

PADRE ISLAND NATIONAL SEASHORE
1988 REPORT
KEMP'S RIDLEY SEA TURTLE
RESTORATION AND ENHANCEMENT PROJECT
INCUBATION AND IMPRINTING PHASE

Report Prepared By:

Donna J. Shaver
Project Coordinator and
Natural Resources Management Specialist

Elizabeth Cheeseman
Park Ranger (Seasonal)

Suzanne Chacon
Student Conservation Association Volunteer

Jennifer Bjork
Chief of Environmental Services

U.S. Department of the Interior
National Park Service
Padre Island National Seashore
9405 S. Padre Island Drive
Corpus Christi, Texas 78418-5597

TABLE OF CONTENTS

	page
Summary.....	1
Project Preparation.....	2
Egg Incubation and Monitoring at Rancho Nuevo.....	3
Egg Arrival at Padre Island National Seashore.....	3
Egg Incubation and Monitoring at Padre Island National Seashore.....	3
Incubation Temperatures.....	4
Hatchling Handling.....	6
Hatchling Length and Weight.....	7
Analysis of Unhatched Eggs.....	8
Histological Sex Determination.....	10
Beach Patrols and Visitor Reports of Sightings.....	10
Additional Nests Incubated.....	11
Public Education.....	14
Future Plans and Recommendations.....	14
Acknowledgements.....	17
Literature Cited.....	18
Table 1. General results of 1988 Kemp's ridley incubation and imprinting at Padre Island National Seashore.....	20
Table 2. General results of 1978-1988 Kemp's ridley incubation and imprinting at Padre Island National Seashore.....	21
Table 3. Rancho Nuevo clutch history information for eggs collected and shipped to Padre Island National Seashore in 1988.....	22
Table 4. Kemp's ridley 1988 year class clutch incubation information.....	23
Table 5. First third of incubation period clutch temperatures at Rancho Nuevo, Mexico.....	24
Table 6. Middle third of incubation period clutch temperatures at Rancho Nuevo, Padre Island National Seashore and overall.....	25

	page
Table 7. Last third of incubation period clutch temperatures at Padre Island National Seashore.....	26
Table 8. Total incubation period clutch, ambient and control box temperatures at Rancho Nuevo, Padre Island National Seashore and overall.....	27
Table 9. Kemp's ridley 1988 year class clutch hatching duration information.....	28
Table 10. Kemp's ridley 1988 year class hatchling pre-release information.....	29
Table 11. Kemp's ridley 1988 year class hatchling release and shipment information.....	30
Table 12. Kemp's ridley 1988 year class hatchling carapace length and weight measurements.....	31
Table 13. Kemp's ridley 1980-1988 year class hatchling carapace length and weight measurements.....	32
Table 14. Kemp's ridley 1988 year class hatchling deformities and deaths at Padre Island National Seashore.....	33
Table 15. Embryological analysis of 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.....	34
Table 16. Embryological stages of development of embryos from 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.....	35
Table 17. Deformed embryos from 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.....	36
Table 18. Embryological analysis of 1980 and 1982-1988 Padre Island National Seashore unhatched Kemp's ridley eggs.....	37
Table 19. Embryological stages of development of embryos from 1980 and 1982-1988 Padre Island National Seashore unhatched Kemp's ridley eggs..	38
Figure 1. Kemp's ridley 1978-1988 year class mean incubation period.....	39
Figure 2. Kemp's ridley 1978-1988 year class hatching percentage.....	40
Figure 3. Histogram of straight line carapace length for all 1988 year class Kemp's ridley hatchlings.....	41
Figure 4. Histogram of weight for all 1988 year class Kemp's ridley hatchlings.....	42

	page
Figure 5. Kemp's ridley 1988 year class hatchling mean straight line carapace length comparison by clutch using the GT-2 method.....	43
Figure 6. Kemp's ridley 1988 year class hatchling mean weight comparison by clutch using the GT-2 method.....	44
Figure 7. Kemp's ridley 1983-1988 year class hatchling mean straight line carapace length comparison using the GT-2 method.....	45
Figure 8. Kemp's ridley 1983-1988 year class hatchling mean weight comparison using the GT-2 method.....	46
Figure 9. Percent of females from 1978-1988 year class Kemp's ridley individuals positively identified as male or female.....	47
Figure 10. Map of a portion of the Texas coast and western Gulf of Mexico showing the location of Padre Island National Seashore.....	48
Appendix I. Clutch shelf placement and handling at Rancho Nuevo and Padre Island National Seashore in 1988.....	49
Appendix II. Number of Kemp's ridley 1988 year class hatchlings from each clutch released on each release date.....	50
Appendix III. Number of Kemp's ridley 1988 year class hatchlings from each clutch transported to Galveston on each transport date.....	50
Appendix IV. Incubation information on sea turtle 1988 year class clutches 12-14 incubated in styrofoam boxes at Padre Island National Seashore.....	51

SUMMARY

One thousand and nineteen Kemp's ridley sea turtle (*Lepidochelys kempi*) eggs were transported to Padre Island National Seashore (PAIS) from Rancho Nuevo, Mexico on 20 June 1988. Each of the 10 styrofoam boxes containing a clutch of eggs was placed into another larger styrofoam box to provide additional insulation. A total of 933 eggs hatched, for an overall hatching rate of 91.6% (Table 1). Four hatchlings died in their incubation boxes prior to beach release and 4 were lost in the surf during release. The remaining 925 hatchlings were recaptured, weighed, measured and transported to the National Marine Fisheries Service (NMFS) Laboratory, Galveston, Texas for headstarting. The final hatchling shipment was made on 20 July 1988. All unhatched eggs were preserved and examined for embryological development. Gonads were removed from 44 late staged embryos and dead hatchlings for histological sex determination. Of these, 28 were females, 10 were males and 6 could not be determined.

The summer of 1988 was the eleventh year of PAIS participation in the Kemp's Ridley Sea Turtle Restoration and Enhancement Program. Females from the early years of the project may now be of reproductive age and may begin returning to Padre Island to nest. Efforts to educate the public about the need to be observant for nesting turtles and to report sightings immediately, continued in 1988. Two sets of sea turtle tracks were reported by visitors. However, the sightings were not reported promptly and hence the sites could not be investigated and no nests were recovered. Systematic beach patrols for nesting sea turtles and tracks continued. Patrols to the Mansfield Channel and back were conducted an average of 4 times per week from 17 April-30 July and 2 times per week from 31 July-3 September. One untagged adult Kemp's ridley was sighted at the PAIS 42.5 km marker during a patrol on 10 July 1988. The turtle excavated a nest cavity but failed to deposit eggs before returning to the sea. A set of turtle tracks was seen at the 50.7 km marker during a patrol the next day. However, no nest was found at that location and no other tracks or nesting females were seen at PAIS.

Two natural sea turtle nests were laid on Mustang Island, Texas this year. Neither nest could be incubated *in-situ*. The eggs were collected, placed in styrofoam boxes and brought to PAIS for incubation. Hatchlings from both clutches were returned to the original nest sites, released and not recaptured. The first nest was laid on 27 April by an untagged Kemp's ridley. The clutch contained 104 eggs, of which 91.3% hatched. Gonads were removed from 4 late staged embryos; 3 were identified as males and 1 as a female. The second nest was a loggerhead clutch laid on 25 June. Sixty-nine percent of the 113 eggs hatched. Excessive incubation temperatures probably led to relatively high late staged embryonic mortality in this clutch. Gonads were removed from 32 late staged embryos. Gender of one embryo could not be determined and 100% of the remaining samples were females.

Two clutches of Kemp's ridley eggs were laid in captivity at Sea Turtles, Incorporated, South Padre Island, Texas. The eggs were packed into styrofoam boxes with sand from PAIS and were brought to the park for incubation. The first clutch contained 39 eggs and the second 61 eggs. No metabolic heat was detected in either clutch and none of the eggs hatched. All eggs were preserved, examined for embryological development and appeared to be infertile.

PROJECT PREPARATION

New styrofoam boxes were purchased this year to replace those used to hold eggs in 1987. Box dimensions and preparations were the same as those used during the last 4 years (Shaver et al., 1986). Sand used to hold the incubating eggs was collected from 5-15 cm depths at the embryonic dune area of Closed Beach, PAIS on 17 March 1988. It was spread into shallow tubs for air drying in the greenhouse and laboratory. Two randomly selected samples of dried sand were transported to Texas A&M University Veterinary Diagnostic Laboratory on 23 March. The sand samples were subjected to aerobic and anaerobic cultures. The only possible contaminant found was *Bacillus* spp. On 7 April the dried sand was packed into 18.9 liter capacity plastic buckets which were immediately sealed. The buckets and styrofoam boxes were transported to the Gladys Porter Zoo (GPZ), Brownsville, Texas, to await shipment to the Kemp's ridley nesting beach at Rancho Nuevo, Tamaulipas, Mexico.

The PAIS incubation shed was readied for egg incubation during mid-April. Thermograph wires were attached to the CR-5 multi-channel digital recording thermograph and run into the incubation shed in preparation for egg incubation temperature monitoring. Wires were strung to 27 locations where styrofoam boxes could be placed. Wires were also run to 3 control boxes. Each of the control boxes consisted of a smaller styrofoam box inside a larger styrofoam box with sand packed into the small space between them. The smaller internal boxes were filled with moist sand collected from the embryonic dune area at Closed Beach. A probe was implanted in the center of each. One control box was placed at each of the 3 shelf heights (157 cm, 89 cm, 20 cm) in the incubation shed. Ambient temperature probes were also attached at each of the 3 shelf heights.

The incubation shed was once again modified in an attempt to elevate incubation temperatures and avoid the potential masculinizing effect of incubating sea turtle eggs in styrofoam boxes (Morreale et al., 1982; Mrosovsky, 1982; Dutton et al., 1985). Prior to 1984 little effort was made to increase incubation temperatures. Dr. David Owens (Texas A&M University), who studied the sex ratios of 1978-1984 year class Kemp's ridleys incubated at PAIS, found a preponderance of males (Wibbels et al., 1985). Alterations were made to the shed during the 1985, 1986 and 1987 seasons in an attempt to elevate temperatures (Shaver et al., 1987). A preponderance of the dead hatchlings, late staged embryos and stranded yearlings examined from the 1985-1987 year classes were identified as females. Of all specimens identified to gender, 53.8% of the 1985 year class (n=156), 83.0% of the 1986 year class (n=53) and 99.6% of the 1987 year class (n=516) were female (Shaver et al., in prep.). Incubation temperature and sex ratio data were correlated to derive the first estimate of a pivotal temperature for Kemp's ridley, which was found to be 30.2 C with 95% confidence intervals from 29.9 to 30.5 C (Shaver et al., in prep.). It was decided that 1988 year class clutch mean middle third of incubation period temperatures should be between 30.2 and 31.0 C so that a preponderance of females would be produced. Shed modifications were similar to those made during the past 3 years. Plastic sheeting and bamboo shades were placed over the shed walls to trap heat. Holes were cut in the sheeting to allow cross ventilation. A floor heater was installed in the shed for use when heating was needed. These modifications would also help prevent incubation temperatures

from becoming too hot, too cold or fluctuating excessively, all of which could stress the developing embryos and reduce their viability (Shaver et al., 1987).

EGG INCUBATION AND MONITORING AT RANCHO NUEVO

Ten clutches of Kemp's ridley eggs destined for Padre Island National Seashore were collected and packed into styrofoam boxes (Burchfield and Foley, 1985) in Rancho Nuevo from 26-29 May 1988 (Table 2, Table 3). All clutches were placed on middle shelves, 124 cm above the floor, prior to their shipment to PAIS. Incubation box, control box and ambient temperatures were measured with a BAT-12 digital thermometer. Temperatures were closely monitored and recorded twice daily (approximately 1200 and 2400 h) and once every 2 hours for a 24-hour period once a week from 29 May until 19 June. Plans were developed and implemented to alter incubation temperatures, when necessary, to deter embryo thermal stress and masculinization. The egg house door was left closed and the windows were often covered to trap heat. Propane heaters were used during a period of unusually cool weather. The eggs were to be shipped to PAIS prior to their middle third of development. However, the first attempt to transfer the eggs was abandoned because high tides and standing water prevented the transport airplane from landing at Rancho Nuevo.

EGG ARRIVAL AT PADRE ISLAND NATIONAL SEASHORE

The 10 clutches of Kemp's ridley sea turtle eggs were received at 0030 h on 20 June 1988. The 1,019 eggs arrived at Corpus Christi International Airport via a U.S. Fish and Wildlife Service (FWS) contract aircraft and were transported by van to the PAIS incubation facility. Eggs arrived at PAIS during their middle third of incubation, ranging from 22-25 days of development (Table 4). Clutches were promptly examined and prepared for placement in the incubation facility. Box lids were removed and the eggs were examined. The visible eggs were white and appeared to be viable. None of the boxes contained larvae or pupae of flies that have been present during some of the previous years. Each styrofoam box, containing 1 clutch of eggs, was placed into a larger styrofoam box and sand was packed in the small space between them to provide additional insulation. Dimensions and preparations of the larger boxes were the same as during 1986 and 1987 (Shaver et al., 1986). The top layer of eggs in each box was covered with plastic window screen, followed by a final layer of moist Padre Island sand approximately 5-7 cm thick. The 2 lids were replaced on each box set. Thermocouple probes, which had been previously placed within each of the styrofoam boxes at Rancho Nuevo, were connected to the CR-5 recording thermograph. Clutches were assigned identifying numbers between 2 and 11. Clutches 2-9 were placed on the top incubation shed shelves (157 cm) and clutches 10-11 on the middle shelves (89 cm) (Appendix I). No clutches were initially placed on bottom shelves (20 cm).

EGG INCUBATION AND MONITORING AT PADRE ISLAND NATIONAL SEASHORE

Incubation temperatures of each clutch were recorded at hourly intervals with a CR-5 thermograph at PAIS (observations began at 0200 h on 20 June 1988).

Hourly measurements were recorded on a cassette interface that was read directly into an IBM-compatible computer once a day. Incubation temperatures were closely monitored to ensure that they did not exceed 38.0 C, fall below 26.0 C or fluctuate excessively. A floor heater was autocycled daily from 2300 h until 0700 h to moderate excessive fluctuations in nocturnal temperatures. Clutch incubation temperatures were monitored particularly closely during the last third of incubation to ensure that they never exceeded 38.0 C. An upper limit was established for incubation temperatures in 1988 because sustained high incubation temperatures (above 38.0 C) in two 1985 and three 1987 year class clutches probably caused their relatively high late stage mortality (Shaver et al., 1987; Shaver and Chaney, in prep.). Usage of the floor heater was discontinued during approximately the last 3 weeks of incubation. Any clutch that reached 36.0 C was permanently moved to a bottom shelf, where ambient temperatures were slightly cooler. Lids were removed from warm clutch incubation boxes again this year as a method of cooling the eggs. However, temperature modification criteria were slightly stricter this summer due to unusually warm ambient temperatures. Lids were taken off any clutches exceeding 36.4 C at 2200 h and any clutches exceeding 35.5 C at 0600 h (Appendix I). Lids were replaced at 0900 h regardless of time of lid removal. This pattern of lid removal decreased temperatures in accordance with thermal cycles of natural nests at mean mid-nest depth (30 cm) (Burchfield et al., 1983, 1984, 1985; Chaney, 1986). Since the temperature decline was slightly greater than that with lids on, this technique aided in cooling the eggs. This method of cooling was relatively rapid and effective. Temperature declines ranged from approximately 0.5-3.0 C and varied with the time and duration of lid removal. Lids were removed approximately twice as much and for 3 times as long as in 1986 and 1987 because of the more restrictive temperature modification criteria and warmer ambient temperatures this year.

Styrofoam incubation boxes were opened approximately once a week throughout incubation to check for fungal infections, insects and sand moisture. Control box moisture content was inspected at a similar frequency. No fungal infected eggs or insects were found in any of the clutches. Moisture content of sand above the plastic-coated screen in each clutch and control box was monitored by the "pie-crust" pinch technique. Distilled water was added in small amounts to the top sand layer in most of the incubation boxes (Appendix I) to prevent the sand from falling through the screen, and to all of the control boxes to maintain a moisture content similar to that found in the incubation boxes.

Boxes were checked for hatching 3 times daily, from day 44 of incubation until hatching was detected. When hatching was found, the plastic screen and surface sand were removed from the top layer of eggs and the thermocouple probe was removed from the styrofoam box.

INCUBATION TEMPERATURES

Mean first third of incubation period temperatures were calculated for each clutch while at Rancho Nuevo (Table 5). Mean middle third of incubation period temperatures were calculated for each clutch while at Rancho Nuevo and Padre Island (Table 6). Weighted mean overall middle third incubation temperatures were also calculated for each clutch. Mean middle third of incubation period

temperatures at Rancho Nuevo ranged from 29.1-30.0 C, at PAIS from 31.4-32.5 C and overall ranged from 30.5-31.0 C. Mean last third of incubation period temperatures were calculated for each clutch while at PAIS (Table 7). Overall incubation temperatures were calculated for each clutch while at Rancho Nuevo and Padre Island (Table 8). Weighted mean overall temperatures were also calculated for each clutch. Incubation temperatures ranged from 26.3-33.0 C at Rancho Nuevo, 28.3-37.7 at Padre Island and 26.3-37.7 C overall. No clutch incubation temperatures exceeded 38.0 C at Rancho Nuevo or PAIS.

Incubation shed modifications at PAIS resulted in relatively high ambient, control box and incubation temperatures. Mean ambient temperatures at top shelf height for 1984 (mean=28.0 C, SD=1.8 C), 1985 (mean=31.1 C, SD=2.8 C), 1986 (mean=30.0 C, SD=2.5 C), 1987 (mean=30.0 C, SD=2.3 C) and 1988 (mean=30.6 C, SD=3.1 C) were significantly different (ANOVA, $F=43.5558$, $P<0.01$). The mean ambient temperatures for 1986 and 1987 were not significantly different (Newman-Keuls' Multiple-Range Test, $P>0.05$). However, mean ambient temperatures for each of the other years were significantly different (Newman-Keuls' Multiple-Range Test, $P=0.01$). Mean top shelf control box temperatures for 1987 were significantly cooler than for 1988 (t-test, $t=-13.2967$, $df=1126$, $P<0.01$), as were mean middle shelf control box temperatures (t-test, $t=-13.3371$, $df=1126$, $P<0.01$) and mean bottom shelf control box temperatures (t-test, $t=-24.4167$, $df=1126$, $P<0.01$).

Mean ambient and control box temperatures were calculated for 20 June-15 July, when clutches 2-11 were incubating at PAIS. Mean ambient shed temperatures recorded from the top (mean=30.6 C, SD=3.1 C), middle (mean=30.4 C, SD=2.9 C) and bottom (mean=30.3 C, SD=2.8 C) shelves in 1988 were not significantly different from one another (ANOVA, $F=1.4140$, $P>0.05$). Mean temperatures of control boxes located on top (mean=30.4 C, SD=1.0 C), middle (mean=30.1 C, SD=0.9 C) and bottom (mean=30.0 C, SD=0.7) shelves in 1988 were all significantly different from one another (ANOVA, $F=41.6309$, $P<0.01$; Newman-Keuls' Multiple-Range Test, $P=0.01$).

The mean clutch incubation period in 1988 was 46.9 days. Incubation periods reported at PAIS measure the number of days from oviposition until hatching detection. Typically hatching is detected at the pipping stage and thus incubation durations do not usually include emergence times. However, during almost every project year, a few clutches have escaped hatching detection until all viable hatchlings reached the sand surface. In these instances, the hatchlings usually emerged as a unit at night and were found in a frenzied condition during the early morning hours. Thus, the incubation periods reported from PAIS should not be considered as "days to pip" or "days to hatch" (Gutzke et al., 1984). When the mean time of 2.7 days from hatching detection to hatchling release (Table 9) was added, the mean overall incubation period was approximately 49.6 days for 1988.

Mean incubation periods for year classes 1978 through 1988 (exclusive of 1983) were significantly different (ANOVA, $F=23.1186$, $P<0.01$) (Fig. 1). The mean incubation period for 1988 clutches was not significantly different from the mean incubation period for 1986 clutches (Newman-Keuls' Multiple-Range Test, $P>0.05$) and the 1987 clutches (Newman-Keuls' Multiple-Range Test, $P>0.05$). However, the mean incubation period for the 1988 clutches was significantly

shorter than the mean incubation period for the 1978, 1979, 1980, 1981, 1982, 1984 (Newman-Keuls' Multiple-Range Test, $P=0.01$) and 1985 (Newman-Keuls' Multiple-Range Test, $P=0.05$) clutches.

Bustard and Greenham (1968), Mrosovsky (1980), Mrosovsky and Yntema (1980) and Limpus et al. (1984) incubated sea turtle eggs at natural and controlled temperatures and found incubation period to be inversely related to temperature. However, incubation periods for 1988 year class clutches were not significantly correlated with their mean first third ($r=-0.21$, $df=8$, $P=0.27$), middle third ($r=-0.14$, $df=8$, $P=0.35$), last third ($r=0.19$, $df=8$, $P=0.30$) and overall incubation temperatures ($r=-0.24$, $df=8$, $P=0.25$).

Larger clutches and clutches with larger percentages of viable eggs produced more metabolic heat than did smaller clutches. Hence, it would be expected that the number of eggs in a clutch may be correlated with clutch incubation temperatures. The number of eggs in each clutch was correlated with mean last third ($r=0.70$, $df=8$, $P=0.01$) and overall ($r=0.59$, $df=8$, $P=0.03$) incubation temperatures but correlated to a much smaller degree with mean first third ($r=-0.17$, $df=8$, $P=0.32$) and middle third ($r=0.53$, $df=8$, $P=0.06$) incubation temperatures.

Also, since clutches with warmer incubation temperatures generally have shorter incubation periods and clutches with larger numbers of eggs produce more metabolic heat, it would be expected that there may be a correlation between the number of eggs in a clutch and the clutch incubation period. However, no correlation was found between the number of eggs in a clutch and clutch incubation period ($r=-0.07$, $df=8$, $P=0.42$).

HATCHLING HANDLING

A total of 933 of the eggs received from Rancho Nuevo hatched. This overall hatching success of 91.6% was the highest recorded at PAIS to date (Table 2, Fig. 2). Clutch hatch varied from a low of 82.6% in clutch 9 to a high of 98.1% in clutches 8 and 10 (Table 1).

After hatching was detected, clutches were not disturbed until hatchling transfer (Table 10). All hatchlings that had completely absorbed their yolk sacs were transferred to other double styrofoam boxes containing PAIS sand. This transference alleviated overcrowding during the hatching process and prevented deaths from suffocation and entrapment in the amniotic fluid saturated incubation box sand.

Hatchlings were held in transfer boxes for up to 3 days to allow them to gain strength and enter their infantile frenzy. Four died in transfer boxes prior to release (Table 14). Hatchlings were released on Closed Beach, PAIS on 7 mornings from 13-19 July 1988 (Appendix II). Almost all were placed on the beach and allowed to crawl approximately 30 m to the surf. However, a few weak and late hatching individuals were released nearer the water than normal (Table 11). Hatchlings were allowed to swim about 5 m and were then recaptured using aquarium dip nets. The few individuals that made no attempt to swim were retrieved more quickly. Four of the hatchlings released were not retrieved.

Recaptured turtles were weighed, measured, examined for external deformities and placed in tubs containing Gulf of Mexico water before transportation to the National Marine Fisheries Service (NMFS) Laboratory, Galveston. Eight deformed hatchlings were found (Table 14). No more than 50 turtles were placed in an individual tub. Hatchlings were held in tubs for as little time as possible. None were held at PAIS for more than one day after release and 99.7% were transported immediately after release (Table 11). Prior to transport to Galveston, the hatchlings were placed in tubs (<50/tub) lined with foam rubber saturated with sea water. The tubs were placed in the rear of an air conditioned vehicle to maintain a temperature of approximately 29 C during the drive to Galveston. Seven trips were made from 13-20 July, 1988 (Appendix III).

HATCHLING LENGTH AND WEIGHT

Straight line carapace length and weight were recorded for each recaptured hatchling (Fig. 3, Fig. 4). Mean clutch lengths and weights were calculated (Table 12). Mean clutch straight line carapace lengths were significantly different (ANOVA, $F=107.2752$, $P<0.01$; GT-2 test [Sokal and Rohlf, 1981], Fig. 5). Mean clutch weights were significantly different (ANOVA, $F=305.7643$, $P<0.01$; GT-2 test, Fig. 6). There was more variation in weight and length between the clutches than there was within the clutches.

The mean carapace length (mean=42.37 mm, SD=1.28 mm) and mean weight (mean=15.25 g, SD=1.34 g) of the 1988 hatchlings were neither the smallest nor the largest for any year class hatched at PAIS (Table 13). Mean straight line carapace lengths of the 1984-1988 year classes were significantly different from one another (ANOVA, $F=963.5288$, $P<0.01$; GT-2 test, Fig. 7). There was more variation in the carapace length within a year than there was between years. Mean straight line carapace lengths of the 1984- and 1986 year classes were not significantly different (Newman-Keuls' Multiple-Range Test, $P>0.05$). However, mean straight line carapace lengths of all other 1984-1988 year classes were significantly different (Newman-Keuls' Multiple-Range Test, $P=0.01$). The mean straight line carapace length of the 1988 year class was significantly greater than the mean carapace length of the 1987 year class (Newman-Keuls' Multiple-Range Test, $P=0.01$) but significantly less than the mean carapace length of the 1984, 1985 and 1986 year classes (Newman-Keuls' Multiple-Range Test, $P=0.01$). Mean weights of the 1984-1988 year classes were significantly different from one another (ANOVA, $F=328.1006$, $P<0.01$; GT-2 test, Fig. 8). There was more variation in weight within a year than there was between the years. Mean weights of the 1984 and 1986 year classes were not significantly different (Newman-Keuls' Multiple-Range Test, $P>0.05$). However, mean weights of all other 1984-1988 year classes were significantly different (Newman-Keuls' Multiple-Range Test, $P=0.01$). The mean weight of the 1988 year class was significantly greater than the mean weight of the 1987 year class (Newman-Keuls' Multiple-Range Test, $P=0.01$) but significantly less than the mean weight of the 1984, 1985 and 1986 year classes (Newman-Keuls' Multiple-Range Test, $P=0.01$).

ANALYSIS OF UNHATCHED EGGS

The 86 unhatched Kemp's ridley eggs from clutches 2-11 were preserved after full-term clutch incubation. They were injected with, and stored in F.A.A. solution. Also, large embryos were injected with 10% buffered formalin during clutch preservation. Prior to 1988, 3,656 unhatched eggs from 1980 and 1982-1987 were examined and 1,333 embryos were classified as to stage of development. The 1988 year class eggs were opened and examined in the same manner as previous years (King et al., 1984, 1985; Shaver et al., 1986, 1987; Shaver and Chaney, in prep.).

Eggs were opened and examined for signs of yolk digestion and the presence of embryonic membranes. All embryos were removed and those not greatly deteriorated were compared to the stages of development described for the olive ridley by Cratz (1982). If the embryos were comparable to Cratz's (1982) stages, they were so classified, and if not, other stages were established. This staging method provided an approximate time of death during the incubation period. Embryos were also inspected for obvious external deformities and were stored in 45% isopropyl alcohol. On the basis of this examination the eggs and embryos were classified into one of the following categories:

Eggs in which no embryos were found

1. Infertile: eggs that showed a round yolk shape, no yolk digestion or change in texture and no embryonic membranes.
2. Fertile: eggs that contained embryonic membranes, showed signs of yolk digestion and changes in yolk texture but embryonic development had ceased early in incubation or the embryos were so deteriorated that they could not be found.
3. Rotten: eggs that could not be classified as either fertile or infertile because their yolks had either deteriorated or were consumed or disturbed by maggots.

Eggs in which embryos were found

1. Staged embryo: embryos that were placed within one of the embryonic stages of development described for the olive ridley by Cratz (1982) or within stages 27-28, 28-29, 29-30 or 30-31 established in this study for Kemp's ridley embryos.
2. Rotten embryo: embryos that could not be staged because of deterioration.

Seventeen eggs were infertile, 30 were fertile but contained no identifiable embryos and 38 contained embryos (Table 15). One egg could not be classified as infertile or fertile because of deterioration. All 39 embryos removed from the 38 eggs that contained embryos were classified as to stage of development (Table 16). One set of twins was found within 1 egg from clutch 5. The earliest stage in which an embryo was classified was stage 10 (approximately 10 days of development) and the latest was stage 30 (approximately 50 days of development). Gonads were dissected from 26 stage 29-30 and 30 embryos and were stored in 10% buffered formalin for later histological sex determination.

Six embryos from 3 clutches were deformed (Table 17). The earliest stage in which a deformed embryo was classified was stage 19, approximately 23 days of development. The more frequent deformity affected the eyes; 2 embryos lacked

eyes and the eyes of another were joined together at the anterior of the head.

The results of these analyses were compared for all 8 year classes of unhatched eggs (Table 18, Table 19). It must be cautioned that the deteriorated condition of some of the eggs and embryos prior to preservation could have influenced the results (King et al., 1984; Shaver and Chaney, in prep.).

Similar results were found in the analyses of 1982, 1984, 1985, 1986 and 1988 year classes of unhatched eggs (Table 18). The percent of eggs which were infertile, fertile but without identifiable embryos and fertile with embryos were similar for the 5 years. However, the results from the analyses of 1980, 1983 and 1987 unhatched eggs were different. The percent of infertile eggs was higher, and percent of eggs which were fertile, but contained no identifiable embryos, was much lower for 1980 eggs than any other year classes. Because of the poor condition of the 1980 eggs, the differentiation between these 2 categories was difficult and many signs of early embryonic development were probably lost from decomposition. The low relative percent of infertile eggs, low relative percent of eggs containing embryos and high relative percent of fertile eggs in which no embryos could be found indicated that most of the 1983 unhatched eggs ceased development very early in incubation. A much larger proportion of unhatched eggs contained embryos in 1987 than in any other study year and the percentages of eggs classified as infertile and fertile but without embryos were relatively low.

Similar results were found for the embryological staging of all year classes except 1985, 1987 and 1988 (Table 19). Many more embryos ceased development late in incubation in 1985, 1987 and 1988. Development ceased at approximately incubation day 40 (stage 28) or thereafter in 84.3% of the 1985 staged embryos, 95.1% of the 1987 staged embryos and 79.5% of the 1988 staged embryos. Considerably fewer staged embryos ceased development during incubation day 40 or thereafter in 1980 (56.5%), 1982 (54.5%), 1983 (51.6%), 1984 (52.8%) and 1986 (49.1%). Large numbers of seemingly normal embryos ceased development late in incubation in 1985, 1987 and 1988. Much of the high late stage mortality in the 1985 year class occurred in 2 clutches, the only ones that reached temperatures of 38.0 C and above for prolonged periods of time. The sustained elevated temperatures in both of these clutches were probably responsible for the high mortality of these late stage embryos. Incubation temperatures of three 1987 clutches with exceptionally low hatching success exceeded 38.0 C on 4 days. High incubation temperatures probably led to high late stage mortality in these 1987 clutches, as in the two 1985 clutches. No 1988 clutch incubation temperatures exceeded 38.0 C. The relatively high late stage embryonic mortality of this year class was probably a mathematical artifact caused by the relatively low numbers of embryos that ceased development during the early and middle stages of development.

One set of twins was found in clutch 5 (Table 17). Both twins were classified in embryological stage 28-29 and neither possessed any external deformities. Only 11 eggs contained twins during all other study years. Two sets were found in 1985 unhatched eggs, 5 in 1986 eggs and 4 in 1987 eggs. Miller (1985) stated that twinning in sea turtles is rare and occurs in only approximately 0.02% of naturally incubated eggs. However, 0.25% of 1986, 0.20% of the 1987 and 0.10% of the 1988 eggs contained twins.

HISTOLOGICAL SEX DETERMINATION

Gonads were removed from 26 late staged embryos, 4 hatchlings that died at PAIS and 14 hatchlings that died at the NMFS laboratory during July and August. Samples from 1 or more individuals were preserved for each clutch, except clutch 6. The number of samples per clutch ranged from 0-13. The samples were taken to the Texas A&M University Veterinary Diagnostic Laboratory (TAMVDL), College Station, Texas, to determine the sex of individuals using histological methods. Six could not be identified because of post mortem deterioration or lack of a sufficient quantity of gonad in the sample. Of the remaining 38 that were positively identified as to sex, 28 (73.6%) were females and 10 (26.4%) were males (Fig. 9). The mean middle third of incubation period temperatures in these clutches ranged from 30.5 C to 31.0 C (Table 6).

BEACH PATROLS AND VISITOR REPORTS OF SIGHTINGS

The summer of 1988 was the eleventh year that PAIS participated in the Kemp's Ridley Restoration and Enhancement Program. Females from the early years of this project may now be sexually mature and may begin returning to PAIS to nest. Systematic beach patrols for returning turtles, naturally occurring nesting turtles, tracks, nests and hatchlings were conducted for the third consecutive year. Patrols covering the entire 105 km length of PAIS (Figure 10) were scheduled to be conducted 3-7 times a week from mid-April through the first week in September. Vehicular patrols took at least 8 h each, 4 h to the Mansfield Channel and 4 h back to the Ranger Station, and were conducted by 2 people in a 4-wheel drive truck. Vehicle malfunctions, park radio malfunctions and periodic shortages in staffing required cancellation of some patrols. Sixty-nine patrols covering the entire length of the park were completed. Patrols were made an average of 4.0 times per week from 17 April-30 July and 1.8 times per week from 31 July-3 September. Also, 74 patrols were conducted specifically to Yarborough Pass, approximately 27 km south of Closed Beach, or destinations between Yarborough Pass and the Mansfield Channel. Park rangers and maintenance workers were on Closed Beach at least once a day and a 9.6 km stretch of beach bordering this site several times each day. These individuals were also watchful for signs of nesting activity.

A number of PAIS employees, representing several park divisions, conducted the patrols to the Mansfield Channel and destinations between Yarborough Pass and the Mansfield Channel. All were listed on scientific permits and trained to detect and respond to turtle sightings. Persons conducting the patrols carried pre-prepared nesting patrol kits. They were trained to collect pertinent biological data, check turtles for the presence of tags and excavate nests. They were to collect all eggs, pack them into styrofoam boxes and return them to the PAIS incubation shed. Hatchlings were to be collected, returned to the laboratory for weighing and measuring and promptly returned to the nest site for release.

One adult Kemp's ridley and one set of sea turtle tracks were seen during patrols to the Mansfield Channel. The untagged *L. kempi* (68.6 cm curved carapace length and 68.6 cm curved carapace width) was sighted at the 42.5 km marker on 10 July. The turtle was seen as it was ascending the beach.

Patrollers and visitors stayed at a distance until she selected a nest site. She excavated a nest cavity at about mid-beach but failed to deposit eggs. A metal flipper tag (B3920) was applied to the trailing edge of the right front flipper. The turtle did not excavate any additional nest cavities and returned to the sea. The next day a set of turtle tracks was seen at the 50.7 km marker. The tracks were not seen when the patrollers passed by heading south that morning but were found at 1400 h on the northward portion of the patrol. The tracks terminated just seaward of the embryonic dunes. It did not appear that a body or nest cavity were constructed and no nest was found. On projected hatch dates, patrols were made to the potential nest sites. However, no evidence of nesting was found.

Four aerial patrols, covering the entire length of PAIS, were made this summer. The first was a test patrol, conducted at low altitudes of 30-60 m and slow speeds of 85-120 knots. The other patrols were conducted at the minimum Office of Aircraft Services (OAS) certified altitude of 150 m. Patrols from 150 m were deemed to be of minimal usefulness due to the difficulty of distinguishing objects on the beach at that altitude. However, trained observers may be able to see nesting turtles and fresh tracks at altitudes of 30-60 m. No sea turtles or tracks were sighted during aerial patrols.

This year visitors reported a few sets of turtle tracks and live turtles on the beach. They also relayed several reports of sea turtles in the surf and around the Mansfield Channel. Two sets of sea turtle tracks were reported long after visitors sighted them. A set of tracks was seen between the 64.4 and 72.4 km marker on 13 April at 1230 h. The sighting was reported 1 week later by a visitor who is credible and frequents PAIS. However, no tracks or nests were found in the area when patrols began on 17 April. Another set of sea turtle tracks was seen at about the 48.6 km marker on 5 June. Visitors reported this sighting 4 months later and provided photographic documentation. They stated that they saw the tracks in the early morning, that the turtle must have nested at night and that they drove over the tracks to obliterate them. The tracks were not seen during the 3 Mansfield patrols conducted during the week of the sighting.

Most reports of live turtles on the beach were of red eared sliders (*Trachemys scripta elegans*) that beach visitors mistakenly believed were sea turtles. Other reports of turtles on the beach were sketchy and when the sites were investigated no evidence of the turtles or tracks was found. Hence, the reliability of these reports was doubted. Most of the reports of turtles in the surf were of juvenile and subadult loggerhead (*Caretta caretta*) and recently released, superheadstarted, juvenile Kemp's ridley turtles. Most turtles seen around the Mansfield Channel were probably juvenile and subadult green (*Chelonia mydas*) and loggerhead turtles.

ADDITIONAL NESTS INCUBATED

Two natural sea turtle nests were laid on Mustang Island this year. Both nests were reported to Tony Amos, University of Texas Marine Sciences Institute at Austin (Port Aransas, Texas) by beach visitors. Neither nest could be incubated *in-situ* because they were located in areas that were subject to beach

cleaning, relatively heavy vehicle usage, human foot traffic, horse traffic and artificial lighting from condominiums. The eggs were collected, placed in styrofoam boxes and brought to PAIS for incubation. Clutch monitoring was identical to that of Kemp's ridley clutches received from Rancho Nuevo. Hatchlings from both clutches were returned to the original nest sites, released and not recaptured.

The first nest, designated clutch 1, was laid by a Kemp's ridley at 1100 h on 27 April between the 3.3 and 3.6 km marker on Mustang Island. This was the first confirmed Kemp's ridley nest laid on Mustang Island since 1962 (Hildebrand, pers. comm.). The nesting turtle was 66.2 cm long (straight line carapace length), did not possess a tag, tag scar or any trace of a living tag and was not tagged before it returned to the sea. The turtle faced directly inland as it deposited 104 eggs in a nest located at the base of a foredune, 47 m from the shoreline. The top eggs were located 35 cm from the sand surface and the nest was 51 cm deep. The eggs were promptly excavated and brought to PAIS. The incubation box was placed on a top shelf in the incubation facility and was not moved throughout development. A floor heater was run continuously during the first portion of the incubation period to ensure that the egg temperatures did not get too cold or fluctuate excessively. Incubation temperatures ranged from 22.5-36.8 C (Tables 5-8). The mean incubation temperature during the middle third of development was 29.7 C (SD=1.4 C). The incubation box lid was never removed to cool the eggs and water was never added to the clutch (Appendix I). Ninety-five (91.3%) of the eggs hatched after 57 days of incubation (Table 1, Table 4). Emerged hatchlings were transferred to another styrofoam box containing a layer of sand from the nest site (Table 10). They were then monitored 24 hours a day to determine when they entered their infantile frenzy and could be released. All 95 hatchlings entered their frenzy at 0530 h on 25 June, 3 days after hatchling was detected in the clutch. Hatchlings were weighed, measured and examined for external deformities prior to release (Table 12, Table 14). Hatchling mean length and weight were greater for this clutch than for any other Kemp's ridley clutch incubated at the park this year. The hatchlings were promptly brought to the nest site for release. Many were disoriented when first placed on the beach because heavy cloud cover darkened the seaward horizon (Table 11). However, as the clouds passed the hatchlings oriented toward the sea. They were extremely active and swam vigorously. None were later found stranded on the shore. All 8 unhatched eggs were preserved and examined (Table 15). All 4 embryos were classified as to embryological stage of development at death (Table 16). Gonads were removed from the 4 late staged embryos, of which 3 were males and 1 was a female.

The second natural nest, designated clutch 12, was a loggerhead clutch laid at approximately 2300 h on 25 June, 1.2 km south of Access Road 1 on Mustang Island. This was the first confirmed nesting of a loggerhead on Mustang Island and only the third confirmed on the Texas coast (Hildebrand, pers. comm.). The nesting turtle was seen by visitors who failed to measure it but stated that it did not possess a flipper tag. They allowed the turtle to reenter the water and notified Tony Amos about the nesting the following morning. PAIS personnel met Amos at the nest site at about 0900 h and investigated the site. The turtle had faced directly inland as it deposited 113 eggs in a nest located at the base of a foredune, 37 m from the shoreline. The top eggs were located 18 cm from the sand surface and the nest was 50 cm deep. The eggs were excavated

and brought to PAIS. The incubation box was placed on a middle shelf in the incubation facility and was not moved throughout development. A floor heater was not run during the incubation period since ambient temperatures were unusually warm. Incubation temperatures were monitored closely and box lids were removed from this clutch at slightly cooler temperatures than outlined for Kemp's ridley clutches to ensure that incubation temperatures did not become too hot and reach lethal levels. Incubation temperatures ranged from 28.8-36.9 C. The mean incubation temperature during the middle third of development was 32.1 C (SD=1.1 C). The incubation box lids were removed 14 times, for a total of 178 h, to cool the eggs. A total of 140 ml of water was added to the clutch during 10 additions (Appendix IV). Seventy-eight (69.0%) of the eggs hatched after 47 days of incubation. Emerged hatchlings were transferred to another styrofoam box containing a layer of sand from the nest site. They were then monitored 24 hours a day to determine when they entered their infantile frenzy and could be released. The 78 hatchlings were divided into 3 groups based upon the degree of yolk sac absorption. Individuals in the 3 groups entered their infantile frenzy at approximately 0600 h on 13, 15 and 17 August (2, 4 and 6 days after clutch hatching was detected). Hatchlings were weighed, measured and examined for external deformities prior to release (Appendix IV). The hatchlings were promptly brought to the nest site for release. They were extremely active, entered the water rapidly and swam vigorously. None were later found stranded on the shore.

All 35 unhatched loggerhead eggs were preserved and examined. Most unhatched eggs were located in a mass in the center of the clutch and contained well developed embryos. Even though incubation temperatures never exceeded 36.9 C, loggerhead eggs may be less tolerant of high temperatures than are Kemp's ridley eggs and it is likely that high temperatures were lethal to those late staged embryos. Incubation of loggerhead eggs at 34 C has been shown to result in poorer survival and at 36 C, no survival (Yntema and Mrosovsky, 1980, 1982). Thirty-two embryos were found within the unhatched eggs. Miller (1985) was used to categorize embryos as to embryological stage of development at death. All were classified in stage 29 and 30 and gonads were removed from each for histological sex determination. Thirty-one were females and 1 could not be sexed.

Two clutches of Kemp's ridley eggs were laid in captivity at Sea Turtles, Incorporated, South Padre Island, Texas. They were designated clutches 13 and 14. David Owens coordinated packing these eggs into styrofoam boxes containing PAIS sand and delivering them to the park. The first clutch was laid on 3 July and contained 39 eggs and the second was laid on 25 July and contained 61 eggs (Appendix IV). Both clutches were placed on a top shelf in the incubation facility. Clutch treatment and monitoring was similar to that for all other 1988 year class clutches. No metabolic heating was detected in either clutch and hence egg temperatures never reached high levels. None of the eggs hatched. Clutch 13 was preserved after 60 days of incubation and clutch 14 after 57 days. All unhatched eggs were examined and appeared to be infertile. The parents of these clutches died during September. Dr. Owens and Dr. Robinson (TAMVDL) necropsied the 2 turtles. They found that the male possessed some reproductive tract abnormalities and may have been sterile.

PUBLIC EDUCATION

Efforts to educate the public about the Kemp's ridley project continued this year. Since PAIS is 105 km long and extensive areas are often devoid of NPS personnel, it is imperative that park visitors assist with turtle detection and report sightings. Therefore, great emphasis was placed on alerting park visitors of the potential for nesting Kemp's ridleys and urging them to look for nesting turtles and tracks.

Kemp's ridley posters and handouts were visible and available at PAIS throughout the year. Beginning in March, posters detailing the need to report sea turtle nestings were displayed at PAIS, other local parks, condominiums, banks, restaurants and stores of various sorts. A display about the Kemp's ridley project was placed in the PAIS Visitor Center. Beach signs, alerting visitors to report live sea turtle sightings immediately, were posted again this year.

Media interest and coverage remained high, as in past years. The need for park visitors to be alert for nesting turtles was stressed during most interviews. As usual, this coverage increased public interest in the project and resulted in numerous telephone calls to PAIS regarding the turtles. To meet this educational demand, interpretive programs were given to the public during 5 of the 7 scheduled hatchling releases. Programs were given to park visitors, school groups and community organizations. The incubation facility and laboratory were opened for public tours for the first time on National Parks Day, 25 August. Seventy-eight people attended the 9 tours given in 5 1/2 hours that day. Incubation conditions and informative posters were displayed. Also, a video tape produced by a local television station that explains the Kemp's ridley project, was shown to the public for the first time. This tape will be available at the park Visitor Center when it opens next year.

FUTURE PLANS AND RECOMMENDATIONS

Pursuant to a decision made by the Kemp's Ridley Sea Turtle Working Group, no additional Kemp's ridley eggs will be transferred to PAIS from Rancho Nuevo, Mexico for incubation and imprinting. It was thought that additional emphasis should be placed on expanding the programs at Rancho Nuevo and other beaches in Mexico where smaller numbers of *L. kempi* nest. Also, the experimental attempt to establish a secondary breeding colony of Kemp's ridley turtles was originally designed to last 10 years. A total of 22,507 eggs (221 clutches) have been shipped to PAIS from 1978-1988 (Table 2). Overall, 77.1% of the eggs have hatched and approximately 12,000 headstarted yearlings have been released into the Gulf of Mexico. To date, no Padre Island imprinted turtles have been confirmed to have returned and nested at PAIS. However, it is unknown how many have survived after release and none may be sexually mature yet. Future plans for the PAIS Kemp's ridley project focus around identifying if Kemp's ridleys return to nest at PAIS. Critical in these efforts are the continuation of public education programs, beach patrols and protection and monitoring of nesting sea turtles and nests.

Public education efforts should, and will, continue and intensify. Visitors

must be watchful for sea turtles while on the beach and must know to report sightings. The 2 natural nests found on Mustang Island this year may not have been detected without the visitor reports. Interpretive programs, media interviews and distribution of posters, signs and handouts should continue. Local organizations will be targeted to receive information about the possibility of sea turtles nesting on south Texas beaches. During the sea turtle nesting and incubation season, handouts, describing what turtle tracks look like and what people should do if they see nesting turtles or tracks, will be given to all park visitors as they pass through the PAIS Entrance Station. Posters will be more widely distributed. New beach signs will be developed and posted during the sea turtle nesting and incubation season. The video tape, that explains the Kemp's ridley project and what visitors should do if they see nesting turtles, will be available for viewing at the new park Visitor Center. More effort will be made to train and educate employees of other agencies who manage or frequent local beaches during the course of their duties, may encounter nesting turtles or tracks or may receive reports of nesting turtles or tracks.

Patrols for nesting sea turtles should, and will, continue and intensify. The goal of the PAIS portion of the international Kemp's Ridley Sea Turtle Restoration and Enhancement Program is the establishment of a secondary nesting population. Hence, PAIS beaches must be searched for signs of nesting activity to evaluate the success of the project and protect nesting females and their eggs. Although visitors can assist by providing reports, they often cannot provide the necessary details that are lost when the nesting female reenters the water. It is therefore preferable to have trained personnel on site as the event occurs so that all possible data can be collected and eggs can be protected as quickly as possible. At least 4 patrols per week to the Mansfield Channel and back will be scheduled from mid-April through August. Vehicle patrols can be supplemented with aerial patrols if lower altitudes and slower speeds can be authorized and if larger numbers of nesting turtles begin to appear on Texas beaches. Closed Beach and approximately 16 km of Kleberg County beach north of the park will also be patrolled by park biologists in the future.

An effort will be made to continue volunteer participation in sea turtle work at the park. Volunteers spent about 1,000 hours assisting with the Kemp's ridley project in 1988. The contributions of these volunteers greatly increased beach patrol coverage and was critical to the success of the program. Volunteers will be allowed to accompany biologists on turtle patrols and will be allowed to assist with public education and egg monitoring.

An action plan has been developed that details threats to nesting turtles, nests and hatchlings, measures that can be used to protect them and recommendations for dealing with eggs and hatchlings from nests laid on PAIS. The plan also outlines suggested procedures that could be followed if nesting activity is found on other Texas beaches southward from Matagorda Island. The draft version of this plan has been distributed to the members of the Kemp's Ridley Working Group and several other interested individuals. The plan will be finalized in 1989. Procedures recommended in the plan for dealing with nesting turtles, nests and hatchlings vary slightly with different levels of nesting. The basic recommendation is that sea turtle nests should be left at

the nest site if they can be protected from threats and that hatchlings should be released at the nest site. If smaller numbers of nests are laid on PAIS and cannot be protected *in-situ*, they will be incubated in styrofoam boxes at the park incubation facility. Larger numbers of nests that cannot be protected *in-situ* will be placed into corrals. Nests from other Texas beaches that cannot be protected *in-situ* and monitored can also be incubated in styrofoam boxes at the PAIS facility. Corrals can also be used at other Texas beaches if trained personnel are available to monitor them. Standard procedures, consistent with the action plan, will be followed at the park. The park incubation facility will be readied for egg incubation in mid-April each year in case natural nests are found and must be relocated. Styrofoam incubation procedures and temperature monitoring and modification practices will be the same as those used during the last few years. Equipment for protecting nests in styrofoam boxes, *in-situ* and in corrals will be investigated and stocked. All nests will be closely monitored and pertinent biological data will be collected for each, regardless of incubation method. The FWS and NMFS will be kept updated on nesting activity and will be consulted if any deviation from the action plan is proposed or necessary.

ACKNOWLEDGEMENTS

Many individuals must be thanked for their contributions to the Kemp's Ridley Restoration and Enhancement Project at PAIS. Rene Marquez Millan (Instituto Nacional de la Pesca), Jack Woody (FWS), Richard Byles (FWS), Patrick Burchfield (GPZ) and their staffs collected and delivered the eggs. Edward Klima, Charles Caillouet and their staff at the NMFS Galveston Laboratory received the hatchlings and provided immediate care for them. Milford Fletcher (National Park Service) provided support to the project at Padre Island.

We would like to thank the many PAIS employees who assisted with the project. John Hunter, Superintendent of PAIS, supported park participation in the Kemp's ridley project. Robert Whistler and his interpretive staff continued efforts to increase visitor's knowledge about the turtle project and provided informative programs to the public during the turtle releases. Pete Amodei and his maintenance staff assisted the project greatly by maintaining the patrol vehicles and completing several tasks that we requested for the program. Paul Reed, an employee in the Environmental Services Division, assisted greatly with beach patrols. The Youth Conservation Corps (Mark Applewhite [crew leader], John E. Amaya, Dalia A. Castellanos, David B. Kaszuba, Trey L. Kelly, Heather A. Mastenbrook and Catherine A. Trevino) retrieved the majority of the hatchlings. Numerous other PAIS employees aided with turtle releases, beach patrols and visitor contacts.

Gratitude is also extended to the large number of volunteers, visitors and media personnel who assisted with the project at PAIS this year. Charlie and Jo Tirrell contributed approximately 750 hours to the project and provided invaluable assistance. Their help with beach patrols greatly increased our coverage. They also made innumerable contributions to other aspects of the project. Other volunteers and visitors helped recapture hatchlings and reported sightings. Lee Dunkelberg, KIII television (ABC), Corpus Christi, covered the project on several occasions and produced an educational video tape for use in the PAIS Visitor Center. Carole Allen, Al Barr and other members of HEART (Help Endangered Animals Ridley Turtles) continued their public education efforts and support of the Kemp's ridley project.

LITERATURE CITED

- Burchfield, P.M., and F.J. Foley. 1985. Report on Republic of Mexico/United States of America conservation effort on behalf of Kemp's ridley sea turtle at Playa de Rancho Nuevo, Tamaulipas, Mexico, 1985.
- _____, _____ and P.T. Noyes. 1983. Report on Republic of Mexico/United States of America conservation effort on behalf of Kemp's ridley sea turtle at Playa de Rancho Nuevo, Tamaulipas, Mexico, 1983.
- _____, _____, C. Spitzer and S.L. Huntress. 1984. Report on Republic of Mexico/United States of America conservation effort on behalf of Kemp's ridley sea turtle at Playa de Rancho Nuevo, Tamaulipas, Mexico, 1984.
- Bustard, H.R., and P. Greenham. 1968. Physical and chemical factors affecting hatching in the green sea turtle, *Chelonia mydas* (L.). Ecology 49:269-276.
- Chaney, A.H. 1986. Beach temperatures at three sites on Padre Island, Texas and Rancho Nuevo, Tamaulipas, Mexico and their relation to the nesting of Kemp's ridley sea turtle (*Lepidochelys kempi*). Final report to the National Park Service, contract no. PX7490-6-0136.
- Cratz, F. 1982. Embryological stages of the marine turtle *Lepidochelys olivacea* (Escholtz). Rev. Biol. Trop. 30(2):113-120.
- Dutton, P.H., C.P. Whitmore and N. Mrosovsky. 1985. Masculinisation of leatherback turtle *Dermochelys coriacea* hatchlings from eggs incubated in styrofoam boxes. Biol. Conserv. 31:249-264.
- Gutzke, W.H., G.L. Paukstis and G.C. Packard. 1984. Pipping versus hatching as indices of time of incubation in reptiles. J. Herpetol. 18(4):494-496.
- King, R.E., P. Plotkin, Y. Weickum, D. Clark and D.J. Shaver. 1985. Padre Island National Seashore 1985 report: Kemp's Ridley Sea Turtle Restoration and Enhancement Project, incubation and imprinting phase. National Park Service, Dept. of Interior.
- _____, D.J. Shaver and K. Phillips. 1984. Padre Island National Seashore 1984 report: Kemp's Ridley Sea Turtle Restoration and Enhancement Project, incubation and imprinting phase. National Park Service, Dept. of Interior.
- Limpus, C.J., P.R. Reed and J.D. Miller. 1984. Islands and turtles: The influence of choice of nesting beach on sex ratios, p. 397-402. In: Proceedings: Inaugural Great Barrier Reef conference, Townsville, Aug. 28-Sept. 2, 1983. J.T. Baker, R.M. Carter, P.W. Sammarco and K.P. Stark (eds.). BCU Press.
- Miller, J.D. 1985. Embryology of marine turtles, p. 270-328. In: Biology of reptilia, vol. 14. C. Gans, F. Billet and F.F. Maderson (eds.). Academic Press, New York.

Morreale, S.J., G.J. Ruiz, J.R. Spotila and E.A. Standora. 1982. Temperature dependent sex determination: Current practices threaten conservation of sea turtles. *Science* 216:1245-1247.

Mrosovsky, N. 1980. Thermal biology of sea turtles. *Amer. Zool.* 20:531-547.

_____. 1982. Sex ratio bias in hatchling sea turtles from artificially incubated eggs. *Biol. Conserv.* 23:309-314.

_____, and C.L. Yntema. 1980. Temperature dependence of sexual differentiation in sea turtles: Implications for conservation practices. *Biol. Conserv.* 18:271-280.

Shaver, D.J., and A.H. Chaney. N.d. Results from an analysis of unhatched Kemp's ridley sea turtle eggs. In: First international symposium on Kemp's ridley sea turtle biology, conservation and management, Oct. 1985. C.W. Caillouet, Jr. and A.M. Landry, Jr. (eds.). National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory and Texas A&M University at Galveston, Dept. of Marine Biology, Galveston, Texas. (in prep.)

_____, E. Cheeseman, K. Brennan, N. Karraker and J. Bjork. 1987. Padre Island National Seahshore 1987 report: Kemp's Ridley Sea Turtle Restoration and Enhancement Project, incubation and imprinting phase. National Park Service, Dept. of Interior.

_____, D.W. Owens, A.H. Chaney, C.W. Caillouet, Jr., P.M. Burchfield and R. Marquez M. N.d. Styrofoam box and beach temperatures in relation to incubation and sex ratios of Kemp's ridley sea turtles. In: Extended abstracts from 8th annual workshop on sea turtle biology and conservation, Feb. 1988. B. Schroeder (ed.). Florida Dept. of Natural Resources, Stuart Field Station. NOAA Technical Memorandum. (in prep.).

_____, P. Plotkin, A. Neville and K. Brennan. 1986. Padre Island National Seashore 1986 report: Kemp's Ridley Sea Turtle Restoration and Enhancement Project, incubation and imprinting phase. National Park Service, Dept. of Interior.

Sokal, R.R., and F.J. Rohlf. 1981. *Biometry*. W.H. Freeman and Company. San Francisco.

Wibbels, T., D.W. Owens, G. Dienberg and J. Noell. 1985. Determination of sex ratios produced in the Kemp's ridley headstart program. Final report to the National Park Service, contract no. PX7490-5-0100.

Yntema, C.L., and N. Mrosovsky. 1980. Sexual differentiation in hatchling loggerheads (*Caretta caretta*) incubated at different controlled temperatures. *Herpetologica* 36:33-36.

_____, and _____. 1982. Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. *Can. J. Zool.* 60:1012-1016.

Table 1. General results of 1988 Kemp's ridley incubation and imprinting at Padre Island National Seashore.

Clutch number	Number eggs in clutch Padre Island	Number eggs in clutch Rancho Nuevo	Number (percent) eggs hatched	Number hatchlings died	Number hatchlings lost during release	Number hatchlings to Galveston
1	104	-	91.3	0	-	0
2	90	91	90.0	0	0	81
3	110	105	93.6	2	0	101
4	103	103	95.1	0	0	98
5	101	101	96.0	0	0	97
6	99	85	92.9	0	1	91
7	117	117	82.9	0	0	97
8	103	103	98.1	0	3	98
9	86	86	82.6	0	0	71
10	105	105	98.1	0	0	103
11	105	104	85.7	2	0	88
Total ^a	1,019	1,000	91.6	4	4	925

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Table 2. General results of 1978-1988 Kemp's ridley incubation and imprinting at Padre Island National Seashore.

Year	Number clutches from Rancho Nuevo	Number eggs from Rancho Nuevo	Number (percent) eggs hatched	Number (percent) hatchlings died at Padre Island	Number (percent) hatchlings lost during release	Number hatchlings to Galveston	Mean incubation period (days)
1978	17	2,191	1,931 (88.1)	64 (3.3)	19 (1.0)	1,848	51.5
1979	20	2,053	1,769 (85.7)	15 (0.9)	93 (5.3)	1,661	52.0
1980	32	2,976	2,502 (84.1)	14 (0.6)	65 (2.6) ^a	1,611	50.5
1981	23	2,279	1,898 (83.3)	11 (0.6)	19 (0.8)	1,868	48.3
1982	20	2,017	1,563 (77.6)	5 (0.3)	34 (2.2)	1,524	51.0
1983	18	2,006	242 (12.1)	10 (4.1)	2 (0.8)	230	52.0 ^b
1984	19	1,976	1,792 (90.7)	239 (13.3)	9 (0.5)	1,544	51.1
1985	20	1,978	1,664 (84.1)	13 (0.8)	25 (1.5)	1,623 ^c	48.8
1986	22	2,011	1,776 (88.3)	1 (0.1)	16 (0.9)	1,759	46.7
1987	20	2,001	1,288 (64.3)	5 (0.4)	1 (0.1)	1,282	47.6
1988	10	1,019	933 (91.6)	4 (0.4)	4 (0.4)	925	46.9
Total	221	22,507	17,358 (77.1)	381 (2.2)	287 (1.7)	15,875	49.7

^a Calculated excluding 810 hatchlings from 11 clutches intentionally released into the Gulf of Mexico.

^b Calculated based only upon the 9 clutches that hatched.

^c Calculated excluding 69 hatchlings from a Padre Island natural nest head started at the Galveston NMFS laboratory.

Table 3. Rancho Nuevo clutch history information for eggs collected and shipped to Padre Island National Seashore in 1988^a.

Clutch number	Rancho Nuevo clutch number	Flipper tag number	Carapace length (cm) ^b
1	-	-	66.2
2	1	T1009	70.0
3	3	T1035	66.0
4	4	T00881	73.5
5	5	T1030	67.0
6	6	T1165	70.3
7	7	K0123	-
8	8	K0159	65.0
9	9	K0242	66.0
10	11	T1116	69.5
11	12	T1119	75.0

^a Data provided by UTMSI (clutch 1) and INP, FWS and Gladys Porter Zoo (clutches 2-11).

^b Straight-line carapace length (clutch 1) and curved carapace length (clutches 2-11).

Table 4. Kemp's ridley 1988 year class clutch incubation information.

Clutch number	Lay date	Days of development upon arrival	Middle third of incubation period	Hatch date	Incubation period (days)
1	27 April	0	16 May - 3 June	22 June	57
2	26 May	25	11 June - 26 June	12 July	48
3	26 May	25	11 June - 25 June	11 July	47
4	28 May	23	13 June - 27 June	13 July	47
5	28 May	23	12 June - 26 June	12 July	46
6	28 May	23	13 June - 27 June	13 July	47
7	28 May	23	12 June - 26 June	12 July	46
8	28 May	23	12 June - 26 June	12 July	46
9	28 May	23	12 June - 26 June	12 July	46
10	29 May	22	14 June - 29 June	15 July	48
11	29 May	22	14 June - 29 June	15 July	48

Table 5. First third of incubation period clutch temperatures at Rancho Nuevo, Mexico^a.

Clutch number	First third of incubation period temperature (C)			No. of days
	mean	<u>Rancho Nuevo^a</u> standard deviation	range	
1	25.8	1.4	22.5-28.8	19
2	30.2	1.3	26.4-33.0	16
3	29.9	1.2	26.7-32.5	16
4	29.8	1.1	26.6-32.4	16
5	29.7	1.2	26.5-31.7	15
6	29.6	1.2	26.3-31.6	16
7	30.1	1.1	26.8-32.2	15
8	29.9	1.1	26.6-31.9	15
9	30.0	1.2	26.5-32.2	15
10	29.7	1.2	26.4-32.2	16
11	29.6	1.2	26.4-31.5	16

Table 6. Middle third of incubation period clutch temperatures at Rancho Nuevo, Padre Island National Seashore and overall.

Clutch number	Middle third of incubation period temperature (C)											
	Rancho Nuevo ^a				Padre Island				Overall			
	mean	SD	range	No. of days	mean	SD	range	No. of days	mean	SD	range	No. of days
1	-	-	-	0	29.7	1.4	25.9-32.9	19	29.7	1.4	25.9-32.9	19
2	29.8	1.2	28.3-32.2	9	32.2	1.3	28.7-33.9	7	30.8	1.5	28.3-33.9	16
3	30.0	1.0	28.6-32.1	9	32.5	1.4	29.3-34.3	6	31.0	1.6	28.6-34.3	15
4	29.6	1.0	28.5-31.7	7	31.9	1.2	28.7-34.4	8	30.8	1.4	28.5-34.4	15
5	29.5	1.0	28.4-31.6	8	31.9	1.2	28.6-33.7	7	30.6	1.4	28.4-33.7	15
6	29.3	1.0	28.2-31.5	7	32.1	1.3	28.5-34.5	8	30.7	1.5	28.2-34.5	15
7	29.8	1.0	28.4-31.9	8	32.4	1.3	29.0-34.2	7	31.0	1.6	28.4-34.2	15
8	29.7	1.1	28.2-32.0	8	32.5	1.4	28.7-34.5	7	31.0	1.7	28.2-34.5	15
9	29.6	1.1	28.1-31.9	8	31.7	1.2	28.3-33.5	7	30.6	1.4	28.1-33.5	15
10	29.2	0.9	28.2-31.3	6	31.9	1.3	28.5-34.9	10	30.9	1.5	28.2-34.9	16
11	29.1	0.9	28.2-31.2	6	31.4	1.1	28.3-33.8	10	30.5	1.2	28.2-33.8	16

^a Data provided by INP, FWS and Gladys Porter Zoo.

Table 7. Last third of incubation period clutch temperatures at Padre Island National Seashore.

Clutch number	Last third of incubation period temperature (C)			No. of days
	mean	<u>Padre Island</u> standard deviation	range	
1	32.7	2.6	25.5-36.8	19
2	35.2	0.8	32.6-37.0	16
3	35.6	0.8	33.8-37.3	16
4	35.1	1.0	32.2-37.2	16
5	35.1	1.0	32.8-37.0	16
6	34.9	1.0	32.3-37.0	16
7	35.4	0.8	33.7-37.1	16
8	35.6	0.8	33.4-37.2	16
9	34.7	1.1	32.3-36.9	16
10	35.5	1.0	33.5-37.7	16
11	35.3	1.0	33.0-37.4	16

total incubation period clutch, ambient and control box temperatures at Rancho Nuevo, and National Seashore and overall^a.

Clutch number	Total incubation period temperature (C)											
	Rancho Nuevo ^b				Padre Island				Overall			
	mean	SD	range	No. of days	mean	SD	range	No. of days	mean	SD	range	No. of days
1	-	-	-	0	29.7	3.4	22.5-36.8	57	29.7	3.4	22.5-36.8	57
2	30.0	1.3	26.4-33.0	25	34.2	1.7	28.7-37.0	23	32.0	2.1	26.4-37.0	48
3	29.9	1.1	26.7-32.5	25	34.7	1.7	29.3-37.3	22	32.2	2.3	26.7-37.3	47
4	29.8	1.1	26.6-32.4	23	34.0	1.8	28.7-37.2	24	31.9	2.2	26.6-37.2	47
5	29.7	1.1	26.5-31.7	23	34.1	1.8	28.6-37.0	23	31.9	2.3	26.5-37.0	46
6	29.5	1.1	26.3-31.6	23	34.0	1.7	28.5-37.0	24	31.8	2.2	26.3-37.0	47
7	30.0	1.1	26.8-32.2	23	34.5	1.7	29.0-37.1	23	32.2	2.2	26.8-37.1	46
8	29.8	1.1	26.6-32.0	23	34.6	1.8	28.7-37.2	23	32.2	2.3	26.6-37.2	46
9	29.8	1.2	26.5-32.2	23	33.8	1.8	28.3-36.9	23	31.8	2.2	26.5-36.9	46
10	29.6	1.2	26.4-32.2	22	34.1	2.1	28.5-37.7	26	32.0	2.4	26.4-37.7	48
11	29.4	1.1	26.4-31.5	22	33.8	2.2	28.3-37.4	26	31.8	2.5	26.4-37.4	48
A ^c	30.1	1.8	26.6-35.5	22	30.6	3.1	24.8-38.0	26	-	-	-	-
B ^c	-	-	-	-	30.4	2.9	24.8-37.2	26	-	-	-	-
C ^c	30.0	1.6	26.4-33.0	22	30.3	2.8	25.1-37.9	26	-	-	-	-
D ^c	29.7	1.5	26.1-32.7	22	30.4	1.0	27.5-32.6	26	-	-	-	-
E ^c	29.1	1.4	25.7-31.6	22	30.1	0.9	27.6-32.1	26	-	-	-	-
F ^c	29.3	1.3	25.9-31.7	22	30.0	0.7	28.1-31.9	26	-	-	-	-

^a Ambient and control box temperatures at Rancho Nuevo from 29 May-19 June and Padre Island from 20 June-15 July (when clutches 2-11 were incubating).

^b Data provided by INP, FWS and Gladys Porter Zoo.

^c A=ambient probes located center of northern middle shelf Rancho Nuevo and top shelf Padre Island, B=ambient probe located middle shelf Padre Island, C=control box located southwest end of northern middle shelf Rancho Nuevo and ambient probe located bottom shelf Padre Island, D=control boxes located northwest end of northern middle shelf Rancho Nuevo and top shelf Padre Island, E=control boxes located northeast end of northern middle shelf Rancho Nuevo and middle shelf Padre Island, F=control boxes located southeast end of northern middle shelf Rancho Nuevo and bottom shelf Padre Island. Overall mean temperatures were not calculated due to differences in shelf heights and control box and ambient probe locations at Rancho Nuevo and Padre Island.

Table 9. Kemp's ridley 1988 year class clutch hatching duration information.

Clutch number	Date and time hatching detected	Date last egg hatched	Duration of hatching	Late hatching individuals
1	22 June 0530	23 June	1 day	no
2	12 July 0615	14 July	2 days	no
3	11 July 0610	12 July	1 day	no
4	13 July 0550	14 July	1 day	no
5	12 July 1330	14 July	2 days	no
6	13 July 1120	16 July	3 days	yes
7	12 July 1330	16 July	4 days	yes
8	12 July 1330	16 July	4 days	yes
9	12 July 1330	15 July	3 days	yes
10	15 July 0655	16 July	1 day	yes
11	15 July 1440	18 July	3 days	yes

Table 10. Kemp's ridley 1988 year class hatchling pre-release information.

Clutch number	Number hatchlings transferred	Date and time transferred	Activity level in transfer box on release morning	Time in transfer box before release (h)
1	84	23 June 0830	active	47
	4	23 June 1115	active	44
	5	24 June 0615	active	25
	2	24 June 1250	active	19
2	18	13 July 0725	active	24
	24	13 July 1130	active	21
	18	14 July 0615	active	25
	21	15 July 1130	active	22
3	72	12 July 0800	inactive	24
	10	12 July 1120	inactive	21
	15	13 July 1200	active	21
	5	13 July 1200	active	45
4	33	14 July 2130	active	11
	50	15 July 0630	active	2
	15	15 July 1140	active	23
	45	13 July 1530	inactive	42
5	25	14 July 0630	inactive	27
	27	15 July 1420	active	19
	21	14 July 0930	active	47
	13	14 July 1030	active	46
6	46	15 July 1045	active	22
	11	16 July 0430	active	4
	1	16 July 0430	active	28
	54	13 July 1330	active	42
7	27	14 July 0630	active	26
	5	15 July 0645	active	2
	8	16 July 0700	active	4
	2	16 July 0700	active	25
8	1	16 July 0700	semi-active	49
	40	13 July 1630	active	16
	38	14 July 0630	active	51
	20	15 July 1330	active	20
9	2	16 July 0430	active	28
	1	16 July 0430	semi-active	52
	50	14 July 0700	active	50
	17	15 July 1220	active	20
10	3	15 July 1250	active	20
	1	16 July 0445	active	28
	94	16 July 0400	active	4
	8	16 July 0715	active	1
11	1	16 July 0715	active	50
	27	16 July 2100	active	12
	38	17 July 0530	active	3
	13	17 July 0635	active	2
	6	17 July 0635	semi-active	25
	2	18 July 0650	semi-active	1
	3	18 July 0650	inactive	24

Table 11. Kemp's ridley 1988 year class hatchling release and shipment information.

Clutch number	Number hatchlings released	Date and time released	Release duration (minutes)	Activity level during release	Disorientation exhibited during release	Date shipped to Galveston	Time held at Padre Island after release (days)
1	95	25 June 0730	60	active	yes	-	-
2	42	14 July 0750	35	active	no	14 July	0
	18	15 July 0745	45	active	no	15 July	0
	21	16 July 0930	25	active	no	16 July	0
3	82	13 July 0745	45	active	no	13 July	0
	15	14 July 0850	23	active	no	14 July	0
	4	15 July 0930	15	active	no	15 July	0
4	83	15 July 0817	33	active	no	15 July	0
	15	16 July 1015	40	active	no	16 July	0
5	70	15 July 0915	55	inactive	no	15 July	0
	27	16 July 0950	40	semi-active	no	16 July	0
6	91	16 July 0855	23	active	no	16 July	0
	1 ^a	17 July 0835	25	active	no	17 July	0
7	86	15 July 0845	47	active	no	15 July	0
	8 ^a	16 July 1052	15	active	no	16 July	0
	2	17 July 0750	40	active	no	17 July	0
	1 ^a	18 July 0832	20	semi-active	no	18 July	0
8	40	14 July 0820	40	active	no	14 July	0
	58	16 July 0915	22	active	no	16 July	0
	2 ^a	17 July 0812	23	active	no	17 July	0
	1 ^a	18 July 0840	1	semi-active	no	18 July	0
9	70	16 July 0830	25	active	no	16 July	0
	1 ^a	17 July 0830	22	semi-active	no	16 July	0
10	102	16 July 0755	47	active	no	16 July	0
	1 ^a	18 July 0848	27	semi-active	no	18 July	0
11	77	17 July 0855	35	active	no	17 July	0
	8	18 July 0750	55	semi-active	yes	18 July	0
	3	19 July 0715	45	inactive	no	20 July	1

^a Released closer to water than usual release point.

Table 12. Kemp's ridley 1988 year class hatchling carapace length and weight measurements.

Clutch number	Number of hatchlings	Carapace length (mm)			Weight (g)		
		mean	SD	range	mean	SD	range
1	95	44.42	0.93	42.10-46.35	17.84	0.72	15.11-19.14
2	81	43.08	0.88	40.45-44.85	16.74	0.64	15.25-18.26
3	101	41.10	0.99	38.65-43.35	14.39	0.87	12.51-16.30
4	98	42.48	0.84	40.55-44.05	15.36	0.52	13.79-16.63
5	97	42.36	0.74	40.45-44.05	14.74	0.45	13.70-15.79
6	91	41.05	0.84	38.60-43.75	13.42	0.59	11.70-14.65
7	97	43.10	0.97	38.90-45.10	15.25	0.86	13.37-16.77
8	98	41.57	1.06	39.65-48.75	14.10	0.66	11.96-15.76
9	71	44.37	0.88	41.65-46.15	17.80	0.56	16.78-19.09
10	103	42.45	0.81	40.30-44.45	15.43	0.56	14.14-16.76
11	88	42.85	0.91	40.75-45.00	16.16	0.83	14.15-17.91
Total ^a	925	42.37	1.28	38.60-48.75	15.25	1.34	11.70-19.09

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Table 13. Kemp's ridley 1980-1988 year class hatchling carapace length and weight measurements.

Year	Number of hatchlings	Carapace length (mm) ^a		Weight (g)	
		mean	SD	mean	SD
1980	317	43.62	2.04	-	-
1981	230	42.14	1.85	-	-
1982	199	44.71	1.66	-	-
1983	233	41.59	1.71	15.31	1.16
1984	1,774	43.53	1.37	16.37	1.26
1985	1,692	43.25	1.77	15.74	1.61
1986	1,759	43.57	1.39	16.28	1.58
1987	1,282	40.55	1.69	14.71	1.41
1988 ^b	925	42.37	1.28	15.25	1.34

^a 1980-1982 curved carapace length, 1983-1988 straight line carapace length.

^b Clutch 1 (Kemp's ridley natural nest) excluded from 1988 totals.

Table 14. Kemp's ridley 1988 year class hatchling deformities and deaths at Padre Island National Seashore.

Clutch number	Deformed		Dead	
	Number deformed	Description	Number dead	Date died
1	5	left margin of carapace indented	0	-
	1	right margin of carapace indented		
2	0	-	0	-
3	0	-	2	13 July
4	1	left side of carapace indented	0	-
5	2	right side of carapace indented	0	-
	1	left side of carapace indented		
6	0	-	0	-
7	3	left side of carapace indented	0	-
8	0	-	0	-
9	0	-	0	-
10	0	-	0	-
11	1	left side of carapace indented	1	16 July
			1	17 July
Total ^a	8	-	4	

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Table 15. Embryological analysis of 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.

Clutch number	Number eggs in clutch	Number unhatched eggs	Number eggs rotten	Number eggs infertile	Number eggs fertile but without embryos	Number eggs with embryos	Number embryos rotten	Number embryos staged	Number deformed embryos
1	104	9	0	3	2	4	0	4	0
2	90	9	1	0	4	4	0	4	0
3	110	7	0	0	1	6	0	6	0
4	103	5	0	0	1	4	0	4	0
5	101	4	0	0	2	2	0	3 ^a	2
6	99	7	0	5	2	0	0	0	0
7	117	20	0	5	7	8	0	8	3
8	103	2	0	1	0	1	0	1	0
9	86	15	0	3	10	2	0	2	1
10	105	2	0	1	1	0	0	0	0
11	105	15	0	2	2	11	0	11	0
Total ^b	1,019	86	1	17	30	38	0	39	6

^a Number of staged embryos exceeds the number of eggs with embryos because of the presence of twins.

^b Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Table 16. Embryological stages of development of embryos from 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.

Approximate days of development	3	4	5	5	6	7	9	10	12	12	15	17	20	21	21	22	23	24	26	27	28	29	30	33	36	36 - 40	40 - 45	45 - 45	45 - 50	50 - 55		
Embryological stage of development	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	27 - 28	28 - 29	29 - 30	30 - 31			
Clutch #																																
1																																
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
TOTAL ^a	0	0	0	0	0	0	0	2	1	0	2	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	3	0	3	24	0

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Table 17. Deformed embryos from 1988 Padre Island National Seashore unhatched Kemp's ridley eggs.

Clutch number	Number deformed embryos	Description of deformity	Embryological stage of development
5	2	#1-twin with no other obvious external deformities	28-29
		#2-twin (of #1) with no other obvious external deformities	28-29
7	3	#1-eyes absent, head enlarged and pointed	20
		#2-left front flipper lacking	30
		#3-eyes absent, large and soft diencephalon, crossed jaws	28-29
9	1	snout absent, eyes nearly joined at anterior of head	19
Total	6		

Ornithological analysis of 1980 and 1982-1988 Padre Island National Seashore unhatched Kemp's ridley eggs.

Year	#(%) of eggs unhatched	#(%) of unhatched eggs examined	#(%) of unhatched eggs examined rotten	#(%) of unhatched eggs examined infertile	#(%) of unhatched eggs examined fertile but without embryos	#(%) of unhatched eggs examined containing embryos	#(%) of embryos rotten	#(%) of embryos staged	#(%) of staged embryos deformed
1980	474(15.9)	450(94.9)	14(3.1)	226(50.2)	37(8.2)	173(38.4)	58(33.5)	115(66.5)	16(13.9)
1982 ^a	105(16.8)	105(100.0)	5(4.8)	28(26.7)	25(23.8)	47(44.8)	3(6.4)	44(93.6)	12(27.3)
1983	1764(87.9)	1629(92.3)	45(2.8)	252(15.5)	1102(67.6)	230(14.1)	17(7.4)	213(92.6)	6(2.8)
1984	184(9.3)	184(100.0)	11(6.0)	39(21.2)	59(32.1)	75(40.8)	3(4.0)	72(96.0)	11(15.3)
1985	341(16.4)	340(99.7)	21(6.2)	62(18.2)	77(22.6)	180(53.0)	4(2.2)	178(97.8)	23(12.9)
1986	235(11.7)	235(100.0)	4(1.7)	67(28.5)	51(21.7)	113(48.1)	2(1.8)	116(98.3)	26(22.4)
1987	713(35.6)	713(100.0)	1(0.1)	54(7.6)	67(9.4)	591(83.5)	0(0.0)	595(100.0)	16(2.7)
1988 ^b	86(8.4)	86(100.0)	1(1.2)	17(19.8)	30(34.9)	38(44.2)	0(0.0)	39(100.0)	6(15.8)
Total	3902(26.6)	3742(95.9)	102(2.7)	745(19.9)	1448(38.7)	1447(38.7)	87(6.0)	1372(94.8)	116(8.0)

^a Based upon the analysis of all unhatched eggs from 7 of a total of 20 clutches received at Padre Island National Seashore in 1982.

^b Clutch 1 (Kemp's ridley natural nest) excluded from 1988 totals.

Table 19. Embryological stages of development of embryos from 1980 and 1982-1988 Padre Island National Seashore unhatched Kemp's ridley eggs.

Approximate days of development	3	4	5	5	6	7	9	10	12	12	15	17	20	21	21	22	23	24	26	27	28	29	30	33	36	36 - 40	40 - 45	45	45 - 50	50 - 55				
Embryological stage of development	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	27 - 28	28 - 29	29 - 30	30 - 31	Total # %				
<u>Year class</u>																																		
1980	#					1				1	2	4	5	1	1		2	3	8	3	4	6			1	2	6	4	12	7	27	15	115	
	%					0.9				0.9	1.7	3.5	4.3	0.9	0.9		1.7	2.6	7.0	2.6	3.5	5.2			0.9	1.7	5.2	3.5	10.4	6.1	23.5	13.0	100.0	
1982	#					1				5	2	1	3	4		1		1						1		1	1	1	7	8	7	44		
	%					2.3				11.3	4.5	2.3	6.8	9.1		2.3		2.3						2.3		2.3	2.3	2.3	15.9	18.1	15.9	100.0		
1983	#					3	3	2		10	12	14	8	4	6	7	5	7	3	4	1	1			1	6	6	11	26	35	38		213	
	%					1.4	1.4	0.9		4.7	5.6	6.6	3.8	1.9	2.8	3.3	2.3	3.3	1.4	1.9	0.5	0.5			0.5	2.8	2.8	5.2	12.2	16.4	17.8		100.0	
1984	# 1									1	10	3	2	1	1	5		1	2		2	1				2	2	3	5	7	9	13	1	72
	% 1.4									1.4	13.9	4.1	2.8	1.4	1.4	6.9		1.4	2.8		2.8	1.4				2.8	2.8	4.1	6.9	9.7	12.5	18.1	1.4	100.0
1985	#					1	6	4	4	2			2	1			1						2	1		1	3	5	11	9	44	80	1	178
	%					0.5	3.4	2.2	2.2	1.1			1.1	0.5			0.5						1.1	0.5		0.5	1.7	2.8	6.8	5.0	24.7	44.9	0.5	100.0
1986	# 1 1					3	3	5		17	9	4	2	2	4	1	2	1					1	1			2	2	6	8	20	21		116
	% 0.9 0.9					2.6	2.6	4.3		14.7	7.7	3.4	1.7	1.7	3.4	0.9	1.7	0.9					0.9	0.9			1.7	1.7	5.2	6.9	17.2	18.1		100.0
1987	#					1				7	1	2		1	1		1		1	2	2		1	1		2	6	4	70	123	256	110	3	595
	%					0.2				1.2	0.2	0.3		0.2	0.2		0.2		0.2	0.3	0.3		0.2	0.2		0.3	1.0	0.7	11.7	20.6	43.0	18.5	0.5	100.0
1988 ^a	#									2	1		2			1		1	1								1	3		3	24		39	
	%									5.1	2.6		5.1			2.6		2.6	2.6								2.6	7.7		7.7	61.6		100.0	
TOTAL	# 2 1					1	7	8	16	55	33	31	19	15	18	10	11	16	13	11	8	10	3	2	3	15	23	31	134	196	405	270	5	1372
	% 0.1 0.1					0.1	0.5	0.6	1.2	4.0	2.4	2.3	1.4	1.1	1.3	0.7	0.8	1.2	0.9	0.8	0.6	0.7	0.2	0.1	0.2	1.1	1.7	2.3	9.8	14.3	29.5	19.7	0.3	100.0

^a Clutch 1 (Kemp's ridley natural nest) excluded from 1988 totals.



Figure 1. Kemp's ridley 1978-1988 year class mean incubation period.

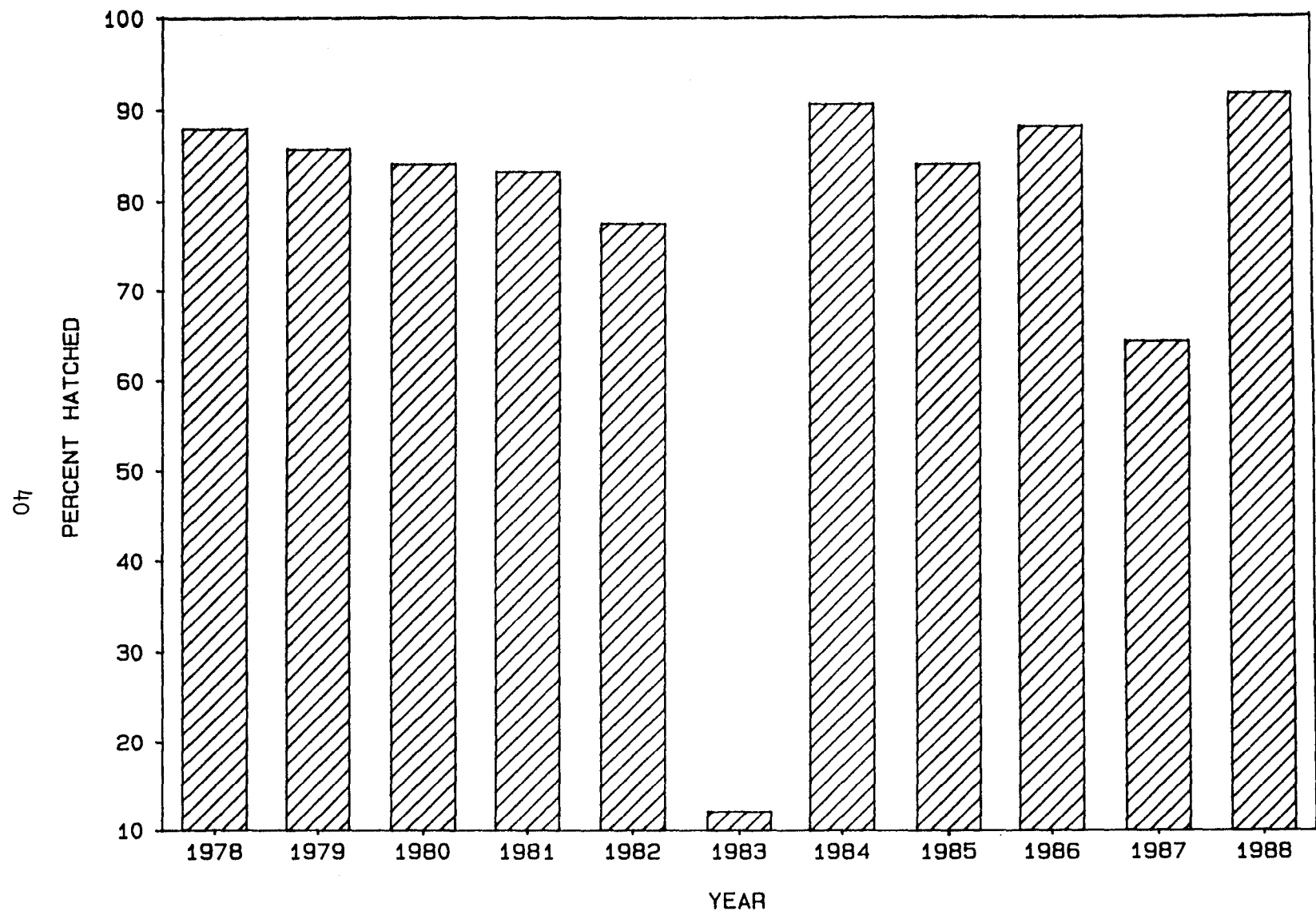


Figure 2. Kemp's ridley 1978-1988 year class hatching percentage.

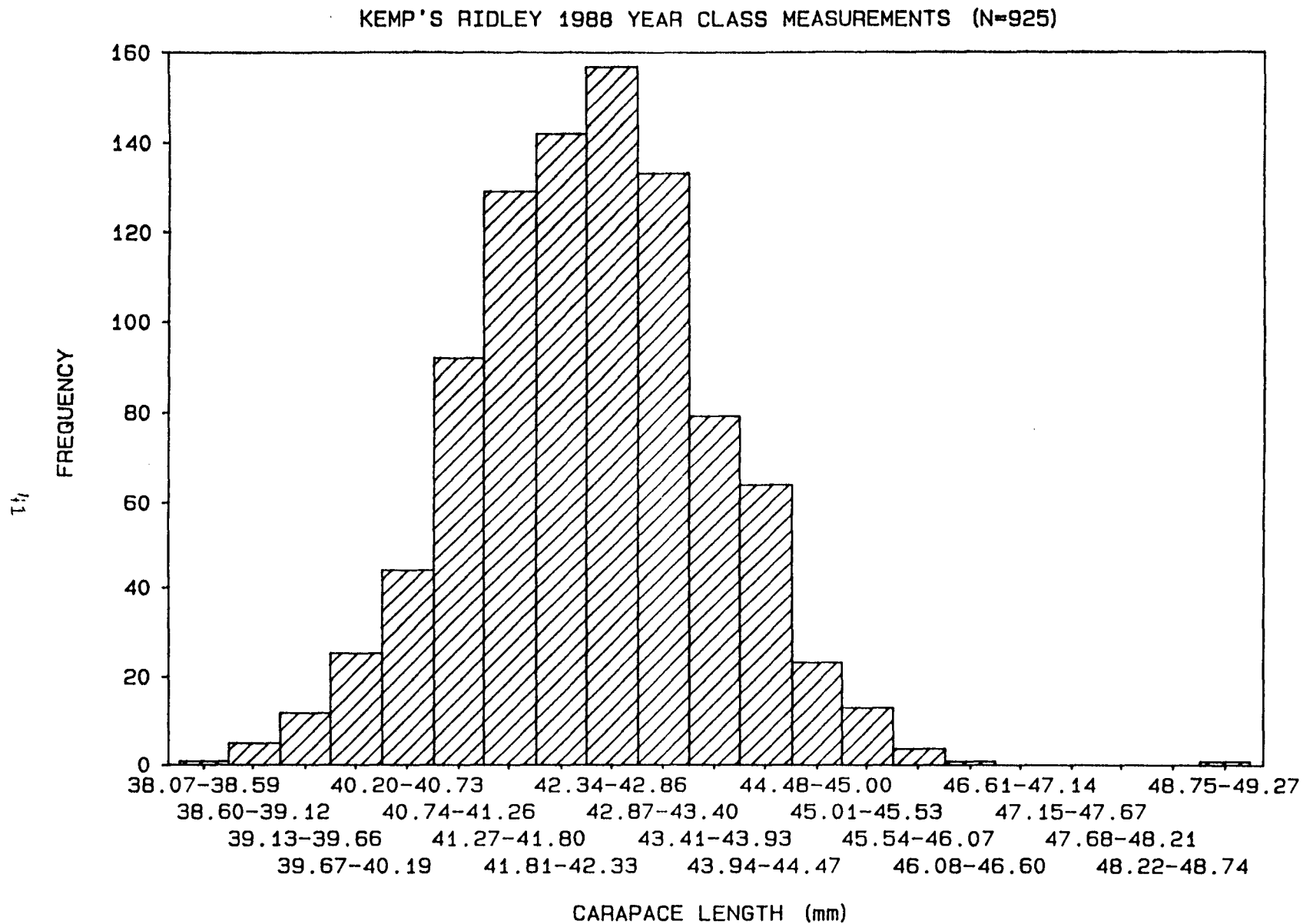


Figure 3. Histogram of straight line carapace length for all 1988 year class Kemp's ridley hatchlings.

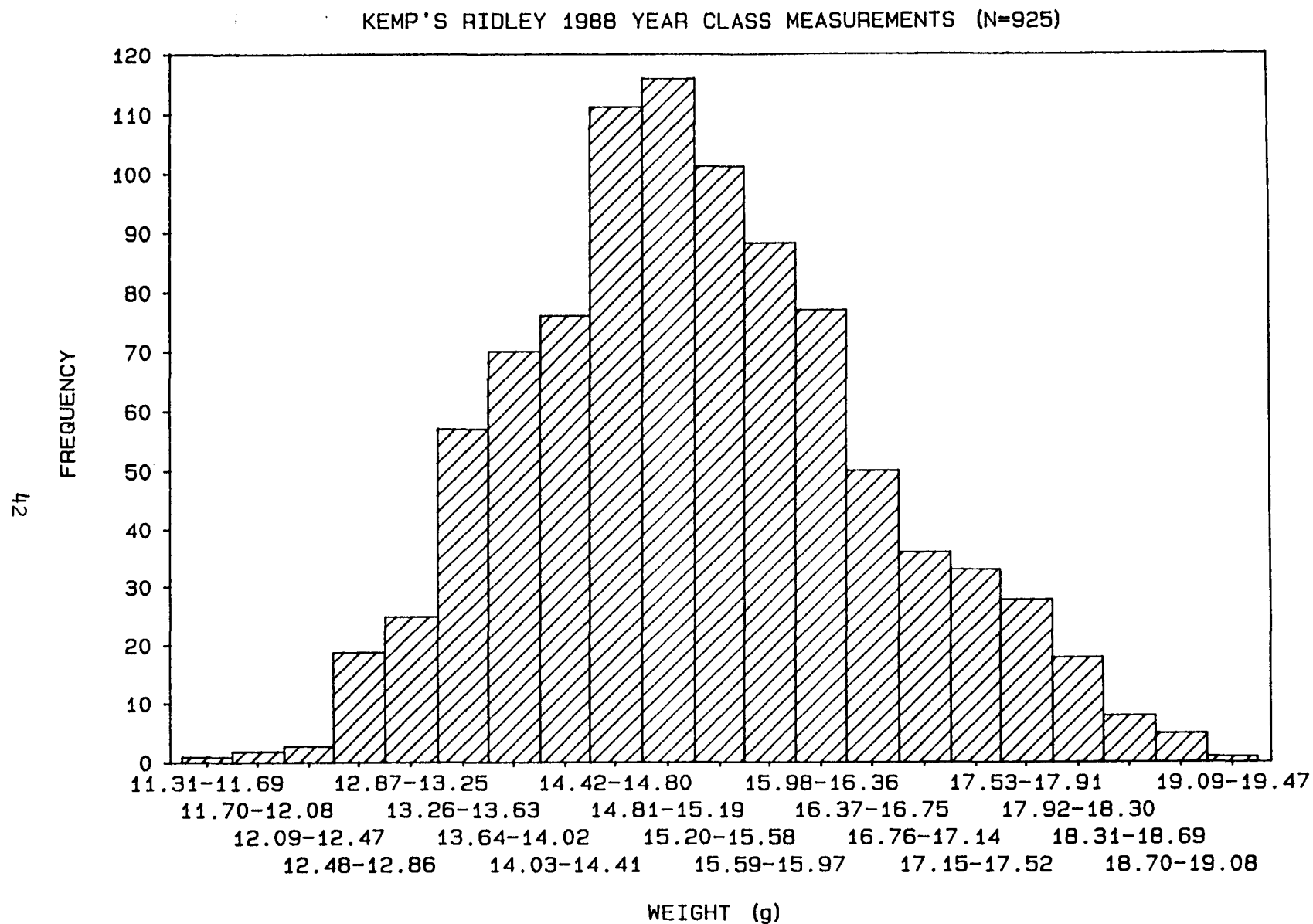


Figure 4. Histogram of weight for all 1988 year class Kemp's ridley hatchlings.

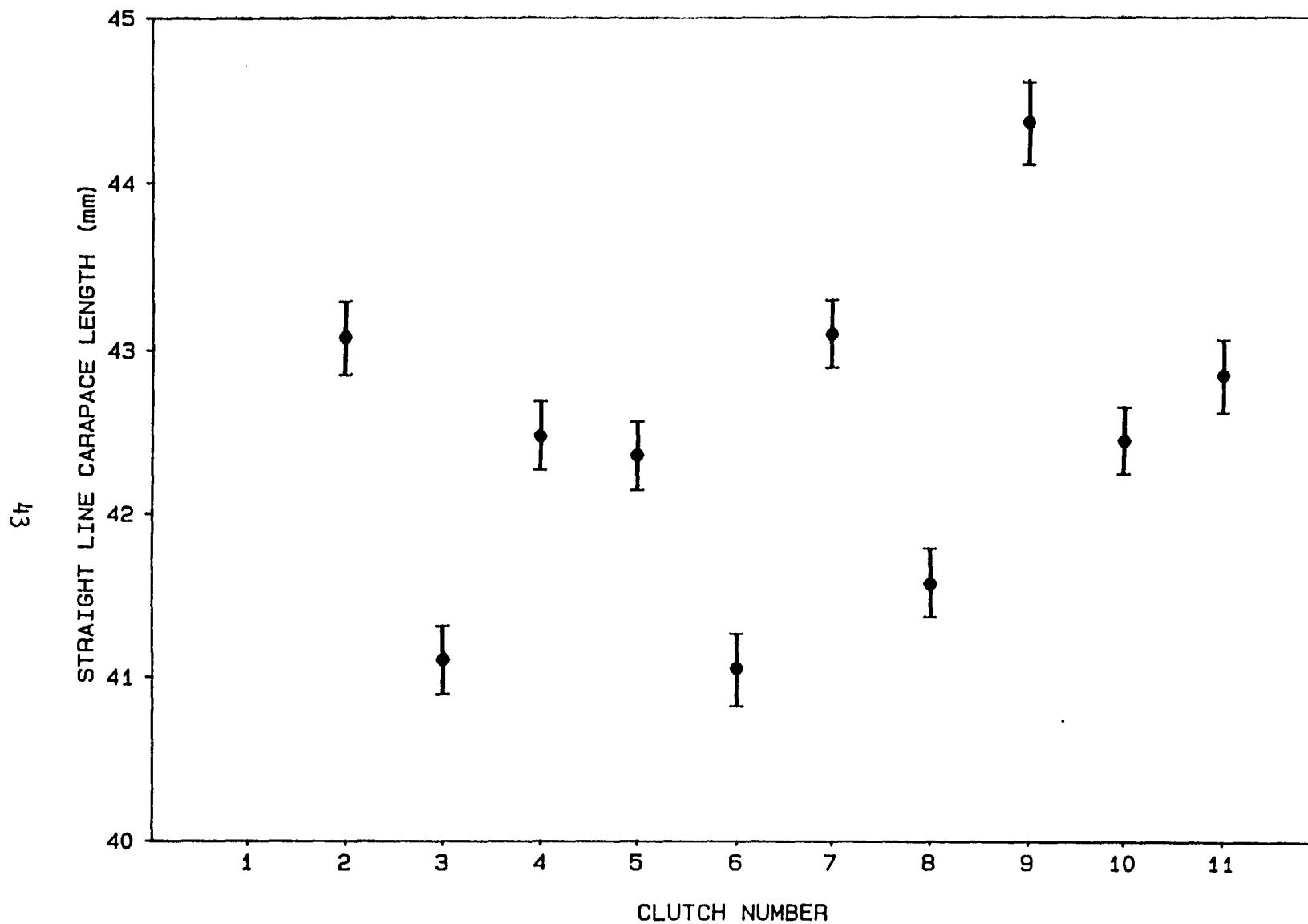


Figure 5. Kemp's ridley 1988 year class hatchling mean straight line carapace length comparison by clutch using the GT-2 method.

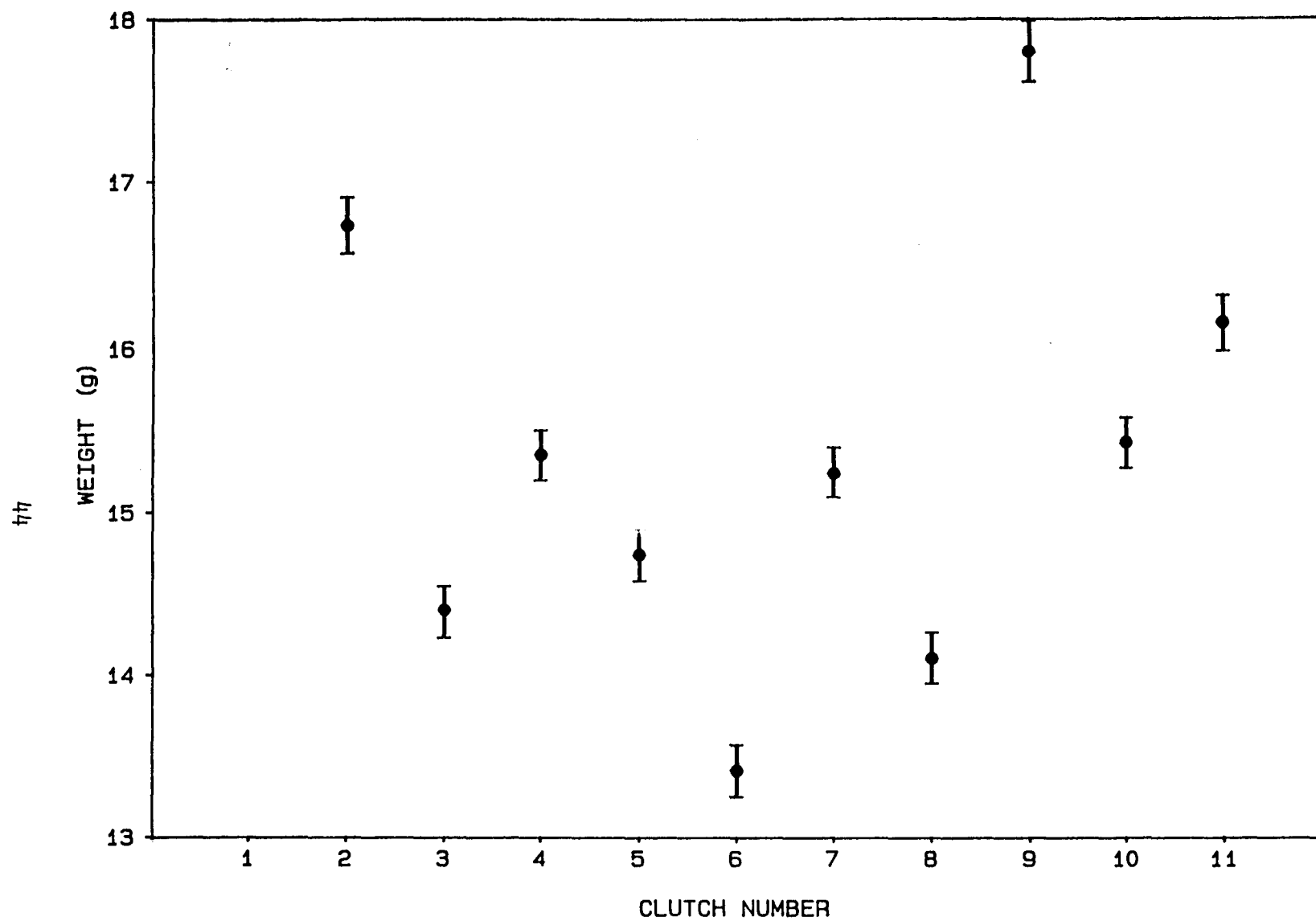


Figure 6. Kemp's ridley 1988 year class hatchling mean weight comparison by clutch using the GT-2 method.

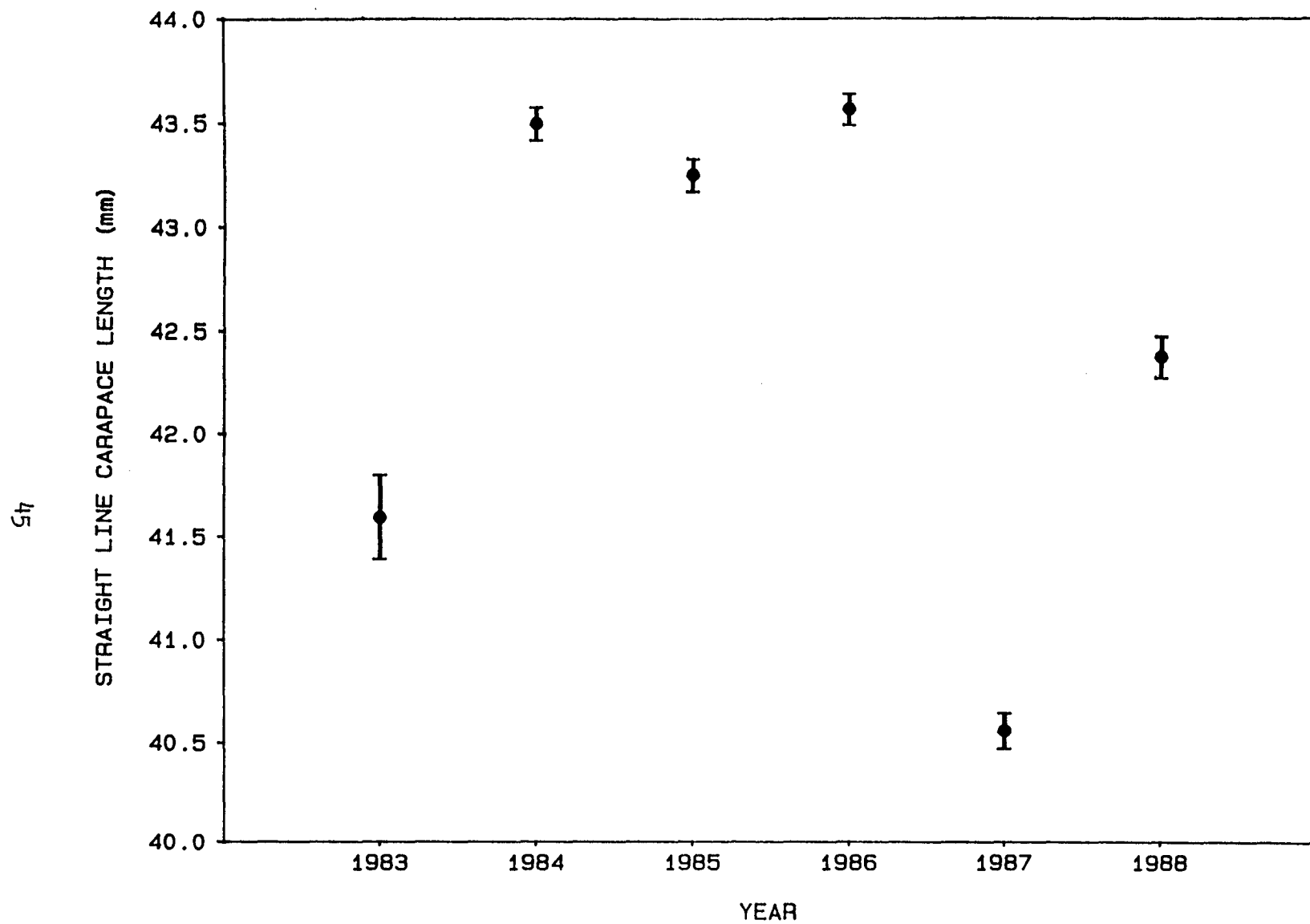


Figure 7. Kemp's ridley 1983-1988 year class hatchling mean straight line carapace length comparison using the GT-2 method.

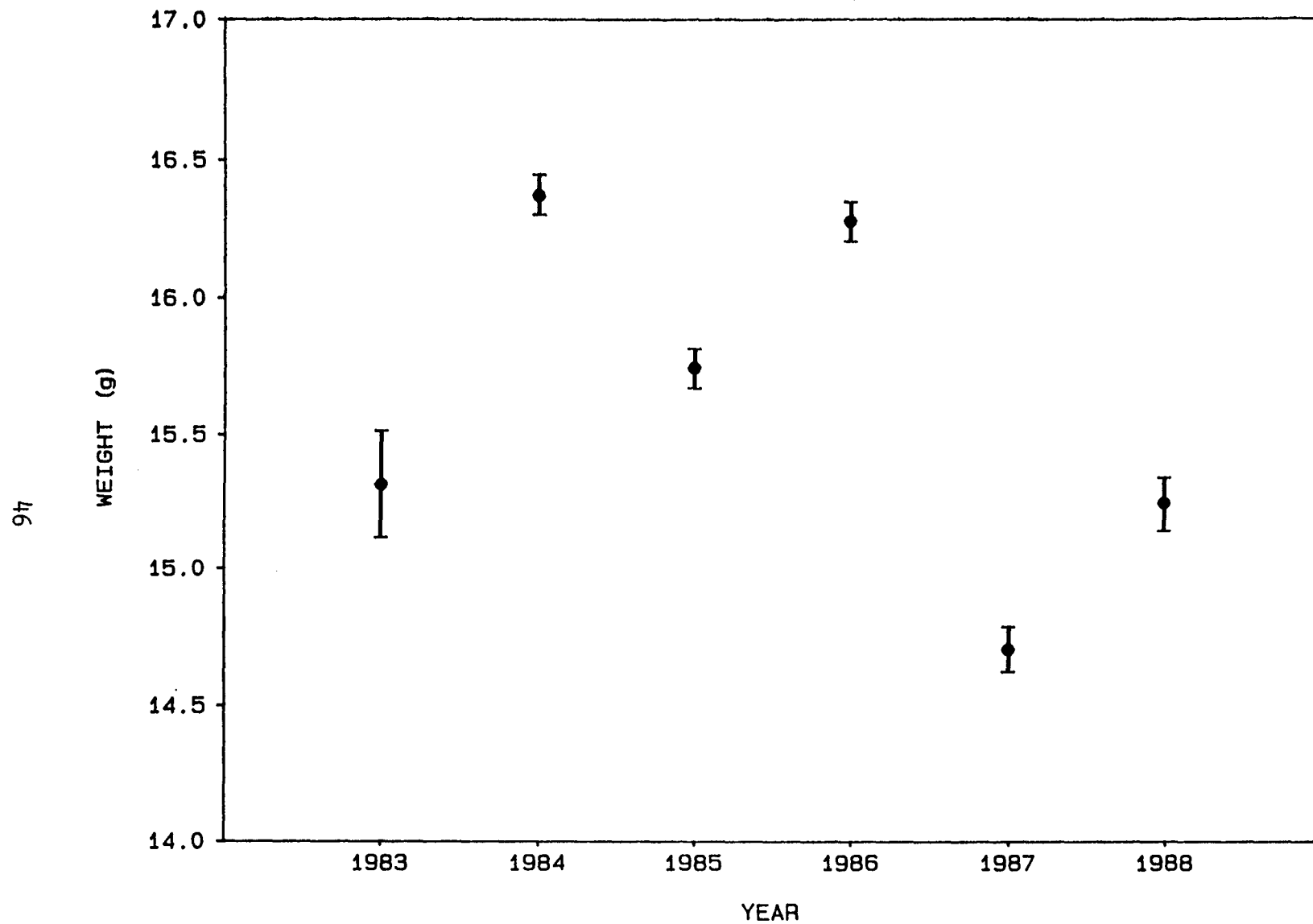


Figure 8. Kemp's ridley 1983-1988 year class hatchling mean weight comparison using the GT-2 method.

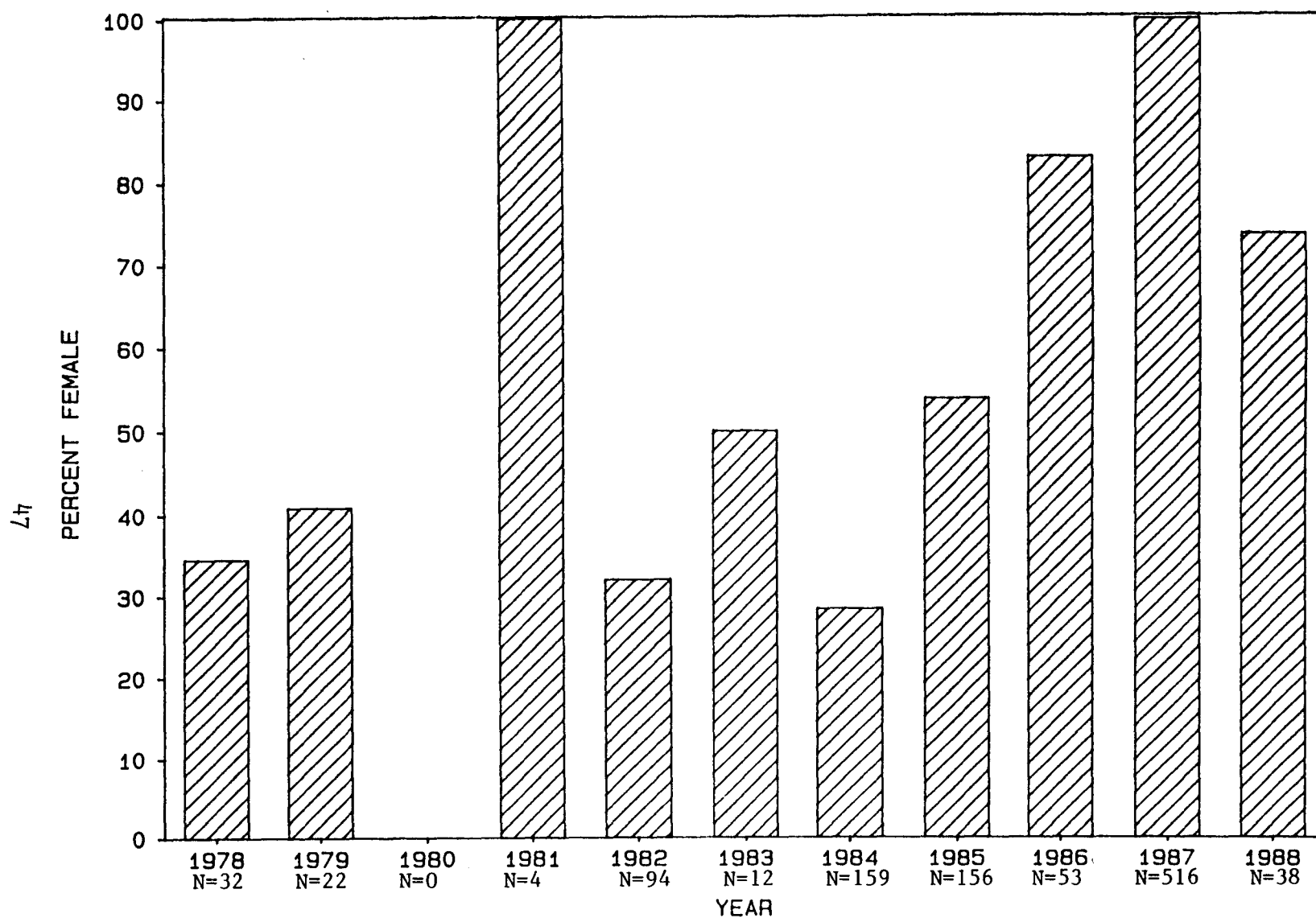


Figure 9. Percent of females from 1978-1988 year class Kemp's ridley individuals positively identified as male or female.

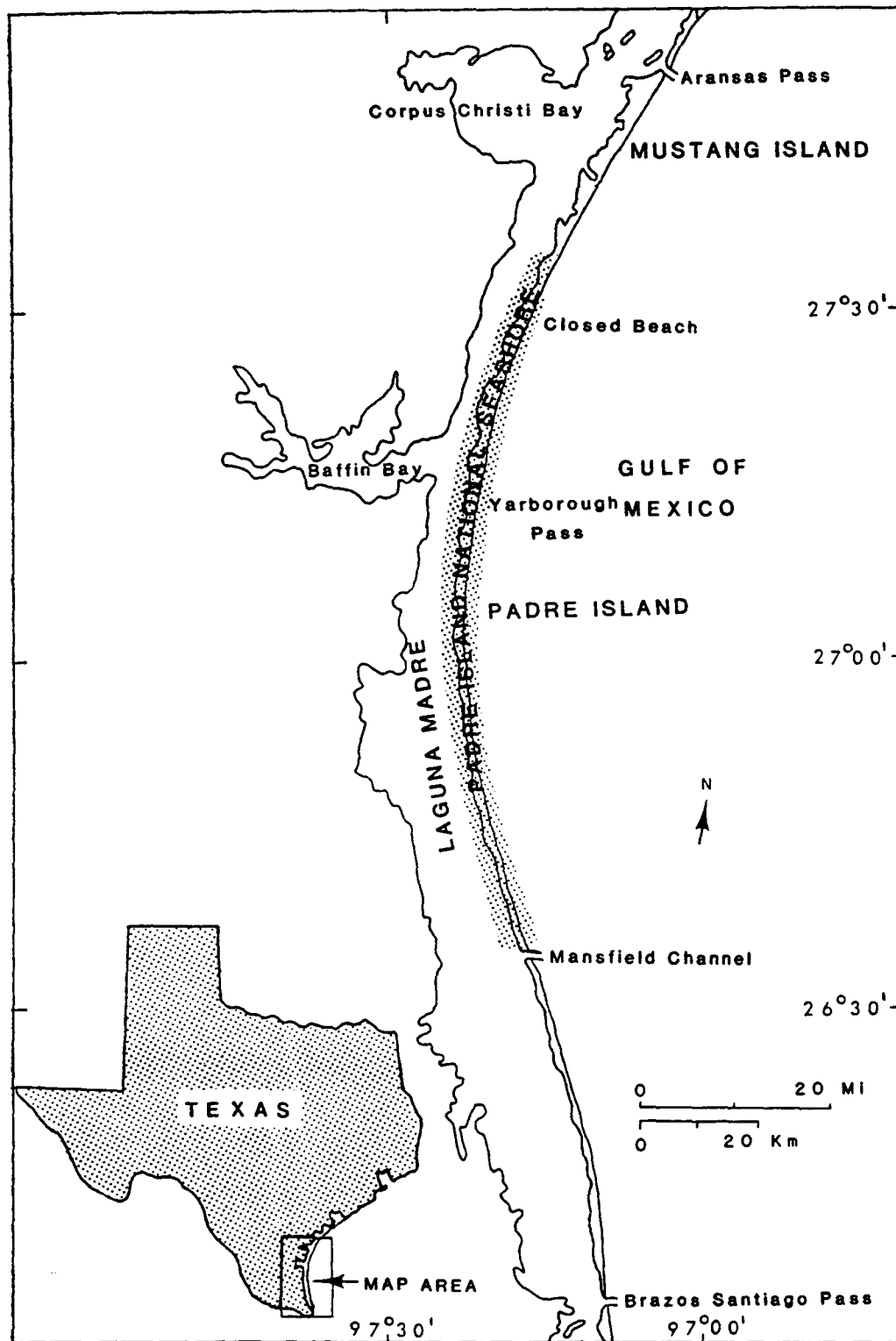


Figure 10. Map of a portion of the Texas coast and western Gulf of Mexico showing the location of Padre Island National Seashore.

Appendix I. Clutch shelf placement and handling at Rancho Nuevo^a (RN) and Padre Island National Seashore (PI) in 1988. 1 = RN middle shelf (124 cm), t = PI top shelf (157 cm), m = PI middle shelf (89 cm) and b = PI bottom shelf (20 cm).

Clutch number	Shelf location				Water addition		Lid removal	
	Rancho Nuevo	Padre Island			Padre Island		Padre Island	
	Initial location	Initial location	Moved to	Date and time moved	No. of additions	Total amount added (ml)	No. of removals	Total time removed (h)
1	-	t	-	-	0	-	0	-
2	1	t	b	1 July 0800	0	-	5	23
3	1	t	b	28 June 1700	2	20	12	104
4	1	t	b	1 July 0800	2	15	16	89
5	1	t	b	1 July 0800	3	55	10	105
6	1	t	b	1 July 0800	2	30	10	94
7	1	t	b	28 June 1700	3	50	11	113
8	1	t	b	30 June 0815	3	35	12	113
9	1	t	b	1 July 0800	1	10	9	61
10	1	m	-	-	3	30	14	144
11	1	m	-	-	2	20	11	116

^a Data provided by INP, FWS and Gladys Porter Zoo.

Appendix II. Number of Kemp's ridley 1988 year class hatchlings from each clutch released on each release date.

Clutch number	Date (1988)								Total
	June	July							
	25	13	14	15	16	17	18	19	
1 ^a	95								-
2			42	18	21				81
3		82	15	4					101
4				83	15				98
5				70	27				97
6					91	1			92
7				86	8	2	1		97
8			40		58	2	1		101
9					70	1			71
10					102		1		103
11						77	8	3	88
Total	-	82	97	261	392	83	11	3	929

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Appendix III. Number of Kemp's ridley 1988 year class hatchlings from each clutch transported to Galveston on each transport date.

Clutch number	Date (1988)								Total
	July								
	13	14	15	16	17	18	19	20	
1 ^a									-
2		42	18	21					81
3	82	15	4						101
4			83	15					98
5			70	27					97
6				90	1				91
7			86	8	2	1			97
8		38		57	2	1			98
9				70	1				71
10				102		1			103
11					77	8		3	88
Total	82	95	261	390	83	11	0	3	925

^a Clutch 1 (Kemp's ridley natural nest) excluded from totals.

Appendix IV. Incubation information on sea turtle 1988 year class clutches 12-14 incubated in styrofoam boxes at Padre Island National Seashore.

Parameter	Clutch 12	Clutch 13	Clutch 14
Species	<i>C. caretta</i>	<i>L. kempi</i>	<i>L. kempi</i>
Nest site	Mustang Island	captivity ^a	captivity ^a
Lay date	25 June	3 July	25 July
No. of eggs	113	39	61
Incubation box shelf location	middle shelf	top shelf	top shelf
Water addition during incubation			
no. additions	10	0	0
total amount added (ml)	140	0	0
Lid removals for cooling			
no. removals	14	0	0
total time removed (hours)	178	0	0
Incubation temperatures (C) ^b			
first third mean, SD, range	30.0, 0.5, 28.8-31.1	-	-
middle third mean, SD, range	32.1, 1.1, 30.3-35.6	-	-
last third mean, SD, range	35.6, 0.7, 33.4-36.9	-	-
overall mean, SD, range	32.6, 2.5, 28.8-36.9	-	-
Middle third of incubation dates	12 July-26 July	-	-
Incubation period (days)	47	-	-
Hatch date	11 August	-	-
Duration of hatching	5 days	-	-
Hatching percent	69.0	0.0	0.0
No. deformed hatchlings	0	0	0
Hatchling transfer dates	12-14 August	-	-
Hatchling release date	13, 15, 17 August	-	-
Hatchling release condition	active and semi-active	-	-
Hatchling measurements			
no. hatchlings measured	78	0	0
length mean, SD, range (mm) ^c	44.35, 1.09, 41.20-47.25	-	-
weight mean, SD, range (g)	22.52, 1.23, 19.63-24.72	-	-
Unhatched eggs			
no. unhatched	35	39	61
incubation day preserved	49, 51	60	57
no. infertile	0	39	61
no. fertile but without embryos	3	0	0
no. fertile with embryos	32	0	0
no. stage 29 embryos ^d	18	0	0
no. stage 30 embryos ^d	14	0	0

^a Clutches 13 and 14 were laid in captivity at Sea Turtles Inc., South Padre Island.

^b Incubation temperature monitoring for clutches 13 and 14 was terminated prior to egg preservation.

^c Straight-line carapace measurements were taken.

^d Miller (1985) was used to categorize embryos as to stage of development at death. Stage 29 corresponds to 86.0+/-2.0% of the incubation period and stage 30 to 94.7+/-2.0% of the incubation period.

