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Survival of Head-Started Kemp's Ridley Sea Turtles (*Lepidochelys kempii*) Released Into the Gulf of Mexico or Adjacent Bays

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ABSTRACT. – During the Kemp's ridley sea turtle (*Lepidochelys kempii*) head-start experiment, the National Marine Fisheries Service's Galveston Laboratory reared, tagged, and released 22,255 yearlings of the 1978 to 1992 year classes along the coasts of Texas, west Florida, and Campeche, Mexico. A total of 805 recaptures were recorded (3.6% of the yearlings released). Annual survival rate, S, was estimated from recaptures of successive age groups. Values of S_{2-3} (annual survival rate estimated from recaptures of age groups 2 and 3 years) were probably more reliable than those of S_{3-4} and S_{4-5}, because they were based on larger numbers of recaptures. For Texas releases S_{2-3} ranged from 0.10 in the 1980 year class to 0.43 in the 1986 year class. For Florida releases S_{2-3} ranged from 0.36 in the 1978 year class to 0.50 in the 1979 year class. With recaptures from year classes combined, S_{2-3} was lower for Texas releases (0.15) than for Florida releases (0.39). Because of tag loss and uncontrollable factors affecting the reporting of recaptures, S estimated from recaptures of foreflipper-tagged turtles are crude approximations which underestimate true survival at sea. A constant S of 0.45 would be required to produce one survivor at age 10 yr (assumed age at maturity) from the average Texas release of 1437 yearlings per year. If S were higher than 0.45 or increased with age, then more head-started ridleys could have survived. It remains to be determined whether head-started Kemp's ridleys survive to maturity and nest.

KEY WORDS. – Reptilia; Testudines; Cheloniidae; *Lepidochelys kempii*; sea turtle; survival; head-start; captive rearing; reintroduction; endangered species; Gulf of Mexico; Mexico; United States

In 1978 a captive rearing and reintroduction experiment referred to as "head-start" was initiated as a component of the recovery program for Kemp's ridley sea turtle (*Lepidochelys kempii*), an endangered species (Woody, 1986, 1989; Phillips, 1989). Participating in this experiment were Mexico's Instituto Nacional de la Pesca (INP), the United States' National Marine Fisheries Service (NMFS), Fish and Wildlife Service (FWS), and National Park Service (NPS), and the Texas Parks and Wildlife Department (TPWD). The Florida Audubon Society (FAS), Maitland, Florida, initially assisted in the experiment, followed by the Gladys Porter Zoo (GPZ), Brownsville, Texas. The primary goal of the experiment was to establish a nesting colony at Padre Island National Seashore (Woody, 1986, 1989; Phillips, 1989), a site of sporadic nestings of Kemp's ridleys near Corpus Christi, Texas (Werler, 1951; Márquez et al., 1989; Shaver, 1990). The working hypothesis was that Kemp's ridley hatchlings exposed to sand and surf at a particular beach would survive, grow to maturity, and return to that beach to reproduce after having been captive reared, tagged, and released.

Kemp's ridley head-start methods have been described in detail elsewhere (see Caillouet and Landry, 1989, and Caillouet et al., 1993, for literature). They included collection and incubation of eggs, exposure of hatchlings to sand and surf at Padre Island or Rancho Nuevo, Tamaulipas, Mexico, captive rearing, tagging, release, and evaluation of recapture information. The NMFS Galveston Laboratory received 25,676 live hatchlings (an additional 133 were dead when received) of the 1978 to 1992 year classes for head-starting, of which 22,255 (86.7%) were released as yearlings into the Gulf of Mexico. Manzella et al. (1988, 1991a, 1991b), Fontaine et al. (1989a), and Manzella and Williams (1992) described the temporal and spatial distribution of released ridleys, and Fontaine et al. (1989a) and Caillouet et al. (1995) described their growth.

This paper estimates annual survival rates of head-started Kemp's ridleys released as yearlings into the Gulf of Mexico or adjacent bays (estuaries).

MATERIALS AND METHODS

The standard tag for head-started Kemp's ridleys was the external Hasco Type 681 foreflipper tag made of monel or inconel alloys (Manzella et al., 1988; Fontaine et al., 1989a, 1989b, 1993). All but five recaptures were based on foreflipper tags. The five exceptions were turtles that had lost their foreflipper tags but were identified as head-started from additional tags or marks described by Fontaine et al. (1993).

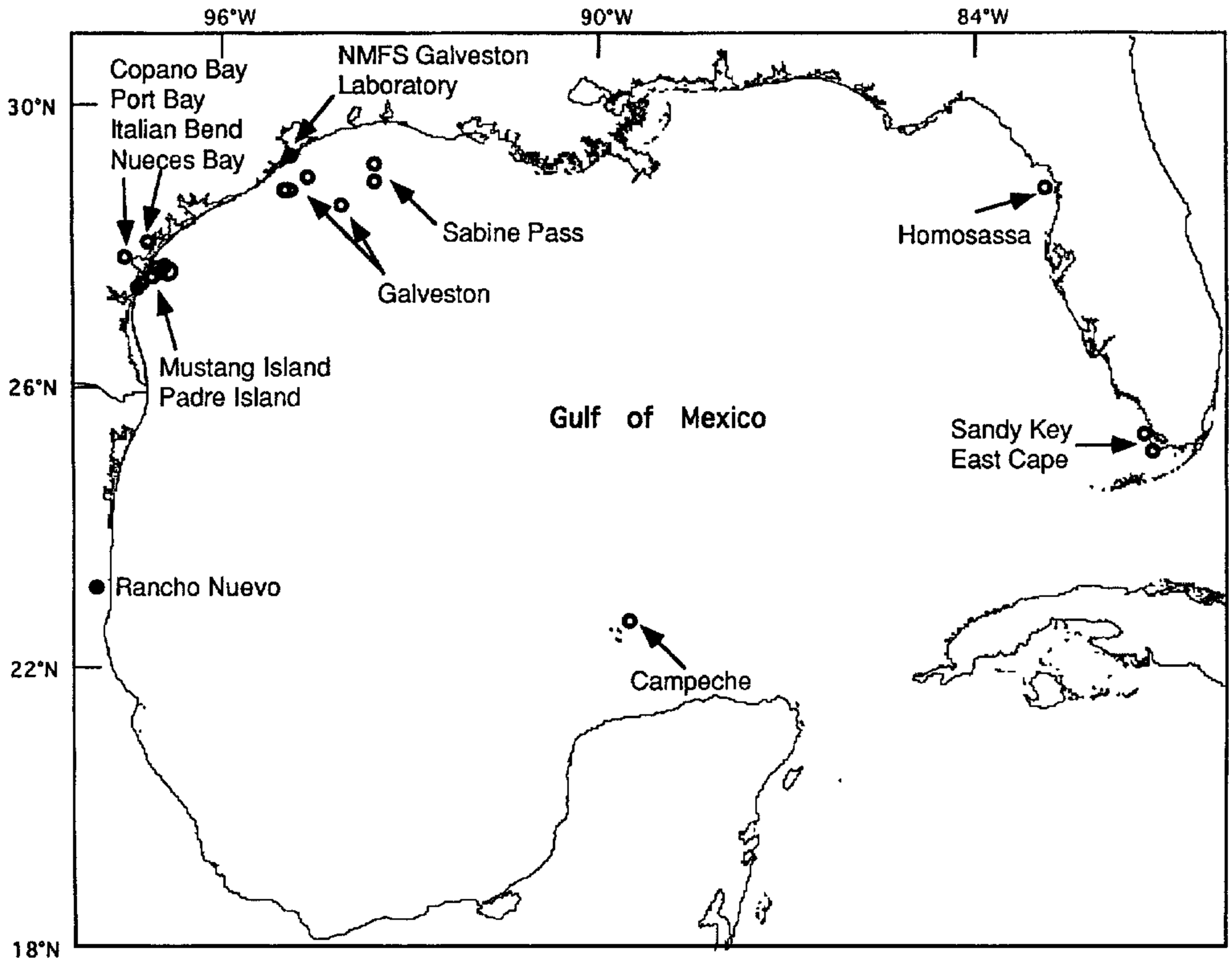

Figure 1. Locations of head-started yearling Kemp's ridley (*Lepidochelys kempii*) release sites (see Table 1), the NMFS Galveston Laboratory, and Rancho Nuevo, Mexico.

Head-started Kemp's ridleys were usually released as yearlings (i.e., during the year following the one in which they were received as hatchlings). They ranged in age from 7–15 months, but 86.1% were 9–11 months old when released. Of the 22,255 yearlings released, 18,790 (84.4%) were released along the Texas coast, 3268 (14.7%) along the west coast of Florida, and 197 (0.9%) off the coast of Campeche, Mexico (Fig. 1; Tables 1 and 2). Most (21,615 or 97.1%) were released seaward of barrier beaches bordering the Gulf of Mexico, and the rest (640 or 2.9%) were released in adjacent bays. Recaptures from an additional 353 "super head-started" turtles, released after being held for longer periods, were excluded from our analysis of survival, because extended captive rearing may habituate sea turtles to artificial conditions and predispose them to exhibit aberrant behavior following release. These turtles, initially retained to develop a captive brood stock, were released after FWS and NMFS terminated their involvement in experimental captive breeding of Kemp's ridleys.

Typically, mark-recapture experiments involving marine animals are conducted on commercially or recreationally exploited species, in which cases the investigators either control or are able to assess the amount of fishing effort allocated toward recapturing tagged animals (Ricker, 1975). We had no control over the effort allocated toward the recapture of head-started Kemp's ridleys, nor were we able to assess it. The recapture information came from NMFS' voluntary Sea Turtle Stranding and Salvage Network (STSSN; see Schroeder, 1989) and from fishermen, both commercial and recreational, who reported incidental captures (Manzella et al., 1988; Fontaine et al., 1989a). Thus, "recaptures" as used herein refer not only to turtles reported as actually captured with fishing gear or by hand, but also to turtles found stranded, either alive or dead, and those for which no source of recapture information was reported.

The annual survival rate (**S**) was estimated from recaptures from Texas and Florida releases only (Tables 3 and 4), because there were too few recaptures from the single release offshore of Campeche (Table 5). For each turtle recaptured more than once, only the last of its recaptures was included in estimating **S**, so as not to give undue weight to such individuals. Estimation of **S** was simplified by knowledge of the ages of the recaptured turtles. For consistency and comparability among year classes, recaptures were compiled by successive age groups, **T** (Tables 3 and 4).

Table 1. Releases of head-started yearling Kemp's ridleys (*Lepidochelys kempii*). Hatchling exposure locations (Exp. Loc.): PINS = Padre Island National Seashore, Texas, RN = Rancho Nuevo, Mexico, CAY = Cayman Turtle Farm (1983), Ltd., and UNK = unknown.

Year class	Exp. Loc.	Release Site	Type	Date	Number
1978	PINS	Sandy Key, FL	Gulf	22 Feb 1979	135
	PINS	East Cape, FL	Gulf	22 Feb 1979	52
	PINS	East Cape, FL	Gulf	28 Feb 1979	1
	PINS	East Cape, FL	Gulf	28 Feb 1979	166
	PINS	Sandy Key, FL	Gulf	5 Mar 1979	172
	RN	Homosassa, FL	Gulf	8 May 1979	751
	PINS	Homosassa, FL	Gulf	8 May 1979	628
	PINS	Padre Isl., TX	Gulf	7 Jul 1979	112
	RN	Padre Isl., TX	Gulf	7 Jul 1979	1
				Subtotal:	*2018*
1979	PINS	Homosassa, FL	Gulf	3 Jun 1980	665
	RN	Homosassa, FL	Gulf	5 Jun 1980	66
	PINS	Homosassa, FL	Gulf	5 Jun 1980	608
	UNK	Key Largo, FL	Bay	9 Jul 1980	24
				Subtotal:	*1363*
1980	RN	Campeche, Mexico	Gulf	3 Mar 1981	197
	PINS	Padre Isl., TX	Gulf	2 Jun 1981	1426
	PINS	Padre Isl., TX	Gulf	2 Jun 1981	100
				Subtotal:	*1723*
1981	PINS	Padre Isl., TX	Gulf	2 Jun 1982	1521
	PINS	Sabine Pass, TX	Gulf	14 Jul 1982	118
				Subtotal:	*1639*
1982	PINS	Padre/Must. Isl., TX	Gulf	7 Jun 1983	1159
	PINS	Nueces Bay, TX	Bay	7 Jun 1983	96
	PINS	Sabine Pass, TX	Gulf	15 Jul 1983	69
				Subtotal:	*1324*
1983	PINS	Mustang Isl., TX	Gulf	5 Jun 1984	172
	RN	Mustang Isl., TX	Gulf	5 Jun 1984	18
				Subtotal:	*190*
1984	PINS	Padre/Must. Isl., TX	Gulf	21 May 1985	1017
1985	PINS	Copano Bay, TX	Bay	22 Apr 1986	448
	PINS	Italian Bend, TX	Bay	22 Apr 1986	22
	PINS	Port Bay, TX	Bay	22 Apr 1986	49
	PINS	Padre Isl., TX	Gulf	6 May 1986	961
	PINS	Galveston, TX	Gulf	23 Sep 1986	54
				Subtotal:	*1534*
1986	PINS	Mustang Isl., TX	Gulf	21 Apr 1987	1630
1987	PINS	Padre Isl., TX	Gulf	17 May 1988	1100
	CAY	Padre Isl., TX	Gulf	17 May 1988	130
				Subtotal:	*1230*
1988	PINS	Padre Isl., TX	Gulf	25 May 1989	794
	CAY	Padre Isl., TX	Gulf	25 May 1989	14
				Subtotal:	*808*
1989	RN	Galveston, TX	Gulf	15 Aug 1990	1894
1990	RN	Galveston, TX	Gulf	5 Jun 1991	1877
	RN	Galveston, TX	Gulf	8 Oct 1991	102
				Subtotal:	*1979*
1991	RN	Galveston, TX	Gulf	19 May 1992	1942
	RN	Galveston, TX	Bay	12 Aug 1992	1
				Subtotal:	*1943*
1992	RN	Galveston, TX	Gulf	18 May 1993	1963
				Total:	***22,255***

T was calculated for each recaptured turtle as the difference between its year of recapture and its year class. **T** could not equal 0, because no releases were made until the year following the one in which the turtles were received as hatchlings. Tabulation by age group avoided problems of interpretation that otherwise would have resulted from the broad mixture of release dates (Table 1; see Ricker, 1975).

For purposes of estimating **S**, we excluded recaptures during the year of release (i.e., those for age group 1) because they occurred during less than a full year and therefore were non-comparable (Tables 3 and 4). The fact that recaptures of age group 1 often were similar to, or fewer than, recaptures of age group 2 clearly demonstrates this non-comparability. We considered recaptures of age group 1 to have occurred during a transition period which allowed time for the turtles to undergo any unusual short-term mortality or tag loss, to adapt to life in the wild, and to disperse from the site of release.

For each year class released in Texas and Florida, annual survival rate (**S**) was estimated with recaptures from age groups 2 to 5 as follows (see Ricker, 1975):

$$\mathbf{S} = \mathbf{R}_{\mathbf{T}+1}/\mathbf{R}_{\mathbf{T}} \qquad [1]$$

where **S** = annual survival rate, **T** = age group, $\mathbf{R}_{\mathbf{T}}$ = recaptures in age group **T**, and $\mathbf{R}_{\mathbf{T}+1}$ = recaptures in age group **T + 1**.

Equation 1 was used to estimate **S** between age groups 2 and 3 ($S_{2\text{-}3}$), 3 and 4 ($S_{3\text{-}4}$), and 4 and 5 ($S_{4\text{-}5}$). Year classes 1991 and 1992 had not been at large long enough to allow such calculations, and there were too few recaptures of turtles older than 5 yr in any year class to estimate annual survival rates beyond $S_{4\text{-}5}$. Age groups $S_{2\text{-}3}$, $S_{3\text{-}4}$, and $S_{4\text{-}5}$ were also adjusted for tag loss (Tables 6 and 7), based on Henwood's (1986) estimate of monel foreflipper tag loss in loggerheads (*Caretta caretta*). He estimated a constant instantaneous rate of 0.135% tag loss per day (or 49.3% tag loss per year) at large, which is equivalent to a tag retention rate of 50.7% per year. Therefore, to adjust for tag loss, we divided $S_{2\text{-}3}$, $S_{3\text{-}4}$, and $S_{4\text{-}5}$ values by 0.507 (Tables 6 and 7).

RESULTS AND DISCUSSION

Of the 22,255 yearlings released, we recorded 805 recaptures (3.6%) from 1979 through 1993. Of these, 710 (88.2%) were from Texas releases, 90 (11.2%) from Florida releases, and 5 (0.6%) from the Campeche release (Table 5). There was an obvious relationship between release location and recapture location. Texas and Louisiana recaptures predominated, probably because most of the turtles were released along the Texas coast. The predominance of Texas recaptures was also influenced by unusually high short-term mortalities following release of the 1982 and 1985 year classes (Table 3; Manzella et al., 1988; Fontaine et al., 1989a). The 1982 year class was released nearshore of Padre

Table 2. Numbers of head-started yearling Kemp's ridleys (*Lepidochelys kempii*) released, by release waters and location.

Release Location	Release Waters		
	Gulf of Mexico	Adjacent Bays	Total
Campeche, Mexico	197	0	197
West Florida, USA	3244	24	3268
Texas, USA	18,174	616	18,790
Total	21,615	640	22,255

and Mustang Islands, Texas, where the turtles unexpectedly encountered oil and tar, and the portion of the 1985 year class that was released in shrimp sanctuaries within Copano Bay, Port Bay, and Italian Bend near Corpus Christi, Texas, was unexpectedly exposed to illegal shrimping (Table 1; Manzella et al., 1988; Fontaine et al., 1989a). Most recaptures from Texas releases were from the Gulf of Mexico and adjacent bays (Table 5), but most recaptures from west Florida releases were from Atlantic sites. West Florida releases were discontinued after release of the 1979 year class in 1980, because there was no direct evidence at that time that Kemp's ridleys in the Atlantic returned to the Gulf of Mexico (Pritchard, 1989). The first such evidence was provided 14 years later when a wild Kemp's ridley tagged on the east coast of Florida nested at Rancho Nuevo in 1994 (Richard Byles, *pers. comm.*).

A recovery source was reported for 694 (86.2%) of the 805 total recaptures (Table 8). Of these 694 those from strandings (356 or 51.3%), commercial shrimp trawling (153 or 22.0%), and hook and line (90 or 13.0%) predominated, with the rest (95 or 13.7%) including capture by hand, gill net, entanglement net, dip net, cast net, "butterfly" net (used to catch shrimp), unspecified net, oyster dredge, beach seine, crab lift net, and pound net.

Recaptures from strandings peaked in 1983 and showed a secondary peak in 1986 but remained relatively stable from 1987 through 1993 (Table 8). Recaptures for which no source was reported also showed a peak in 1983. Reported shrimp trawl recaptures peaked in 1982, showed a secondary peak in 1986, then declined thereafter. Hook and line recaptures exhibited a peak in 1992. Recaptures from all other sources were most numerous in 1993. Recaptures exhibited pronounced seasonal variation, with summer peaks clearly demarcated by winter lows (Table 9), supporting our choice of age group compilation of recaptures for purposes of estimating survival rates.

Annual survival rates varied considerably among year classes and consecutive age groups (2-3, 3-4, and 4-5 yr) within year classes. Estimated values of $S_{2\text{-}3}$ (Tables 6 and 7) were probably more reliable than those of $S_{3\text{-}4}$ and $S_{4\text{-}5}$, because they were based on larger numbers of recaptures (Tables 3 and 4). For Texas releases $S_{2\text{-}3}$, with no adjustment for tag loss, ranged from 0.10 in the 1980 year class to 0.43 in the 1986 year class. For Florida releases $S_{2\text{-}3}$ was 0.36 in the 1978 year class and 0.50 in the 1979 year class. With year classes combined $S_{2\text{-}3}$ was lower for Texas releases (0.15) than for Florida releases (0.39).

According to Ricker (1975) the death of any considerable number of tagged animals or the loss of any considerable number of tags shortly after release does not affect the estimate of **S** based on equation 1 (see above). This is particularly important because two year classes, 1982 and 1985, experienced high short-term mortality following release (Manzella et al., 1988). Incomplete reporting of tag returns would not affect estimates of **S** based on equation 1 if there were no change in the efficiency of reporting of tag returns over successive years (Ricker, 1975).

As applied to a year class, estimates of **S** could be affected by (a) any loss of tags which occurred at a steady instantaneous rate throughout the whole series of years, (b) extra mortality among tagged animals similarly distributed over time, and (c) emigration of animals from the recovery area similarly distributed in time (see Ricker, 1975). The adjustment for steady instantaneous rate of tag loss based on Henwood (1986) approximately doubled the estimates of $S_{2\text{-}3}$, $S_{3\text{-}4}$, and $S_{4\text{-}5}$ (Tables 6 and 7), but this seemed excessive. For example, the adjusted $S_{4\text{-}5}$ estimate for Texas releases (all year classes combined) was 1.18 (> 100% annual survival), which is obviously impossible (Table 6). It

Table 3. Numbers of head-started Kemp's ridleys (*Lepidochelys kempii*) recaptured[a] after release as yearlings along the Texas coast, by age group[b] and year class.

Year class	Age group[b]										
	1	2	3	4	5	6	7	8	9	10	Total
1978		2									2
1979											0
1980	27	49	5							1	82
1981	8	34	5	2	1						50
1982	113	28	3	1							145
1983	6	6	1						1		14
1984	9	15				1					25
1985	78	30	7		2						117
1986	19	14	6	2		1					42
1987	11	9	2								22
1988	3	15									18
1989	3	26	9								38
1990	15	38	9								62
1991	4	40									44
1992	4										4
Total	300	306	47	5	3	2	0	0	1	1	665

[a] For each individual recaptured more than once, only the last of its recaptures was included.
[b] Calculated by subtracting the year class from the year of tag recovery (e.g., if the year class was 1980 and the year of tag recovery was 1983, then the age group was 3 at recovery).

Table 4. Numbers of head-started Kemp's ridleys (*Lepidochelys kempii*) recaptured after release as yearlings along the west Florida coast, by age group and year class (see Table 3 for definitions).

Year class	Age group					
	1	2	3	4	5	Total
1978	26	25	9	2	1	63
1979	8	6	3	1		18
Total	34	31	12	3	1	81

Table 5. Numbers of head-started Kemp's ridleys (*Lepidochelys kempii*) recaptured after release as yearlings, by release and recovery location.

Recovery Location	Release Location			
	Campeche	Texas	West Florida	Total
Mexico Gulf		9		9
U.S. Gulf				
Texas	1	544	1	546
Louisiana	3	101	3	107
Mississippi		5	2	7
Alabama		6	1	7
Florida		26	24	50
U.S. Atlantic				
Florida		5	17	22
Georgia		6	6	12
South Carolina		3	10	13
North Carolina		3	17	20
Virginia			2	2
Maryland			2	2
New Jersey			2	2
New York	1		1	2
France		1	1	2
Morocco			1	1
Nicaragua		1		1
Total	5	710	90	805

may be that there were too few recaptures for age groups older than 3 (i.e., sample sizes were inadequate). At the rate determined by Henwood (1986), almost 100% of the foreflipper tags applied to loggerheads were lost by the end of the second year at large. The rate of foreflipper tag loss in head-started Kemp's ridleys may be less than that in the wild loggerheads tagged in the field, possibly because the ridleys were smaller and were tagged under laboratory conditions. Limpus (1992) showed that tag loss rates in loggerheads and green turtles (*Chelonia mydas*) varied with species, tag design, tagging position, age of the tag, and type of study; so results based on our use of Henwood's (1986) tag loss rate to adjust **S** of head-started Kemp's ridleys should be viewed with caution.

Incremental improvements in facilities, husbandry, and health care over the years of the head-start experiment could have produced a trend of improved quality of turtles released, which in turn could have produced a trend of increase in post-release survival over the year classes. It is also possible that improvements in tagging procedures over the years could have produced a trend of improved tag retention leading to an apparent increase in survival over the year classes. There were no apparent trends in **S** over year classes (Tables 6 and 7). In any case improvements in quality of turtles or tagging procedures over year classes are different from factors affecting an individual year class over the years it is at large.

The observed annual variation in numbers of recaptures by source (Table 8) could reflect variation in the numbers of turtles released as well as random variation and trends in efficiency of reporting of recaptures. The increase in public awareness of the head-start experiment may have produced a trend of improvement in reporting of recaptures. Conversely, the number of recaptures associated with shrimp trawls declined after 1986. Regulations requiring the use of turtles excluder devices (TEDs) in shrimp trawls were promulgated in 1989, and prior to that time NMFS had been encouraging the voluntary use of TEDs (Oravetz, 1989). A decrease in reporting of incidental capture of head-started Kemp's ridleys in shrimp trawls would be expected as a result of effective use of TEDs, but this could not be distinguished from a decrease resulting simply from non-reporting. Our survival rate estimates were based for the most part on years during which TEDs were not in use in the commercial shrimp fishery, with the exception of the 1990 year class. Survival $S_{2\text{-}3}$ for the 1990 year class was exceeded by that of the 1986 and 1989 year classes, so the expected improvement in Kemp's ridley survival with use of TEDs was not demonstrated by our results.

Assuming 0.15 as a worst case **S**, unadjusted for tag loss (based on $S_{2\text{-}3}$ for all Texas releases combined, Table 6) and constant over all age groups, a release of 1437 yearlings (average of Texas releases of year classes 1980 to 1992) could be expected to produce 216, 32, 5, and 1 survivors at ages 2, 3, 4, and 5 yr, respectively. Assuming age at first maturity to be 10 yr (Caillouet et al., 1995), none of the turtles would be expected to have survived to maturity. A constant **S** of 0.45 would be required to produce one survivor at age 10 yr from the average Texas release. Only one recapture of a head-started Kemp's ridley 10 yr old has been reported (Table 3). If age at maturity is greater than 10 yr (Zug and Kalb, 1989; Zug, 1990), then **S** greater than 0.45 would be required to produce one mature survivor from the average Texas release. If **S** were higher than 0.45 or increased

Table 6. Estimated annual survival rates of head-started Kemp's ridleys (*Lepidochelys kempii*) released as yearlings along the Texas coast, by year class. To adjust for tag loss, each **S** (assuming no tag loss) was divided by 0.507 (see Henwood, 1986).

Year class	Assuming no tag loss			With tag loss adjustment		
	$S_{2\text{-}3}$	$S_{3\text{-}4}$	$S_{4\text{-}5}$	$S_{2\text{-}3}$	$S_{3\text{-}4}$	$S_{4\text{-}5}$
1980	0.10			0.20		
1981	0.15	0.40	0.50	0.29	0.79	0.99
1982	0.11	0.33		0.21	0.66	
1983	0.17			0.33		
1985	0.23			0.46		
1986	0.43	0.33		0.84	0.66	
1987	0.22			0.44		
1989	0.35			0.68		
1990	0.24			0.47		
Combined	0.15	0.11	0.60	0.30	0.21	1.18

Table 7. Estimated annual survival rates of head-started Kemp's ridleys (*Lepidochelys kempii*) released as yearlings along the west Florida coast, by year class. See Table 6 for definitions.

Year class	Assuming no tag loss			With tag loss adjustment		
	$S_{2\text{-}3}$	$S_{3\text{-}4}$	$S_{4\text{-}5}$	$S_{2\text{-}3}$	$S_{3\text{-}4}$	$S_{4\text{-}5}$
1978	0.36	0.22	0.50	0.71	0.44	0.99
1979	0.50	0.33		0.99	0.66	
Combined	0.39	0.25	0.33	0.76	0.49	0.66

Table 8. Numbers of head-started Kemp's ridleys (*Lepidochelys kempii*) recaptured after release as yearlings, by recovery method and year. Includes all recaptures, whether single or multiple (i.e., individuals recaptured more than once).

	Recovery Method					
Recovery Year	Stranded	Shrimp Trawl	Hook/ Line	Other[a]	Not Reported	Total
1979	8	2		8	10	28
1980	6	6	2	9	14	37
1981	8	16		6	19	49
1982	12	30	9	2	11	64
1983	96	28	3	6	33	166
1984	15	12	2	9	4	42
1985	4	11	2	4		21
1986	70	21	1	3	4	99
1987	25	13	8	6	1	53
1988	17	5	3	6	1	32
1989	9	3	3	3	1	19
1990	14		8	6		28
1991	23	4	8	8		43
1992	25	1	29	4	3	62
1993	24	1	12	15	10	62
Total	356	153	90	95	111	805

[a] Includes capture by hand, gill net, entanglement net, dip net, cast net, "butterfly" net (used to catch shrimp), unspecified net, oyster dredge, beach seine, crab lift net, and pound net.

with age, as expected if growth of Kemp's ridleys reduces their vulnerability to natural predators, then larger numbers of head-started ridleys could be expected to have survived. The actual annual survival rate of head-started Kemp's ridleys probably is greater than 0.15 because it is known that foreflipper tags are lost and a number of the estimates of **S** exceeded 0.45 (Tables 6 and 7), both with and without an adjustment for tag loss. Sex ratios of any mature head-started Kemp's ridleys will depend on their year class (Caillouet, 1995) and whether or not survival in the wild is sex-dependent. The 1978 to 1984 year classes were male-dominated and the 1985 to 1992 year classes female-dominated (Caillouet, 1995).

Table 9. Numbers of head-started Kemp's ridleys (*Lepidochelys kempii*) recaptured after release as yearlings, by recovery method and month. See Table 8 for definitions.

	Recovery Method					
Recovery Month	Stranded	Shrimp Trawl	Hook/ Line	Other	Not Reported	Total
Jan	7	4	1	1		13
Feb	4	2				6
Mar	16	5	3	5	5	34
Apr	26	9	8	1	12	66
May	72	28	9	20	10	139
Jun	135	27	14	18	33	227
Jul	28	14	18	17	17	94
Aug	24	20	27	12	11	94
Sep	19	16	8	14	11	58
Oct	11	14	2	5	5	37
Nov	10	10		2	7	29
Dec	4	4				8
Total	356	153	90	95	111	805

Márquez et al. (1982) estimated that annual survival rates in wild Kemp's ridleys during 1966 to 1979 were slightly greater than 0.50 in the second year of life but declined thereafter. Our estimates of $S_{2\text{-}3}$ unadjusted for tag loss were lower than 0.50, except for the Florida release of the 1979 year class (Tables 6 and 7). Because of the potential for tag loss and uncontrollable factors that affect the reporting of recaptures, we believe that any estimates of **S**, whether of head-started or wild Kemp's ridleys, based on recaptures of turtles with foreflipper tags, are at best only crude approximations which underestimate true survival at sea.

The National Research Council (1990) concluded that the greatest single source of sea turtle mortality caused by humans was incidental capture by shrimp trawls. Strandings and shrimp trawls together accounted for 73.3% of head-started Kemp's ridley recaptures for which a source was reported (Table 8; see also Manzella et al., 1988; Fontaine et al., 1989a). Not only were direct reports of incidental capture of head-started Kemp's ridleys by shrimping received, but shrimping may have also contributed to strandings of head-started Kemp's ridleys, because sea turtle strandings are statistically associated with shrimping (Caillouet et al., 1991).

Head-starting of Kemp's ridleys was discontinued in 1993 (Byles, 1993) after release of the 1992 year class and a scientific and technical review of the experiment (Eckert et al., 1994). Emphasis has shifted to searching for the turtles already released into the wild (Fontaine et al., 1993; Williams, 1993). We are encouraged by successful nestings of head-started Kemp's ridleys in captivity by age 7 yr (Wood and Wood, 1988, 1989) and by indications they may mature by age 10 yr in the wild (Caillouet et al., 1995). Nevertheless, in the absence of evidence of nesting in the wild, it remains to be determined whether or not head-started Kemp's ridleys released into the wild will survive to maturity and nest. Until then, some will speculate that maturation and nesting of head-started Kemp's ridleys may have already occurred (Bowen et al., 1994).

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