1.26	19.5	2.17	23.4

was a tag recovery reported from Morocco which could represent a range extension (Manzella et al., 1988a).

Some head-start recaptures were of more than passing interest. For instance, a 1985 year-class turtle released in Copano Bay, Texas, was captured three times, first 275 days after release, on 22 January 1987, stranded in the mud near Rockport, Texas. The turtle was badly emaciated, suffering from cold shock and very white in color. The carapace was covered with mud and bits of algae indicating it might have been burrowing on the bottom. The University of Texas Marine Science Institute at Port Aransas, Texas, rehabilitated this turtle and released it for the second time with the 1986 year-class on 21 April 1987 about 19 km offshore of Padre Island, Texas. On 9 May 1987, 18 days after this second release, the same turtle was captured basking in shallow water (ca. 1 m deep) in Matagorda Bay near Palacios, Texas, and released the same day. On 3 July 1987, 55 days later, the same turtle was taken in a shrimp trawl in Matagorda Bay, this time near Port Lavaca, Texas. The turtle was reported as alive and very active and was re-released. The movement of this turtle is especially interesting. First, it was found near its release location in Copano Bay, possibly attempting to over-winter. After rehabilitation and release offshore, the turtle had returned to the bay system and showed signs of having stayed there for some time.

Table 3. Number of released head-started Kemp's ridley sea turtles 1978–92 and number that were recaptured and nested through 2000.

Year-class	Number released	Number recaptured	Percent recaptured	Number nested
1978	2019	66	0.0326	
1979	1370	23	0.0168	
1980	1723	89	0.0516	
1981	1639	51	0.0311	
1982	1329	148	0.1113	
1983	190	17	0.0894	1
1984	1040	29	0.0279	2
1985	1534	119	0.0775	
1986	1727	57	0.0330	4
1987	1280	39	0.0304	2
1988	899	25	0.0278	1
1989	1962	48	0.0245	
1990	1979	50	0.0253	
1991	1942	65	0.0334	
1992	1963	52	0.0265	
Total	22,596	878	0.0388	10

Usually, the cause of death of a stranded turtle is not apparent. Even though most head-started turtles caught in trawls were reported to have been released alive, the actual condition of the turtles was not known and some of the stranded dead animals may have originally been taken by shrimp trawls. Recreational fishing may also play an important role in the incidental capture of sea turtles (Andrea Cannon, NMFS Galveston Laboratory, pers. comm.). Methods of recapture for all head-started turtles reported are presented in Table 4.

The highest numbers of tag recoveries were reported in the spring. This could be related to several factors: (1) spring is the usual time for the release of head-started turtles and almost 37% of the recoveries occur within two months after release; (2) an increase in recreational activities along the coast increases the chances of stranded turtles being found along the beaches; and (3) an increase in recreational and commercial fishing occurs in the spring.

Growth After Release. — The fitted von Bertalanffy growth equation for head-started ridley sea turtles recaptured after release into the Gulf of Mexico was determined by Caillouet et al. (1995a) to be:

$$SCLt = \{1 - e{-}0.3170(t + 0.1445)\}$$

To obtain an approximation of the age at sexual maturity for head-started ridleys it was assumed that the turtles became

Table 4. Methods of recovery for all NMFS Galveston Laboratory tagged/released head-started Kemp's ridley sea turtles 1978–92. The total number of recoveries ($n = 958$) is larger than the number of individuals recaptured ($n = 878$) because some turtles were recaptured more than once.

Recovery Method	Number Recovered	Recovery Percentage
Stranded Dead	291	30.38
Shrimp trawl	161	16.81
Stranded Alive	127	13.26
Hook and Line	116	12.11
Not Reported	112	11.69
By Hand	52	5.43
Entanglement Net	34	3.55
Gill Net	28	2.92
Dip Net	15	1.57
Cast Net	4	0.42
Unknown	3	0.32
Research Trawl	3	0.32
Beach Seine	2	0.21
Butterfly Net	2	0.21
Floating Dead	2	0.21
Oyster Dredge	2	0.21
Crab Pot	1	0.10
Power Plant Intake Screen	1	0.10
Trammel Net	1	0.10
Pound Net	1	0.10

Table 5. Reported nesting of tagged/released Kemp's ridley sea turtles from the NMFS Galveston Laboratory on North Padre and Mustang islands near Corpus Christi, Texas. The results of these nests, showing the head-started turtles reached sexual maturity after release, mated and laid successful clutches of eggs, is a strong indication that the concept of head-starting may hold true value as a management tool for this endangered species. Values in [brackets] are means.

Year of Nesting	Head-Start Year-Class	Date Turtle Released	Date Eggs Laid	Estimated Age (yrs)	Number of Clutches	Number of Eggs	Number of Hatchlings	Percent Hatch	Carapace Length (cm)
1996	1983	6/05/84	5/27/96	12.8	1				—
	1986	4/21/87	5/29/96	9.8	1				67.7
Σ 1996	2 turtles			[11.3]	2	177	111	62.7	[67.7]
1997	None								
1998	1984	5/21/85	4/25/98	13.8	1				62.9
			5/21/98	13.9	1				62.9
	1986	4/21/87	5/22/98	11.8	1				61.0
	1987	5/17/88	6/02/98	10.8	1				59.7
Σ 1998	3 turtles			[12.6]	4	390	239	61.3	[61.6]
1999	1984	5/21/85	4/08/99	15.7	1				64.1
			5/01/99	15.8	1				64.1
	1986	4/21/87	5/10/99	12.8	1				62.2
	1988	5/25/89	5/06/99	12.9	1				—
			5/26/99	12.9	1				—
Σ 1999	4 turtles			[13.7]	7	692	482	69.7	[63.5]
2000	1987	5/17/88	4/19/00	12.9	1	85	71	83.5	60.5
Σ 1996-2000	9 turtles			[13.0]	14	[96] eggs/clutch	[64] hatchl/clutch	[66.7]	[62.3]

sexually mature at least by the time they reach 60 cm SCL. By substituting 60 cm for SCL in the above equation and solving for t, the average age at sexual maturity of head-started ridleys released into the Gulf of Mexico was estimated to be 10 years.

Nesting. — During five nesting seasons (1996–2000) nine head-started females were documented nesting on Mustang and North Padre Islands in south Texas (Shaver and Caillouet, 1998) (Table 5). These 9 turtles laid 14 documented clutches which produced 1344 eggs that were relocated from the natural sites to within the temperature-controlled incubation facility at PINS. The eggs produced 903 hatchlings — a hatch rate of 67.2%. All of the nesting head-started females were identified by the living tag in the carapace and some also by the presence of magnetic or metal flipper tags. The head-started nesting females averaged 62.3 cm SCL (range, 59.7–67.7) and an average age of 13.0 yrs (range, 9.8–15.8).

There has been one confirmed nesting of a head-started turtle at Rancho Nuevo, Mexico. The turtle was identified by the presence of a living tag in the carapace and a magnetic wire tag in the left flipper. The turtle was from the 1987 head-start year-class and nested at Rancho Nuevo on 3 May 1998; no size information was collected.

DISCUSSION

The recent increase in Kemp's ridley females nesting in Mexico is very exciting and impressive, however, it should be kept in mind this success is tenuous at best and the numbers still lag far behind those reported from the 1940s. Due to continuing mortality of wild Kemp's ridleys, protection efforts at the nesting beaches must be continued.

The results of the head-start experiment conducted at the NMFS Galveston Laboratory are very encouraging to us. With documented nesting by head-started females and the production of viable second generation head-started hatchlings not only at PINS but also at Rancho Nuevo, it appears the experiment was a success. Only the future will tell if nesting activity by head-started females will continue or perhaps increase, however, we are very optimistic and positive this event will continue and become routine.

The question will be asked—was head-starting worth it? From a biological standpoint—yes, it was. Because of head-starting a very large volume of pertinent biological information and data have been obtained and shared with the sea turtle research community that might have otherwise never been discovered. Further, it would appear, at least at this point in time, the ridley head-start experiment may very well contribute greatly to the long-term recovery of this endangered species. From a financial standpoint—perhaps it was worth it. The concept of head-starting sea turtles, by the very nature of closed seawater systems in an environmentally controlled situation, is quite expensive. For instance, we estimate it cost $162.50 to produce each head-started ridley released in the Gulf of Mexico. However, if the recovery of an endangered species is to be measured only in monetary cost then all endangered species, both aquatic and terrestrial, are forever doomed.

Should head-starting of Kemp's ridleys have been continued for a longer period of time? In our opinion—no. The experiment had lasted for 15 years and, with the return of adult head-started females, appeared to be successful as originally planned and configured. However, perhaps a captive rearing program for sub-samples of second generation head-started hatchlings should be pursued primarily to investigate genetic makeup of these turtles (for instance, was there multiple paternity for these clutches?) and to compare growth and survival of the second generation with the original head-started turtles. In this manner, it could be determined if these second generation turtles were viable and healthy. Secondly, a tagging program should be initiated to place, at least, wire tags into the flippers of the second generation hatchlings before they are released into the Gulf of Mexico. Presently, none of the turtles are tagged prior to being released so no second generation nesting female can ever be recognized.

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