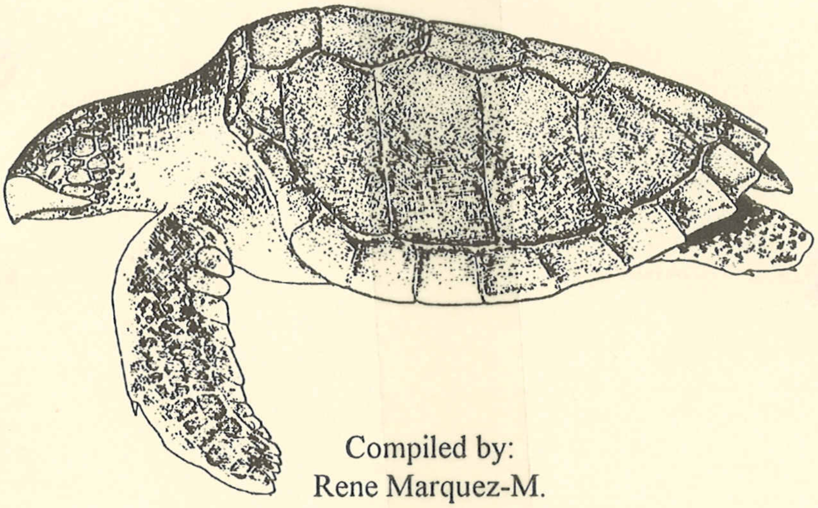
NOAA Technical Memorandum
NMFS-SEFSC-343

Synopsis of Biological Data on the Kemp's Ridley Turtle, *Lepidochelys kempi* (Garman, 1880)



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U.S. Department of Commerce
Ronald H. Brown, Secretary

National Oceanic and Atmospheric Administration
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NOTICE

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1. IDENTITY

1.1 Nomenclature

1.1.1 Valid Name

Lepidochelys kempi (Garman, 1880)

1.1.2 Synonymy

The synonymy was adapted from Deraniyagala, 1943; Smith and Taylor, 1950; Wermuth and Mertens, 1961; Pritchard and Marquez, 1973; Zwinenberg, 1977; Smith and Smith, 1979; Marquez, 1990.

Thalassochelys kempi Garman, Bull. Mus. Comp. Zool., Cambridge 1880, 6:123. Gulf of Mexico (Restricted to Key West, Fla. by Smith and Taylor, Bull. U.S. Nat. Mus., 1950, 199:15)

Colpochelys kempi Garman, Bull. Mus. Comp. Zool., Cambridge 1880, 6:124. Gulf of Mexico (Restricted to Key West, Fla. by Smith and Taylor, Bull, U.S. Natl. Mus., 1950, 199:15)

Thalassochelys ((Colpochelys) *kempi* Garman, Bull. U.S. Nat. Mus., 1884, 25(6):301

Thalassochelys kempi Boulenger, Cat. Chelon. Rinchoceph. Crocod. Brit. Mus., 1889, p 186

Lepidochelys kempi Baur, Amer. Natur., 1890. 24:487. Gulf of Mexico (Restricted to Key West, Fla., by Smith and Taylor, Bull. U.S. Nat. Mus., 1950, 199-15)

Lepidochelys kempi Hay, Carnegie Inst. Wash. Pub., 1908a, 75:9

Colpochelys kempi Hay, Proc. U.S. Nat. Mus., 1908b, 34:183

Caretta kempi Siebenrock, Zool. Jahrf. Sept. Suppl., 1909, 10:551, 3 pls.

Brongersma comments on the confusion which exists with *Testudo viridi-squamosa* Lacepede, 1788, originally included in the synonymy of *L. kempi* by Wermuth (1956) and followed by several authors (Wermuth and Martens, 1961, Zwinenberg, 1977) and concludes: "by its morphology and restricted area in Boca del Toro, Panama, outside the area of distribution of L. Kempi", that its inclusion was not well founded and agrees with Loveridge and Williams (1950) in considering this a synonym of the green turtle *Chelonia mydas*. *Testudo mydas minor* Suchow, 1788, is identified with Kemp's ridley by Wermuth (1956), Mertens and Wermuth (1960, 1961) and Wermuth and Mertens (1961), but according to Brongersma (1961) there is an error in the type locality, outside the species distribution, as in *viridi-squamosa*, and which "should have been applied to a Pacific turtle". Pritchard (1969a) makes additional comments on these synonyms, reaching the same conclusion as Brongersma (1961) and Smith and Taylor (1979).

The 1985 Code of Zoological Nomenclature mandates Article 31a that patronymic species group names follow the rules of Latin grammar. Consequently, *Lepidochelys kempii* is corrected to *Lepidochelys kempi*. - Ed.

1.2 Taxonomy

1.2.1 Affinities

Suprageneric:

- Phylum Chordata
  - Subphylum Vertebrata
    - Superclass Tetrapoda
      - Class Reptilia
        - Subclass Anapsida
          - Order Testudinata
            - Suborder Criptodira
              - Superfamily Chelonioidea
                - Family Cheloniidae

Generic:

Genus *Lepidochelys* (adapted, according to Smith and Smith, 1950; Romer, 1956 and Loveridge and Williams, 1957)

Lepidochelys Fitzinger, 1843: Syst. Rept., fasc 1, p. 30. Type: *Chelonia olivacea* Eschscholtz, 1829, Zool. Atlas 1, p. 3 (by original designation)

Caouana Gray, 1844: Cat. Tort. Croc. Amphist., Brit. Mus.: 53. Type: *Chelonia olivacea* Eschscholtz

Colpochelys Garman, 1880; Bull. Mus. Comp. Zool. Cambridge, 6, p. 123. Type: *kempi* Garman (monotypic)

- Generic

Genus *Lepidochelys*, monotype, see specific diagnosis.

- Specific

Species *kempi* Garman, 1880

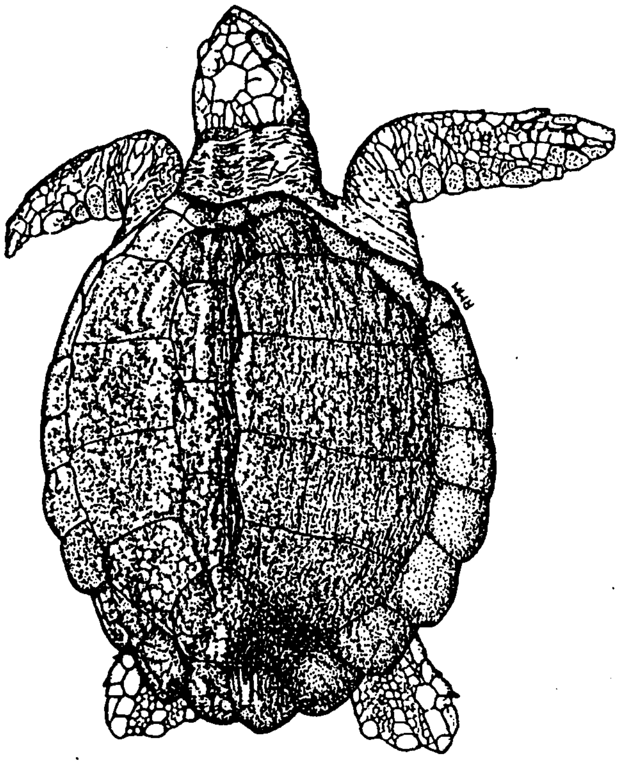

Figure 1. Kemp's ridley, *Lepidochelys kempi*. Post-juvenile: SCL - 48cm.

Diagnosis: In the adults the dorsal view of the carapace is semicircular, depressed body, slightly flatter than in *L. olivacea*, its width (in a straight line) is always more than 90% of its length. The head is relatively small (near 20% of the carapace length), subtriangular in shape (Figure 1), with a beak similar to that of a parrot. The carapace length (SCL), normally varies between 60 and 65 cm, the average weight is between 30 and 35 kg. Normally the carapace has the following numbers of scutes: 5 central, 5-5 lateral (more than 5-5 in *L. olivacea)* and 12-12 marginals; its plastron has 4-4 inframarginals, each one with a small pore directed towards the posterior-external margin. Each flipper has a well developed claw and a small one, on the anterior medial-distal border, the smaller one almost hidden; the claws in the males are more developed and stronger and also have a long and thick tail. The color pattern on the dorsal side is olive-gray to olive-brown, and the ventral side cream to yellow-white. More detailed information on these aspects can be found in: Deraniyagala (1930, 1939a), Carr (1952), Loveridge and Williams (1957), Chavez (1968), Pritchard (1969a), Marquez 1970, 1977, 1981, 1984, 1990), Brongersma (1972), Pritchard and Marquez (1973), Hughes (1974), Marques et al. (1976), Zwinenberg (1976, 1977), Frazier (1983), Pritchard and Trebbau (1984), Marquez and Carrasco (1992).

1.2.2 Taxonomic Status

Lepidochelys kempi, is well defined by its morphology, geographic separation, and its peculiar behavior during nesting. It is different from the Olive ridley, *L. olivacea*, which nests consistently at night during the months of June and December. *L. kempi* nests in the daytime during April and July. The evolutionary divergence is not only evident in its behavior, morphology and geographic distribution, but also different in the mitochondrial DNA. The difference indicates that the separation of the two species probably occurred during the formation of the Isthmus of Panama (Bowen et al., 1991). The DNA research results also indicate that the divergence between the *L. olivacea* of the Costa Rican Pacific and that of the Surinam Atlantic are indistinguishable (P= 0.000), while *L. kempi* demonstrated a substantial difference (P=0.012+1-0.003) with respect to both olive ridley populations.

In trying to determine this evolutionary difference between *L. kempi* and *L. olivacea*, Bowen et al. (1991) arrived at the conclusion that the two species separated about 3 to 6 million years ago, which is congruent with the view that both species where geographically isolated 3 million years ago. It is also appears that *L. olivacea* was an offshoot of *Caretta* at the Miocene period, or about 10 to 20 million years ago. The only fossil evidence of *Lepidochelys*' relationship with modern species *L. kempi* was found in Bone Valley, Florida, from the beginning of Pliocene (about 4.5-5 million years ago) noted by Dodd and Morgan (1992).

1.2.3 Subspecies

None are recognized to date. Several authors (Deraniyagala, 1943; Schmidt, 1953; Mertens and Wermuth, 1955, 1960; Loveridge and Williams, 1957; Wermuth and Mertens, 1961) consider *kempi* as a subspecies of *L. olivacea*, but at present after several studies on behavior and morphology, Carr (1942, 1957); Pritchard (1969a, 1989); Marquez (1970, 1990); Brongersma (1972), Marquez et al. (1976, 1981), Friar (1979, 1982); Friar and Shah (1981); Pritchard and Trebbau (1984) have concluded that *L. kempi* should be considered a distinct species.

L. kempi is a monotypic species that shows uniform characteristics over the full length of its geographic distribution and hardly ever has been found overlapping with the areas where *L. olivacea* is distributed (Marquez, 1977). Chavez and Kaufman (1974) published the only known occurrence relative to the southeast Caribbean, in which an adult female tagged in Rancho Nuevo, Tamaulipas in May 1966 was recaptured in Magdalena, Colombia in June 1971. Records of juveniles and subadults from the Atlantic and Gulf of Mexico coast of U.S. are common (Ogren, 1989). Ogren notes that these animals are more abundant in Louisiana, Alabama and northeast Florida. Pritchard and Marquez (1973) provide extensive information on the occurrence of the species, from the east coast of Florida to Nova Scotia, including one from Bermuda (Mowbray and Caldwell, 1958) and one from the Azores (Deraniyagala 1938, 1938b). Excepting from Colombia, there are no more confirmed occurrences for this species in the Caribbean. Apparently, on various occasions it has been confused with *L. olivacea*, noted in a few reports from Cuba (Aguayo, 1953, Varona, 1974) and Puerto Rico (Caldwell and Erdman, 1969) which could be from individuals originating from Guyana, Surinam and French Guiana. In certain areas of their geographic distribution *L. olivacea* and *L. kempi* may occasionally make contact, such as northwest Africa. Brongersma (1961, 1972) lists occurrences from Europe, up to 1972 for *L. kempi*, noting that all specimens were immature and probably originated from the only nesting beach located in the Gulf of Mexico. Brongersma and Carr (1983) published the only reported occurrence for the Mediterranean, from Malta. Klima and McVey (1981) and Wibbels (1983) noted the recapture of a juvenile turtle in Vieu Baucau-Biarritz, France, which was raised in Galveston, Texas and released in Homosassa, Florida in June, 1980. Povreau (1987) notes that this turtle was again recaptured on June 6, 1982 at Biarritz. Fontaine et al. (1985) reported on the recapture of another one in Morocco, both turtles had been raised for one year at the Galveston, Tx. Lab. (NMFS). Duguy (1986) summarizes data on the recovery of turtles noted from 1929 to 1986, including a dead one found on the north beach of Saint-Martin, Island of Re', France, November 21, 1985.

1.2.4 Common Names

Kemp's ridley turtle (English)

Tortuga lora (Spanish)

Tortue de kemp (French)

1.2.5 Definitions of Size Categories

In this case the definition is purely morphological. However, certain aspects should be considered about behavior and physiology so that the descriptions make more sense and it should be understood that these changes are gradual and the separation of the categories listed below are based on practical factors.

The definitions by size categories were adapted from Witzell (1983) for the hawksbill turtle (*Eretmochelys imbricata*), and Dodd (1988) for the loggerhead (*Caretta caretta*), in the following manner:

1) hatchlings - from emergence from the egg shell to closure of the umbilical opening, generally in two weeks. During this period the hatchlings are carried by ocean currents.

2) juveniles - small turtles without an umbilical scar, to medium size, with a maximum weight to 20 kg., dorsal and ventral ridges or spines visible. They leave the drift mode and approach coastal waters and start the benthic feeding mode.

3) subadults - in these the secondary characters start to appear, their weight is 20 to 25 kg. Ridges or dorsal spines disappear. Their feeding is primarily benthic.

4) adults - the animals are sexually mature, their weight is 25 kg or more and the standard length (SCL) is more than 50 cm. It is noted both sexes are the same length, yet the female of the same length can weigh about 10% more.

1.3 Morphology

1.3.1 Internal/External Morphology and Coloration

The general morphology of this turtle is described by Deraniyagala (1943), Carr (1952), Pritchard (1969a), Pritchard and Marquez (1973), Marquez (1970, 1977, 1990 in press), Rebel (1974), Zwinenberg (1977), Smith and Smith (1979) and Marquez and Carrasco (in press).

The first descriptions of the species were either confusing or were included with the synonymy of *Caretta* (see also Sections 1.1.2, 1.2.1). These results may have been influenced by measuring immature individuals which had not developed fully, therefore their morphological measurements and color patterns differed from those of the adults. According to Carr and Caldwell (1958), up to the

1950's, the only adults known were the holotypes used for the descriptions made by Garman (1880) and Hay (1908b). Consequently, the idea persisted that the turtle was a hybrid, an resulted in the common names: "bastard turtle", "mulato" or "bastardchild-kroten" (still used today). This contributed to increase the perplexity of its little known life cycle (Brongersma, 1972). This problem and its taxonomy were food for thought for many researchers (Carr 1942, 1957, 1961, Carr and Caldwell, 1956, 1958, Deraniyagala, 1943). Finally Hildebrand discovered the film showing the nesting beach on the west coast of the Gulf of Mexico (Carr, 1963a, Hildebrand, 1963). Since then the taxonomic position of this turtle, relative to *Lepidochelys olivacea* has been clearly shown. This is also discussed in Sections. 1.2.1, 1.2.2 and 1.2.3.

The morphometric descriptions and measurements of this turtle are shown in the following sources (see also Sections. 3.4.3):

- Garman (1880) two adults from Florida, U.S. (original description of the species, osteology and lepidosis);

- Coker (1906), 4 juveniles (2 carapaces and 2 live individuals) 3 from North Carolina (morphometric description and lepidosis);

- Hay (1908b), 5 juveniles and one adult from the east and southeast of the U.S. (morphology, osteology and lepidosis);

- Deraniyagala (1938a,b), 2 juveniles from Ireland (morphometric measurements of the carapace); (1939b) Azores Islands (measurements and lepidosis);

- Smith and Smith (1950), one juvenile from Louisiana (morphology and lepidosis);

- Liner (1954) 8 juveniles and adults from Louisiana (weights);

- Carr and Caldwell (1956), 96 juvenile and subadults from the Florida west coast (morphometric analyses and length/weight relationships; (1958) 2 adult and 4 hatchlings from Veracruz, Mexico, morphology and lepidosis);

- Brongersma (1961), 8 juveniles from Europe (same measurements and lepidosis); (1982) 25 juveniles from Europe (morphometric data and lepidosis);

- Dobie et al. (1961), 5 subadults from Louisiana (morphometric data);

- Dobie et al. (1961), 2 juveniles from Florida (growth data);

- Hardy, Jr. (1962), 3 juveniles from Maryland (morphometric measurements and lepidosis);

- Brongersma (1968), 2 juveniles and one subadult (morphometric measurements & lepidosis);

- Chavez et al. (1968a, b), eggs and hatchlings and adult females from Rancho Nuevo, Tamaulipas, Mexico (morphometric analysis and lepidosis);

- Pritchard (1969a), adults from Mexico (morphometric analysis and lepidosis);

- Marquez (1970, 1977, 1990, in press) eggs, hatchlings and adults from Tamaulipas (morphometric analysis, lepidosis and weights); (1972) hatchlings juveniles and adults (growth analyses);

- Pritchard and Marquez (1973), eggs, hatchlings and adults from Mexico (morphometry, lepidosis and growth curve);

- Zwinenberg (1977), juveniles and adults from Mexico (bibliographic compilation of morphology data);

- Zangerl (1980), adults (comparative osteology);

- Brongersma and Carr (1983), one juvenile from the Island of Malta (morphometric data and lepidosis);

- Rudloe et al. (1989), 106 juveniles and subadults from Florida (carapace length - SCL and weight);

- Standora et al. (1989), 5 juveniles from New York (growth rate in captivity and successive recapture);

- Zug and Kalb (1989), juveniles from northeast U.S. (chronology of skeletal growth);

- Wood and Wood (1989), 43 juveniles and adults from Mexico/Grand Caiman (growth and reproduction in captivity.

The adults are the smallest of all marine turtles (Marquez, 1970, 1977, 1990, 1993; Pritchard and Marquez, 1973; Zug and Kalb, 1989, Marquez and Carrasco, in press). The nesting behavior of this turtle is unique because it occurs during daylight hours. The external morphology it is also unique in having a depressed body, with a circular carapace and pores along inframarginal scutes of the plastron. Like other species, the mandibles are covered by a horny sheath, called tomium, which aids in the chewing of hard-shelled prey items such as crustaceans and mollusks. The tomium has in its palate a molar border in the shape of a "V" with the apex pointing forward and ending in a small depression which meshes with the cusp of the lower jaw and the border of the edge of the beak (Deraniyagala, 1943; Marquez 1970, 1990). The throat, as in the other marine turtles, is covered by spiny conical papillae (Harwell, 1982), which probably serve to keep soft and slippery food from sliding out, such as squid and jelly fish, or as proposed by Yoshie and Honma (1976), "these papillae may serve to break down food into small pieces", however, the most plausible is to aid in swallowing food particles; in the case of *kempi*, mainly crustaceans and mollusks.

The hatchling carapace, in contrast to that of the adults, is clearly longer than its width, as described by Chavez et al. (1968a) and Marquez (1970, 1990). The relationship between length and width is between 81% and 85% depending on relative growth and changing to 92% to 99% or more in the adults. The scutes in the hatchlings are slightly imbricated and juxtaposed at the final juvenile stage. The hatchlings show three dorsal longitudinal ridges and 4 in the plastron, with a small sharp protrusion or spine on each scute. With growth, the ridges will differ in the number of spines, one on each scute of the carapace and plastron, the ones on the latter disappear before the former ones. In some young adults, one can observe small nodules where the spines were. The marginal scutes on the hatchlings form a serrated border which blunt with age and become smooth in the adults. The head and flippers are proportionally larger in the hatchlings than in the adults. The "milk tooth" (**Figure 2**) present on the beak of the new born hatchlings, may persist for at least one month (Marquez, 1970, 1990; Pritchard and Marquez, 1973).

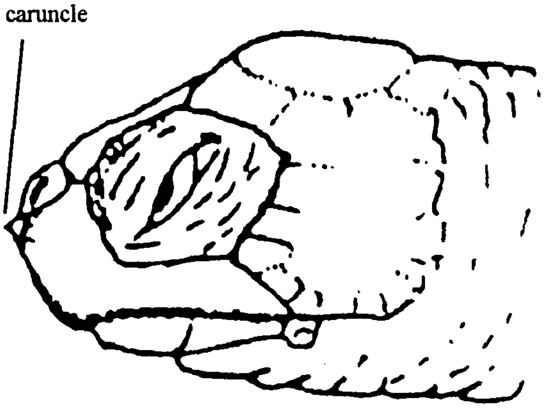

Figure 2. External morphology of a hatchling's head.

The early color descriptions were made on a small number of specimens, some of them preserved. Later, with discovery of the nesting beach in 1963, a greater opportunity arose to utilize live specimens, making further color description more accurate. Some of these sources, in chronological order follows: Deraniyagala (1934), no locality, probably juveniles; (1943), western Atlantic, adults; Carr (1952), Gulf of Mexico, subadults; Carr and Caldwell (1958), Veracruz, Mexico, four preserved hatchlings; Hardy, Jr. (1962), Maryland, preserved juveniles; Chavez et al. (1968a); Tamaulipas, hatchlings and adult females; Brongersma (1968a) Madeira Islands, juveniles and one preserved subadult; Pritchard (1969a), hatchlings, juveniles and adult females; Marquez (1970, 1977, 1981, 1990 in press) Tamaulipas eggs, hatchlings and adults; Zwinenberg (1977), data extracted from references, Mexico, juveniles and adults; Smith and Smith (1979) referenced data; Pritchard et al. (1983), western Atlantic and Gulf of Mexico, hatchlings and adults.

As in other turtles, the coloration changes with age, which is shown in the various development stages noted above. Possibly, because *L. kempi* comprises only one population, which (almost) jointly nest along the coast of Tamaulipas, the original color pattern changes little: the new-born hatchlings are dark gray or black, with green shades along the edges, the neck ad base of the fins; a whitish border can also be observed around the posterior border of the flippers, mainly the pectoral ones. With age, whitish spots appear around the scales on the head, especially the post-ocular ones, the edge of the beak, spines of the plastron, the edge of the plastron and of the flippers. In one year old juveniles the carapace remains black. The plastron becomes almost white, as well as the underside of the neck, beak and upper eyelids, the tail and proximal parts of the tail. At that age, dorsally, the turtle appears to be edged by a narrow white border, giving a sense of mimicry or camouflage when the animal is at rest or swimming near the bottom.

Nearing maturity the dorsal coloration becomes lighter, changing from dark gray to olive gray, the ventral side changes from white to cream with white undertones, especially along the side of the body, the sides of the head may also show rose color undertones. Adult turtles, dorsally are pale olive gray in color, darker when damp; they can also be covered by irregular yellow spots, randomly scattered; ventrally they are the same color as subadults with extended olive toned spots which extend out to the distal parts of the flipper. Usually this color pattern is constant throughout the nesting population and there is no distinguishable difference between sexes.

Illustrations and photographs of color patterns of the various development stages of the Kemp's ridley are generally scarce. The following sources provide some information: Coker (1906), North Carolina, diagram of dorsal and ventral sides of a juvenile; Carr (1942), dorsal sketch of a juvenile; Deraniyagala (1943), diagram of the bridge scutes and dorsoventral photograph of the head (adults?); Carr (1952), subadults of the Gulf of Mexico, photos of the ventral and dorsoventral part of a juvenile, and the ventral side of a female; Carr (1963a), photo of the front and dorsoventral side of a female, U.S.; Carr and Caldwell (1958), dorsal ventral and lateral photos of the head of four preserved hatchlings, Veracruz, Mexico; Brongersma (1961), sketch of the mandibular scales and plastron scutes of a juvenile; Holanda (1968a), sketch of the bridge scutes of a juveniles; Madeira, (1968b) sketch of the dorsal side of a juvenile; Holanda, (1972) sketch of lepidosis of the carapace, plastron, head and tomium of subadults and adults, Europe; Pritchard (1967), lateral-front photo of an adult female, Gulf of Mexico, (1969a) sketch of marginal scutes of a female and dorsal scales of the head of hatchlings and females, lateral view of the head of a juvenile and the dorsal plates of a female, Tamaulipas; (1979a) frontal-lateral view of the head and carapace of an adult female, dorsal, lateral and head photos of hatchlings, juveniles and subadults, Tamaulipas; Chavez et al. (1968b) photos of the posterior-dorsal-lateral sides and the head of an adult female, Tamaulipas; Marquez (1970, 1977, 1990) sketch of the inside of the mandible and lateral view of the head, lateral and dorsolateral photos of adult females, Tamaulipas; Seater (1972), frontal photo of an adult female, Mexico; Pritchard and Marquez (1973), dorsal and ventral photos of an adult female plus a lateral view of its head; Rebel (1974), dorsolateral photo of a juvenile, U.S.; Zwinenberg (1977), anteriorlateral, lateral and posteriorlateral photos of adult females, Mexico; Brongersma and Carr (1983), dorsal and lateral photo of a juvenile, Malta; Pritchard et al. (1983), dorsal sketch of dorsal and ventral sides, and head of a subadult, dorsal and ventral photos of hatchlings and subadults, Gulf of Mexico; Fontaine et al. (1985), dorsal photo of a juvenile (raised in Galveston), Tamaulipas; Marquez (in press) head and lateral sketch of the head of a hatchling and a juvenile, lateral-front of an adult female, photos of hatchlings and an adult female.

Illustrations of the internal morphology of this species are scarce. Zangerl (1953) published skeletal measurements between the families *Cheloniidae* and *Toxochelyidae*, including *L. kempi*. He hypothesized the close similarities with *Toxochelyidae* and that the existing two marine groups (Subfamilies: *Chelonia* and *Carettini*) are derived from a general group of the *Chelydridae*. These lived together during the Cretaceous age. The same author (Zangerl, 1980, 1988), shows illustrations of the anterior and posterior fin bones, and compares the length of the long bones of the fins with the relative length of the humerus (100%), indicating that the morphology of the long femur is more primitive and shows in *Lepidochelys* and *Caretta*, and the more advanced evolution of a short femur is shown *Eretmochelys*, *Chelonia* and *Natator*. Marquez (1970, 1990), shows cranial sketches of an adult and the plastron bones of a juvenile, both from Tamaulipas (**Figure 3a,b**).

The exoskeleton growth pattern of a subadult specimen examined by Rodin (1985) appears similar to that of *Caretta, Pseudemis, Scripta* and *Carettachelys insculpa*. The uncalcified cartilage is without vascularization, a typical pattern for Chelonidae.

Pritchard (1989), without illustrations, notes the skeletal peculiarities of the adult *L. kempi*. Similarly to its cogenus *L. olivacea*, they are different from the other marine turtles, owing to the absence of frontals in the carapace (Pritchard and Trebbau 1984) and also the number of neural bones which are normally 8 and in this species can be up to 15. Also, the wide shell could be the result of a behavioral reproductive adaptation in which the nest is compacted with lateral blows of the body. They also note that the plastron is excessively ossified, and cartilagineous areas persist only in the midline and the extreme lateral sides of the bridge, allowing some flexibility of the ventral side of the shell (**Figure 3b**).In this respect Zangerl (1980) notes that the slender dermal bones and the presence of fontaneles along the border of the carapace, between the side and periferic bones there exists little ossification, which is indicative of pelagic habits. Another characteristic of this species is the presence of Rathke glands, which are encysted in the outer margins of the hio-hipo-plastron and connect

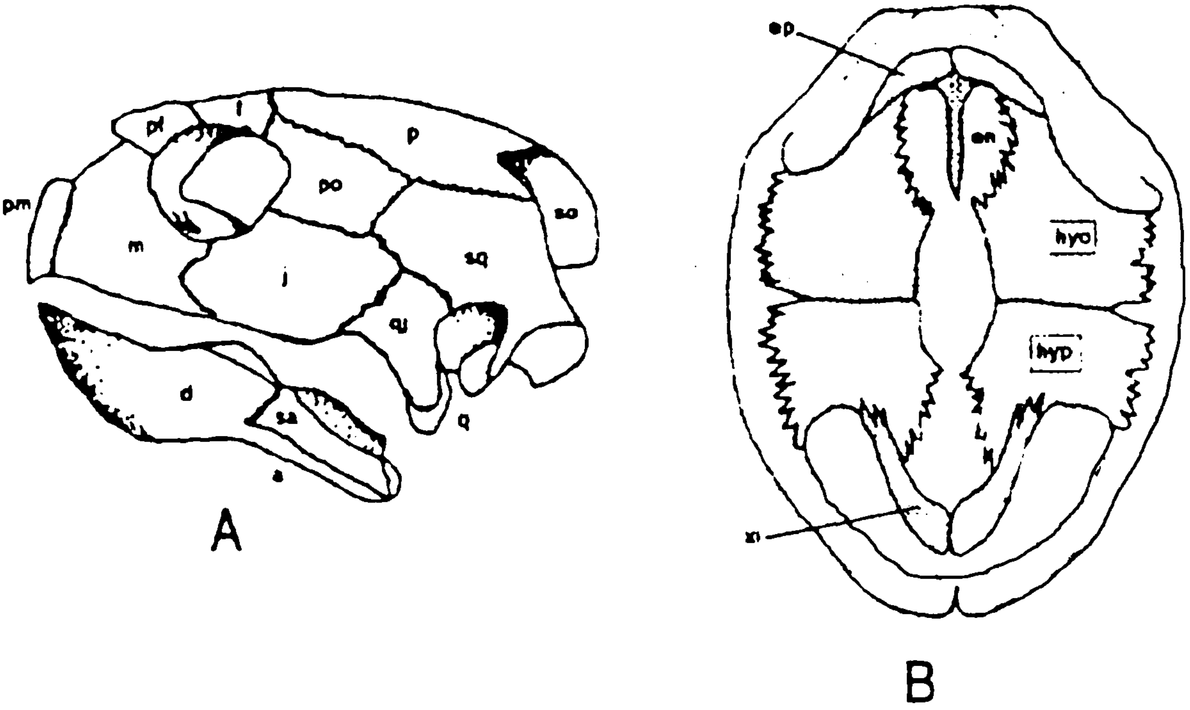

Figure 3. Skeletal morphological characters of the Kemp's ridley.
A. adult cranium B. juvenile plastron (note the frontanels at its midpoint. a. angular, ar. articular, c. coronoid, d. dental, en. endoplastron, ep. epiplastron, f. frontal, hio. hio-plastron, hip. hipo-plastron, j. jugal, m. maxilary, p. pariental, pf. prefrontal, pm. premaxilary, po. postorbital, q. quadrate, qj. jugal quadrate, sa. subangular, so. supraoccipital, sq. squamous, xi, xiphiplastron.

with the four inframarginal scutes, and opening to the exterior through a small pore (see also Section 3.5.2). Pritchard (1969, 1989), referring to the skull of *L. kempi*, concludes that there are morphological differences with *L. olivacea*, such as smaller size of the orbits which could be the diurnal and nocturnal habits in nesting respectively, and other bone differences related to food mastication. Differences can also be observed in the height and shape of the carapace in both species, being higher and slightly heart-shaped in the olive ridley.

1.3.2 Cytomorphology

No studies have been made concerning the number of chromosomes in *L. kempi*. No sexual chromosomes have been found in other marine turtles (Mrosovsky 1983). Studies to detect heteromorphism on turtles in general have failed (Bull, 1980), except for two species of Kinosternidae. The sexual chromosomes appear to be of recent evolutionary origin and, if they existed, the X and Y would only differ in a heterochromatic knot, and maybe in a nuclear organizer (Bull 1980). Sex determination appears to be influenced by external factors, such as temperature and humidity, and it is felt that there may be sex inversions during growth (see also Sections 3.1.1, 3.1.5). There is evidence that the sexes are genotypically different at the molecular level, yet the sexual chromosomes have not been observed through a microscope (Caillouet and Duronslet, 1985).

In a study by Brandon-Galloway and Inabnett (1987) to determine the level of genetic variation in five species of marine turtles, they found that only two species *Caretta caretta* and *Chelonia mydas* showed significant polymorphism in the number of polymorphic loci. These were tabulated for four enzymatic systems: dehydrogenase lactate acid, phosphate, peptidase and a combination of esterase.

Friar (1977a), studying red blood cells, found that the turtles with the longest carapace show: the largest volume of platelets, larger cells in length/width and in volume, less in number and probably rounder cells with significant physiological implications. Friar (1977b) noted that the erythrocytes

Table 1. Red blood cell parameters of the Kemp's ridley from Friar (1977b).

	Hematocrit ($cm^3/100cm^3$)	Length (microns)	Width (microns)	Number ($\#/mm^3 x 10^3$)
Average	29.8 ± 1.7	22.4 ± 0.5	14.7 ± 0.5	436 ± 50
Interval	20 - 39	16.5 - 26.8	11.2 - 19.5	402 - 503
Samples	12	5	5	4

are nucleated and elliptical. He also included a table on statistical values for marine and fresh water turtles. **Table 1** shows data of a juvenile Kemp's ridley.

Marine turtles are considered among the largest and active existing reptiles. Their needs for metabolic gas (O_2 and CO_2) exchange frequently matches that of the majority of reptiles. For this reason it is expected that marine turtles have efficient mechanisms for gas exchanges, including exchange of ions (HCL3 CL) in the erythrocytes (Stabenau et al., 1991). These authors describe the transport characteristics of anions in the erythrocytes of marine turtles.

Cannon (1992) reported the morphology and chemistry of the leukocytes of three juvenile kemp's ridley turtles. He found the following proportional values in the peripheral blood: an average of 75% large red corpuscles, 9% small red corpuscles and 20% of small lymphocytes; basophiles are rare. He notes that the different types of leukocytes vary between the species groups of *Chelonia*. No intermediate sizes between large and small red cells were noted; both sizes appear to be mature cells. He suggests that the phagocyte functions can be carried out by both types of cells. The anaerobic metabolism in the lymphocytes can be insignificant, which reflect a negative affinity for oxidizing enzymes. The lack of hydrolases in these lymphocytes is surprising since the small lymphocytes are not phagocyte cells, their function being more with the humoral and cellular immunity. Other chemical implications are also discussed.

1.3.3 Protein Composition and Specificity

The concentration of protein in the serum of turtles is between 2% and 6%. For an immature Kemp's ridley, Friar (1964) found 2%. The concentration of protein in the serum increases concomitantly in relation with the enlargement of the erythrocytes in the same animals (Friar 1977, Friar and Shah, 1982). The anatomic similarity in turtles is serologically well correlated and possibly could be useful as a taxonomic tool (Friar, 1964). Electrophoresis and immunoelectrophoresis reveal that *Caretta, Eretmochelys* and *Lepidochelys* share similarities in their blood serum proteins and that the proteins in *Chelonia* have greater affinity with *Caretta* and *Lepidochelys* than with *Eretmochelys* and *Dermochelys* is the most distinct (Friar 1982). There also is evidence that *Lepidochelys*, because of its characteristics, is the closest one to the ancestral marine turtle (Friar, 1979).

Rathke glands produce secretions which are common to Lepidochelys. According to Radhakrishna et al. (1989), these secretions contain 10 mg/ml of protein in *L. kempi* and 20 mg/ml in *C. caretta*. These secretions are similar according to results of analysis on the composition of amino acids and amino sugars made on protein fractions of high molecular weight. These secretions also contain glucosamines.

Chen et al., (1980) studied the evolutionary relationships suggested by immunological cross-reactivity of albumens; the immunological distances of the albumens suggest a time difference of 29 million years (of oligocene origin) for *Lepidochelys*. The estimated difference in time between the species studied, calculated on the basis immunological distances obtained, agree with those obtained through the fossil record.

The measurement of testosterone in the serum for radioimmunoassay, can also be used to predict sex proportions for immature individuals of the kemp turtle (Morris, 1982; Morris et al., 1981; Wibbels et al., 1985). See also Section 3.1).

Generally, turtle serum stored as sterile liquid loses one third of its reactivity in a period of 10 year (Friar, 1969).

After analyzing the keratin in the scutes and skin of marine turtles, Hendrickson (1979) found that the proportion of amino acids is determined genetically and is subject to small variations dependent on changes in diet. There are significant statistical differences between the species. The Kemp's ridley is high in alanine and low in tyrosine, as compared to other chelonids.

Fatty acids contents in marine turtles of the Atlantic (*Dermochelys, Caretta* and *Lepidochelys)* were compared with each other and with those of fresh water turtles. The acid, trans-6-hexadecinoid, was found only in marine species (Ackman et al. 1971). Results of the ester fatty acids analysis of the marine turtles, by degree of unsaturation are summarized in **Table 2**. The value of unsaturation corresponds to the amount of iodine grams which combine with 100 g of fat, using chloride, iodine bromide or iodine-mercury chloride). In the case of the Kemp's ridley the author took only 2 samples - from the side of the body (a) and the posterior of the carapace (b).

Table 2. Values of iodine in methyl esters prepared from body fats and associated with the percentual composition of the fatty acids analysis of methyl esters (Ackerman et al., 1971)

	Lk (a)*	Lk (b)*	Dc *	Cc *
Value of iodine:	85	83	86	130
Fatty acids:				
SATURATED	40.9	44.7	45.0	35.3
MONO-UNSATURATED	43.8	44.1	43.8	39.6
DI-UNSATURATED	1.0	0.7	1.4	1.2
TRI-UNSATURATED	0.9	0.2	1.5	0.6
TETRA-UNSATURATED	3.3	2.8	2.2	3.7
PENTA-UNSATURATED	3.9	3.9	3.7	7.8
HEXA-UNSATURATED	4.1	2.6	2.5	11.4
UNKNOWN	1.4	0.8	0.1	1.4

* Lk = Kemp's ridley, Dc = leatherback, Cc = Loggerhead, a = body, c = carapace.

2 DISTRIBUTION

2.1 Total Area

L. kempi is found in tropical and subtropical environments of the western north Atlantic; adults are almost exclusively restricted to the Gulf of Mexico (Carr, 1963b; Pritchard and Marquez, 1973; Marquez, 1970, 1990; Groombridge, 1982; Wilson and Zug, 1991). Reports from the Caribbean and from further south are almost absent and have not been authenticated. In addition to those from the Gulf of Mexico, many immature specimens have been reported from the temperate east coast of U.S., up to Canada. Reports are more frequent from December to March from off southeast Florida (Henwood and Ogren, 1987). Also during the winter months observations have been made on individuals drifting in European waters (Brongersma, 1972).

There are no reports concerning hatchlings and post hatchlings at sea, although it is felt there is a relationship with seaweed masses and fronts, as a pelagic habitat where the animal finds food and protection (Carr 1982, 1986). Carr and Meylan (1980), referring especially to *Chelonia* and *Caretta*, note that these may remain drifting for long periods of time, sometimes directly off the beaches where born, or they can be transported long distances by the ocean currents.

Up to now, certain important factors have not been considered, such as: - Is there an internal environmental triggering factor which induces the hatchlings to leave the pelagic phase? What portion of an annual group is taken and dispersed by unfavorable surface currents? What influence, if any, does the sargasso have in the survival of the organism during the pelagic phase? Is the hatchling "swimming frenzy" of a fixed duration? And how often must turtles eat? Do the hatchlings exhibit any special behavior which indicates the need to reach a certain goal or recognize certain currents or sargassum? We do not know that the hatchlings find floating objects or sargassum masses (Collard, 1987). There are other questions: How frequent and extensive are migrations between currents and calm water masses, and what is the relative importance of wind and wave action in their dispersion? The most obvious and least discussed question concerns the lack of obvious oceanic currents that might disperse hatchlings when they leave the Rancho Nuevo beach. Each hatchling is exposed to specific oceanographic conditions and at present we do not know what these are. Finally, we also do not know how the subadults and adults make their first return trip to Rancho Nuevo to reproduce.

Based on present knowledge almost the entire population of adult female Kemp's ridleys nest along a narrow band along the western Gulf of Mexico, just south of the Tropic of Cancer in the State of Tamaulipas, Mexico (**Figure 4**), except for a few solitary females that may sometimes nest in other areas of the Gulf of Mexico. The different nesting sites are discussed in Section. 3.1, listed in **Table 3** and shown in **Figure 5**. References on the occurrence of adults in areas different from the nesting sites are included in the following paragraph, according to their distribution from south to north.

Few confirmed nesting records are known from the Caribbean, although several records have been reported (see also Section 1.2.3). One was a female tagged at Rancho Nuevo and later nested in Magdalena, Colombia (Chavez and Kaufman, 1974).

Table 3. Time and location of nesting for Kemp's ridley. The more important months are in parentheses.

Nesting site	M A M J J A	Sources
Messive nesting: Tamaulipas, México (Rancho Nuevo)	X (X X) X	Carr,1963a,1967;Hildebrand,1963,1981;Márquez,1965,1970,1972,1974,1976,1978,1981,1983a,b,1984a,1992;Chávez etal.,1967,1968a,b; Montoya,1969;Pritchard,1969a,b, 1979;Casas-Andrew,1971,1978; Pritchard and Márquez,1973;Zwinenberg,1977;Ruíz del Junco,1978; Hendrickson,1980; Hirt,1980;Márquez,Villanueva and Sánchez,1981;Carr et al.,1982;Groombridge,1982;van Schravendijk and van Dissel,1982;Wibbels,1984,Márquez et al.,1985a,b,1990,1992;Márquez and Fritts,1987.
Single nest: Tamaulipas, Mx. (documentation)	X X	Carr,1961,1963a; Hildebrand,1963; Márquez and Fritts,1987.
Veracruz, México	X (X X) X	Fugler and Webb,1957; Carr and Caldwell,1958, Carr, 1961,1963; Hildebrand,1963; Márquez, 1970; Pritchard and Márquez,1973; Carr et al.,1982; Márquez and Fritts, 1987.
Campeche, México	X X X	Carr et al.,1982; Márquez and Fritts,1987.
Texas, U.S.A.	X X	Werler,1951; Carr,1961,1963a; Hildebrand, 1963,1981; Pritchard and Márquez,1973; Adams,1974; Lund, 1974; Francis,1978; Rabalais and Rabalais,1980; Carr et al.,1982.
Florida, U.S.A.	X	Meylan et al.,1991.
South Carolina , U.S.A.	X	Anon.,1992
North Carolina U.S.A.	?	Anon.,1992
Magdalena, Colombia	X	Chávez and Kaufman,1974.

The second, more recent, was a turtle released at Padre Island, Texas after 11 months in captivity and recaptured 103 months later (8.6 yrs) near Miskito Keys, Nicaragua between January 12 and 16, 1990. It would be fruitful to verify the origin of that tag, since it has not been clearly authenticated. Another record exists from Jamaica (Dunn, 1918), which has not been confirmed, which in the opinion of many, refers to an olive ridley instead of a Kemp's turtle (Brongersma, 1972). The same rationale applies for the records originating in Venezuela, made by Donoso-Barros (1964 a, b) and Flores (1969), which definitely belong to *L. olivacea*. The existing records from Cuba, noted by Aguayo (1953) fell under the same situation. Information on recoveries in the Caribbean become more numerous towards the Northeast, along the Yucatan Peninsula, the north of Quintana Roo (Smith and Taylor, 1950; Carr, 1957; Carranza, 1959) which includes Isla Mujeres in the species' distribution. Fishermen from the North of Yucatan State appear to identify the Kemp's ridley more readily (Carranza, 1959). There are also several records of recaptured turtles from the west of Holbox Island and from the Northeast of Chiquila-Puerto (Marquez, 1990).

When the nesting season approaches in the Gulf of Mexico, sightings of adult Kemp's ridleys becomes more frequent owing to their proximity to the nesting beach. Later they are observed more frequently off Campeche, which is considered a feeding and foraging area for the turtle, and an occasional nesting area (one individual has been observed nesting in Isla Aguada , Campeche since 1980). In this region confirmed reports of observations and recaptures are more common (Chavez, 1967, 1968; Fuentes, 1967; Pritchard and Marquez,

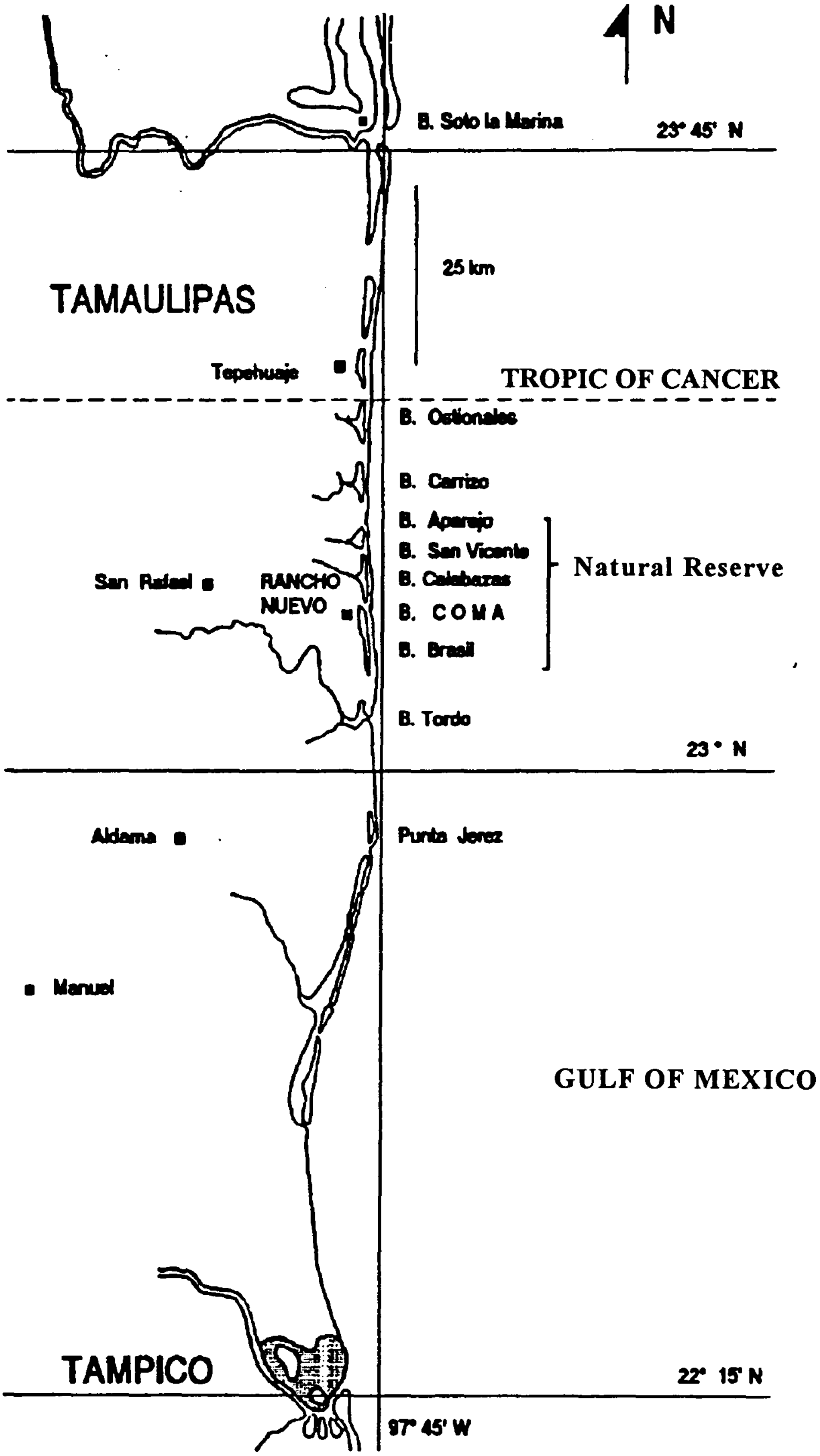

Figure 4. Kemp's ridley nesting areas.

Nesting Sites:
1. Padre Island, Texas
2. Playa Lauro Villar, Tamaulipas
3. RANCHO NUEVO, Tamaulipas
4. Cabo Rojo, Veracruz
5. Tecolutla- Nautla, Veracruz
6. Veracruz, Veracruz
7. Alvarado, Veracruz
8. Mecoacan - Chiltepec, Tabasco
9. Isla Aguada, Campeche

Note: numbers in parentheses are approximate numbers of nesting turtles per year.

Figure 5. Nesting sites and nesting density of Kemp's ridleys.

1973; Vargas, 1973; Marquez, 1976b, 1990; Pritchard, 1976; Marquez, Villanueva and Penaflores, 1978; Hildebrand 1981; Marquez et al., ms.) Off Tabasco observations are also numerous (Chavez, 1967, 1968; Pritchard and Marquez, 1973; Pritchard, 1976; Zwinenberg, 1977; Marquez, Villanueva and Penaflores, 1978; Hildebrand, 1981; Marquez et al., ms). The presence of this turtle has been recorded from Tabasco and Veracruz through recapture data of tagged turtles and observations made during the nesting season. Confirmed records also exist from fishing activities undertaken over several decades off Veracruz and Campeche (Carr and Caldwell, 1958; Hildebrand, 1963, 1981; Chavez, 1967, 1968; Pritchard and Marquez, 1973; Vargas, 1973; Marquez, 1976b, 1990; Pritchard, 1976; Zwinenberg, 1977; Marquez, Villanueva and Penaflores, 1978; Marquez et al. ms) and in Tamaulipas (Chavez, 1968; Marquez, 1973; Vargas, 1973; Zwinenberg, 1977; Marquez, Villanueva and Penaflores, 1978; Marquez et al., ms).

The north and northeast of the Gulf of Mexico are considered foraging habitats for juveniles, subadults, and post nesting females (Dobie et al., 1961; Marquez, 1984, 1990; Ogren, 1989; Rudloe et al., 1991). They are often observed in association with concentrations of portunid crabs (Ogren, 1989), particularly juveniles in shallow waters (<35 m). Many records exist from the coasts between Texas and west Florida. Zoogeographically the coast of Texas has continuity with Tamaulipas, where the adult turtles meanders before migrating north, towards the feeding grounds (Carr, 1961; Hildebrand 1963, 1981; Chavez, 1967, 1968; Vargas, 1973; Marquez et al., 1978; Neck, 1978; Rabalais and Rabalais, 1980; Fritts and Reynolds, 1981; Odell et al., 1982; Anon., 1983, 1984, 1985; Fritts et al., 1983; Reeves and Mcgehee, 1983; Reeves and Leatherwood, 1983; Wibbels, 1983; McVey and Wibbels, 1984; Ogren, 1989; Whistler, 1989; Marquez et al., ms.). Ridleys are recorded from Louisiana and Mississippi, with some records being of adult females tagged in Rancho Nuevo. In Louisiana: (Liner, 1954; Dobie et al., 1961; Viosca, 1961; Chavez, 1967, 1968; Pritchard and Marquez, 1973; Vargas, 1973; Marquez et al., 1973; Hildebrand, 1981; Odell et al., 1982; McVey and Wibbels, 1984; Anon., 1985; Ogren, 1989; Marquez et al., ms.). In Mississippi: (Dobie et al., 1961; Vargas, 1973; Marquez et al., 1978; Gordon, 1981; Klima and McVey, 1981; Odell et al., 1982; Wibbels, 1983; Anon. 1985; Marquez et al., ms.), in Alabama (Marquez et al., 1978; Carr, 1980; McVey and Wibbels 1984; Ogren, 1989; Marquez, et al., ms.). In Florida (Garman, 1880; De Sola, 1935; Carr, 1942, 1955, 1957, 1963b, 1980; Grant, 1946; Carr and Caldwell, 1956, 1957, 1958; Dobie et al., 1961; Caldwell, 1962; Chavez, 1968; Sweat, 1968; Marquez, 1972, 1984, 1990, in press; Marquez et al., 1978; Fritts et al., 1981, 1983; Klima and McVey, 1981; Odell et al., 1982; Anon., 1983, 1984, 1985; Ehrhart, 1983; Johnson et al., 1984; Ogren, 1989; Rudloe et al., 1991).

Some Kemp's ridleys enter the Gulf Stream and apparently all are carried through the Straits of Florida northwards, because no records exist from the south and southeast such as the archipelagos of the Bahamas and Cuba (Pritchard and Marquez, 1973). These turtles are directed northward, following the U.S. Atlantic coastline, where strandings and sightings have been recorded during their migration along the coast. These are noted in the following sources:

- Georgia; (DeSola and Abrams, 1933; Carr, 1942; Martof, 1963; Hillestad et al., 1978; Klima and McVey, 1981; Ogren and McVey, 1981; Odell et al., 1982; Anon., 1983, 1984; McVey and Wibbels, 1984). South Carolina: (Odell et al., 1982; Anon., 1983, 1984, 1985).

- North Carolina; (Coker, 1906; Hay, 1908b; Schmidt and Dunn, 1917; Carr, 1942; Schwartz, 1978, 1989; Odell et al., 1982; Anon., 1984; McVey and Wibbels, 1984).

- Virginia; (Carr, 1942; Hardy, Jr., 1962; Schwartz, 1967; Odell et al., 1982; Anon., 1983, 1984, 1985; McVey and Wibbels, 1984; Lutcavage and Musick, 1985; Byles, 1985a, b, 1989).

- Maryland; (DeSola, 1931; Hardy Jr., 1962; Schwartz, 1967; Harris, 1975).

- Delaware: (DeSola, 1931; Spence, 1981).

- New Jersey: (Hay, 1908; DeSola, 1931; Carr, 1942; Odell et al., 1982).

- New York (De Sola, 1931; Babcock, 1938; Carr, 1942; McVey and Wibbels, 1984; Burke and Standora 1991; Morreale et al., 1992).

- Connecticut and Rhode Island (there are no records).

- Massachusetts (Babcock, 1930; Ditmars, 1936; Barbour, 1942; Carr, 1942, 1957; Dodge, 1944; Bleakney, 1965; Lazell, 1976, 1977; Prescott, 1979; Smithsonian Inst., 1979; Odell et al., 1982; Anon., 1983, 1985; McVey and Wibbels, 1984).

- New Hampshire (there are no records).

- Maine (DeSola, 1931; Bleakney, 1955, 1965; Lazell, 1976, 1980; Carr, 1980; Shoop, 1980).

- New Brunswick (there are no records).

- Nova Scotia (Bleakney, 1955, 1965). It is noted that Newfoundland is the northern limit of the Kemp's distribution in the Atlantic (Squires, 1954; Bleakney, 1965). Ogren (1985) reviewed the distribution of juveniles and subadults from Texas to New England.

In some areas off the east coast of North America young turtles may be trapped in spinoff circulations of the Gulf Stream and carried across the Atlantic, entering the north-Atlantic current and continue into European waters. In such northerly movements the turtles can reach Bermuda, Azores, Madeira and the coast of Morocco or continue to the north to the Bay of Biscayne. However, up to 1985 Pascual (1985) had not found records or observations on the turtle in the literature, from the coasts of Spain. The records for Bermuda are: (Mowbray and Caldwell, 1968); for the Azores (Deraniyagala, 1938a, 1943, 1957; Loveridge and Williams, 1957); for Madeira (Brongersma, 1968a, 1972, 1981); and for Morocco (Fontaine et al, 1985, 1986b; Manzella et al., 1988). European records are mainly from the north east Atlantic, including Great Britain, Ireland, Holland, and France (Deraniyagala, 1938a, b, 1943; Brongersma, 1961, 1967a, b, 1972, 1981, 1984; Rebel, 1974; Zwinenberg, 1977; Fontaine, Leong and Harris, 1983b; Wibbels, 1983; Fontaine et al., 1985; Duguy, 1986, 1987; Manzella et al., 1988). From Biarritz, France, records exist on two juvenile turtles which were raised in Galveston, Texas; one was released in June, 1980 and recovered in December 1981, after 568 days; the second one was released in June 1982, and recovered 1394 days later (3.8 yrs.), (Manzella et al., 1988).

A large group of juvenile turtles was observed between Madeira and Gibraltar (Maigret, 1983), which was erroneously identified as *L. kempi*. Later, Maigret (pers. comm., 1985) noted they were *C. caretta*. Delaugerre (1987) noted the presence of *L. kempi* in the Mediterranean, but up to the present only one record exists, on a juvenile taken near the Island of Malta (Carr, 1955, 1957, 1963a; Mertens, 1968; Cole, 1970; Brongersma and Carr, 1983). Finally, there is an interesting report about a turtle maintained at the Galveston Lab. for one year, released at Homosassa, Florida June 5, 1980 and recaptured after 893 days off the coast of Morocco. It was in perfect health and weighed 20 kg (Fontaine et al., 1986a; Manzella et al., 1988).

2.2 Differential Distribution

2.2.1 Hatchlings

There is little information available on the geographic distribution and habitat of Kemp's ridley hatchlings once they leave the nesting beaches, and scientists can only speculate about their behavior and habitat. For example, why is the outside coloring of hatchlings black or almost black, which would lead to believe their habits would be benthic (in contrast to the hatchlings with a whitish plastron such as the green turtle (*Chelonia mydas*) which have a pelagic nectonic habit and during this period in their life cycle adrift). Consequently, the first few months of life should be spent in shallow waters or with other floating objects, such as algae masses, where they make repeated dives for food. Later, when about 20 cm long, the plastron turns whitish and its habitat changes to that of a pelagic environment, as they move near shore, where evidence indicates a near shore existence. Another opinion, noted by Pritchard and Marquez (1973) is in agreement with the distribution observed and sizes of the immature turtles, it would appear more logical, that after the hatchlings enter the water in the Tamaulipas area, they will actively swim for hours or days to lessen the chance to be swept to shore again and thereafter drift freely (maybe on occasion in association with algae masses) in a great gyre of the Gulf of Mexico. Sometimes they could be carried by the Gulf Stream around southern Florida and north along the Atlantic coast of North America. During this period they would be feeding and growing, until reaching New England. By that time, they would have grown in size and strength to be active swimmers instead of just drifting with the currents. By then their size would be 24 to 30 cm.

Up to now, no reliable method has been developed which would determine the dispersion pattern of marine turtles during the "lost year". There is evidence that their dispersion is developed through ocean currents (Witham, 1980; Carr, 1980) but at this time there are not sufficient records that show a distribution model which this species follows using its oceanic migrations. On the other hand, Collard and Ogren (1990) note that the circulation in the western Gulf of Mexico is dominated by an ocean front formed by anticyclonic gyres derived from "loop currents" so that when the hatchlings cross the narrow shelf off Rancho Nuevo they enter this current and remain in the gyres. In agreement with sizes of the small turtles (20-30 cm) observed, according to Zug (1989, 1991) they should be about 2 years old. After this phase in the gyres, they begin approaching the coast, especially off west Louisiana or Florida, where benthic feeding begins. Those carried outside the Gulf, some up to New England, should start migrating actively towards the south. The size gradient from smaller to larger is observed from north to south, as noted by records on stranded turtles in the United States. Ogren (1989) hypothesized that when the turtles return to the Gulf their route is along shallow water, while the smaller turtles leaving the Gulf are carried offshore.

2.2.2 Juveniles, Subadults and Adults

Hatchling coloration becomes lighter with growth, the plastron being the first to change, becoming almost white in a few months. This coincides with a change in outer morphology and also a change in behavior and habitat of the juveniles from pelagic-nectonic to neritic environments in shallow coastal waters. From then on records on observations become more abundant, especially from the northeast coast of North America and following the general track of the Gulf Stream (see Section 2.1 for records). The most northerly point of this migration appears to be New England, "where the Kemp's ridleys are the smallest to be found along the coast of the United States or Mexican coasts, with the possible exception of Alabama" Carr, 1980; other areas where immature turtles can be found are both coasts of Florida (Carr and Caldwell, 1956; Caldwell and Carr, 1957; Carr, 1963 & 1980).

Following the life cycle; "after reaching the northernmost point in their migration and a carapace length of approximately 30 cm, they turn south and along the way begin to mature . As they approach the Gulf waters along Florida and later upon reaching adulthood they arrive at crustacean rich waters such as the Mississippi River discharge and near the Carmen Lagoon, Campeche. Both male and female continue on their reproductive migration towards South of Tamaulipas and then return to the nesting area; after that, again to the feeding grounds" (Pritchard and Marquez, 1973). Carr (1957, 1963 a.b. 1980) thought that the small immature Kemp's which went around the Florida straits on to the north would never return, especially those traveling to the eastern Atlantic and European waters, where small juveniles are observed between October and February (Brongersma, 1973, 1973). Pritchard (1969b) felt that individuals remaining near the Coast in the western Atlantic, can grow normally and reverse their migration to the south and enter the Gulf of Mexico as they approach maturity. Byles (1989), based on the juvenile turtles in Chesapeake Bay, Virginia, believed that each fall these turtles (carapace lengths from 30 to 45 cm) migrated to warmer southern waters each year. Additionally, based on information gained from release and recapture of head-started juvenile Kemp's ridleys, Fontaine et al. (1986) also felt that these turtles seasonally migrated along the coast.

Some doubts on the distribution of this species have been cleared through research efforts of the joint U.S.-Mexico program "Restoration and Conservation of the Kemp's Ridley". Under this program, between 1979 and 1992 a total of 20,634 yearling juveniles had been released, belonging to the year classes 1978 to 1991. Releases were in Texas and Florida (Fontaine et al, 1985, 1986a). Results of this program support existing distributional and habitat information of these juveniles and immature individuals (**Figure 6**). See also Section 2.1.

The normal distribution of adults in the Gulf of Mexico (**Table 4**), should apply also to hatchlings, juveniles and subadults. However, confirmed records for these developmental phases are scarce or almost non-existent. As a result of the tagging work done on females at the nesting site (1966-1991), it was found the turtles split into two groups when returning to their feeding grounds in the southern Gulf (Marquez et al, 1978, 1987, 1991). Only one record existed until 1974 which was different from this distribution pattern. That was for a mature female which, supposedly, was observed nesting at Magdalena Beach, Colombia (Chavez and Kaufman, 1974; Meylan, 1981); however, in the morning of

Table 4. Data on the recovery of female turtles tagged in Rancho Nuevo (1966 - 1992).

State	Frequency	Percentage
Florida	4	2.27
Alabama	4	2.27
Mississippi	5	2.84
Louisiana	37	21.02
Texas	16	9.09
Tamaulipas	36	20.45
Veracruz	20	11.36
Tabasco	18	10.23
Campeche	34	19.32
Yucatán	0	0.00
Quintana Roo	1	0.57
Colombia	1	0.57
Totals	176	99.99

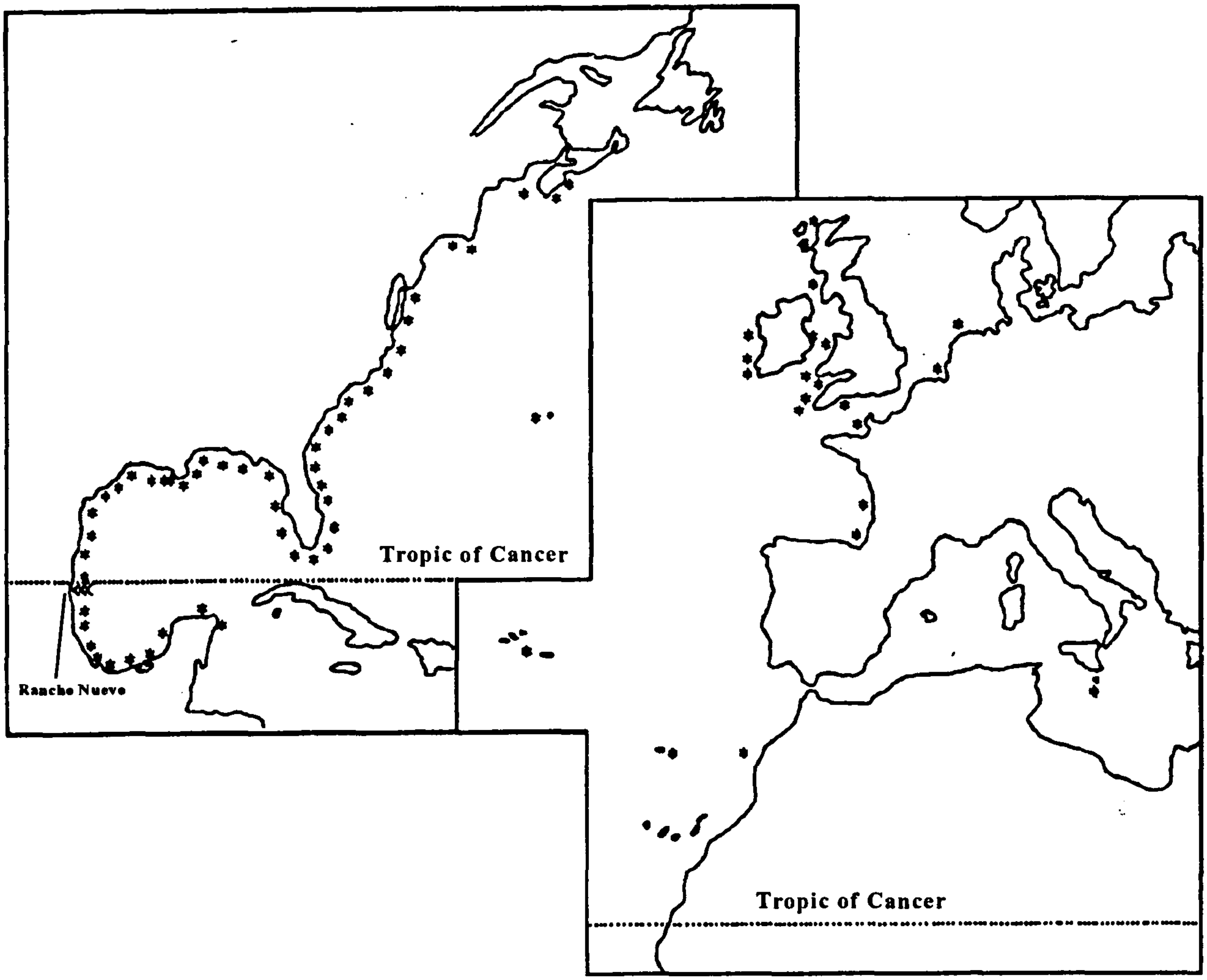

Figure 6. Geographic distribution of the Kemp's ridley.

May 30, 1989, a female laid 116 eggs at Madeira Beach, St. Petersburg, Florida (Meylan et al, 1991) and in summer of 1992 a solitary female nested in the coast of South Carolina and another one in North Carolina (Anon, 1992). The U.S. National Marine Fisheries Service Sea Turtle Stranding and Salvage Network documents stranding events occurring along the U.S. Gulf of Mexico and Atlantic coasts (see also Section 2.1). These data also help provide information on ridley geographic distribution. There are three areas of abundance; Florida Bay, the Mississippi River region, and the Campeche Sound as feeding grounds, rich in crustaceans, especially crabs and shrimp (Osborn et al., 1969; Marquez, 1990, 1993). Relative abundance, derived from the above noted data could be biased because of localized captures and commercial fishing efforts, especially trawling. Another area of seasonal abundance is the coast of Tamaulipas, near the nesting beach and where a portion of the adult population concentrates during spring and summer. Tagging and recapture results show limited and extensive movements between nesting and feeding areas (see also Section 3.5.1).

Documented cases of kemp's ridleys nesting outside Rancho Nuevo are scarce: Colombia (Chavez and Kaufman, 1974; Meylan, 1981), Florida (Meylan et al., 1991), and Carolina (Anon., 1992).

Interestingly, there appears to be a total lack of information about the different phases of the life cycle of the Kemp's ridley in the Caribbean. However, since during the initial development phase is oceanic, it is logical not to expect them to swim against the 1 to 4 knot current flowing into the Gulf through the Strait of Yucatan, and enter the Caribbean. The Gulf of Mexico current pattern is in the form of loops and gyres and eventually flows through the Straits of Florida (Nocolin, 1971). This appears to be the normal dispersal mechanism by which some juvenile Kemp's Ridley follow, and is proven by the frequent records from the east of the United States.

2.3 Determinants of Distributional Changes

As noted in Section 2.2.1, distribution patterns change with age, as well as feeding habits and maturation. During the early life stages they stay in a pelagic-nectonic environment until they reach 20 or 25 cm in carapace length. During this period, currents, fronts, and gyres determine their distribution. According to Wibbels (1984) the geographic location and winds are lesser factors than the flow and direction of currents. With growth they become strong and then can move voluntarily to shallow coastal waters where they can readily dive for food (see also Sections 3.4.1 and 3.5.1.). Upon reaching maturity, they start moving closer to shore supposedly in groups, which is the initial phase of the migration to reproduce in the nesting beaches, mainly along the coast of Tamaulipas.

Like other marine turtles, this is a tropical species indigenous to the western north Atlantic, mainly in the Gulf of Mexico, with a broad band of spotty distribution in the warmer waters of the northern Atlantic. Temperature is a limiting factor in their distribution, in temperatures less than 13°C they tend to float, making awkward movements. Specimens over 30 cm carapace length die within 20-24 hours at 6.5C, but Smaller turtles can tolerate temperatures down to 5°C before they die (Schwartz, 1978, 1989). During the winter months, at temperatures under 15° to 16°C, the feeding activity stops and growth is reduced to a minimum (Marquez 1972, 1990).

The previous section noted some rare nesting records of specimens nesting at sites distant from the historical Rancho Nuevo nesting beach. With the exception of Campeche which at one time was an important nesting area and where this turtle is still often observed, there is no clear explanation, for the nestings which take place outside the Gulf of Mexico. It is not known if this is normal behavior or is it provoked by unknown environmental or genetic changes, or are these aberrant in their behavior, which could have been effected by human actions such as the protection activities taking place in Rancho Nuevo, the NMFS head-start program in Galveston, or the incidental capture and release of the specimens.

2.4 Hybridization

No hybrids have been recorded for the Kemp's ridley. The fishermen of the West coast of Florida at one time felt that the turtle, which they called "bastard turtle" was a hybrid, conceived from a loggerhead and a green, a loggerhead and hawksbill or green and hawksbill (Carr, 1942).

The biography that follows provides further information on the subject: Garman (1984), Carr (1952, 1957, 1961, 1963b), Brongersma (1972), Zwinenberg (1977), van Schravendijk and van Dissel (1982), Marquez (1990). Other names for these aberrant turtles are "mulatto turtle" or mule turtle; however, since all recorded observations were made of immature individuals in areas remote from the nesting sites, taxonomic identification is more difficult and can be mistaken for a juvenile or subadult loggerhead with abnormal characteristics. The name "bastard turtle" has been known for 200 years and was mentioned by Lacepede in 1788 (Hay 1908b). During the work developed over the past 26 years (since 1966) at the Rancho Nuevo field station. To date no specimen has been observed which appeared to be a hybrid, be it adult females or newborn hatchlings.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

Various factors directly affect the reproductive development in marine turtles. These can be separated into those of internal origin, such as abundance of food, state of health, age, sexual maturity, hormone levels, hereditary factors, etc., and external ones, especially environmental factors (to be covered in Section 4.3). It was not until recently that studies were undertaken on certain aspects of reproduction of this species. Rabalais et al., (1989) studied the hormonal levels in males and females previous to breeding and noted that serum testosterone in males increased before sterol rises in the female. Studies on ovulation at the hormonal level related to the reproductive cycle were made by Rostal et al. (1987). Rostal (1991) described the reproductive behavior of the turtle in captivity and its endocrine patterns, and then attempted to apply the results to specimen in the wild. The Kemp's ridley shows specific seasonal periods of courtship and breeding prior to nesting (Wood and Wood, 1984, 1988; Rostal, 1991); the testosterone level in males rises 3 or 4 months before breeding takes place, which indicates spermatogenesis. The female testosterone levels are correlated with its sexual receptivity and the ovum formations take place 4 to 6 months before breeding. The testosterone levels in the females decreased with successive nestings. These results suggest that testosterone affects the physiology and behavior of both sexes (Rostal, 1991).

Morris et al. (1981) and Morris (1982) studied the hormonal (progesterone and testosterone) level in the blood of juveniles and noted the sex of these specimen could be predicted and also found that hormonal levels vary cyclically as a function of the ambient temperature. There was little relationship with salinity. They also noted that stress could be determined by measuring corticoesteroids levels (eg. egg occlusion, hatchlings leaving the nest, etc.).

3.1.1 Sexuality

Like all marine turtles, Kemp's ridley is heterosexual with specific dimorphism in the adults. The difference between sexes are described by: Carr and Caldwell (1958), including photographs of 2 females and one male; Pritchard (1969); and Zwinenberg (1977). The differences are noted from reviews of available references Marquez (1970, 1990). Pritchard and Marquez (1973) show data obtained on adults from the coast of Tamaulipas, noting there was a difference in average size between sexes, although further proof is needed. Adult males weigh 2 to 5 kg less than adult females, which may relate to the egg mass contained by the females.

In viewing the external morphology, the secondary sex characters are easily observed in the final developmental phase of the subadults and the adults. The males have a larger tail, which extends beyond the carapace border, which is prehensile and ends in a horny point. They also have a strong claw in each flipper which together with the tail allows the male to hold the female firmly during copulation. The females have a smaller tail and their claws are much shorter and slimmer. They can exhibit scratches and scars on the carapace and along the forward border which are probably caused by the male during copulation. There is no apparent difference in coloration between the sexes. Sex differences in juveniles using external features have not been yet shown. However, the sexes can be determined by using internal characteristics by laparoscopy in living specimens and dissection in dead ones. Hormonal studies to determine sex have been made on this species by various authors, Owens et al. (1978), Wood and Wood (1981), Morris et al. (1981) Morris (1982) Wood et al. (1983). The techniques available at present have not been used for hatchlings but it has been suggested that the sex can be predetermined by manipulating the temperature during incubation and then evaluating the sex proportion in the gonads through histological studies. The following sources provide information on methodology and results obtained from the study of fresh water as well as marine turtles: Pieau (1971, 1973, 1976, 1982), Yntema (1976, 1979), Bull (1980, 1981), Mrosovsky and Yntema (1980), Miller and Limpus (1981), Pieau and Dorizzi (1981), Morreale et al, (1982), Vogt and Bull (1982), McLean et al. (1983), Benavib (1984), Mrosovsky et al. (1984a,b), Standora and Spotila (1984). See also Section 3.1.5.

3.1.2 Maturity

The Kemp's ridley is the smallest of the marine turtles and is similar to the olive ridley of the Pacific and southeast Atlantic. The carapace length in the adult female Kemp's ridley generally varies between 58.5 and 72.5 cm (SCL), and the average minimum size observed at the nesting site was 55.0 cm and the maximum 78.0 cm (SCL) (**Table 5**). The average weight of the females at the nesting beach after egg laying was between 25 kg and 54 kg with a median of 37.8 kg (N=88) and adult males (N=9), and varied between 33 and 49 kg in total weight. The egg mass in a nest averaged 3.35 kg to which the weight of the ovules should be added (near 2% of the total weight of the female) which will be deposited later during the same season. This will amount to about 1 kg, thus the total weight of the gonads in a female can be 10% of the total weight of the animal in those cases where nesting takes place at least twice during the same season (Marquez, 1972, in press) (see also Sections 3.1.5, 4.3.1).

The age of maturity when the first nesting takes place is not well defined. This turtle, because of its small size, its feeding habits of crustaceans and mollusks (high in protein), and its migratory habits, should give it a high metabolic rate which would favor early sexual maturity.

Few studies have been made to determine growth in marine turtles and to date no reliable method has been found. Frazier (1981 a, b) has written a preliminary report on normal and decalcified bones which clearly show growth rings; however, the interpretation of these studies are not simple. It is also possible to use the eye lenses and epidermal scales, however, results on this approach are not available for this species. The use of tetracycline on hatchlings and juveniles (Frazier, 1985 a, b) coded wire, living tags, and "pit tags" (coded electronic chips) open the possibility of resolving this issue, which up to now have been evaluated through deductive mathematical methods. The recovery of tagged turtles provide reliable information. Meanwhile, the available data derived from tagging and recapture, using metal tags, as well as growth in captivity data, have allowed the first attempts on determining growth and age at sexual maturity (Marquez, 1972) from which it has been assumed this turtle matures when reaching 580 mm in carapace length, and can then be 6 to 7 years old. Maturity at minimum length of 600 mm may mean a delay of 2 or 3 years. Pritchard and Marquez (1973) discuss these same results, as do Zwinenberg (1972), Groombridge (1982) and Marquez et al. (1981, 1983a,b).

Recently, two Kemp's ridleys were observed nesting at the turtle farm in Grand Cayman Island (Wood & Wood, 1984). Both were 5 years old, one 53.3 cm carapace length and weighing 24.5 kg and the other 48.5 cm and 20 kg. A total of eggs produced six hatchlings, which soon died. This was the first recorded incident in which Kemp's ridleys nested in captivity. See also Section 7 and Table 32.

It is felt that the nesting occurrence at Grand Cayman was premature and probably induced by the processed feed and excessive handling. However, in the wild, size is not that important in determining sexual maturity, since nesting females can be observed at the Rancho Nuevo Beach which are only 55 cm carapace length (SCL), similar to those in captivity. In addition, it is logical to surmise that the age at maturity can vary considerably, caused by external and internal factors. These factors will cause some generations to reach sexual maturity early and in retarded others, and that there may be variations in the same cohort due to genetic characteristics (internal factors). This indicates that the arrival of reproductive turtles are composed of a combination of different year groups, and that the average size of the nesting turtles at any given time (**Table 5**) may show pronounced variations. Therefore, the age and size at initial maturity are so variable that they should be checked annually in order to conduct meaningful population analysis.

Table 5. Annual variation in carapace length (SCL, cm) of female Kemp's ridleys at Rancho Neuvo.

Year	Number	Median	Maximum	Minimum	S.D.
1966	284	64.38	75.00	59.00	2.47
1967	281	65.07	77.50	57.90	2.73
1968	319	65.60	74.00	57.00	3.05
1970	32	63.27	70.00	55.00	2.97
1971	6	65.00	68.00	62.00	1.83
1972	35	65.69	70.00	62.00	1.91
1973	74	65.80	72.00	60.00	2.53
1974	76	64.87	70.50	59.00	2.32
1975	109	64.92	70.00	59.50	1.92
1976	144	64.86	70.00	59.00	2.06
1977	80	65.24	70.50	61.70	2.06
1978	228	64.00	72.50	58.50	2.31
1979	364	65.56	78.00	59.00	2.61
1980	247	66.08	74.00	58.00	3.06
1981	245	65.12	71.17	57.14	2.37
1982	235	65.32	73.03	57.71	2.53
1983	293	65.94	72.10	59.00	2.46
1984	357	64.88	73.94	57.48	2.52
1985	265	65.77	73.94	59.96	2.33
1986	273	64.18	70.03	55.99	2.56
1987	297	65.15	71.64	57.71	2.36
1988	391	64.69	73.94	59.96	2.36
1989	268	64.94	72.10	57.71	2.62
1990	311	64.48	72.10	57.71	2.62
1991	307	64.98	71.17	55.64	2.90
1992	423	64.88	75.17	57.03	2.48
AVERAGE		65.03	72.40	72.40	
S.D.		0.62	2.35	2.35	

It is generally believed that marine turtles will reproduce when older than 15 years. The recent studies of Zug and Kalb (1989) are included in the Recovery Plan for the Kemp's Ridley Sea Turtle, (FWS/NMFS, 1992), but such ages are considered valid for turtles which develop in the northeast Atlantic. By extrapolating growth information from tag and recapture studies and growth information obtained at the NMFS Galveston laboratory, it has been estimated that age to sexual maturity in the Gulf of Mexico, where the waters are warmer, is seven years (Caillouet, pers. comm.), and five years for the Grand Cayman Farm (Wood & Wood, 1983). Therefore, based on present day knowledge, it is believed that turtles can reach sexual maturity at the minimum age of 7 years and improbable that they would do so after 15 years (see also Section 3.2.2 and Figure 11).

3.1.3 Mating

Only a few observations have been made of these turtles mating: (Chaney et al., 1967; Pritchard, 1969a; Marquez, 1970). Once in a while mating pairs can be observed off the Rancho Nuevo Beach. The females are firmly held dorsally by the male with the fin claws and tail which is curled backwards and under the carapace of the females. They remain in this position about two hours with the female surfacing at intervals to breathe. Usually the pairs float separately and disperse, in contrast to other species which are escorted by several eager males.

There is no information on courtship behavior in the wild, but since this a gregarious species, it is believed the event is similar to that of other species. From observations of turtles in captivity at U.S. aquaria and the Grand Cayman Farm a few research projects have been initiated on the subject, these

Figure 7. Kemp's ridley arribada at Rancho Nuevo, May 23, 1968, between Cemetary and Calabazas Bar. It was estimated that 2,000 females were nesting. Photo: A. Montoya.

have not yet been published (Wood, pers. comm.). A photograph of a pair copulating which was obtained by Caillouet and Revera (1985) at the Grand Cayman Farms.

3.1.4 Fertilization

Fertilization is internal and there are no data available for Kemp's ridley. Marquez et al (1976) published a diagram of the sperm of an olive ridley which should be identical to those of the Kemp's.

3.1.5 Gonads

Both males and females have a pair of functional gonads, one on each side in the pleuroperitoneal area, fixed dorsally to the kidney by mesenteries, known as mesovaria and mesorchium, respectively (Wolke and George, 1981). Further information on the general anatomy can be found in Ashley (1962), or for the olive ridley in Owens (1980). However, there is no specific information published on the Kemp's.

Recently, many studies have been conducted concerning temperature dependant sex determination in reptiles. However, most of these studies have dealt mostly with fresh water turtles. Relevant studies conducted on both turtle groups were made by: Pieau (1973, 1976, 1982); Yntema (1976, 1979, 1980); Yntema & Mrosovsky (1979, 1982); Bull (1980, 1981), Bull and Vogt (1979; Bull et al., (1982a,b); Mrosovsky (1980, 1982); Mrosovsky & Yntema (1980); Mrosovsky et al., (1984); Miller and Limpus (1981); Morreale et al. (1982); Vogt and Bull (1982); Wood and Wood (1982); Van der Heiden et al. (1984). Others have worked on the interrelation of humid environment combined with temperature fluctuations, obtaining different results for the fresh water turtles (Gutzke and Paukstis, 1983;. There are no published data for the Kemp's ridley, probably because of the difficulty of sacrificing the hatchlings of an endangered species.

3.1.6 Nesting Process

Description Of The Beach: there is no evidence, at least in historical times, on the existence of other important nesting beaches besides the arribadas at Rancho Nuevo (**Figure 7**). It can be noted that almost the entire population of this species nests in large groups along a narrow band of sandy beach located at Rancho Nuevo, an area of the Tamaulipas coast; between 23°18'10N and 97° 45'40 and 97° 45'30W (Marquez, 1976, 1978, 1990; Hopkins and Richardson, 1984; FWS/NMFS, 1992). These geographic data may vary somewhat with those recently obtained (April 1992) through satellite positioning techniques (GPS) which are shown in **Table 6**.

The beach is formed by low dunes of tidal origin, isolated on the land side by shallow coastal lagoons with several narrow cuts which open during the rainy season forming estuaries or temporary sand bars (Figure 4). The inland side dunes vary in height from 1 m to 4 m above sea level, excepting for the one south of the Coma Bar. This dune has decreased in height recently in height over the last few years, but had reached 10 m to 12 m in 1966 according to Chavez et al. (1967). This dune has also been moving southward from its original location of 1966, decreased in height, and has become wider and longer. The beach is formed by two berms, which vary in width from 15 m to 45 m (Hildebrand, 1973; Chavez et al., 1967; Casas-A, 1978). Looking south, the small bars are higher than the average elevation of the dunes.

The beach sand contains a high portion of fine grains, 80% less than 0.2 mm in diameter, 15% mid-sized grains, and 0.3% coarse grains of over 0.5 mm in diameter (Flores, 1985). Some of the primary berms on the sea side contain large amounts of broken shells or flat disk like rocks the size of a plate (Hildebrand, 1973; Chavez et al., 1967, 1968b). These were particularly abundant when uncovered by Hurricane Gilbert in September 1988. The dunes of this high energy beach are stabilized by bushy coastal vegetation, similar to that of Padre Island, Texas and described by Otteni (1972). This vegetation consists of various grasses such as sea oats (*Uniola sp.*), cord grass (*Spartina sp.*) and others. On the sea side of the berm the vegetation is made up of low growing brush: *Croton sp.*, *Ipomea pes-caprae*, *Salvai sp.*, *Tasptisia sp.*, *Sesubium sp.*, *Solanum sp.*, *Psidium sp.*. On the same dune, but farther inland, the most abundant are low spine bushes such as: *Rhandia sp.*, some mangrove, mainly *Rhizophora sp.* and *Avicenia sp.* which grow around marsh areas or form islands in them.

It is along this section of the coast where currents converge and the beach can change depending on the force and direction of the wind. It has been noted that arrival of the turtles coincide with the washup on the beach of large amounts of trash which accumulates along almost the entire beach. Also, between March and May large masses of marine algae (*Sargassum sp.*) accumulate along the tide line. Rancho Nuevo is considered a high energy beach (Price, 1954 & Hildebrand, 1963) with several sand flats running near and parallel to the coast, in shallow depths, forming beaches and reef-like barriers. Several species of snapper abound in the shallows (Hildebrand, 1973; Chavez et al., 1967).

The Kemp's ridley may nest sporadically in groups or alone, along several sandy beaches between Texas and Campeche, for example, Padre Island (Werler, 1951; Carr, 1961; Adams, 1966, 1974; Pritchard, 1969; Pritchard and Marquez, 1973; Zwinenberg, 1977; Francis, 1978; Carr et al., 1982, Hopkins & Richardson, 1982; Marquez, 1990). Groups of up to 20 to 25 turtles will nest at the Lauro Villar or Washington, Tamaulipas near the border with the United States (Marquez et al., 1981; Mager, 1985). On two flights made in May and June, 1982 and 1983, nesting tracks of 28 Kemp's turtles were recorded between the border and western Veracruz (Marquez, 1984; Marquez and Fritts, 1987). A beach near Tecolutla produces about 60 nests, and the same occurs along the west of Tuxpan, both in Veracruz (Marquez, 1983; Villalobos, pers. comm.). The easternmost nesting records from the southern Gulf of Mexico are from Aguada Island, located southeast of Sabancuy (Gonzales & Escanero, pers. comm.: Gonzales and Sanchez, 1993). Historical records are available on solitary nestings between Padre Island, Texas and Sabancuy, Campeche in the following sources: Fugler and Webb (1957), Carr (1957, 1963), Carr & Caldwell (1958), Hildebrand (1963), Pritchard & Marquez (1973), Hopkins & Richardson (1984) Mager (1985), Marquez (1990). Outside the normal distribution region, there is one published report by Chavez and Kaufman (1974) for Colombia, another for Florida by Meylan et al (1991), two more recent ones for North and South Carolina (anon. 1992) which were discussed in Sections 2.2.2 and 2.3.

Nesting: The nesting season at Rancho Nuevo is between April and July and occasionally until August. Between May and September a small group of green turtles also nests, which has been increasing to the point where in 1990 a total of 39 nests were collected. In 1992 along the south of the beach there was an inordinate increase in the area, a total of 256 nests, not including eight poached ones, three destroyed by predators and six left in "in situ". In addition, each year one or two loggerheads (*Caretta caretta*) nest there and possibly the same for leatherbacks (*Dermochelys coriacea*). During nesting there is no spatial separation between the different

Table 6. Kemp's ridley nesting zones, Tamaulipas, Mexico.*

LOCALITY	MARKERS EXTENT(km)	LATITUDE	LONGITUDE
Soto la Marina	63.9	23°46'35.4"	97°43'14.3"
Punta Piedra	41.4	-	-
Tepehuajes	34.5	23°29'50.2"	97°45'34.3"
	31.2	23°28'01.6"	97°45'43.5"
TROPIC OF CANCER	28.2	23°26'16.7"	97°45'51.4"
Camp-Ostionales		23°24'35.3"	97°45'59.1"
Boca Ostionales	24.9	23°24'20.9"	97°45'59.3"
	21.8	23°23'17.1"	97°46'05.2"
	20.4	23°21'59.6"	97°46'10.1"
	17.4	23°20'21.9"	97°46'13.5"
Barra Carrizo	16.8	23°19'58.6"	97°46'13.5"
	14.4	23°18'44.7"	97°46'13.6"
Barra Aparejo	13.3	23°15'56.2"	97°47'18.8"
	11.4	23°17'08.7"	97°46'12.0"
San Vicente	9.9	23°26'19.8"	97°46'09.8"
	8.4	23°15'31.0"	97°46'12.1"
Cachimba	7.5	23°15'00.8"	97°46'10.6"
1 Calabazas	5.3	23°13'47.1"	97°46'07.5"
2 Jarcias	3.9	23°13'15.0"	97°46'04.0"
3 Cementerio	2.1	23°12'02.8"	97°46'02.2"
4 Barra Coma (N) Pens	0.3	23°10'57.7"	97°46'00.9"
(Nests)	0.0	23°10'53.4"	97°46'01.8"
C. (Temperatures)	-0.1	23°10'48.0"	97°46'06.1"
5 Barra Coma (S)	-0.3	23°10'52.8"	97°46'03.7"
6	-0.9	23°10'25.7"	97°46'02.2"
7 Brasilito	-1.2	23°10'14.7"	97°45'58.4"
8	-1.8	23°09'58.9"	97°45'58.1"
9	-2.7	23°09'39.1"	97°45'51.0"
10 Brasil	-3.5	23°09'36.4"	97°45'37.2"
	-5.4	23°07'58.0"	97°45'57.0"
	-6.3	23°07'29.1"	97°45'52.4"
	-8.1	23°06'29.2"	97°45'49.2"
	-9.0	23°05'54.7"	97°45'46.5"
	-10.8	23°04'58.0"	97°45'44.6"
	-11.7	23°04'29.9"	97°45'44.6"
Barra del Tordo	-13.4	23°03'30.1"	97°45'42.2"
Playa Dos	-17.1		
El Estero	-19.8		
La Barrita	-22.2		
La Boya	-23.7		
Punta Piedras	-27.6		
Punta Jerez	-31.5	22°54'11.1"	97°45'00.0"
Los Troncos	-36.9		
El Arbol	-41.1		
Camaronero	-46.8		
B. Chavarría	-55.5	22°41'24.2"	97°52'51.4"

(*) The positions of the markers were selected electronically (Automatic Global Position) during a visit by Dr. H.Kimoto of "Janus", Kyota, Japan. (1-10) Zone convered by the Natural Reserve.

nesting species and the activity of other species is not great enough to cause competition for space with the Kemp's ridley. However, there are seasonal separation factors which reduces even further possible inter-specific interference along this beach where two shelves of different levels exist with a continuous low dune between the first and second berm seen in **Figure 8** (Marquez, 1976b). The Kemp's ridley usually nests just beyond the high tide mark in front of the first dune, on the windward slope or on the top of the dune, and the green turtle generally nests just over the top of the primary dune. The relative position of the Kemp's ridley nest is shown in **Table 7**, indicating that the site preference changes over the years. This is also true for nesting sites during the same season.

It is felt that humidity and temperature are factors influencing nest site selection. Ridleys push their beak into the sand when crawling up on the

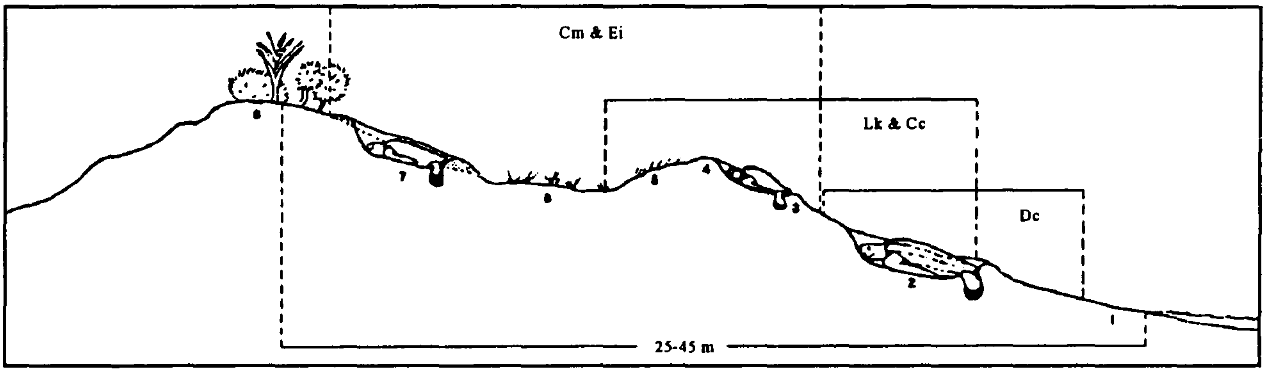

Figure 8. Profile of the Rancho Nuevo beach. Positions 1-8 with respect to the sea. Cm = green, Ei = hawksbill, Cc = loggerhead, Lk = ridley, Dc = leatherback.

beach before selecting the nest site. This behavior has been interpreted as an olfactory clue to identify the turtles birthplace and the selection of a nest site (Carr, 1963a; Chavez et al., 1967; Pritchard, 1969a). This behavior has also been observed in the olive ridley by Pritchard (1969a) and Marquez et al., (1976a) and without the same persistence for other species (Carr and Giovanoli, 1957; Carr and Ogren, 1960; Carr and Hirth, 1962; Bustard and Greenham, 1969; Hirth and Carr, 1970; Hirth, 1971; Stoneburner and Richardson, 1981; Marquez, 1990). To date, there is no conclusive study on this habit, but apparently it must primarily be of a tactile nature, to determine the size of the sand grains, humidity and the temperature, as well as to detect roots and other obstacles. It may also permit the turtle to detect the beach odor, particularly if it has previously nested. The peculiar habit of this genus (*Lepidochelys*) of organizing into arribadas can also be a determining factor for the development of such a characteristic habit. This may be closely related with the detection of the odor with which the beaches are impregnated during nesting of thousands of turtles and the incubation of millions of eggs and birth of millions of hatchlings.

These turtles crawl up the beach during the daytime to nest, which is not common to other species except for the ones forming arribadas such as the olive ridley of the Pacific (Hughes, 1973; Marquez et al., 1976; Casas-A., 1978; Marquez, 1990), or when they crawl up the beach to sun themselves or escape from the pursuit of males. This occurs specially with the genus *Chelonia* in Hawaii; (Balazs, 1976, 1977, 1980; Balazs and Ross, 1974; Kam, 1984; Sheekey, 1982; Whittow and Balazs, 1979); in the Galapagos Archipelago (Smell & Fritts, 1983); in the Gulf of Carpentaria, Australia (Garnett, 1985); and in Michoacan, Mexico (Villanueva and Marquez, 1976). There are few other reports concerning daytime excursions of other species: loggerheads in Florida (Fritts & Hoffman, 1982), South Carolina (Caldwell et al., 1959), and Australia (Bustard, 1973); hawksbills in the Seychelles Islands

Table 7. Average distribution by percent of the sites (P) of Kemp's ridley at Rancho Nuevo, 1979-1992.

P	79	80	81	82	83	84	85	86	87	88	89	90	91	92	Total
1	2.3	17.4	0.1	0.8	0.6	0.8	0.3	0.5	1.3	0.4	11.5	1.9	0.8	0.9	2.83
2	12.5	34.3	19.2	35.5	8.4	10.4	19.4	19.6	28.8	28.3	48.3	32.2	14.8	25.8	24.11
3	33.6	24.5	54.5	44.6	52.1	51.9	54.8	62.2	51.9	49.2	29.1	45.1	57.0	56.4	47.64
4	26.1	13.8	17.5	15.6	24.8	28.1	19.8	14.6	14.3	18.5	7.6	11.4	21.8	14.9	17.77
5	18.3	5.6	4.9	1.5	9.6	5.1	3.3	2.9	2.2	2.1	1.6	4.3	3.9	1.7	4.79
6	5.4	3.0	2.5	1.6	2.8	2.1	1.6	0.8	0.7	1.1	1.8	2.4	0.8	0.2	1.91
7	1.1	1.0	1.2	0.2	1.2	1.1	0.5	0.5	0.3	0.3	0.0	2.1	1.0	0.0	0.75
8	0.8	0.4	0.0	0.1	0.4	0.4	0.3	0.0	0.6	0.1	0.1	0.5	0.0	0.0	0.26
%	100	100	99.9	99.9	99.9	99.9	100	101	100	100	100	99.9	100	99.9	100.0
N	920	799	913	789	819	982	761	658	692	796	800	949	776	890	11544

(Fryer, 1911; Diamond, 1976; Garnett, 1978; Frazier, 1976, 1979, 1984) and later by the Japanese Association for the Hawksbill Turtle (1973, as per Witzell, 1983), who notes this turtle nests during the daytime only in uninhabited areas.

Because the Kemp's ridley is the smallest of the marine turtles, their nests are the shallowest and smallest in size, but not the least in number of eggs (see also Sections 3.1 & 4.3 and Tables 7 and 19). After selecting the nest site by "feel", checking the humidity of the sand with its beak, they arrange their bodies in the desired position by movements of their front and back flippers and immediately start to dig the egg cavity with their hind flippers. They do not form a "bed or trench" to accommodate their body, as in other species. The average depth at the deepest point is between 35 cm and 40 cm. Cavity excavation takes from 10 to 15 minutes. The turtle starts laying and is unperturbed by its surroundings and almost nothing can distract it. After depositing the eggs the female rapidly covers the nest after making several lateral movements of the body in which the nest is flattened with the plastron. A characteristic sound ensues during these movements. After that, she scatters sand in all directions with all four flippers, then turns in a half circle and returns directly to sea. The nesting process takes from 50 to 60 minutes. This process was described in greater detail by Pritchard and Marquez (1973) and in two shorter versions by Chavez et al. (1967) and Casas-A. (1978).

3.1.7 Eggs

Fresh Kemp's ridley eggs are usually white but can sometimes cream or lightly rose colored, turning pure white a day later when incubation starts. Infertile eggs may turn dark and collapse, or becoming yellow, gray, or rose colored and remain turgid and unchanged. Most are the size of a ping-pong ball. Freshly laid eggs have smooth leathery shells covered with a mucus coating that is quickly absorbed, leaving the egg surface dry. The humid (15% to 18% moisture) nest chamber causes the eggs to absorb water and become completely turgid. There is a small white spot on the upper surface. This determines the eggs polar position and that of the embryo rimmed by the vitelum. Within a week the spot covers almost the entire egg which turns completely white. In this species, size does not determine the number of eggs in the nest.

Kemp's ridleys do not often produce deformed eggs, but once in a while double eggs are produced, or are larger than the normal, or smaller and without a vitelum. Sometimes eggs are joined into a necklace or elongated with or without a vitelum (Chavez et al., 1967).

The number of eggs per nest varies from one nesting season to the next (**Table 8**) from a high average of 111.9 eggs in 1975 to a minimum of 96.8 in 1992, with an overall average of 104.0 from 1966 to 1992 (Marquez et al., 1992). The standard deviation has varied from 23.7 (1968) to 11.2 (1978), and the number of eggs per nest is apparently decreasing as compared with the numbers of two decades before (**Figure 9**). The egg diameter varies from 34.5 mm to 45.5 mm, averaging of 38 mm to 39 mm, a mass ranging from 24 g to 41 g with an average of 31.5 g to 33.0 g (Marquez, 1993).

The number of eggs per nest appears to have an adaptive relationship with the underground incubation, metabolic heat, and the interchange of gases and fluids in the embryos (Seymour and Ackerman, 1980), for which an optimum number of eggs must be present for each species and site. Considering this, the conservation project taking place at Rancho Nuevo has been able to substantially increase survival of the embryos during incubation by dividing in two equal portions all clutches containing more than 120 eggs.

Fecundity estimates of the nesting population has varied considerably. In past observations it was noted that most females nested only once during a season. Early observations indicated that 27% nested twice and 3% nested three or more times. It follows that each female could produce an the average of 140.8 eggs (Marquez et al, 1981). In 1992, with improved research coverage, it was noted that 55.5% individuals nested twice, 16.4% three times, and

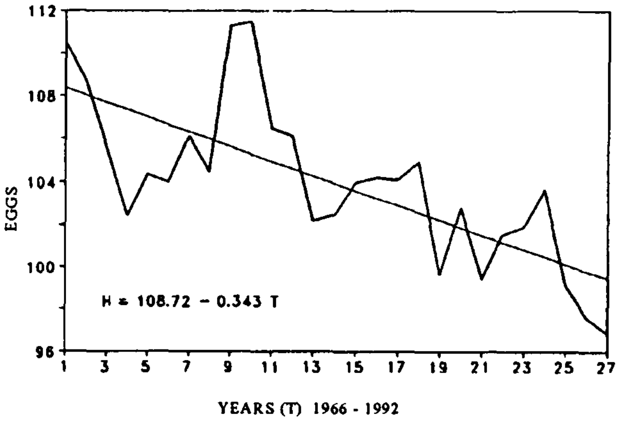

Figure 9. Annual variation in number of eggs deposited by Kemp's ridley at RanchoNuevo.

Table 8. Annual average number of riddley eggs per nest at Rancho Nuevo.

Year	Minimum	Maximum	Average	S. D.	N	Authors
1966	54	185	110.47		271	Chavez et al., 1967
1967	52	145	108.71	17.65	125	INIBP/SH
1968	44	148	106.02	23.75	49	INIBP/SH
1969	46	154	106.31			INIBP/SH
1970	42	167	104.34	17.65	145	Casas-A.,1978
1971			104.00		172	INP/PNITM
1972	47	157	106.19	19.46	85	INP/PNITM
1973	49	165	110.18	21.63	82	INP/PNITM
1974	45	162	111.42	16.71	156	INP/PNITM
1975	32	159	111.90	18.64	224	INP/PNITM
1976	59	192	105.38	16.79	475	INP/PNITM
1977	63	164	106.13	16.82	158	INP/PNITM
1978	36	150	102.25	11.15	834	INP/MEXUS-Gulf
1979	34	165	105.79	16.31	954	INP/MEXUS-Gulf
1980	30	153	104.23	16.55	797	INP/MEXUS-Gulf
1981	31	161	103.19	15.79	616	INP/MEXUS-Gulf
1982	33	156	104.09	17.81	753	INP/MEXUS-Gulf
1983	37	163	104.92	18.14	734	INP/MEXUS-Gulf
1984	31	189	99.63	17.72	819	INP/MEXUS-Gulf
1985	34	144	102.80	18.85	681	INP/MEXUS-Gulf
1986	21	171	98.44	17.72	656	INP/MEXUS-Gulf
1987	21	152	101.53	17.96	712	INP/MEXUS-Gulf
1988	23	169	101.89	18.80	826	INP/MEXUS-Gulf
1989	41	149	103.65	17.99	811	INP/MEXUS-Gulf
1990	30	160	99.14	19.13	758	INP/MEXUS-Gulf
1991	17	173	97.62	20.29	820	INP/MEXUS-Gulf
1992	20	174	96.84	18.90	888	INP/MEXUS-Gulf
Average S.D.	38.7 12.8	159.5 12.5	104.04 3.9			

S. D. - Standard deviation
N - Number of nests
1969 - Calculated average values
INIBP/SH - National Research Institute for Fishery Biology/Herpetology Sect. Research
MEXUS-Gulf - Joint U.S./MEX. Program in the Gulf of Mexico

0.7% four times during the season. With these new data the estimated average number of eggs per female is between 167.14 and 192.43, which converts to 5,382 g and 6,192 g of "protein" for each female during the season. Further information on this is available in Chavez et al. (1967, 1968a,b), Pritchard (1969a), Marquez (1970, 1990, 1993), Pritchard and Marquez (1973), Zwinenberg (1977), Marquez et al. (1981).

Recent advances in the use of ultrasound (Rostal, 1991) has indicated that 2.3 nests per female are produced annually (see also Section 4.3.2 and Table 19). Using these data and the average number of eggs per nest, converts to about 7,700 g produced per turtle per season (Marquez, 1993). The time lapse of incubation as well as its success will be discussed in Section 4.3.

The turtle population appears to be composed of small groups, which succeed each other during the nesting season and leave the general area after nesting two or three times. These groups probably have annual migration patterns, with some turtles returning every two or three years (Marquez et al., 1981). Little variation exists in the morphology and physiology of individuals in an adult population, except for a slightly lower fecundity, suspected to be in the younger individuals. Table 8 shows that in 1966-1967, the average number of eggs per nest was six to eight more than in the last few years. The reason for this may be that the reproductive population of the 1960's was generally older than that of recent years, and younger individuals are less fecund than older ones (Wood and Wood, 1980; Van Dissel and Van Schravendijk, 1981; Marquez, 1984, 1990). This can possibly be explained because up to 1965, a year before the conservation program was initiated at Rancho Nuevo, almost all eggs were removed or destroyed by man or wild animals. Therefore recruitment up to that year was almost nil (Marquez et al., 1992).

When conservation measures started in 1966, and recruitment was reinitiated, (the first hatchlings were released and had not yet reached sexual maturity) the population continued to age and therefore exhibited a high level of fecundity. When the young females started to reproduce the overall fecundity of the population began to decrease, which was initially observed in 1976, that is 10 years after the conservation measures were initiated (Marquez et al., 1992). It can also be noted that by 1984 all the "old" females had been replaced by the new population, indicating that these turtles begin to reach sexual maturity in their natural environment between 10 and 18 years of age.

Human poaching of Kemp's ridley eggs was first reported by Carr (1963a,b), Hildebrand (1963), and Adams (1966). The authors learned from local residents that the egg harvests during 1950s and first part of the 1960s was very high and that practically all of the eggs were destroyed. Natural predation has also been reported noted by several authors. Hildebrand (1963) reported coyotes present during that period. In 1984 a study was conducted on natural predation (Flores, 1985; Marquez, ms), utilizing 20 nests "in situ" and protected by a wire mesh enclosure (**Table 9**). The most efficient predators were the coyote, skunk, and ghost crab. In 1967, a jaguar (*Felis onca*) was observed for several nights moving along the beach dune, but did not disturb the nests, the nesting females or the hatchlings, as was suggested by Doves (1974) for the eggs of marine turtles in Texas. Other predators include raccoon, *Procyon lotor*, coati, *Nasua narica*, badger, *Taxidea tasux*, skunks, *Spilogane sp.* and *Mephitis sp.* If uncontrolled, the ghost crabs *Ocypoda albicans* and ants would destroy many of the eggs during incubation and allow for the invasion of fly maggots, mites and bacteria, which will destroy the entire clutch. Buzzards (*Coragryps otratus*) can be observed devouring the eggs in the nests after these are uncovered by other predators, which make them facultative predators. Another predator, but on open nests is the caracara (*Caracara sp*) and the grackle (*Cassidix mexicanus*) which are very abundant on the beach near the hatchery, particularly when the hatchlings are born. There are also present several species of herons, as well as gallinules, avocets, terns and gulls; however, none of these have been observed preying or destroying nests.

Natural phenomena, such as high tides, storms or excessive rain can directly destroy the eggs by causing erosion, flooding or drowning of the eggs (Marquez, 1982, 1983, 1985, 1990). This is similar to what occurs with the nests of other species in different nesting beaches.

3.2 Embryonic and Hatchling Phase

3.2.1 Embryonic Phase

To date, no complete embryonic studies have been conducted on the Kemp's ridley, although the Pacific olive ridley has been described in detail (Crastz 1982) in which morphogenesis and measurements are used as diagnostic parameters. Shaver and Chaney (1985) describe 35 development stages for unhatched Kemp's ridley eggs of which only nine stages were selected from Crastz (1982). It is suspected that the embryonic development of olive and kemp's ridleys are very similar (**Figure 10**).

Further information on the embryonic development of the Kemp's ridley are not available. However, there have been several recent studies concern-

Table 9. Kemp's ridley predation at Rancho Nuevo during the 1984 season.

Site (+)	Nests (No.)	Type of predation (*)				Nests affected	Hatches (%)	Days (@)
		Coyote	Skunk	Crab	All			
3	12	1.25	12.00	18.83	32.08	1	71.9	7.4
4	6	0.5	8.67	12.67	21.84	1	72.4	2.3
5	1	0.0	12.00	7.00	19.00	0	94.4	0.2
8	1	3.0	10.00	3.00	16.00	0	96.4	0.3

+ Position of the nest in relation to beach profile from tide mark to top of beach (see Fig. 8).

* Number of times predator attacked nests during incubation period.

(@) Time lapse of incubation, until hatchlings emerged.

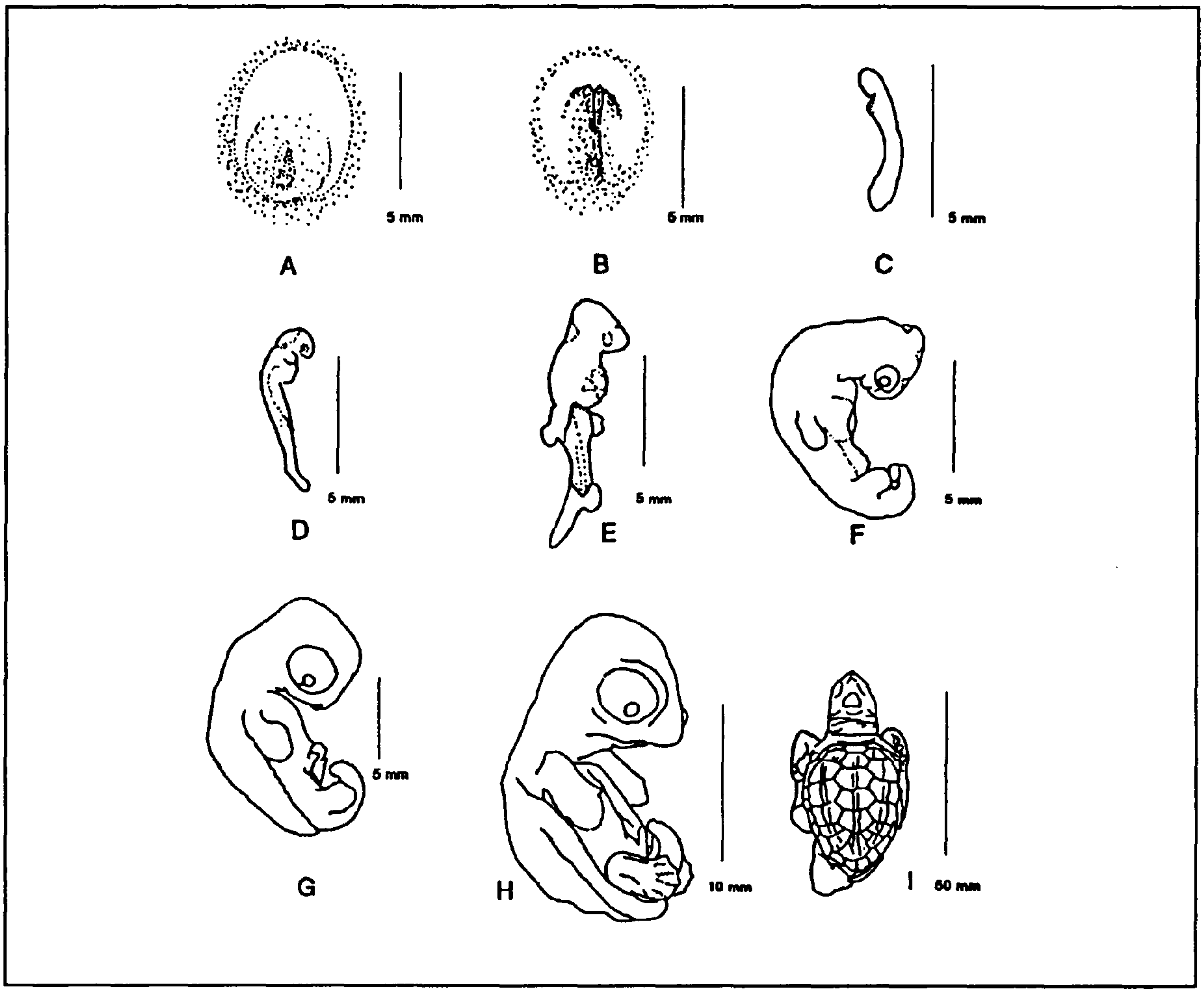

Figure 10. Some embryonic phases of the oliver ridley, *L. olivacea*, A-1(0), B-3(3), C-4(4), D-8(7), E-10(10), F-12(12), G-16(21), H-20(24), I-31(55). # = phase, (days). (from Crastz, 1982).

ing temperature dependant sex determination, in which the sex ratio in hatchlings is determined by the temperature during incubation. In marine turtles, it is believed that low temperatures produce more males and vice versa and it is believed possible to manipulate this parameter to obtain more males or females (see also Sections 3.1.1 and 3.1.5). It has been noted in other reptiles that there is a narrow temperature range where the proportion of males and females is about equal; these temperature limits are about 2°C, varying between species, but is generally between 27° and 31°C (Bull, 1980). This intermediate temperature is named "pivotal or critical", where both sexes are produced, including the same egg clutch (Pieau et al, 1984). Further, variations for this same temperature may occur when the geographic distribution is broad (Mrosovsky, pers. comm.). Preliminary research on Kemp's ridley hatchlings kept at the NMFS Galveston, Texas Laboratory have been conducted by Wibbels et al. (1985).

Goodwin (1981) and Penaflores et al., (1976) reported that embryonic mortality was greater during the early incubation for hawksbills and olive ridleys, respectively. This high mortality, specially during the first week of development, can be caused by internal and external factors, including the transfer of the clutches for conservation purposes. Any inclination of the egg once the germinal disk in embryo is polarized will affect later development, including increased mortality in the entire nest. Handling of the eggs between 6 and 48 hours after egg deposit takes place is critical and can reach 100% mortality. This mortality reaches almost 0% as occlusion is approached. The same problem applies to loggerheads and greens in Australia (Limpus, Baker & Muller, 1974; Parmenter (1980). Another cause of high mortality is heavy rainfall (Marquez, 1982, 1983b, 1990) since the eggs, embryos and hatchlings can drown, specially in areas of poor drainage. High humidity in the sand, over 20%, can cause problems, primarily the growth of fungus during incubation (Burchfield and Foley, 1985). This can cause high egg mortalities or cause lethal deformities during embryonic development. Ragotzkie (1959) reported higher loggerhead mortalities in Georgia after a heavy rainfall.

3.2.2 Hatchling Phase

Hatchling emergence is similar to other marine turtles, in which most turtles simultaneously emerge through a coordinated movement of all the animals in the nest. The mode of escape through a 25 cm or thicker sand cover has been described by several authors although not precisely for the Kemp's ridley, but it is felt that there are no meaningful differences between all the species (Moorhouse, 1933; Hendrickson, 1958; Carr and Ogren, 1959; Hughes, 1969; Uchida, 1970; Schultz, 1975; Marquez and Carrasco, in press). When the shell is perforated by the hatchling, the egg collapses as the amniotic fluid runs out. The liquid that accumulates during incubation (Bustard and Greenham, 1968; Seymour and Ackerman, 1980) is rapidly lost and the hatchlings remain still until they adjust to the new environment. After most of the hatchlings have ruptured their shell, the simultaneous movement begins; rasping the sides and roof of the cavity and so sending the sand downwards and under them. This results in rising the floor and elevating the roof, which gets them nearer to the surface. After a while the roof collapses, forming a depression, which indicates the nest will soon burst (Chavez et al., 1967. Generally, one or two days later, the hatchlings emerge from the nest almost in unison (Pritchard and Marquez, 1973). Sometimes they emerge in small groups or singly, retarding nest evacuation for one or two days beyond the norm. The hatchlings come to the surface during the coolest hours of the day (Mrosovsky, 1968), between midnight and dawn (Chavez et al., 1967; Pritchard and Marquez, 1973). High temperatures inhibit the departure from the nests particularly when the temperature is over 28°C (Marquez, 1990). At that point, the hatchlings stop leaving the nest and those remaining near the surface die soon thereafter because of overheating of the sand, which can reach over 45°C. The hatchlings emerge during poor or bad weather, sunny, cloudy or windy (Chavez et al., 1967). If cloudy, emergence from the nest can be extended through the whole morning, as well as be initiated earlier in the afternoon. Upon emergence they remain still for several minutes then suddenly "run to the sea", which is normally 10 to 35 meters distant (13 to 45 m, as per Chavez et al., 1967). Consequently, most of the hatchlings abandon the nest in less than an hour. Upon leaving the nest, it is felt that their orientation is governed mostly by eyesight, as in other turtles, since they move directly to the brightest point in the horizon, usually to the sea (Deraniyagala, 1939a; Mrosovsky, 1967; Ehrenfeld and Carr, 1968; Mrosovsky and Settleworth, 1968; Mrosovsky et al., 1979; O'Hara, 1980).

While in the nest, the hatchlings are exposed to attacks by ants, fly maggots, mites and ghost crabs, which enter directly or use the crabs tunnels. Some beetles infect the neck, tail and flanks of the hatchlings. These parasites probably invade the nest together with the fly maggots (Mast and Carr, 1985), although the most viable method is probably through the ghost crab burrows. The fly maggots of the family *Sarcophagidae* burrow through the sand to the eggs after the adult flies deposit eggs on top of the nests. The adults are attracted to the site by the odor of decomposed eggs or when the hatchlings rupture their shells. Because the hatchlings remain in the nest for 2 or 3 days, it allows for greater infestation and attacks by predators, thus increasing mortality. Even the undisturbed nests appear to attract mammalian predators, probably due to the odor coming from the nests due to rupture of the eggs. In order to reduce the infections caused by the flies, the nest which are transferred to the pen enclosures are covered with plastic screening at least one week prior to the hatchling time.

Predators are attracted visually to the hatchlings after they emerge from the nests the (Marquez, 1990). The greatest risk to the hatchlings occurs during the time lapse from the nest to the sea, and it is then when maximum predation occurs. To avoid this predation, the hatchlings rush in search of the sea with little rest stops and re-orientation. When they reach the water, they swim strongly with the front flippers, moving directly under the waves to the open sea. The swimming ability of the hatchlings is probably developed near the surface since their specific weight is still low, because of the egg yolk, which makes them float as well as providing reserve nourishment until they reach the feeding grounds. This part of the life cycle is very similar to that of other species of marine turtles such as the green (*C. mydas*) by Carr (1967), the hawksbill (*E. imbricata*) by Witzell (1983) or loggerhead (Kraemer and Bennett, 1981; Dodd, 1988).

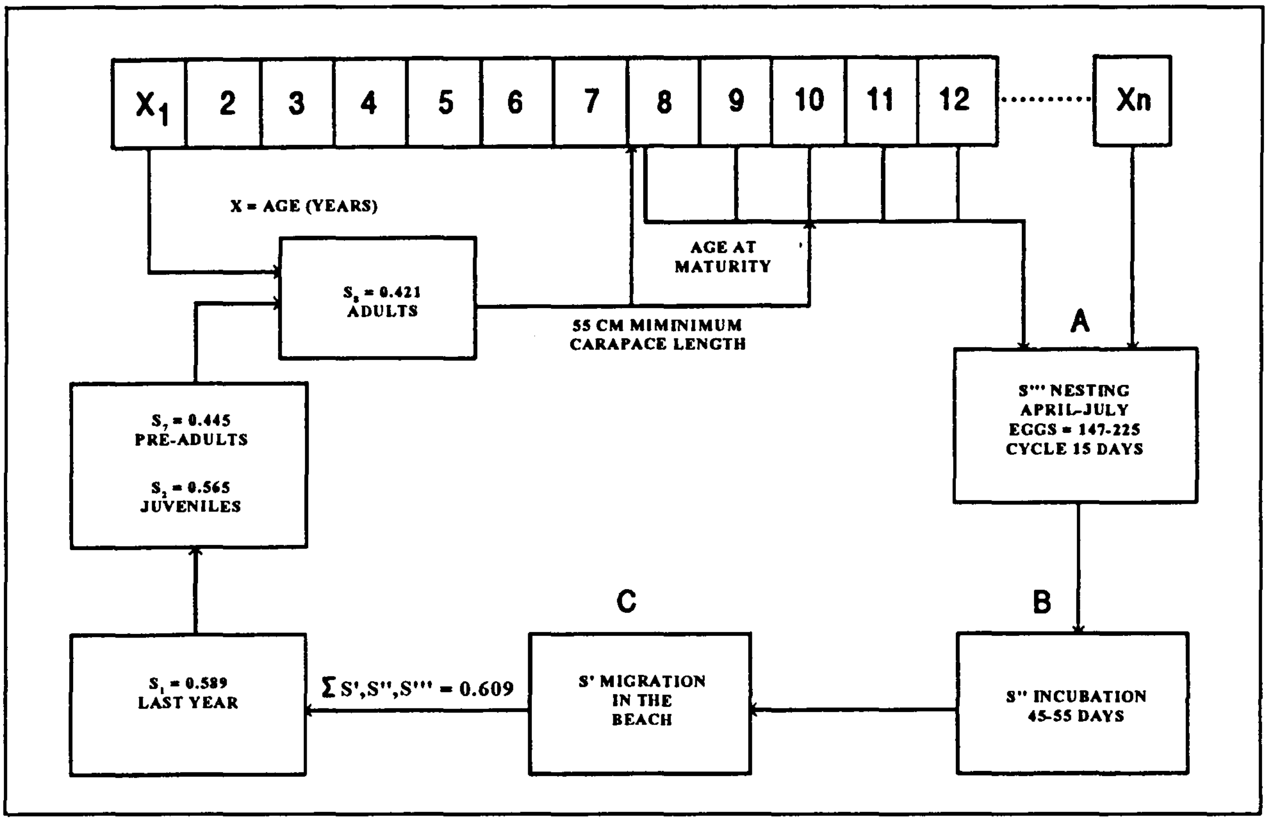

Figure 11. Kemp's ridley life cycle. S = theoretical survival rate by development phase and age (Marquez et al. 1981).

As in other species, Kemp's ridley hatchlings suffer high mortality (Marquez et al, 1981, 1985a). In **Figure 11**, squares A,B, C, D summarize the survival rate, from the egg to the water edge. During this time lapse, immediately after the hatchlings burst from the nest, is when the greatest mortality occurs and when the majority of the predators that had already attacked the eggs are present; ghost crabs, buzzards, blackbirds, coatis and skunks. Once in the ocean attacks come from above include gulls, frigate birds, sharks, barracudas, carangids, sea trouts, dolphin fishes, tunas, snappers and groupers, etc. There is little existing published information on predation of Kemp's ridley hatchlings (Hidelberg, 1963; Caldwell, 1966; Chavez et al., 1967; Pritchard & Marquez, 1973; Mrosovsky, 1983; Caillouet, 1984; Marquez, 1990). Another source on predation of this and other species of marine turtles is by Stancyk (1981) who also gives recommendation for its control.

Kemp's ridley hatchlings use visual cues to orient themselves from the edge of the nest to the sea (Wibbels, 1984), but their route at sea is unknown. Phototropic responses are common in the behavior of marine turtles relative to their orientation and disorientation (Ireland, 1979), which also has been suggested by McFarlane (1963), Bustard (1967), Ehrenfeld (1968), (Ehrenfeld and Carr (1967), Mrosovsky (1967, 1968, 1972, 1978), Mrosovsky and Shettleworth, (1968, 1974), Mrosovsky et al., (1979), and Wibbels (1984). After the hatchlings enter the sea and disappear from sight, nobody knows their route until the juvenile stage when they approach the coast along the western Atlantic; this period is called the "lost year" (Carr, 1980; Witham, 1980).

Because the hatchlings usually emerge during nightfall, any bright light can be fatal because it disorients them on the way to the sea (McFarlane, 1963; Raymond, 1984).

A joint effort between the U.S. and Mexico was initiated in 1978 for "The Restoration and Improvement of the Kemp's Ridley in the Gulf of Mexico and western Atlantic Ocean" (Marquez, 1984c, Fontaine et al, 1986a; Woody, 1985; FWS/NMFS, 1992; Marquez et al., 1992). One of the goals was to establish a second nesting colony of Kemp's ridley turtles on Padre Island, TX, based on the hypothesis that the turtles would return to their birth place when mature due to natal beach imprinting. This instinct has not yet been adequately explained, but is apparently the one affecting the nesting colony and the existence of single nesting beach for the Kemp's ridley. The joint U.S./Mexico project is based on this theory and has been discussed (Owens et al., 1992; Grassman and Owens, 1985). They note that this learning process "imprinting" is based primarily on the sense of smell and possibly other senses, whereby the hatchlings memorize the beach characteristics of their birthplace so that later they can return to the same place to nest. Up to now it has not been possible to give this theory credence (Grassman and Owens, 1985).

Further information on the behavior of the hatchlings in the natural environment is not available, however, experimental research performed on captive hatchlings are ongoing. These experiments are intended to gain knowledge on their survival, optimum growth, celestial orientation, and disease prevention (Fontaine et al., 1985). Several treatments have been tried on various ailments, as well as diagnostic methodology, such as x-rays with contrasting techniques using barium sulfate, relative to gastrointestinal ailments (McLellan and Leong, 1981). See also Section 3.3.

An important aspect to be considered in keeping the hatchlings in captivity is their aggressive behavior when kept in the same tank (Klima and McVey, 1981; Fontaine et al., 1985). To avoid severe mortalities it is recommended that they be separated and raised individually in small buckets, suspended in tanks with circulating water (Fontaine and Caillouet, 1985).

Deformed hatchlings have been observed at Rancho Nuevo. They can be identified as follows: abnormal scutes in the carapace and plastron, total or partial albinism, enlarged or unabsorbed egg yolk, depressed back, wider than normal carapace, flat plastron, short flippers, front or back flippers missing, double front flippers, undulated front flippers, crossed beak (usually associated with the absence of one or both eyes), and dwarfism. Some of these deformities for were recorded by Chavez et al. (1967) and Fontaine et al. (1985), and King et al. (1985) described different embryonic deformities from the Padre Island, Texas hatchery during the 1985 season.

Kemp's ridley hatchlings have relatively large heads and flippers in proportion to their body size as compared to adults (Chavez et al., 1967; Marquez, 1972). The head in the hatchlings is close to 41% of the carapace length, in the adult it is only 20%; its carapace is narrower, about 83.5% of its length, while in the adults it is 95.5% (Marquez, 1970, 1990). Further data on morphology is noted in Section 1.3.1 and morphometrics are presented in **Table 10**. The 1983 year class data from Padre Island are included in the table but is not considered representative because of the high mortalities which occurred during the initial development studies caused by higher than normal humidity inside the incubation boxes (Burchfield and Foley, 1985), and an invasion of bacteria and fungus. In this year class only 12.5% of the eggs hatched and the hatchlings were poorly developed (from a total of 2,006 eggs). See also Section 4.4.

3.3 Juvenile, Subadult, and Adult Phases

3.3.1 Longevity

Flower (1925, 1937) notes the lack of information on the longevity of wild and captive Kemp's ridleys. More recently however, Ernst and Barbour (1972) reported four females that had been kept for over 20 years at the Marineland Aquaria in Florida.

Captive Kemp;s ridleys at the Cayman Island Turtle Farm had nested when only five years old (Wood & Wood, 1984) and, as of February, 1993, the two turtle groups at the farm are 13 and 14 years old respectively (J.R. Wood, pers. comm.). Observations on tag returns from Rancho Nuevo indicate that ridleys have remained in the wild for up to 10.7 years after initially nesting (Table 20). Based on these observations we can expect a longevity much greater than 15 years for turtles in the wild. It is unknown if there is a difference in longevity between the sexes.

3.3.2 Hardiness

As noted in Sections 2.1 and 2.2, the Kemp's ridley is highly migratory, undertaking long distance movements from the nesting beach in the Gulf of Mexico to distant areas, such as New England, apparently without survival problems. This is surmised primarily based on tag and recapture information of head-started turtles (McVey and Wibbels; Fontaine et al., 1986a). There is some speculation concerning the mechanism for survival during the winter: one view is they migrate to warmer waters and then return to their former habitat (Pritchard & Marquez, 1973); another theory is that the turtles spend winter semi-buried in mud bottoms and thus avoiding low temperatures since at 10° C they become stunned and float helplessly (see also Section 2.3).

It is difficult to keep Kemp's ridleys in captivity, even when confined in small numbers. Relative to other turtle species, they are inclined towards cannibalism, causing severe lesions among themselves which are often lethal. Under certain conditions they easily develop diseases caused by virus, herpes, bacteria, and fungus. Therefore, when raised in intensive culture, individuals are isolated as an effective method of controlling infections as well as the turtle's aggressive behavior ((Klima and McVey, 1981; Clary and Leong, 1984; Fontaine et al., 1986b).

3.3.3 Competitors

Competition with other organisms changes with each developmental stage of the turtle. For example; during nesting the beach is not used intensively, at the same time, or in the same location by other turtle species or animals. It is assumed that completion starts when the hatchlings enter the sea, although their feeding behavior is not well known (see also Section 2.2). The subadults and adults are carnivores, with a specialized diet of benthic crustaceans (Pritchard, 1969a; Marquez, 1970; Hendrickson, 1980), discussed in Sections 3.4.1 and 3.4.2. This diet may cause some competition with various shallow-water fishes, e.g. *Lutjanidae, Sciaenidae, Serranidae, Pomadasydae*, etc. During its feeding activity the Kemp's ridley can forage into shrimp habitats where they are subject to capture by shrimp trawls (see Sections also 3.5.1, 5.1, 5.2, 6.1, and 6.2).

3.3.4 Predators

As in the previous section, predation on Kemp's ridleys vary with successive stages of its life cycle, beginning on the beach where various species prey on the nests abandoned by the females. Predation continues during incubation and increases when the hatchlings leave the nests and run for the sea (see

Table 10. Annual variation in size of Kemp's ridley from the Rancho Nuevo nesting beach (except 1955).

Year	Carapace (mm) length	Carapace (mm) width	Total weight (g)	No.	Authors
1955	43.0	34.0	-	4	Fluger & Webb, 1957 +
1966	42.7	36.1	16.4	124	Chávez et al., 1967
1967	44.4	38.0	17.4	167	Márquez, 1972
1974	43.9	38.1	17.3	243	I.N.P./SEPESCA
1977	42.5	35.2	-	50	Ruíz del Junco, 1978
1978	44.0	*38.9	16.9	3080	Fontaine and Caillouet,1985
1979	41.6	33.7	15.5	603	I.N.P./SEPESCA
1979	45.1	*40.2	18.1	1843	Fontaine and Caillouet,1985
1980	44.7	*38.5	16.2	1815	Fontaine and Caillouet,1985
1981	47.7	*44.3	20.6	1864	Fontaine and Caillouet,1985
1982	45.9	*42.1	19.2	1524	Fontaine and Caillouet,1985
1983	41.2		15.3	233	King et al., 1983
1984	43.5		16.4	1774	King et al., 1984
1985	43.3		15.7	1692	King et al., 1985
1986	43.6		16.3	1579	Shaver et al., 1986
1987	40.6		14.7	1282	Shaver et al., 1987
1988	42.4		15.3	925	Shaver et al., 1988
1989			16.1	65	Fontaine et al., 1990
ME	43.5	38.1	16.7		
D.E.	1.7	3.1	1.5		

\+ ME collected in State of Veracruz

* Per Caillouet et al. (1986), using formulas in Tables 4&5

M.E. Arithmetic mean
S.D. Standard Deviation

also Sections 3.1.7 and 3.2.2). Predation on the juveniles is mainly by various carnivorous birds, fishes, and sharks. With growth, bird and fish predation is avoided although the larger carnivores, such as sharks, are their more formidable enemies. Some of the nesting females in Rancho Nuevo show remnants of old or recent attacks of varying seriousness, reported by Chavez et al., (1967), who noted a frequency of attacks between 12% and 15%. These attacks varied in seriousness from small bites to flippers and shell to the loss of an entire flipper or large section of the carapace. Once in a while dead or dying females are washed up on the beach, where they can be clearly show evidence of shark attacks. Sometimes the lesions are so recent that it is assumed predation occurred in the breakwaters, just before the female approached the beach to nest. No information is available on the predators which commonly attack the Kemp's ridley.

The defense behavior of the Kemp's ridley may be the same as described for hawksbills, which rotates so that its carapace is perpendicularly to the direction of attack in such a manner that the shark confronts a flat surface and is unable to secure a grip (Vaughan, 1981; Witzell, 1983).

3.3.5 Parasites, Commensals, Injuries, and Abnormalities

Little information is available on these aspects. However, there is a good chance of nematode infections because crabs are an intermediary host for many vertebrates (Overstreet, 1978). Caballero (1962) notes that the parasites of marine turtles in general have not been adequately studied, particularly for the Kemp's ridley.

Copepods and leeches are infrequently seen on ridleys but are attached to the smooth skin around the neck and tail if present. The cirriped barnacles are commonly found on the carapace, plastron, and head scales of the turtle (Chavez et al., 1967). *Stomatoslepas praequestator, Platylepas hexastilos and Chelonifia testudinaria* are the more commonly found commensals on the turtles' carapace in waters of Virginia, United States (Lutcavage and Musick, 1985). *Chelonibia testudinaria and Balanus amphitrite* are also common, but on the turtles of northeast Florida (Rudloe et al., 1991). However, these cirripeds are less frequently seen on the Kemp's ridley than in other species, particularly the loggerhead. No other external parasitic crustaceans have been recorded.

Algae or other surface organisms normally do not adhere to the shell of this species, as often occurs with other marine turtles. Hildebrand (1980) noted that frequently the hatchlings reaching the Texas beaches are covered with a fine coat of green algae and sometimes with hydrozoans and bryozoans. It is possible that these turtles washed up dying or dead, spending considerable time adrift thus facilitating this external growth.

Neoplasms or dermopapilomas are occasionally observed on the nesting females at Rancho Nuevo (Chavez et al., 1967). The small tumors are usually rose colored. Their etiology is not known, however, some authors believe that these tumors are linked to trematode eggs in the green turtle (Smith and Coates, 1939) or are caused by leeches (Nigrelly and Smith, 1943). Green turtle fibropapilloma research has been reviewed by (Balazs and Pooley. 1991). Occasionally papillomas are found around the scratches made by the males along the edge of the female's carapace during copulation. Recently the growth of these tumors have been associated with chemical and radioactive contaminants.

Several types of traumas can be observed on nesting females, such as multiple fractures of the carapace, bite marks on various parts of the body from minor ones to deep and lethal ones (see also Section 3.3.4). Scratches on the carapace are common, some caused by the male during copulation, and various cuts, sores, and bites, which could lead to infections induced by virus, bacteria or fungus. Bone deformities, from hereditary or newborn traumas, have not yet been observed in the adult population in Rancho Nuevo but can be observed in the recently hatched ones or in those which did not complete their embryonic development; and on occasion these are present in captive turtles (see also Section 3.2.2).

Infections caused by bacteria or fungus in turtles in the wild have not yet been recorded. However, these infections are present during the embryonic phase which can lead to the complete loss of some nests. The same can occur at the moment of hatching when invaded by ants, mites and fly maggots, etc.

3.4 Nutrition and Growth

3.4.1 Feeding

Feeding behavior in marine turtles is generally not well known. Based on the limited feeding studies on subadults and adults, it has been possible to verify that the Kemp's ridley is a benthic feeder, especially on crustaceans found on clay, sandy-clay and sandy bottoms, in shallow coastal waters (see also Section 3.4.2). Dobie et al. (1961) examined two Kemp's ridleys from Louisiana and suggested that feeding takes place in clay bottoms close to bays and estuaries. Supposedly, the Kemp's ridley feeds mainly on bottom fauna in their foraging area (Groombridge, 1982), but during migrations over deep waters they must feed on pelagic fauna such as swimming crabs, fish, egg masses, squid, medusae and gastropods like the olive ridleys (Marquez et al., 1976). Fritz et al. (1983) noted that in October, 1980 during an aerial survey over the west coast of Florida, a Kemp's ridley was observed near an aggregation of medusae and believed they could be a potential "source of food". Recently (1983-1989) using the organisms collected in Texas, the stomach contents of 101 specimens were examined. These consisted of: five juveniles (5.2-20 cm), 86 subadults (20-60 cm) and ten adults (60 cm); the wild turtles varied from 5.2 to 71 cm, X=43.3 cm, and the head-started turtles from 14.6 to 48.2 cm, X=23.3 cm). Meaning that the majority of the specimens examined were of the post-pelagic phase (larger than 20 cm, Ogren, 1989); of which 50 were from the wild and 51 cultured at Galveston. Initial results show there are differences in food preferences between juveniles and adults, nevertheless both showed significant preference for benthic crabs, the remaining groups, combined, had only 6.4% of their stomach content composed of other matter. **Table 11** shows a partial list of these results. The author believes that the cultivated as well as the wild turtles feed in depth less than 50 m and that they can also eat some of the bycatch discarded by shrimp trawlers.

The feeding behavior of hatchlings and juveniles in the natural habitat is not well known and much is speculation (see also Section 2.2.1). In captivity, however, many of the observations are valid. These observations made on newborn hatchlings show they respond to visual stimuli and quit feeding in the dark. They accept almost any kind of animal food if chopped small enough, particularly fish, but will also feed on greens such as lettuce.

Table 11. Stomach contents of 101 Kemp's ridleys stranded in south Texas (Shaver 1991).

Material	% of Frequency	% of dry Material
Crabs	77.72	93.60
Mollusks	62.38	2.20
Fish	25.74	0.44
Vegetables	61.39	0.25
Shrimp	8.91	0.24
Other material	28.71	3.19
Trash	61.39	0.08

During the first few days of their life the hatchlings eat little or nothing and generally feed on surface organisms. They soon start diving and can feed to depth of 52 cm, although floating food is more readily accepted. They utilize their front flippers when feeding to rasp the larger pieces held in their beak; apparently they do not chew before swallowing, but break the food into small portions and then swallow them.

The NMFS, Galveston laboratory studied the visual stimuli during feeding by utilizing small pieces of peeled shrimp tails, colored red, yellow, blue and green. After 480 trials it was found that red was the preferred color, next yellow, then green, uncolored, and finally blue.It is possible that the turtles may have also reacted to a chemical stimulus created by the different dyes used, however, the responses were primarily visual (Fontaine et al., 1985).

The ridleys aggressive temperament, when crowded, often results feverish attacks among themselves ensues, which can lead to serious injuries and subsequent infections. To resolve this problem and raise them in a proper manner, they must be kept in small containers suspended in larger tanks with running water (Klima and McVey, 1981; Clary and Leong, 1984; Fontaine et al., 1985). See also Section 3.3.2).

Caldwell reported that a juvenile Kemp's ridley (216 mm) refused food for 150 days before dying. He concluded that the ridleys ability to fast for long periods allows it to survive during long migratory periods, when far from typical foraging areas. Nonetheless, this reinforces the belief that the western Atlantic (outside the Gulf of Mexico) is a natural distribution areas for the juveniles and not an expatriation one, as was also believed (see Sections 2.2.1 and 2.2.2).

3.4.2 Food

Few studies have been made on food preferences of the Kemp's ridleys, both qualitative and quantitative, for the various stages of their life cycle. At present it would be difficult to undertake such a study owing to its endangered status which obviates undue harassment. On the other hand, as noted by Hildebrand (1981), since their harvest is prohibited even when taken and drowned accidentally by shrimp fishermen, much potentially useful information is lost.

There are several publications noting the qualitative composition of the diet and explain the vari-

Table 12. Food identified in Kemp's ridleys' stomachs relative to locality and developmental phase.

Georgia (subadults)	Crabs-*Ovalipes* (*Platyonichus*) *ocellatus*	De Sola and Abrams.1933
Florida (2 juveniles)	Crabs-*Ovalipes ocellatus*. *Heppatus epheliticus*	Carr. 1942.1952
Mississippi (adult female)	Crabs-*Callinectes*. *Heppatus* Gastropods- shell fragments	Smith and List. 1950
Louisiana (subadult and adult)	Crabs-*Callinectes*. Gastropods	Liner. 1954
Louisiana (2 subadults)	Crabs-*Callinectes* (*sapidus u ornatus*) Gastropods Clams-*Nassarius* Miscellaneous small mud balls Vegetables-pine	Dobie et al.. 1961
Virginia-Maryland (juveniles)	Crabs-*Callinectes* (95%). *Panopeus* o *Menippe*. fragmentos	Hardy. Jr.. 1962
Tamaulipas (adults)	Crabs. shrimp. fish. mollusks. squid egg masses	Montoya. 1966
Tamaulipas females (adults) males	Crabs-*Gastropods* Clams On occasion. shrimp. vegetable. fish	Márquez. 1970
Not specified	Crabs. Gastropods Clams On occasion: vegetales. shrimp. fish	Ernts and Barbour. 1972; Pritchard and Márquez. 1973; Zwinenberg. 1977; Coastal Ecosystems Project. 1980. Márquez. 1990
Not specified	Crabs. shrimp. fish. meduzas	Márquez. 1977
Virginia	Benthic animals. crustaceans. and mollusks	Musick. 1979
Not specified	Fish. echynoderms. crustaceans. gastropods. cephalopods	Honegger. 1979
Not specified	Tropical crustaceans	Hendrickson. 1980
Louisiana. Tabasco-Campeche	Crabs	Hildebrand. 1981; Mortimer. 1981
Virginia	Crabs	Lutkavage and Musik.1985
Texas (5 juveniles. 86 subadults & 10 adults)	Crabs Mollusks Fish Shrimp Miscellaneous Trash	Shaver. 1991 (Table 2)

ability of such diet. These data indicates the Kemp's ridley is mostly a benthic feeder, preferring crabs, with a limited diversity of species when in shallow water. The food matter identified in the studies are shown in **Table 12**.

DeSola and Abrams (1933) dissected two juveniles and, although the lengthy intestinal track corresponded to a vegetarian diet, the stomach contents consisted of crabs - a carnivorous regime.

In captivity this species accepts cut fish and the hatchlings develop normally with floating pelletized food, similar to that used for trout (Fontaine and Caillouet, 1985). See also Section 7.

The work published by Shaver (1991) is the most complete on this subject to date, including data on 101 Kemp's ridleys found stranded in Texas beaches between 1983 and 1989 (Table 13). Of these, 50 individuals were from the wild and 51 head-started from the Galveston laboratory. The sample size for juveniles was small and the conclusions reached on behavior and food preferences are probably premature. The head-start turtles did not have enough time to adapt to the wild and their diet was probable not normal for this age group (i.e. sargassum, bird feathers, insects, oil, cloth, and plastic). The differences between wild and head-started turtles, as well as the different size classes, should be considered when analyzing stomach contents. These size differences must also imply different habits and types of food, which would make it more reasonable for individuals measuring 50 to 60 cm to be considered adults and therefore somewhat exhibiting different habits. By handling individuals ranging from 20 to 60 cm as one group, the possibility for detecting differences in diets and habits are

Table 13. Frequency percentiles (F) in dry weight (DW) found in stomachs of 101 Kemp's ridley tutles stranded in south Texas (Shaver, 1991).

MATERIAL	F(S)	DW(S)	F(C)	DW(C)
JUVENILES	N=2	N=2	N=3	
Crabs	50.00	11.77	0	0
Mollusks	50.00	23.52	0	0
Fish	0	0	0	0
Vegetable	100.00	17.65	66.67	81.30
Shrimp	0	0	0	0
Other	50.00	47.06	33.33	14.03
Trash	0	0	66.67	4.67
SUBADULTOS	N=38	N=38	N=48	
Crabs	76.32	90.95	77.08	63.29
Mollusks	57.89	2.23	70.83	11.42
Fish	18.42	0.17	37.50	8.57
Vegetable	57.89	0.29	64.58	1.71
Shrimp	5.26	0.39	14.58	1.14
Other	76.32	5.80	47.92	13.74
Trash	34.21	0.17	18.75	0.13
ADULTOS	N=10			
Crabs	100.00	99.71		
Mollusks	60.00	0.20		
Fish	0	0		
Vegetable	40.00	0.09		
Shrimp	0	0		
Other	60.00	0		
Trash	40.00	0		

(S) - Wild, (C) - Cultured

lost. **Table 13** shows some of the results of this study.

3.4.3 Growth Rate

A commonly used method for determining growth is tagging and recapture. Preliminary analysis indicate that growth is very slow after sexual maturity (Marquez et al., ms). Errors are common, usually resulting from the different procedures and equipment used in measuring. The turtle is often recaptured commercial fishermen, who do not pay too much attention to detail in collecting the data, particularly on active animals. Growth data from turtles tagged during nesting at Rancho Nuevo from 1966-1992 and recaptured outside the tagging area, in the Gulf of Mexico, are not considered reliable for accurate growth analyses (**Table 14**). However, the results obtained from measurements taken only on the nesting beach are more reliable because the animals were measured by trained researchers (Marquez, 1993).

Table 15 shows tagging and recapture results published by various authors. However, because the inaccuracy of measurements taken outside the research area, the reader must use caution interpreting these data. At present there is not much knowledge available on growth in the wild and the existing data are not sufficiently reliable for growth analysis.

Growth data on captive hatchling and juvenile turtles are more abundant (**Table 16**). Early studies consisted of a few specimens, with little control over their health or food, which consisted of cut fish, squid, blue crab, crab meat, and other seafood. These growth data were not as reliable as those obtained at present. However, they did show that the Kemp's ridley has a high metabolic rate and grows fast (**Figure 12**). The high metabolism may result from the specialized diet, based on animal protein.

Observations made during these studies showed that growth rates and movement of the turtles were directly related to temperature (Marquez, 1972) as

Table 14. Results of the growth (SCL) of some female Kemp's ridleys tagged at Rancho Nuevo and recaptured in the Gulf of Mexico.

No. of TAG	A (mm)	B (mm)	B-A (mm)	DAYS FREE	YEARS FREE	PER MONTH (mm)	PER YEAR (mm)
C17199	670	685	15	6	0.02	75.0	912.5
A4508	650	700	60	30	0.08	50.0	608.3
C17180	629	668	39	47	0.13	24.9	302.9
A4515	650	670	20	45	0.12	13.3	162.2
G4841	645	700	55	197	0.54	8.4	101.9
A3868	650	760	110	740	2.08	4.5	54.3
T0590	650	710	60	457	1.52	3.9	47.9
A4499	650	660	10	106	0.29	2.8	34.4
A1116	650	690	40	623	1.71	1.9	23.4
C13108	627	650	23	707	1.94	1.0	11.9
A1263	660	680	20	1510	4.14	0.4	4.8
C17797	710	720	10	1412	3.87	0.2	2.6
A1145	665	670	5	1067	2.92	0.1	1.7
G4633	635	638	3	3580	9.81	0.0	0.3
A1329	660	660	0	2073	5.68	0.0	0.0
G4708	695	695	0	92	0.25	0.0	0.0
K0140	700	700	0	903	2.47	0.0	0.0
F0605	640	640	0	33	0.09	0.0	0.0
T0744	685	670	-15	428	1.17	-1.1	-12.8
G9970	742	660	-82	1034	2.83	-2.4	-28.9
G4888	635	630	-5	48	0.13	-3.1	-38.0
J1028	650	575	-75	355	0.97	-6.3	-77.1
A1279	650	640	-10	32	0.08	-9.4	-114.1
K0003	715	685	-30	78	0.21	-11.5	-140.1
A3857	680	625	-55	70	0.19	-23.6	-286.8

A - Measurement at time of tagging
B - Measurement at time of recapture

Table 15. Growth of Kemp's ridleys (SCL) juveniles tagged at Galveston, Texas and adult females tagged at Rancho Nuevo, and recaptured outside tagging area.

Tag no.	Initial SCL	Months free	SCL gained	Growth (cm/months)	Authors
G0104	15.2	1.6	0.3	0.19	McVey and Wibbels, 1984
G0190	15.4	17.5	15.1	0.86	
G0366	14.4	1.7	-0.4	-0.36	
G0460	15.5	20.0	14.9	1.59	
G0467	13.0	1.8	-0.3	-0.15	
G0618	18.4	1.7	3.0	1.50	
G0904	17.0	15.8	12.2	0.78	
G0914	15.2	15.7	11.1	0.69	
G0985	17.2	10.3	7.8	0.75	
G2385	15.4	11.7	10.6	0.90	
G2406	14.0	17.7	14.5	0.69	
G2667	15.0	13.1	15.5	1.17	
G2697	13.8	13.7	7.7	0.54	
A1117	62.0	60.0	9.0	0.15	Chávez and Kaufman, 1974
A1071	65.0	7.1	4.0	0.56	Sweat, 1966
A1437	65.5	8.8	1.1	0.12	Márquez, 1972
A4558	65.5	9.3	4.5	0.48	
A1232	62.5	11.6	0.5	0.04	
A1251	63.5	11.8	0.5	0.04	
A1010	65.0	12.1	-1.0	-0.08	
A1260	61.0	12.3	3.0	0.24	
A1263	62.0	12.3	-0.5	-0.04	
A1252	65.0	12.4	1.0	0.08	
A1002	61.0	12.9	6.5	0.54	
A1280	66.0	12.9	-1.0	-0.70	
A1012	68.0	13.3	-2.5	-0.18	
A1184	61.5	20.2	3.0	0.15	
A1116	65.0	24.0	4.0	0.16	

Table 16. Growth in captivity of Kemp's ridley turtles, carapace length (SCL) in cm and total weight in kg.

Initial		Final		Elapsed time in (days)	Monthly Growth		
Length	Weight	Length	Weight		Length	Weight	Authors
(4) Hatchlings(*):							Werler, 1951
4.4	0.016	10.5 11.7 11.9 12.1		120 120 120 120	1.525 1.825 1.875 1.925		
(1) Juvenile:							Caldwell, 1958
-	6.975	46.1	18.600	3375		0.103	
(2) Juvenile:							Caldwell, 1962
26.0 27.6	3.178 2.838	30.5 34.0	4.767 6.016	316 690	0.427 0.265	0.151 0.138	
(6) Hatchlings(*)							Chávez, 1968c.
4.45	0.016	10.9	0.269	188	1.029	0.040	
(167)Hatchlings(*):							Márquez, 1972
4.44	0.017	10.5 13.1 19.2 24.8 31.4 32.1	0.254 0.399 1.262 2.340 4.550 5.025	180 180 180 180 180 60	1.010 0.433 1.017 0.933 1.100 0.351	0.040 0.024 0.144 0.180 0.368 0.079	
(100)Hatchlings(*):							Casas-Andrew, 1971
7.15	0.023	7.7	0.027	23	0.717	0.006	

Average values length and weight of hatchlings.

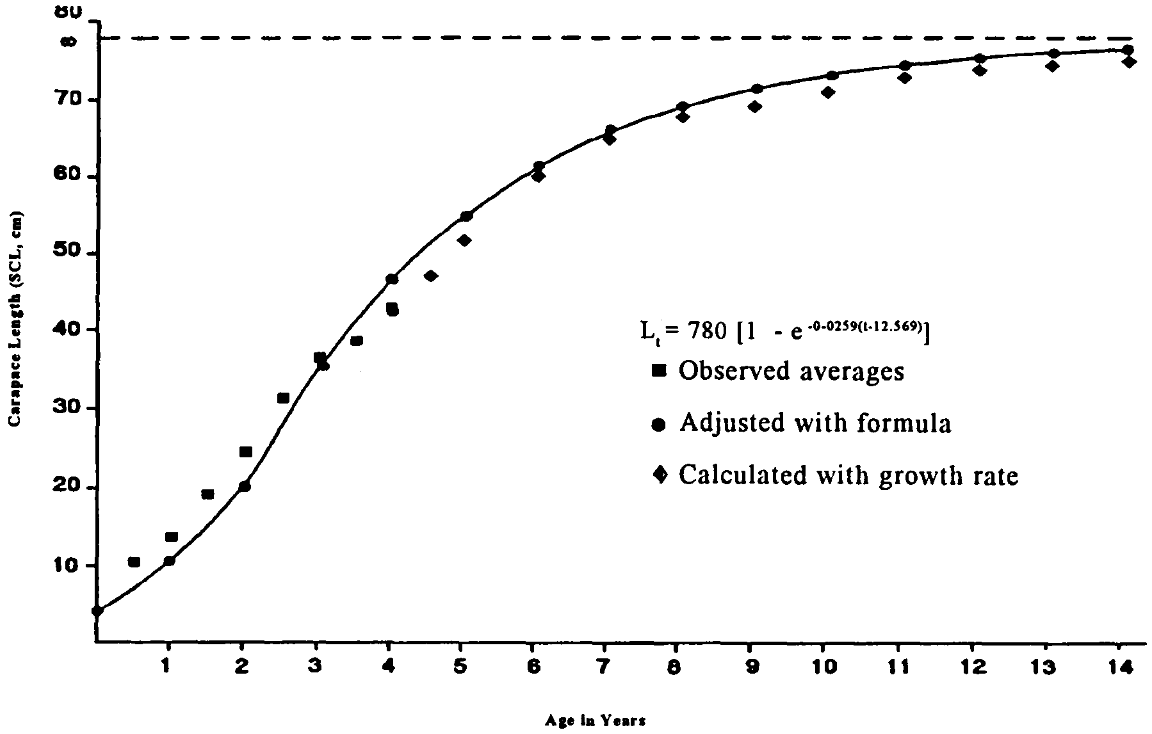

Figure 12. Theoretical Kemp's ridley growth curve (Marquez, 1972).

well as the amount and quality of the food (Frazer and Ehrhart, 1985). It is possible to increase the growth rate by taking advantage of its high metabolic rate, if feeding is kept within optimum levels, since adverse results may result in its physiology and reproductive capabilities (infertility) illnesses, etc.

Growth is faster in captivity than in the wild (Limpus and Walter, 1980; McVey and Wibbels, 1984), and the average age at maturity is reached sooner (Caillouet et al. (1986). However, a head-started turtle recovered in Morocco after 1,230 days free (Fontaine et al., 1986) grew faster than two turtles at the Cayman Turtle Farm (Wood and Wood, 1984). This needs to be reviewed to determine if these turtles, raised in captivity for almost a year, underwent some metabolic change and their rate of growth was modified in some way.

The U.S. and Mexico initiated a program designed to reduce hatchling mortality by head-starting 2,000 ridley hatchlings each year at the NMFS Galveston, TX Laboratory (Klima and McVey, 1981; McVey and Wibbels, 1984). Hatchling growth results of the 1978 to 1983 head-started year classes have been published (Caillouet and Koi, 1985) with the following results: a heterogeneous variability was noted between individuals of each group, increasing with each year group, this was greater in some year classes than in others (1981-1983). **Figure 13** shows the differences obtained during known periods, in months, for the cultured 1978 to 1983 year classes (Fontaine et al., 1985), and it is noteworthy that the 1980 year class grew fastest and the 1983 one was the slowest (Caillouet and Koi, 1985). Growth rate diminished during the cold weather which occurs during the middle of the culture period (Marquez, 1972). It is also felt that some of the differences noted between the year classes can be attributed to the methods used in measuring. However, until the studies are focused on the factors affecting growth rates, the cause of the observed variability will remain unknown (Caillouet et al., 1986).

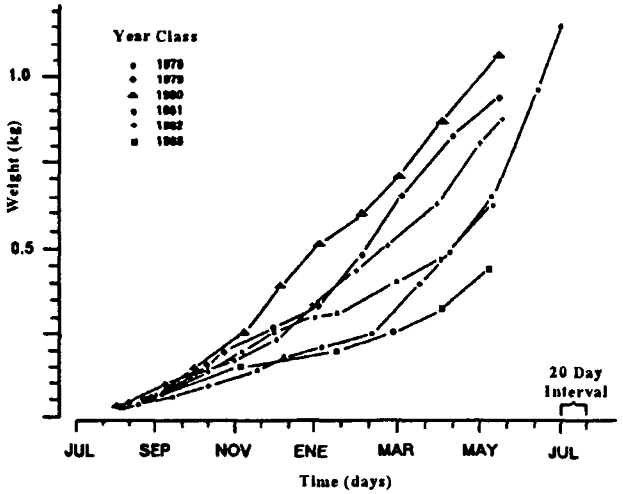

Figure 13. Average weight variation against time. Year classes 1978-1983 kept at Galveston Laboratory (Fontaine et al.

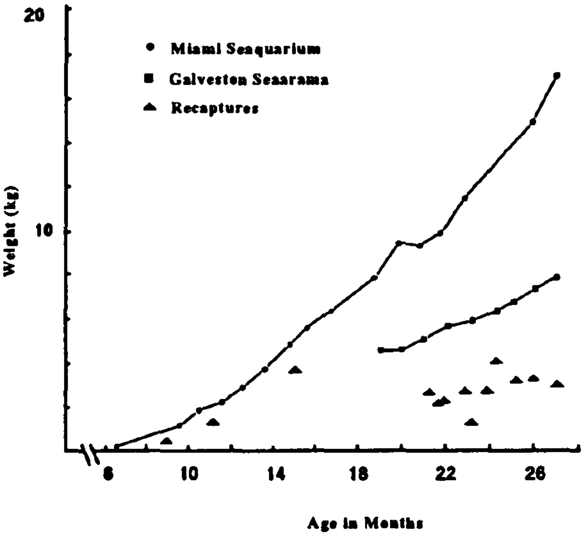

Figure 14. Mean weights of ten Kemp's ridleys kept in public aquaria (Fontaine et al., 1985).

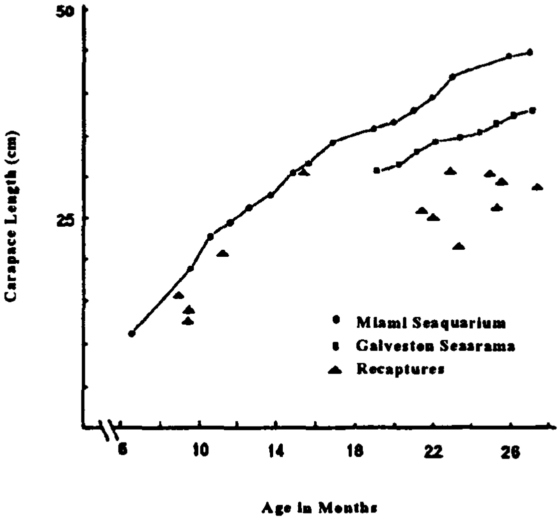

Figure 15. Mean lengths of ten Kemp's ridleys kept in public aquaria (Fontaine et al., 1985).

Figures 14 and 15 (adapted from McVey and Wibbels, 1984) show the average values of length and weight reached during a known period of time of turtles kept at the Galveston Sea Arama and the Miami Sea Aquarium as compared with recaptured turtles which had been released into the wild. The greatest growth rate was noted for the turtles kept in captivity, but among these individual differences were also noted. Further information on this can be noted in Caillouet et al. (1986).

A growth equation (**Table 17**) was developed by extrapolating growth data on captive and tagged animals (Marquez, 1972). The asymptotic length or maximum growth rate could be over-evaluated because of the rapid growth observed in cultured specimens. The present techniques are still in the experimental stages which, when proven valid, will allow for better evaluation of the results (Marquez, 1972; Bustard, 1979; Frazer and Schwartz, 1984; Frazer and Ehrhart, 1985; Caillouet, 1986; Zug, 1991). Recently a method called "skeletocronology" has been used, which consists in making thin histological cuts of the long bones (femur) and interpreting the growth lines (Zug, 1991; Zug and Kalb, 1989). This technique has promising results (see also Section 3.1.2).

Length-weight relationships (Table 17) change with age and size, owing to allometric growth and to the seasonal differences which affect the physiological condition of the individuals during their development phase; particularly in the females which are heavier during the period of reproduction. This variability is present in the equations for the adult females which reflects the changes in their weight before and after nesting and also after the long migration from the feeding areas to the nesting beach. This is shown in **Figure 16**. Consequently, in order to calculate regression equations, it is advisable to develop individual equations for each growth phase, from hatchlings to adults, including the separation of sexes, and for the females, before and after eggs are deposited and at the beginning and end of the nesting season so that data can be found on physiological changes and relative condition of individuals.

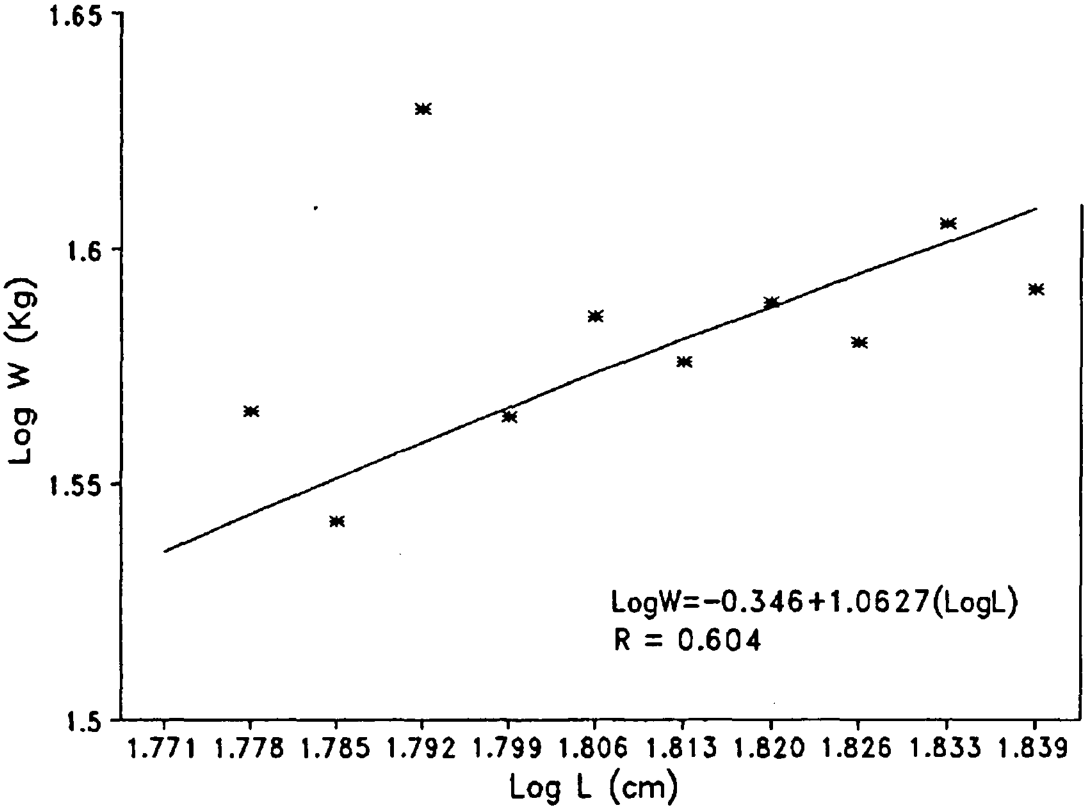

Figure 16. Length weight regression of 88 female Kemp's ridleys.

Table 17. Growth equations and morphometrics of the Kemp's ridley in the Gulf of Mexico[1].

Parameter	Model	Equation	N	R	Status[2]	Phase[3]	Authors
Age and Growth							
month mm	vonBertalanffy	$Lt=780[1-e^{-0.026(t-12.60)}]$			C,R	H,J,A	Marquez, 1972
day kg	Gomperz	$W=29.2e^{4.756(1-e^{-0.002T})}+d$	10	0.959	C	H,J,S	Caillouet et al, 1986
year mm	vonBertalanffy	$L=639.5(1-0.901e^{-0.2t})$	44		S	J,S,A	Zug, 1991
Length - Weight							
in lb		$W=0.0204L^{2.490}$	73		S	J,S,A	Carr &Caldwell, 1956, 1958
cm kg		$W=0.0488L^{1.628}$	17	0.639	S	Af	Chavez et al., 1967,1968
cm kg		$W=0.0488L^{2.156}$	9	0.925	S	Am	Marquez, 1970
cm g		$W=0.230L^{2.882}$	5064		C	H,J,S	Fontaine et al., 1986a
cm g		$W=0.285L^{2.850}$		0.995	C	J	Caillouet et al., 1986
cm kg		$W=0.346L^{1.063}$	88	0.604	S	Af	Figure 16

1 - W = Total weight; L = carapace length (SCL)
2 - C = Cultured; R = Recapture data, S = Wild
3 - H = Hatchlings; females, S = subadults; A = adult, Af = Females, AM= male

3.4.4 Metabolism

Based on aquaria studies, much information has been gathered on the activity and behavior of marine turtles. Apparently the Kemp's ridley sleeps on the bottom or the surface during the night, but does not close its eyes completely and is very alert to external stimulus (Parrish, 1958). In the wild this species greatly differs with the Pacific olive ridley, which does not stay on the surface for any length of time, particularly during daylight hours. Mendoza and Pritchard (1986), utilizing a radio scanner, measured the time lapse that adult females remained on the surface, this was .02 to 24 minutes, with an average of .39 minutes.

The results MEXUS-GULF sponsored satellite studies conducted during 1988, 1990 and 1991 are very similar. It was found that the turtles remained submerged close to 95% of the time, that is 2.9 to 3.2 minutes at the surface, supposedly to breath (Byles, 1989, pers. comm.). The average time spent submerged was 22 minutes. The duration of the time spent afloat and submerged varies with the time of day, weather, and behavior.

Various authors have noted that the metabolic rate in reptiles increases during exposure to the sun (Bustard, 1970, 1973; Whithold and Balazs, 1979; Balazs, 1980; Mrosovsky, 1980; Garnett, 1985). However, that behavior is not common to the Kemp's ridley, at least not when close to the nesting beach, where the water is warm (20°C). Basking behavior may be true in colder waters away from the nesting beach, however, evidence is not currently available as for other marine turtles, as noted and reviewed by Fritts et al. (1983). Basking loggerheads can raise their body temperatures about 3.75°C above ambient water temperature (Sapsford and van der Riet, 1979. It has been noted that the turtles may possess a mechanism to regulate their body heat, especially the leatherback (Mrosovsky and Pritchard, 1971; Mrosovsky, 1980). Among the marine turtles, the Kemp's ridley exhibits the least difference between its body temperature and that of the surrounding water; the leatherback shows the highest difference as measured in its cloaca and eggs.

Table 18 shows some temperature readings taken in the cloaca at depths of 6 cm and 13.5 cm from nesting Kemp's ridleys at Rancho Nuevo. The average temperature respectively was 3.2 and 3.4°C above that of the adjacent sea water, which was 25.4°C. The internal temperature varied from 21 to 32°C at 6 cm depth and from 24 to 33°C at 13.5 cm depth, and the water varied from 25 to 29°C. However, according to these results the elevated body temperatures were more constant when measured at 13.5 cm in the cloaca than at 6 cm. It may also be possible that the temperature in the muscle tissue is higher than in the cloaca. It was suggested by Standora et al. (1982) that since the active tissues in the green turtle has a higher temperature called "regional endothermia", it must also occur in the other marine turtles.

Variations in the ambient sea temperature affect the normal behavior, low temperatures can kill the Kemp's ridley. Juveniles measuring 30 cm in length can die at 6.5°C, smaller ones die at 5°C but before that they float and appear torpid (Schwartz, 1978).

Swimming speed in loggerheads is affected by temperatures (O'Hara, 1980) and the same may occur with the Kemp's ridley; however, there is no data on this. Swimming generates metabolic heat, which leads to increased body temperature. The results noted in Table 18 which shows temperature differences between the body and surface water were probably affected by metabolic changes as the turtles approached and crawled up the beach.

It is unknown whether all marine turtles undergo hibernation and what metabolic and physi-

Table 18. Relationships of sea surface and cloaca temperatures of Kemp's ridleys before nesting.

depth in cloaca (cm)	Equation */	N	r	Covariance	°C In the water	
					25	29.5
					°C In the cloaca	
6	$Tc=18.832+0.395\ Tw$	16	0.388	0.442	27.8	29.4
13.5	$Tc=6.3533+0.825\ Tw$	17	0.616	1.072		

* TC = Temp. in the cloaca
TW = Surface sea temp.
N = Number of samples

ologic changes occur, if any, during periods of inactivity. In marine turtles hibernation demonstrates special adoptive characteristics in which metabolic rates are lowered as well as their vital requirements, otherwise they would not survive semiburied in the clay bottoms during the long winter periods. There is evidence that the Kemp's ridley remains in a torpid state during the winter in Florida waters (Ehrhart, 1977; Mrosovsky, 1980; Carr et al., 1980). They have been found together with the loggerhead in water temperatures of 11°C and cloacal temperatures from 13° to 15°C, which were the same as that of the mud in which they were buried, but were higher than the lethal ones noted by Schwartz (1978). It is hypothesized that hibernation must be an adaptation to avoid thermal (Fritts et al., 1983). Generally, closed bodies of water such as estuaries and bays lead to massive mortalities when the turtles get trapped during extremely cold days. For example, Witherington and Ehrhart (1989) reported five extreme cold spells at Mosquito Lagoon, Indian River, FL, during which a total of 342 green turtles, 132 loggerheads and 2 Kemp's ridleys were cold stunned.

Metabolic rate probably changes with growth although these values are unknown for the Kemp's ridley. Although metabolism may be higher during the reproductive and migration stages, the basic metabolism rate must be much higher in hatchlings and juveniles because the relationship between surface area and body mass is greater than in the adult; leading to higher loss of body heat per unit of weight, consequently a higher metabolic rate is required to maintain equilibrium. It must be higher when the hatchlings leave the nest, enter the water, and go through the breakwater zone as noted by Dial (1987) for loggerheads. He indicates the hatchlings are in an anaerobic state, which translates to a physiological adaptation, allowing them to leave the beach rapidly and so avoid the high level of predation occurring in that zone.

The metabolic rate in the eggs rises during the incubation period (Ackerman, 1980) as well as the temperature. Oxygen consumption in the green and loggerhead turtles is sigmoidal and reaches the highest level just before hatching. The oxygen (O_2) consumed by the eggs inside the nests is influenced directly by the total egg mass and incubation time (Ackerman, 1981).

Marine turtles are adapted to remain submerged for long periods. During the few seconds the turtle spends at the surface, the structure of the lungs allow for quick and almost complete exchange of gases, the oxygen inhaled is enough to permit the majority of immersions to be aerobic (less than 30 minutes). However, prolonged immersion lasting several hours are made under conditions of anoxia, when their tissues become anaerobic and their brain has the special ability to remain functional (Lutz and Bentley, 1985). It appears that hemoglobin in marine turtles is better adapted to free oxygen from their tissues than to increase oxygen in the blood (Friedman et al., 1985). Therefore, the reduced affinity for oxygen can be seen as an adaptation to promote the consumption of "stored" oxygen during immersions (Palomeque et al., 1977).

Marine turtles are among the largest and most active reptiles. Therefore, their requirements for metabolic gas exchange with respect to other species is relatively high. Stabenau et al. (1991, 1991a) describes studies on the physiology of the ionic transfer system of the erythrocytes of marine turtles, with emphasis on the Kemp's ridley, particularly when they are under stress during incidental capture in shrimp trawls. For these tests, the turtles were forcibly submerged for a maximum of 7.3 minutes. During this time period, a metabolic acidosis was induced, the ph declined almost to 0.4 units and lactic acid increased six fold, relative to before and after the trawling event. Significant changes occurred in blood parameters, independent of submergence time (2.7 to 7.3 minutes) suggesting that activity without breathing contributed to the acid-base imbalance.

Marine turtles are able to close their nostrils and avoid entry of water into their respiratory organs; the glottis also acts as a valve and closes during immersion. The nostrils open during submergence and the floor of the mouth moves slowly up and down allowing water to enter the buccal cavity, probably to detect certain odors passing through the nostrils (Walker, 1959).

Crustaceans make up the main diet of the adult Kemp's ridley. These crustaceans have a salt concentration in their body fluids similar to that of sea water (Green, 1963), which they apparently consume when feeding. Because marine turtle urine is composed mainly of uric acid, ammonia and urea, it is not hypertonic; excess salt is excreted through their lacrimal glands or "salt glands" (Jameson, 1981). There is no specific information for the Kemp's ridley but Hirth (1971) and Witzell, 1983) have recorded information on the green and the hawksbill turtles, which must be similar to the Kemp's ridley. Corticosterone is also implicated in the function of the salt gland (Morris, 1982).

No studies have been made on the caloric values of the egg yoke and the remnants in newborn Kemp's ridley hatchlings. It is noted that in the loggerhead the dehydrated mass of the egg yoke, free of ashes, has less caloric values than the remnants in the hatchlings. This may be due to preferential use of protein during development of the embryo leaving the fats and carbohydrates intact until hatching time. During this period about half of the yolk remnant is consumed probably because of the exertion to free itself from the egg shell and the subsequent efforts to reach the ceiling of the nest. During the race from the nest to the breakers and the urgent swim to go through them to the feeding area, the remaining yoke must be consumed. In this manner the hatchlings leave the coastal area as soon as possible and so avoid much predation (Kraemer and Bennett, 1981).

An analysis of the amino acids making up the scutes and skin show differences between turtle species (Hendrickson et a., 1977). It was initially hoped to use these differences as a means to identify and separate the species, but the utilization of the skin for that purpose does not appear feasible. The composition of amino acid of the scute keratin has significant variations at the local population levels, but does appear clear and consistent between species and genera (Hendrickson, 1979). For these studies, emphasis was placed on the Atlantic green turtle; however, data on other species including the Kemps' ridley are also given.

3.5 Behavior

3.5.1 Migrations and Local Movements

The spatial distribution of the Kemp's ridley is not fully known, having a distribution from the Gulf of Mexico across the Atlantic to western Europe (see also Section 2). Before 1961 the main nesting site at Rancho Nuevo was unknown and was a puzzle years (Carr, 1963a). For that reason, the migration patterns were mere guesses (Carr, 1942, 1957, 1961); Deraniyagala, 1957; Carr and Caldwell, 1958). With the use of massive tagging at the nesting site their distribution patterns became better understood (Chavez, 1968c; Vargas, 1973; Pritchard and Marquez, 1973; Marquez et al., 1978). It was found that after nesting the Kemp's ridley migrate northward to areas off Mississippi and Alabama and southward to the Campeche Sound (Chavez, 1968c; Pritchard and Marquez, 1973; Marquez et al., 1978; Carr, 1980; Marquez, 1990), where the feeding grounds are located (Marquez, 1970, 1990; Carr et al., 1982; Hildebrand, 1983). Nonetheless, the available information concerning migration routes was unknown. With the new technology available utilizing satellite telemetry, the routes taken by the turtles began to be known; preliminary results indicate that the turtles follow the coast in shallow waters (Byles, pers. comm.).

Based on present knowledge, it is deduced that the Kemp's ridley is a neritic species, preferring shallow waters with an abundance of benthic crustaceans (Hildebrand, 1983). The migrations to and from the nesting area and feeding grounds apparently occur along that type of habitat. During aerial surveys, made by off Florida and Texas, a total of twelve sightings of Kemp's ridleys were made, ranging in depths of 11 and 77 m and 7 to 127 km from the coast (Fritts et al. (1983). The adults are more commonly observed in the Gulf of Mexico and rarely elsewhere; yet the juveniles and subadults have been found along the entire Atlantic coast of North America (Pritchard and Marquez, 1973; Byles, 1985, 1989; Ogren, 1989). See also Sections 2.1, 2.21, 2.22. and 2.3).

In addition to the nesting areas already mentioned, there are other areas of relative importance for juveniles and subadult: off the west coast of Florida (Carr and Caldwell, 1956; Carr, 1957, 1963b; Ogren, 1985, 1989) and possibly the waters off Georgia, North and South Carolina and New England states (Carr,1967; Lazell, 1976, 1980; Schwartz, 1989). Since the presence of this species outside the Gulf of Mexico is discussed in this section, the question arises: can these turtles upon reaching sexual maturity or before, return to the Gulf of Mexico as recruits and join the reproductive population? There is evidence that these turtles can survive several winters in temperate waters, depending on their size (Carr, 1980) usually over 20 cm, 30 to 45 cm in Chesapeake Bay (Byles, 1985). How these small turtles can survive has not been explained. If they do not remain in the cold waters, do they spend the winter semi-buried, or move into deeper waters of the Gulf of Mexico, (Pritchard and Marquez, 1973, Wibbles, 1984)? In other areas, such as Cape Cod (Shoop, 1980; Virginia (Byles, 1985) or New England (Lazell, 1980) the Kemp's ridley can remain trapped in cold waters, yet some of them could survive and return to the Gulf of Mexico (Pritchard and Marquez, 1973); Smith and Smith, 1979; Carr, 1980; Hendrickson, 1980; Lazell, 1980; Fritts et al., 1983; Lutcavage and Musick, 1985). Kemp's ridley hatchlings and juveniles tend to swim against the current, also known for the loggerhead (Stoneburner et al., 1982), which in some manner enables them to undertake the return trip to Rancho Nuevo once they reach the proper size.

Egg bearing females usually reach the Rancho Nuevo nesting area in March or April, with most arriving in May and June, although some may continue to arrive until the end of August (Marquez, 1976b, 1978, 1990). Males are usually not observed off the nesting beach but sometimes are taken near Rancho Nuevo by shrimp trawlers during November and April (Marquez, 1970, 1990). There are reports on solitary females or small groups nesting in other beaches such as Padre Island, Texas, Washington Beach, Tamaulipas, Cape Rojo, southeast Tuxpan, Tecolutla and Monte Pio, Veracruz, Mecoacan, Tabasco, between Aguada Island and Sabancuy, Campeche (Marquez, 1970, 1990); Marquez and Carrasco, in press; Marquez et al., 1985b) and Magdalena, Colombia (Chavez and Kaufman, 1974) although there is doubt about the latter (Pritchard, pers. comm.) in St. Petersburg, Florida (Meylan, et al., 1991) and recently (1992) one nested in North Carolina and another in South Carolina (anon. 1992). See also Sections 2.1 and 2.2.1, Figures 4, 5, 6 and Table 3, for further references.

Very little tagging has been done outside the Rancho Nuevo beach, for example off west Florida, with significant results (Carr and Caldwell, 1956). However, since 1979, when the U.S.-Mexico agreement came into effect concerning the restoration of the Kemp's ridley, tagging has increased, especially of juvenile turtles head-started at Galveston, TX (see also Section 6). Data on recapture of these turtles has been published in several sources (Klima and McVey, 1981; Fontaine et al., 1983a,b, 1990; McVey and Wibbels, 1984; Manzella and Williams, 1992; Manzella et al., 1988). Most of these authors note that the released juveniles soon adapt to the environment in the wild and grow "healthily". Depending on the point of release, recaptures are noted from the coast of Mexico across the entire Gulf of Mexico as well as the Atlantic coast of the United States as far north as New York. Some have been recorded from as far away as France and Morocco (Fontaine et al., 1986a, 1990). See also Section 2.1.

Other tagging results of nesting females is their homing instinct, noted in turtles which nest several times during the same season or during consecutive seasons. A difference has also been observed between the young and old females, the latter being more "exacting" in nest site selection, in the same season and also in consecutive ones. The older females also appear to be more constant, forming groups in two typical periods: from 18 to 20 days for some turtles and 38 days for others, for the young turtles this pattern is less orderly. The tagging studies have also provided information about their reproductive cycle: 58% of the females nest every year, 29% every two years and 13% nest every three years (Marquez et al., 1981, 1985b, 1989).

Radio and radio-satellite tracking is another tool to study behavior and migration of marine turtles (Timko and LeBlanc, 1981; Timko and Kolz, 1982; Mysing, 1985). Each method has different possibilities, the radio for local short term studies and the satellite is useful for long range migrations. Both have been used on the Kemp's ridley, although, because of its size, the satellite has been used on adults only. Radio tracking in Rancho Nuevo obtained preliminary data on behavior of the Kemp's ridley during the nesting period (Mendonca and Pritchard, 1986; Byles, 1989; pers. comm.). Results indicate that this turtle does not spend as much time floating on the surface as the olive ridley, especially during the day; also, the time spent at the surface varies between 0.02 and 24 minutes with an average of 0.39 minutes. After nesting the turtle travels north or south and out of range of the radio receiver and is observed again when ready for the next nesting. The data can also be used to determine individual fecundity, based on the number of times a turtle nests successfully. Standora et al. (1989, 1990) also utilized radio telemetry on juveniles in Long Island waters and noted they do not dive deeper than 13 meters, and more often to 8 meters, owing probably to diminishing visibility, which is reduced by 90% at 3 meter depth, and reaches only 1% at eight meters.

3.5.2 Aggregations

Historically, this species must have formed large "fleets" in certain areas of its overall distribution as occurs with the olive ridley in the Pacific. However, at present, not many concentrations are observed, except for several hundred females which aggregate during spring and summer (from March to September) off Rancho Nuevo to reproduce. The Kemp's and olive ridleys form "arribadas" during the season of reproduction. The mechanism that triggers the arribada formations has yet to be explained (Pritchard and Marquez, 1973). Coincidentally, these two species have pores along their inframarginal scutes, called "Rathke Glands", which produce a substance similar to pheromones. This secretion may be related to the formation of the arribadas, although this relationship has not been verified (Pritchard, 1969, 1979; Pritchard and Trebbau, 1984; Marquez, 1990). Also these arribadas could be related to imprinting which theoretically permits them to recognize their birth place after several years in the wild, either by organoleptic memory learned by the hatchlings (Grassman, et al., 1984) or a combination of several factors.

Certainly, the turtles probably travel together as they approach the nesting beaches from the north and south, and later after reproducing, when they return to the feeding grounds. Simultaneous recaptures of tagged turtles could mean they have traveled together nearing or departing the nesting beach (Vargas, 1973). These ideas are still speculative, and further work on tagging is needed to accurately describe these fleet migrations for this species.

3.5.3 Responses to Stimuli

Turtles depend closely on environmental factors. For example, the temperature and humidity during incubation and subsequent emergence (Chavez, 1967); Pritchard and Marquez, 1973; Marquez, 1990). Their orientation in the sea is apparently visual because an existing preferential phototaxis toward bright horizons, which theoretically allows them to maintain the right or correct direction (Mrosovsky and Shettleworth, 1968). See also Sections 3.2.1 and 3.2.2.

Since nesting takes place during daylight, female Kemp's ridleys must be guided by visual cues, because any obstruction or moving person or object will cause the turtle to return to the sea. However, once nesting, it is not affected by moderate molestation and will continue until completed and returns to sea. It is during nesting that tagging, measuring, etc. takes place without apparent reaction by the turtle. However if the tagging and other actions are attempted before egg laying starts, she will return to the sea before nesting commences.

Strong winds appear to stimulate the nesting action in the Kemp's ridley (Chavez et al., 1967; Marquez, 1970, 1990; Pritchard and Marquez, 1973; Pritchard, 1979). Casas-A (1978) believes that arribadas are initiated by small changes in water temperature (2°C) rather than by the wind.

The lowering of activity in marine turtles during winter or cold spells is characterized by lethargy rather than hibernation, considered a characteristic for mammals. This state of lethargy has been noted in other turtle species as well as in the Kemp's ridley. Some coastal areas in shallow water are known where the turtles remain semi-buried during cold spells, especially along the east coast of the United States and the northeast Gulf of Mexico (see also Section 3.4.4).

The Kemp's ridley is described by Carr (1942, 1952) as: being "unstable and irascible" and "when captured exhibits almost violent hysteria and obstinince", "but in the water it makes little effort to bite" (Carr, 1957). It is possible Dr. Carr was referring to juveniles and subadults from the west coast of Florida since in some areas in Mexico it is called the "dumb turtle" owing to its peaceful nature and ease of capture (Marquez, 1970). The bellicose nature seems to apply to the very young turtles, shown in the hatchlings by their cannibalistic tendency when crowded (Klima and McVey, 1981). It is observed that this violent behavior diminishes with age, which has been noted in the turtles kept alive at the Grand Cayman Farm (Wood, pers. comm.). Females at the nesting beaches have never shown the intent to attack when they are handled for tagging and measurements (Pritchard, 1979; Marquez, pers. obs.).

It is believed that chemical factors could be indicators which help marine turtles recognize the beach where they were born, and that imprinting starts when the egg comes in contact with the sand in the nest, continues through incubation, hatchling emergence , the race to the breakers, and their first contact with the water. Theoretically all this is memorized by the hatchlings and used, as in the case of the females, on their return to nest (Owens and Grassman, 1982). Experiments conducted by Grassman et al. (1984) appear to indicate that an olfactory imprinting exists which permits the turtle to "remember" the characteristics of the beach and adjacent water habitat, by the sense of smell. Maybe, because of this the females cover several meters of the nesting beach with their beak plowing the sand, apparently smelling and checking the temperature, humidity and consistency of the substrate.

The behavior of turtles has not been extensively studied, especially of the Kemp's ridley. Observations on captive turtles made by Parrish (1958) note that marine turtles are not aggressive, showed specific respiratory patterns, and showed variations in territoriality. Rest when floating was categorized into four postures based on the position of the flippers in relation to the body. The only difference of the Kemp's ridley in contrast to other turtles (green, loggerhead and hawksbill) is it does not close its eyes when "sleeping". In captivity they can be observed asleep in the aquaria. Food preference of the hatchlings in captivity can be associated with color stimulus (Fontaine et al,, 1985). See also sections 3.4.1 and 3.4.4).

The response of the Kemp's ridley to fishing gear is not well documented. Among the different gears, trawls impact marine turtles the most (Pritchard & Marquez, 1973; Marquez, 1989, 1990), although the extent of this impact depends on the distribution area and season. Some studies have been conducted on the relationship of the turtles with respect to trawls. It appears that the first intent is flee in the same direction the trawl is moving "so that soon the turtle tires and is overtaken by the net" (Seidel and McVey, 1981). If the turtle is trapped during period of the trawling action, it will probably drown, but if taken at the end of the trawling operation, it will probably be alive when hauled on deck of the vessel.

Preliminary studies undertaken by Marquez et al. (1989, 1990) utilizing tagging and recapture data (since 1966) show that adult female Kemp's ridleys are impacted by different fishing gears, in varying proportions; the trawl and gill net being the most important. Relative to head-started juveniles, results of tagging indicate that between 1978 and 1990 a total of 18,690 juveniles had been released of which 3.8% had been recaptured, about 717 up to December, 1991 (Fontaine et al., 1986a; Manzella et al., 1988; and NMFS (preliminary) . The recaptures were as follows: 43.6% by return to a beach, 21.3% by shrimp trawls, 7.7% by hook and line (recreational fishing), 6.3% by hand, 3.1% by gill nets, 1.5% in butterfly nets, 2.1% by other gear and in 14.4% method of capture was not reported. Of the total taken, 40.67% was in coastal waters and 46.2% in oceanic waters, no information was available on the remaining 13.2%. Of interest is that in many cases the cause of death in stranded turtles is difficult to determine (43.6%) and for other recaptures (14.4%) the method of capture is not well defined. That means in 58% of the cause of death is in doubt (see also Section 5.4 and Table 24). However, the effect of fishing gear on adult and juvenile Kemp's ridleys is quite different, depending on the seasonal distribution of the various size classes. Also, the vulnerability to the fishing gear varies with respect to other species. For example, Henwood and Ogren (1987) noted that in Cape Canaveral, Florida, the Kemp's ridley and the green turtle represent only 1% of the total captured by trawls, while the loggerhead make up the remaining 99%. This proportion may also reflect the relative abundance of the species present in the area, and it also should be noted that the behavior and habits of these species can also be reflected in the effectiveness of the capture gear.

4 POPULATION

4.1 Structure

4.1.1 Sex Ratio

The sex ratio, as in other species of marine turtles in the wild, is virtually unknown. Some studies have been conducted on cultured head-started Kemp's ridleys at the Galveston Laboratory of six year classes (Wibbels et al., 1985). The results show 1978 and 1979 years classes were skewed towards males, 1.9M:1F (N=32), and 1.4M:1F (N=22), respectively). The 1981 year class were all females (N=4); in 1982 and 1984 there were significantly more males 2.9M:1F (N=92), and 2.5M:1F (N=159), respectively. In 1983 there were no deviations (n=12). Although the data is limited, it is consistent with the hypothesis that sex is determined by environmental factors; however, the results must be examined with care owing to small samples studies (Wibbels et al., 1985).

4.1.2 Age Composition

Some guesses can be made on age composition by classes in the wild. For example, this composition can be determined through cohort analyses, utilizing the mortality estimates of eggs, hatchlings, subadults and adults. Using these data, a theoretical table can be developed, showing population changes and abundance of each age group, including both sexes (Marquez et al., 1981, Table 6).

It is presently impossible to undertake direct studies on age composition for the Kemp's ridley. Because it is a protected species only specimens taken incidentally to commercial fishing may be available. Also, at present, there is not practical method for determining age without having to kill the animal. Sampling of adults for statistical analysis for age by size frequency is difficult for this species, because of the small number of specimens available and because they hardly grow when mature. Therefore, the data is generally limited to separation of size frequencies for a statistical analysis. Some data and relative results are shown in Tables 16 and 17. Age at first nesting is discussed in Section 3.1.2 and maximum age in Section 3.3.1.

4.1.3 Size Composition

The majority of the adults and subadults are found mainly in the Gulf of Mexico, and juveniles are more frequently observed along the northeast U.S. Atlantic coast. Turtles measuring 30 to 45 cm in length, are often observed near shore as in Chesapeake Bay (Byles, 1985), and between 23 and 38 cm in New York waters. Juveniles, subadults and adults are more common off Alabama (Carr, 1980; Ogren, pers. comm.) and the bays and estuaries of North Carolina. Some historical records exist concerning frequent sightings off Cedar Keys, Florida (Ogren, 1985, 1989). Carr and Caldwell (1956) reported that individuals from 26 to 64.7 cm and weighing from 3 to 26.5 kg were observed off western Florida. In a recent tagging study off northwest Florida, Rudloe et al. (1991) reported that the median size of individuals observed in winter is considerably greater that in summer, 40.4 to 30.9 cm, respectively. Subadults and adults were also observed in waters off Tabasco and Campeche, outside the nesting area (Chavez, 1967, 1968c; Fuentes, 1967; Pritchard and Marquez, 1973; Marquez, et al., 1978; Hildebrand, 1981; Marquez, 1990).

According to 1991 observer records on board trawlers operating in U.S. waters (Table 28) the zones of greatest abundance of Kemp's ridleys were: Texas (81), Gulf of Florida (20), Louisiana (16), Mississippi (9). Outside the Gulf of Mexico were: Georgia (26), Florida (14), Massachusetts (11), New York (10), Virginia and North Carolina (6) and South Carolina (5) (Teas, 1992; Klima, pers. comm.). In accordance with data reviewed by Thompson and Marquez (ms) the size distribution in the Gulf of Mexico shows a larger percentage of adults then in the outside.

The average carapace length of adult Kemp's ridley females that nest at Rancho Nuevo, since 1966 to date (Table 5) has varied from 62.3 cm (1970) to 66.0. cm (1980), with minimum lengths of 55.6 cm and 62.0 cm, and a maximum lengths of 68.0 and 78.0 cm. Information about total weight of adult individuals is scarcer. However, 88 turtles averaged 37.7 kg (range 25-54 kg; SD= 5.02). Figure 16 was derived from these weight data, illustrating a highly variable length to weight relationship. There is probably a direct relationship between the length and the height but this parameter has not been measured and evaluated. The average weight for eight males was 34.6 kg (Marquez, 1990). Some growth parameters are discussed in Section 3.4.3 and shown in Table 17.

4.2 Abundance and Density

4.2.1 Average Abundance and Density

Some data abundance and density have already been discussed in Sections 2.1.2.2 and 3.5.1, however quantitative data are hard to obtain because the information is scattered among many sources. The spatial distribution of juveniles, subadults and adults in the coastal and oceanic environment is not known as a whole and only a small segment of the population is accessible (i.e. the number of nesting females at Rancho Nuevo). **Figures 17 and 18** show the annual population change determined from the total number of nests and eggs produced and the number of hatchlings that were protected and released each year at that beach. In Figure 17, the column marked "estimated number of eggs" was compiled from historical data of observations made by INP personnel between 1966 and 1977, and were empirically evaluated (Montoya, 1969; Casas-A., 1971, 1978: Pritchard and Marquez, 1973; Vargas-M., pers. comm.). Since 1978 the data is derived from the direct count of number of nests, and includes information on nests stolen, destroyed by predators, and by meteorological causes, as well as estimates of nestings prior to the arrival of the technical personnel to the beach site (between March and April).

The egg clutches left by the females are transferred to the hatchery at the camp to prevent predation. In 1990 a second camp was installed to the north, in a place called "Oyster Bar", and in 1991 a third camp was also built to cover the beach to the south at "Barra del Tordo". There are presently at least 120 km of sandy beach is under surveyance (Figure 4). When the nests are over six hours old, they are protected "in situ" to avoid high mortality, or are placed in styrofoam boxes and incubated at a special location in the camp. During 1966 and 1967 Dearl Adams of Brownsville, Texas collected over 40 nests and took them to Padre Island for incubation. Later, from 1978 to 1988 through a bilateral agreement (MEX-US Gulf), an average of 20 nests (2,000 eggs) per year were taken to Padre Island for incubation; from 1989 to 1992, an average of 2,000 hatchlings per season have been sent to Galveston, TX for head-starting (see also Sections 6.2 and 6.3).

The present nesting population at Rancho Nuevo has decreased considerably, when compared with the arribada of 1947, which was empirically evaluated by Carr (1963a) and Hildebrand (1963) from a 16 mm movie made by Mr. Andres Herrera of Tampico while fishing near the Rancho Nuevo beach. The estimated number of nesting turtles at that time

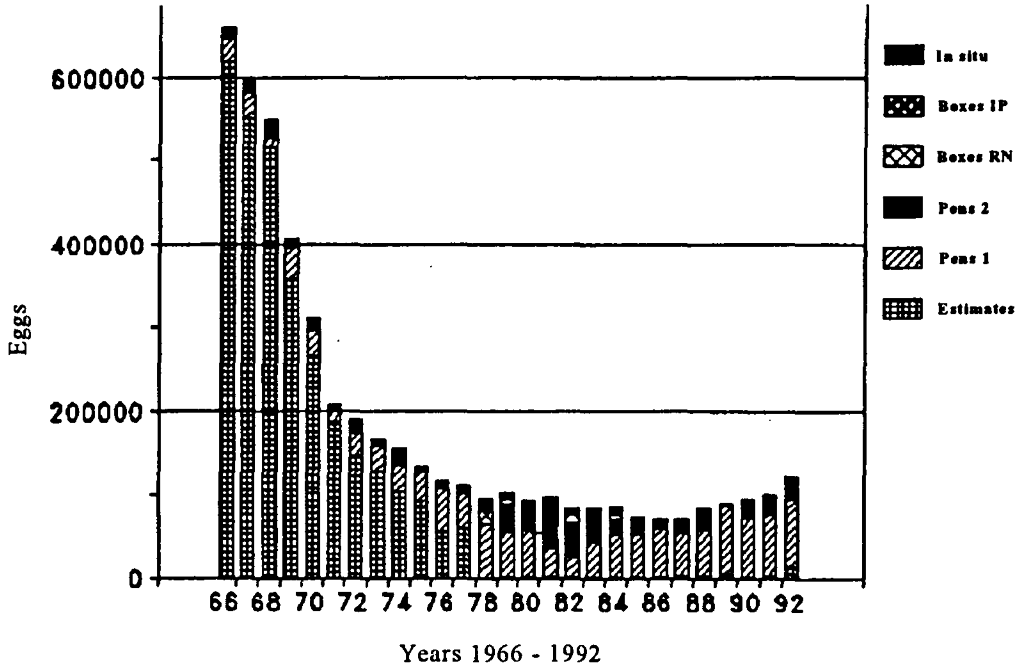

Figure 17. Egg distribution from Rancho Nuevo.

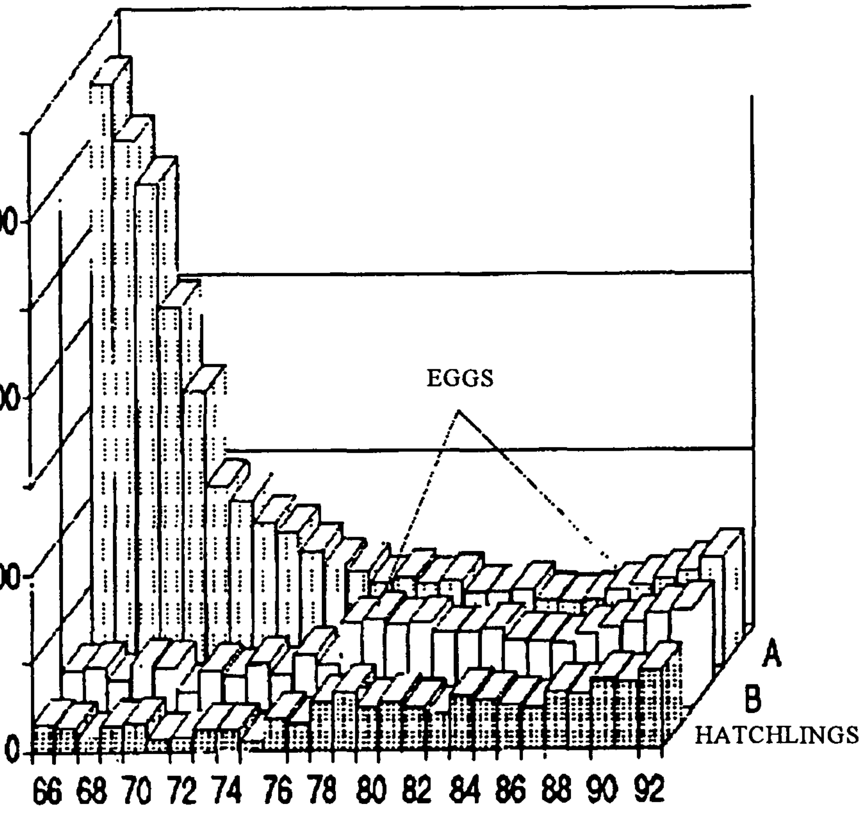

Figure 18. Total number of: (a) eggs deposited, (b) eggs protected, and hatchlings released from Rancho Nuevo.

was 40,000 (Figure 7). In May, 1968 the estimated numbers were declined to 4,000 to 5,000 (Montoya, pers. comm.). The population continued to decrease to about 2,000 females by 1970 (Casas-A., 1978), and only 500 to 600 females nesting during the entire season during the 1980's (Marquez et al., 1985a).

The explanations for this decline (over 98%) are varied, but overexploitation along the entire area of distribution was a leading factor. This exploitation not only included the taking of eggs deposited in Tamaulipas beaches but also the incidental capture of juveniles, subadults and adults throughout the Gulf of Mexico along the U.S. east coast. Pollution, pesticides, debris, and petroleum exploitation, and habitat destruction have contributed to the decline of the species.

Henry Hildebrand (1963, 1980, 1981) felt that the population declined because of various causes, mainly through the various non-directed fisheries taking place along its entire area of distribution. This species (and loggerheads) were taken indirectly in the green turtles fishery near Cedar Key, Florida and were also consumed occasionally in Port Aransas, Texas. It was also taken in the Campeche Bank until recently, as noted by Fuentes (1967) who observed the three species mentioned above, being sold at the Campeche market place, although the Kemp's ridley was the least common. In a letter from Mr. Dodley Heilliger, dated September 13, 1967, regarding the area off the Mississippi River where a tagged turtle was taken speculated that "the number of nesting turtles of this species has decreased greatly since I was transferred here (FWS) in 1938. Probably one of the main reasons for the decline was their use for target practice by the "fly boys" during World War II".

The seasonal harvest of the nesting beach before the implementation of the research and management program (1966) was confined to the eggs, with very few females slaughtered for their meat (Hildebrand, 1980). See also see Sections 3.3.5, 4.3.2 and 5.

4.2.2 Changes in Abundance and Density

Changes in abundance can not be adequately assessed. These changes are due principally to emigration, immigration, mortality, recruitment, reproductive behavior and feeding and are not yet completely understood (Pritchard, 1980). Initial estimates were developed in a population model based on changes in abundance of the population (starting with eggs, hatchlings, and adults), that are affected by different mortality and survival rates (Marquez et al., 1981). **Figure 19** was developed from these data on population changes of the Kemp's ridley and brought up to date with recent information from 1980 to 1985. The annual theoretical abundance, beginning with the curves derived from the virgin stock (total number of eggs deposited each season), can be drawn with the addition of the remaining number of each cohort, in a manner that the size and composition of the population is obtained for each year.

Other evaluations on the abundance of females in the population are empirically given by Pritchard and Marquez (1973) for Rancho Nuevo, about 2,500 to 5,000 adult females in 1971. Such data are published often, with the number derived theoretically, around 500 to 600 females nesting each year (Marquez, 1983, 1990; Caillouet, 1984; Fontaine et al., 1985; Thompson, 1988). The annual rate of decrease for the nesting population , beginning at maturity and breeding cycle, is shown in Table 24, and in Figures 20 and 21, included in Section 4.4.1.

It is more difficult to estimate non-nesting abundance (Pritchard and Marquez, 1973). Data are available for immature turtles in Chesapeake Bay from strandings and aerial surveys. Using the proportion of ridleys to loggerheads in this area (about 10%) the abundance of ridleys has been estimated from 200 to 300 in the lower reaches of the bay during the summer of 1984 (Byles, 1985).

4.3 Natality and Recruitment

4.3.1 Reproduction Rates

This parameter is based on the average number of eggs per nest (See Table 8, Section 3.1.7), the number of times the turtles nest per season, and the renesting interval. See also Section 4.3.2 and Table 22). The average nesting rate by using metal tags and recapture data, was preliminarily given as 1.326 times that each turtle nests per season (Marquez et al., 1981). This value multiplied by average number of eggs per nest will equate to a variation of 120 to 148 egg/female/season. However, new information gained at the nesting beach, which is currently being reviewed, will allow us to fine-tune this parameter. For example, relative to 1992, 55.5% of the females nest twice, 16.4% nested three times, and 0.7% nested four times. Therefore, they can lay an average of 167 to 192 eggs per season. From information recorded at the Cayman Island Farm, the number of nestings between 1986 and 1992 was 1.715 per season per female (it varied from 1.43 and 2.12), numbers similar to those obtained from tagged females nesting at Rancho Nuevo. This nesting rate appears low when compared to other species such as the hawksbill which has 258-387 eggs/female/season (Witzell, 1983). There is no explanation for this difference since the egg and hatchling size are similar (see also Section 4.3.2). Perhaps the answer lies in the annual (for Kemp's ridley) or biannual (for hawksbill) nesting cycle, since the turtles with longer nesting cycles save energy which otherwise is expended when migrating. Recent studies at the beach utilizing blood hormones (Owens pers. comm.) as well as ultrasound techniques of the ovaries and reproductive organs have resulted in giving higher nesting values of 2.3 times per season (Rostal et al., 1990). With the results of these studies it will be possible to reevaluate the reproduction parameters, such as fecundity and nesting cycle.

In a study conducted by Marquez et al. (1989), differences were found in the reproduction parameters when the nesting female population was separated into first time nesters and reimmigrants, the former group being identified by a lack of tags or scars from previous flipper taggings, and the latter group identified by having tags or tagging scars. In comparing both groups, a difference in fecundity was noted, as well as in nesting frequency and survival rate of the eggs during incubation, these factors being higher in the reimmigrant or "old" females (Table 19).

It is clear that, in this species, the renesting interval during the same season is influenced by weather conditions (necessary for the formation of arribadas) and also the physiological rhythm. Time differences of 20 to 28 days were given by Chavez et al. (1967) and Pritchard & Marquez (1973), and an average of 15 day cycles by Marquez et al. (1981).

Renesting frequency in subsequent seasons have been evaluated utilizing tagging and recapture results. These results indicate 58% of the turtles nest every year, 29% every two years and 13% every three years (Marquez et al., 1981). The longest consecutive nesting for the same female Kemp's ridley was 9.13 years (Table 20 and Section 3.3.1). This infor-

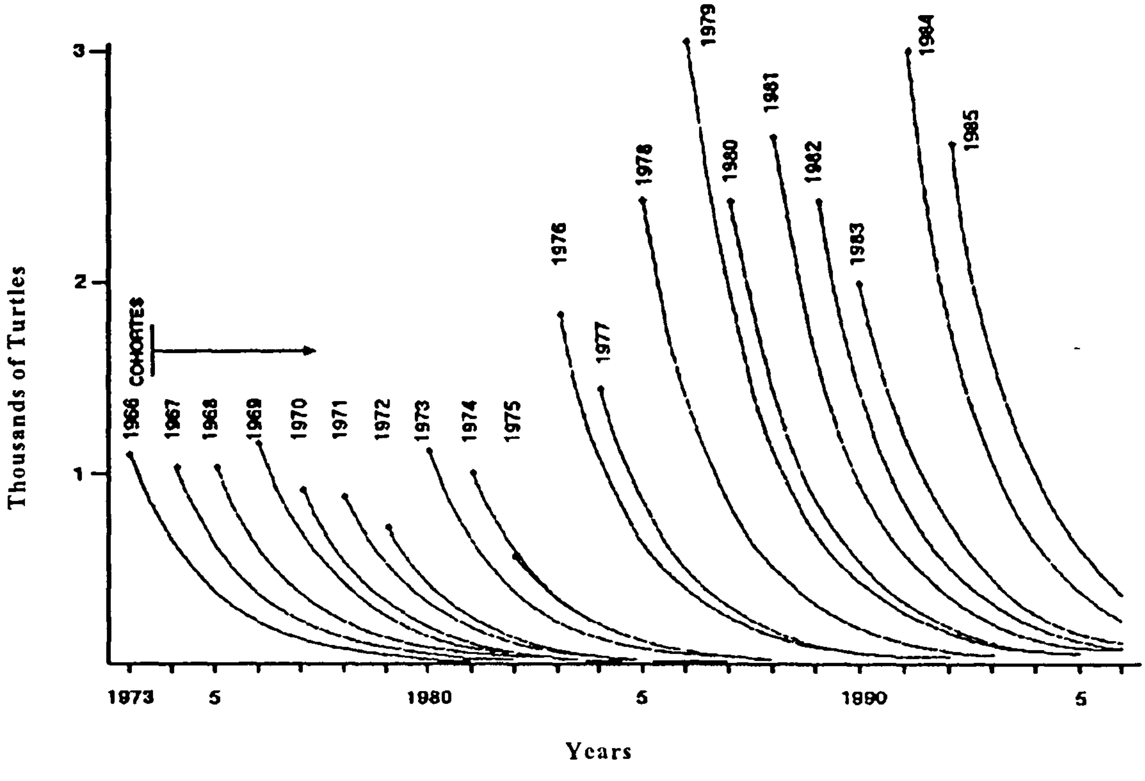

Figure 19. Theoretical extinction rate by years of Kemp's ridley. The "virgin stock" being considered as the total number of eggs deposited at Rancho Nuevo. The calculation shown starts at age seven taking mortality as a constant value in agreement with the life cycle of Figure 11 (Marquez, et al., 1981).

Table 19. Relative fecundity between Kemp's ridley neophites, reimmigrants, and survivors (%S) of small nests (<120 eggs) and large nests (>120 eggs). The larger nests were divided before incubation.

		SIZE CATEGORIES OF NESTS		
	TOTALS OF:	ALL NESTS	EGGS/NEST (<120)	EGGS/NEST (>120)
NEOPHITES:	NESTS	390	330	60
	EGGS	39536	32046	7490
	EGGS/NEST	101.37	97.11	124.83
	HATCHLINGS	31250	25711	5539
	HCHLNG/NEST	80.13	77.91	92.32
	%S [100*(H/E)]	79.04	80.23	73.95
REIMMIGRANTS:	NESTS	120	95	25
	EGGS	12568	9352	3216
	EGGS/NEST	104.73	98.44	128.64
	HATCHLINGS	10028	7287	2741
	HCHLNG/NEST	83.57	76.71	109.64
	%S [100*(H/E)]	79.79	77.92	85.23
ALL:	NESTS	510	425	85
	EGGS	52104	41398	10706
	EGGS/NEST	102.16	97.41	125.95
	HATCHLINGS	41278	32998	8280
	HCHLNG/NEST	80.94	77.64	97.41
	%S [100*(H/E)]	79.22	79.71	77.34

mation has been brought up to date and must be compared with the results obtained from internal PIT Tags (**Table 21**). Consequently, the possibility of finding tagged turtles nesting at Rancho Nuevo has greatly increased, and it is recommended to re-evaluate the results obtained previously, such as those of Pritchard and Marquez (1973) and Marquez et al. (1981).

As noted in **Table 22**, and taking into account the increase in observations at the beach, we can conclude that a large proportion of individuals return in consecutive nesting seasons, both in annual and bi-annual cycles and even more extended ones. In the above noted table only individuals which survived more than five years are included. Nevertheless, additional information is being analyzed to determine nesting cycles as well as individual and population fecundity. With the use of the PIT tags (Table 21), this information can be refined further.

4.3.2 Factors Affecting Reproduction

The nesting cycle described in Section 4.3.1 appears low when compared with that of other species. The Kemp's ridley is the smallest among the marine turtles and therefore must possess a higher metabolic rate (see Section 3.4.4) and, as a result, nests almost every year, has a lesser amount of reserve energy for use during migrations, and so produces less eggs. This as a whole relates to a synergistic equilibrium, unique for this species (Table 22). This issue is evident in the last columns of the table, where the body weight for each season is compared, and between each average nesting cycle. Apparently, the annual expenditure (except for leatherbacks), is similar in all the species if calculated for one season, but holds an inverse proportion relative to the average weight of the females when examined in relation to the annual nesting periodicity as well as the bi-annual, tri-annual one, or their average values.

The nesting success, including emergence, is dependent on external factors: wind, temperature, humidity, illumination, time of day, sand texture, currents, etc. Dry sand affects nesting in that the nest walls collapse, and wet sand is compact and prevents the nest excavation. This often results in the turtle returning to the water without nesting. The presence of obstacles, rocks, roots, or lumber on the surface or buried also prevent nest construction

Table 20. Multiple nestings of Kemp's ridleys at Rancho Nuevo. Each square shows the year observed (metal tags).

TAG No:	0	1	2	3	4	5	6	7	8	9	Times	Years
A1070	66						72	73			3	7.02
A1233	66							73		*	2	7.00
G4969	70								78	79	3	9.03
G4714	77							84	85		3	7.90
G4757	79					84	85		87		4	8.12
G9736	79			82		84		86		88	5	9.13
G9855	79	80		82			85	86			5	7.04
G9895	79		81		83	84		86			5	6.99
C01185	80			83	84	85	86				5	5.98
C07892	80					85		87			3	7.04
C13117	80	81			84		86				4	5.93
C17098	82	83	84		86	87	88	89	90		8	8.10
C17270	82	83	84			87	88		90		6	8.00
C13287	83								91		2	8.01
T00052	83					88		90			3	7.04
T00017	83			86		88		90			4	7.02
T00153	84		86		88	89+					4	5.10
T00095	84		86		88		90		92		5	8.05
T00410	84		86				90				4	5.99
T00161	84		86	87				91	92		5	8.06
T00426	84	85			88	89	90				5	5.98
T00171	84			87			90				3	6.02
T00174	84	85		87					92		4	7.95
T00373	84				88	89		91			4	6.91
T00387	84		86		88		90				4	5.92
T00156	85		87		89			92			4	7.06
T00529	85		87	88	89	90					5	5.01
T00405	85				89	90	91				4	5.92
T00699	85		87	88		90					4	5.04
T00666	85		87	88		90					4	5.01
T00941	85		87	88		90		92			5	7.05
T00767	86	87		89	90		92				5	6.03
T00617	86	87					92				3	6.04

Table 21. Frequecy of observations of Kemp's ridleys nesting at Ranch Nuevo. Turtles with PIT-tags.

Year Tagged	Year Recovered					
	1988	1989	1990	1991	1992	Sums*
1988	169	21	47	15	35	
1989		107	10	24	22	35
1990			267	16	70	37
1991				194	15	141
1992					179	62
TOTAL	169	128	324	249	321	916
Observers	1	3	6	6	6	

*The sums column is calculated diagonally and represents the number of tagged turtles recaptured after 1, 2, 3 and 4 years as well as the total tagged in 1992.

and frequently prevent nesting. These turtles nest during daylight hours, from early morning to early afternoon (see also Section 3.1.6). Normally they do not nest at night (Chavez et al., 1967; Marquez, 1970, 1990; Pritchard and Marquez, 1973); however, away from Rancho Nuevo, nesting may occur at night.

Factors which directly impact reproduction such as nesting, incubation, emergence from the nest and movement of the hatchlings to the sea, are mostly environmental: temperature, cloud cover, storms, tides, flooding, wind, pollution, time at which hatchlings emerge from the nest, etc., and biological: fungus, bacteria, ants, fly maggots, mites, crabs, roots, and larger predators of eggs and hatchlings.

Other factors which affect the female turtles, not just their emergence from the sea but also their nesting are the physical impediments of the animal itself such as partial or total absence of flippers, especially the back ones, or paralysis of these members where the animal cannot fabricate the nest and lay their eggs on the surface of the beach. (see Sections 3.3.4 and 3.3.5). The impact on the success of reproduction are discussed in more detail in Section 3.1.7 and factors which affect arribadas in Section 3.1.5. The work leading to improved survival of the species is included in Section 6.2.

Rancho Nuevo is an isolated beach almost outside the reach of human disturbance, therefore, at present, their impact is controlled by various Mexican federal agencies in the Rancho Nuevo Natural Reserve, as well as the joint MEX-US Gulf program (since 1978) called "Restoration and Improvement Program for the Kemp's Ridley (*Lepidochelys kempi*) in the Gulf of Mexico" which is in Sections 6.1 and 6.2.

4.3.3 Recruitment

Recruitment, defined as the number of new individuals of harvestable size, added to a population

Table 22. Reproductive paramaters of sea turtles.

Species	Nesting Cycle (yrs)	Nests per Year	Eggs		Total Eggs (kg)		Weight by Female (W)	% Y/WH	%Y/WH by Cycle
			N	W (g)	Per Nest	Per Year (Y)			
Caretta caretta	2-3	4.0	104	40.8	4.243	16.972	80.0	21.2	8.48
Chelonia mydas	2-3	2.6	114	50.3	5.734	14.622	138.0	10.6	4.24
Ch. agassizii	2-3	2.8	75	39.6	2.970	8.316	52.2	15.9	6.36
Eretmochelys imbricatta	2-3	3.5	143	28.8	4.118	9.471	53.9	17.6	7.04
Lepidochelys kempii	1-2	2.3	104	32.2	3.349	7.703	38.6	19.9	13.27
L. olivacea	1-2	2.3	111	32.6	3.619	8.323	38.1	21.8	14.53
Natator depressus	2-3	2.8	53	75.2	3.986	11.161	71.9	15.5	6.20
Dermochelys coriacea	2-3	5.5	73	77.6	5.665	31.157	394.0	7.9	3.16

# = average number of eggs per nest
W = average weight per egg
Y = average total weight of eggs per female
WH = average weight per female
Y/WH = total eggs as a proportion of body weight
Compiled from: Marquez, et al., 1976; Marquez, 1990, 1993; Rostal, 1991; Dodd, 1988; Witzell, 1983; Limpus et al., 1983, 1984; Pritchard and Trebbau, 1984.

(Ricker, 1971) can not be calculated in the classical method for the Kemp's ridley, since no organized fishery exists or existed. However, it can be deduced from data on virgin stocks such as the number of eggs produced in a nesting season and the number of turtles with the theoretical age of initial sexual maturity. Since Rancho Nuevo is the only nesting beach of importance for this species, most of the recruits originate from there, which facilitates calculations.

Recruitment should be evaluated annually. From 1966 to 1979, (Marquez et al., 1981) it was R=0.0572. The affect of head-started turtles on these values are unknown.

4.4 Mortality

4.4.1 Mortality Rates

There is little quantitative information on mortality rates. A theoretical population model (Fig. 19) can be calculated by using cohort analysis with a constant mortality rate (Marquez et al., 1981). See also section 3.2.2 and Fig. 11). The origin for this is the virgin stock as noted in Section 4.3.3. The graph also shows that some annual classes can survive, theoretically for more than 15 years.

The total mortality rate used for developing the population model in Figure 19 was derived from tag and recapture data of females from and outside the nesting beach. The mortality rate from incubation and hatching was obtained from the incubation hatchery at Rancho Nuevo. The annual mortality rates from the time of hatching to age of first maturity can be derived from regression calculations and extrapolation of the mortality (Marquez et al., 1981). Some of these data are shown in Table 23. These calculations are made only for females and, although it is possible that male mortality is different, these rates cannot be evaluated with the information available at present. The equation used (Ricker, 1958; Doi, 1975) was:

Table 23. Theoretical Kemp's ridley survival (S) rates and mortality (Z) rates at known ages.

Age	Z	S
Hatchlings	0.496	0.194
7 years	0.810	0.025

$S=e^{-zt}$

where:

S is the survivors

Z is the total mortality at age t.

The new tagging results derived from PIT tags will allow the reevaluation of these mortality rates. This information should be evaluated annually, since the environmental pressure on the population undoubtedly changes each year. See Sections 4.4.2, 6.1 and 6.2.

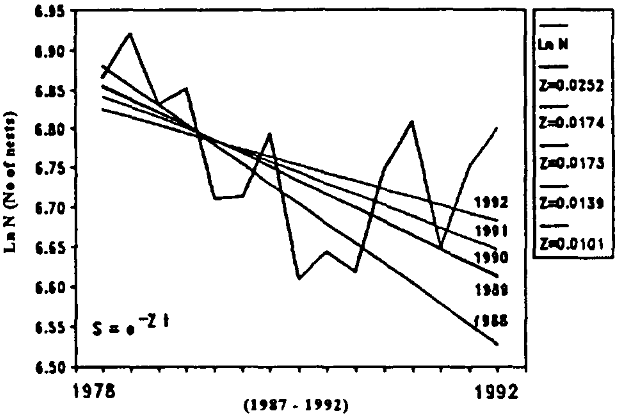

Figure 20. Mortality (Z) or decrease in Kemp's ridley population based on total nests at Rancho Nuevo.

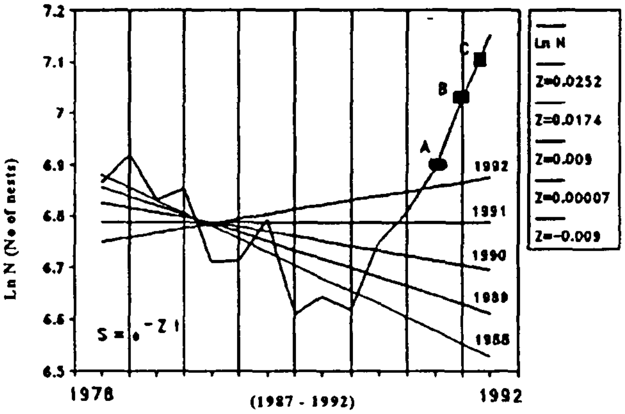

Figure 21. Total mortality (Z) based on total nests at Rancho Nuevo. The 1990 data includes Ostionales Beach (A), and 1991-92 data includes Ostionales Beach El Tordo (B,C).

Table 24. Mortality (Z) and survival (S) rates, decrease (D), and recruitment (R) at Ranch Nuevo derived form total nests production 1978-1992.

Period 1978 to:	Rancho Nuevo			Rancho Nuevo, Ostionales and El Tordo *			
	Z	S	D(%)	Z	S	D(%)	R (%)
1986	0.0339	0.967	3.33	0.0339	0.967	3.33	
1987	0.0331	0.967	3.25	0.0331	0.967	3.25	
1988	0.0252	0.975	2.49	0.0252	0.975	2.49	
1989	0.0174	0.983	1.72	0.0174	0.983	1.72	
1990	0.0173	0.983	1.71	0.0093	0.990.9991	0.92	
1991	0.0139	0.986	1.38	0.0007	1.009	0.00	
1992	0.0101	0.989	1.00	-0.0090			0.9

* The Ostionales Camp was established in 1990, 1991 and 1992. El Tordo was started in 1988 with three nests and officially operated in 1992.

Based on the evaluation of the total number nests that develop each season at Rancho Nuevo, the rate of decrease can be obtained for the population, which shrank up to 1986 at an annual rate of 3.33%. Since then some improvement has been noted: 1987 (3.25%); 1988 (2.49%); 1989 (1.72%); 1990 (1.71%); 1991 (1.00%). These figures indicate a minor improvement in the nesting population (**Figure 20**). This is being reinforced with the establishment of the two new satellite camps which doubles the coverage. Thus, in evaluating the combined data, the results show that for 1990 the decrease was lowered to 0.92%, 1991 (0.0069%), and 1992 there was a slight increase (**Figure 21**) to 0.9% annually (Marquez et al., 1992) which could be considered an omen for the nesting population (**Table 24**).

Natural mortality in marine turtles is caused by a great variety of factors, classified as physical, chemical, and biological (discussed in Sections 3.2, 3.3 and 4.3.2) and can increase by man's action, directly and indirectly, through commercial capture, tourism, industries, deterioration or loss of habitat, power plants, pollution, trash, and recreational fishing (Mager, 1985). Mortalities can even be caused by conservation activities, such as the inadequate handling of the females, nests, and eggs (the latter during transport, excessive handling, vibrations, drying, embryo rotation, overheating, contamination, inadequate incubation, experiments which affect survival, etc.). Head starting hatchlings under unhealthful conditions with inadequate feeding during prolonged periods and released in poor health could impact survival and could carry contagious diseases to wild stocks. See also Sections 3.1.6, 3.1.7, 3.2 and 6.3). Comparative studies were conducted between "in situ" nests and "natural" nests (Marquez, 1990). The results showed that natural predation and environmental factors have a greater negative impact than a well planned handling of the eggs and nests, as well as the immediate release of the hatchlings at the natal beach.

4.4.2 Factors Causing or Affecting Mortality

The juvenile and subadult mortality of individuals which leave the Gulf of Mexico and disperse as far as Newfoundland, England, northern France and northwest Africa (Morocco) is unknown. see also Sections 3.3.2 and 3.3.5). These turtles carried northward can be trapped by cold climates as noted by Lutcavage and Musick (1985) for Chesapeake Bay, where hundreds of dead turtles are annually stranded; in 1980, a total of 527 were loggerheads, 28 Kemp's ridleys, 7 leatherbacks and 87 not identified. The authors believe that pound nets fish cause the greatest mortality of turtles in that area.

As previously noted (Tables 11, 12, and 13, and Section 3.4.2), Kemp's ridleys feed mostly on benthic crustaceans (DeSola and Abrams, 1933; Carr, 1942; Dobie et al., 1961; Hardy, 1962; Marquez, 1970, 1990; Pritchard and Marquez, 1973; Marquez and Carrasco, 1993). Consequently, they frequent sandy and mud bottoms where shrimp may also abound and are therefore impacted by shrimp trawling activities (Marquez, 1981, 1982a, 1990; Berry, 1985; Marquez et al., 1985; Oravetz, 1985; Woody, 1985).

It can be stated that at present that trawling and other large scale fisheries are important factors preventing the restoration of the subject species (see also Sections 5 and 6).

Fishing nets and hooks can cause turtle mortality (Hildebrand, 1980) including Kemp's ridleys hooked by recreational fishermen (Harwell, 1982). Mortality from commercial and recreational fishing activities such as trawling, gill netting (fixed or drift), surf and pier fishing, or the presence of trash and garbage should be addressed. See also Sections 5 and 6 for further information.

Trash, such as plastic, oil cloths, polyethylene bags, hydrocarbons, etc. can also cause much harm to marine turtles (Balazs, 1985). The ingestion of any of those materials can effect the turtles digestive tract and choke the turtle by direct mechanical action or by closing off the gullet. This problem has not been noted, up to now, at Rancho Nuevo (see also Sections 5 and 6). Nonetheless, Rancho Nuevo receives a constant intrusion of all types of garbage and trash, carried in by prevailing currents, the most commonly observed being plastics and oil, the latter from natural oil seeps or from ships and oil rigs. Sometimes, pieces of netting or synthetic cloth may entangle the turtles which may be washed ashore dead or dying. Garbage and trash can be dangerous even for the researchers who may not know their makeup and how to handle them (Reisenhoover et al., 1986).

Hydrocarbon pollution affect marine turtles. Kemp's ridley and other species of turtles of various ages are periodically beached, partially or completely covered with crude oil, and sometimes have some in their mouth and esophagus. In extreme cases, they reach the beach dead or dying (Witham, 1978; Fritts, 1983; Balazs, 1985; Marquez, 1990). Some of the juvenile turtles that are beached, covered with oil and are still alive, after being cleaned are kept in aquaria and later released. Because of its present low abundance, its neritic distribution, and restricted nesting area, the Kemp's ridley is especially vulnerable to oil spills (Lutz and Lutcavage, 1985).

Mortalities attributed to hydrocarbons and mineral oils in the sea, are more common every day, particularly in juveniles (Witham, 1978; Coston-Clemens and Hoss, 1983; McVey and Wibbels, 1984; Amos, 1985; Fontaine et al., 1986a; Lutz and Lutcavage, 1985; Klima et al., 1988), although the impact has not been quantified (Fritts, 1983; Coston-Clemens & Hoss, 1983). Hall et al. (1983) reported on the necropsies of three turtles found dead near the Ixtoc I oil spill occurring in the Campeche Sound in July, 1979. Two of the turtles were badly decomposed but none appeared to have died from the exposure to the hydrocarbon spill, yet their tissues showed evidence of a chronic exposure to it. In comparing these results to similar ones made on birds, it was determined that at least 50,000 ppm were consumed daily.

The petroleum industry continuously affects the survival of marine turtles because of the spills occurring at the rigs during petroleum extraction activities in the continental shelf. At these installations not only oil spills occur, but once capped the structures are abandoned and become navigational hazards for which reason they are removed or destroyed. For this, explosives are placed at their base for removal. These structures, if remaining standing and lit, become a habitat for different marine species as a safe haven or for feeding, so that predators are also attracted, such as sharks, dolphins and turtles. In order to evaluate the effects of explosives on marine turtles Klima et al. (1988) conducted a study of a mass mortality which occurred in Texas between March 19 to April 19, 1986 when 51 dead turtles were found along the beaches. The results were not conclusive as to whether the mortalities were caused by submarine explosions which took place at the time, but it was felt some mortalities were caused by incidental captures, by garbage and pollution, etc. From the number of stranded turtles along the U.S. coasts, it is often not possible to determine the portion caused by various activities.

The damages caused by pesticide pollution has not been evaluated. Preliminary studies conducted on dead eggs and hatchlings obtained at the Padre Island facilities indicate lower levels than those expected to produce adverse effects. In that case, the residual values of organochlorides, biphenyl and polychlorides reached 0.01 ppm and 0.05 ppm respectively (J.B. Woody, pers. comm.).

4.5 Population Dynamics

Since legally harvesting turtle has been banned since 1973 in all major areas of its distribution, the classic statistical models derived from fishing and sampling effort can not be used. The only model available for now is the one taken from its life cycle and sampling of eggs, hatchlings, and adult females, conducted at the nesting beach (Marquez et al., 1981). In the theoretical model the size of the population at sea is evaluated by Marquez et al. (1981). See also Sections 4.2.1 and 4.2.2). Of course, these population models contain several inferences (Pritchard, 1980).

4.6 The population in the Community and the Ecosystem

The Kemp's ridley has a restricted distribution. The adults are only found only in the Gulf of Mexico and the juveniles and subadults can reach temperate zones of the North Atlantic. The population in the Gulf of Mexico is composed largely of sexually mature animals distributed along a limited coastal segment and migrate during certain parts of the years toward Rancho Nuevo to reproduce (Hendrickson, 1980). Hatchling and small juvenile habitats are hardly known due to the lack of information. See also Sections 2.1, 2.2. and 2.3). Small turtles (larger than 20 cm) are usually found in shallow coastal waters, moving either north or south, depending on the season of the year. The more common sizes found along the east coast of the U.S. from New York to Florida are from 30 to 45 cm in carapace length. Subadults are almost unknown outside the Gulf of Mexico and even here are seldom seen. Information on these animals is generally acquired from stranded specimens, therefore its habitat must be limited to the shallow waters of the continental shelf with sandy and mud bottoms. This information is mostly derived from adults, since studies on the feeding habits of the different development phases of the hatchlings and subadults is limited.

The Kemp's ridley appears to be composed of only one population, divided into groups that have varying breeding cycles, mainly annual, with two additional smaller groups, one with a biannual cycle and yet a smaller one with a triannual cycle which at times may coincide at the nesting beach (see also Section 3.1). It may also be possible that the turtles with an annual cycle are the youngest and the triannual ones the oldest. After nesting, the adult turtles disperse in two directions towards the feeding grounds, one to the northeast towards Florida and the other southeast to the Campeche Bank, reaching as far as the northeast of the Yucatan Peninsula (see Section 3.4).

There is no information on competition for habitat in the feeding areas, except for some data discussed in Sections 3.3.4, 3.4.1, and 3.4.2. The nesting habitat is more or less isolated from human settlements, the nearest fishing ports are LaPesca to the north, and Rio Soto La marina and Barra del Tordo to the south. However, there are some local cattle ranches, and some temporary fishing camps. At times the ranchers run their cattle along the beach, and at Barra de la Coma, goats may create a problem by overgrazing on the dune vegetation. In the last few years, large forested areas have been cleared for farming, which apparently has altered the rain pattern in the area. Hurricanes and storms lash the coast with certain frequency and, if they coincide with the nesting season, will increase nest mortality by flooding or erosion of the sand dunes, or can even alter the beach profile and impede proper nesting (Marquez, 1982a, 1983b). In the case of Hurricane Gilbert (September 1988), the Rancho Nuevo beach front was eroded to the level of the first berm, thus exposing a large extent of coral rock, which impedes nesting, causing about 20% of the females to move several kilometers northward (Barra de Ostional) to nest.

Competition for nesting sites may have existed during peak Kemp's ridley abundance about 40 years ago. At present though nesting activity may overlap, as to time, during the end of the season (between July and August) with the arrival of the green turtle, which had over 200 nestings during 1992. Occasionally, one or two loggerheads may also nest, as well as the leatherback; hawksbills have not been observed in the area. Competition for space is almost non-existent since there is little overlapping as to nest sites, since these species have different nesting site requirements. See Figure 8 and Section 3.1.6).

As with other marine turtles (Witzell, 1983), the eggs, hatchlings, subadults and adults of the Kemp's ridley are attacked by different predators. As such, the adults can only be attacked by sharks or some other large predator. See also Section 3.3.4).

Large cyclical changes in abundance have not been noted for the Kemp's ridley, only the decrease since the nesting beach was discovered in 1947. This decline was caused by uncontrolled harvest which took place for two decades, on eggs, subadults and adults, not only at Rancho Nuevo but at feeding areas in the Gulf of Mexico, northwest Florida, mouth of the Mississippi River including Texas and Alabama and the Campeche Sound. See also Sections 4.4 and 5).

5 EXPLOITATION

5.1 Fishing Equipment and Methods

Presently there is no commercial fishery for Kemp's ridley turtles. Up to the 1950s some were taken together with green turtles off the Florida west coast in gill nets 100 to 200 m in length, 2.4 to 3.0 m deep, with a 20 to 30 cm stretched mesh size (Carr and Caldwell, 1955). The nets were set across the channels running between sand bars (Carr, 1963b). It is believed this fishing method was commonly utilized to capture turtles along the coastal areas of the northern Gulf of Mexico. Similar nets were used in Campeche and Veracruz (Marquez, 1965, 1967a, 1977, 1990; Fuentes, 1967). Some variations were also used: 50 m in length, 4 to 12 m depth and 35 to 45 cm stretched mesh, a few floats and light lead line. This gear was also used in the Caribbean for taking greens and loggerheads.

Another method used in the Caribbean was the spear and harpoon; however, it was not recorded for the Gulf of Mexico. In general, harpoons have not been generally employed because their use for taking turtles has been prohibited, yet many different fishing vessels used them for red snapper and grouper as well as recreational fishing. These were used for taking turtles when they were drifting on the surface.

Grapple hooks were also used on fishing boats as noted by Witzell (1983). This method is employed in clear, shallow water or when the vessel can get close to the turtles, especially during noon when they are sunning themselves.

Turning turtles at Rancho Nuevo and Tecolutla was not commonly employed. At Rancho Nuevo the harvest consisted mainly of taking recently deposited eggs (Hildebrand, 1981). Up to 1965, harvest of eggs was extensively practiced at this beach and dozens of burros were used to transport the eggs to market (Hildebrand, 1963, 1981). In 1966, when the Research and Conservation Program for the Kemp's ridley turtle was initiated by INP, the destructive practice of harvesting eggs was halted (Chavez et al., 1967; Pritchard and Marquez, 1973; Marquez, 1990). Even in 1967 an egg buyer showed up during the start of the nesting season but was dissuaded to discontinue that illegal trade. See also Sections 3.3.4, 4.2.1 and 4.4.2).

The last attempt to commercially exploit this species in Mexico (5,000 turtles, half males and half females) took place in 1970. The permit was granted to take only turtles captured by the "jump" method (used commonly for the harvest of olive ridleys in the Pacific) at the nesting beach. For this purpose, the permit holder built a platform and storage bin in the area of Cachimbos, 7.5 km north of the Barra de la Coma. Since this turtle is different from the olive ridley in not remaining for very long at the surface (Mendoza and Pritchard, 1986), combined with the reduced number of available turtles scattered over a large area, the fishermen were not able to capture a single turtle. In addition, much pressure was evidenced by national and international conservationist groups. The end result was the operation was halted before a single turtle was processed.

At present, since 1983, the harvest of the Kemp's ridley is prohibited along its entire range in Mexican territory by any capture method. However, the problem of incidental capture is an important factor for its restoration. The incidental capture of sea turtles has been commonly reported in the east coast of the U.S. due to shrimp trawling activities. However, the incidental take of Kemp's ridley is proportionally less than for loggerheads, then greens (Marquez, 1965, 1976a, 1977, 1981, 1982a,b, 1990; Pritchard, 1976, 1981; Gunter, 1981; Hillestad et al., 1981; Seidel and McVea, 1981; Berry, 1985; Marquez et al., 1985a; Oravetz, 1985; Woody, 1985; Marquez and Carresco, 1992). Turtles are also taken by recreational hook and lines and pelagic long lines. Apparently the Kemp's ridley is not taken by diving. See also Sections 4.4.2 and 5.4).

5.2 Fishing Areas

Marine turtles are vulnerable to capture because of their reproductive habits. The Kemp's ridley was taken along its entire distribution range although certain areas were more important than others, such as: west coast of Florida, between Texas and Louisiana, from Tamaulipas to Veracruz and the Campeche Sound. The waters of the Gulf of Mexico are described as: a closed body with low lying coastlines, a very wide continental shelf, a low level of productivity, and small seasonal differences (Rosa, 1965). At present the Kemp's ridley can be taken incidentally in shallow coastal waters where certain crustaceans abound, such as: blue crabs, other crabs, and shrimp. The Kemp's ridley, is not found in the Caribbean, except for the north coast of the Yucatan (Rainey and Pritchard, 1972; Marquez, 1990). About 20 years ago the Kemp's ridley appeared on a regular basis in the commercial catches of marine turtles at Holbox, Contoy and Mujeres Islands, and in the area northeast of Yucatan, although normally less that 5% of the total take, which mostly consisted of green and loggerhead turtles. The entire catch was exported to the United States. During the same period, a fishery for marine turtles existed off the west coast of Florida, mostly directed to the green turtles (Caldwell and Carr, 1957; Ogren, 1985, 1989).

Table 25. Seasonal mortality for 850 Kemp's ridleys recorded from Texas (Manzella and Williams, 1992).

Season	Strandings	Shrimp vessel	Incidental[1]	Other[2]
Winter	69	9	0	3
Spring	283	35	13	28
Summer	174	31	33	35
Autumn	104	10	4	6

[1] **Gillnets and hook-and-line**

[2] **Hand, electric power stations, and unknown gear.**

5.3 Fishing Seasons

The Kemp's ridley were taken commercially throughout the year and wherever it was found, as in hawksbills (Witzell, 1983) and loggerheads (Dodd, 1988). Presently, the incidental capture of this turtle depends on the season for other fisheries, particularly where trawls and gill nets are used. For example, the results noted by Manzella and Williams (1992) from a compilation of records dating from 1940 to early 1990 for Texas (**Table 25**), show a higher rate of incidental take and strandings during spring and summer than in other seasons. The eggs were taken during the nesting season, mainly from April to July at Rancho Nuevo, although egg harvest may continue at other beaches of lesser importance as are Cabo Rojo, Tecolutla and Tuxpan, Veracruz.

Monitoring strandings were initiated in the U.S. during 1980 through the "Sea Turtle Stranding and Salvage Network" (**Table 26**). These data show that strandings occur mainly between November and December, diminish from January to March and increase again in April, May and June, and thereafter fluctuate somewhat at lower levels in August and September (Anon, 1983, 1984, 1985; Schroeder, 1986, 1987; Schroeder and Warner, 1988, 1989; Teas, 1992a,b; Teas and Martinez, 1989, 1992).

The evaluation mortalities caused by incidental capture and other man induced causes such as pollution, undersea explosions at oil rigs, mutilations aboard fishing vessels, as well as natural causes such as torpor owing to cold weather, etc., are difficult to define or explain adequately without a necropsy, which must be performed by competent technicians. Also, it is almost impossible to determine the total number of deaths, because the proportion of dead stranded turtles to those that never reach the shore is not known. Nevertheless, these data show some of the turtle mortalities that can be related to man's activities in the sea.

In Mexico, a directed fishery for Kemp's ridley never existed and the commercial catch statistics did not separate turtles by species. Veracruz and Campeche reported the highest landings, the former being higher. Based on these landing records, April and May showed peak levels with smaller ones for September and October. Landings on the east coast were comprised mostly of green, loggerhead, and hawksbill turtles, least was the Kemp's ridley (Marquez, 1970, 1976a, 1990; Marquez and Carrasco, 1992).

Table 26. Monthly strandings of Kemp's ridleys along the U.S. Gulf and Atlantic costs (National Marine Fisheries Service data 1980-1992)

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
1980	0	0	1	2	5	1	7	9	2	8	15	0	50
1981	1	1	1	2	3	8	8	3	2	3	16	7	555
1982	3	1	4	8	5	11	7	3	4	4	12	6	68
1983	2	1	1	4	8	23	22	8	17	14	18	0	118
1984	3	0	2	13	8	16	11	17	11	8	13	2	104
1985	3	0	4	11	12	17	17	6	10	4	23	41	148
1986	0	1	25	55	60	27	9	15	10	6	3	0	211
1987	5	4	12	18	22	7	19	13	8	15	8	14	156
1988	3	3	11	12	17	13	13	7	13	28	62	35	217
1989	13	8	7	21	14	16	14	11	11	20	30	19	184
1990	8	7	11	23	14	28	61	33	33	25	50	47	340
1991	11	0	12	23	20	12	27	27	14	17	9	18	190
TOTALS	52	26	91	192	188	179	215	152	135	152	259	189	1293

Landing records for tagged turtles also show valleys and peaks related in part to the shrimp trawling seasons. Peaks appear in March, July and August, which coincide with beginning and end of the nesting season for the Kemp's ridley and its movements to and from the nesting beach.

5.4 Fishing Operations and Their Results

Ridleys are often mistaken for the loggerheads, both of which were harvested incidentally with green turtles in Florida and Texas (Hildebrand, 1981). This confusion between species casts some doubt about the validity commercial sea turtle landings data in the U.S. and Mexico (Marquez, 1976, 1990). In the 1950's there was much demand for turtle meat, however, Kemp's ridleys and loggerheads were less popular and were packaged together and labeled second grade (Caldwell and Carr, 1957). A sea turtle packing house in Key West, Florida operated until the end of 1800 where Kemp's ridley meat was mixed with that of green turtle or sold as loggerhead (Cato et al., 1978). The main processed product was "Turtle soup". During that period, several processors also operated in Texas (Doughty, 1984).

Table 27. Average weight (kg) and percentage values of body parts and organs of two females and four male Kemp's ridleys taken by shrimp vessels beween 1967 and 1969 off Tampico (Marquez 1970).

PARTS	AVERAGE	PERCENT
MEAT	7.520	20.40
LIVER	0.890	2.42
HEART	0.115	0.31
KIDNEYS	0.210	0.58
FLIPPERS	2.375	6.44
SKIN	1.995	5.41
FAT	0.720	1.97
INTESTINES	3.080	8.36
LUNGS	0.655	1.85
SPLEEN	0.090	0.24
HEAD	2.060	5.59
CARAPACE	6.120	10.60
PLASTRON	2.000	5.42
BONES	4.065	11.03
GONADS	0.675	1.83
EGGS*	3.260	8.84
LIQUIDS**	1.000	2.71
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TOTALS	38.860	100.00

*One turtle contained 98 eggs with shells.

** Usually over one kg.

It is believed that the main fishing areas for the Kemp's ridley were Veracruz and Campeche, however, there are no records to confirm this. It is possible that in Tamaulipas, where the nesting beach is located, the Kemp's ridley was never commercially exploited. The eggs, however, were extracted for many years and several years after the field station was established in 1966, many attempts were made to continue poaching (Hildebrand, 1981; Marquez, 1985a, 1990).

The exploitation of marine turtle skins never included the Kemp's ridley, since their numbers had declined considerably by the time the international market developed in 1968. Until the mid 1970s turtles of the Atlantic were an important protein source for the coastal and, often, inland towns. Fat and oil extracted from the turtles were also sold commercially. In some coastal towns, the consumption of turtle products, especially the eggs were traditionally very important and in certain areas the eggs are considered to possess aphrodisiac properties. **Table 27** shows the results on the dissection of six turtles which drowned during shrimp trawling from 1967 to 1969 in which the body parts are expressed as percentage of weight of the whole animal.

According to Hillestad et al. (1981), the "incidental catch of turtles is a menace to the survival of certain marine turtles, especially certain populations". Considering this, the Kemp's ridley because of its small population and limited coastal distribution could be one of the most vulnerable species (see also Sections 3.4.1, 4.2, 4.4.2). During the period of 1965 to 1980 it is estimated that 40,000 loggerheads and 500 Kemp's ridleys were taken incidentally in the Gulf of Mexico. These were made up of various ages and captured with a variety of fishing gears, particularly shrimp trawls. Some of these turtles were kept by the vessels' crews for food (Marquez, 1967a, b; 1977, 1978).

Reports about the incidental catch of marine turtles, including the Kemp's ridley are: Pritchard and Marquez (1973), Ogren et al. 1977), Zwinnenberg (1977), Bullis and Drummond (1978), Hildebrand (1980, 1981), Watson and Seidel (1980), Hillestad et al. (1981), Berry (1985), Rayburn (1985), Seidel and Oravetz (1985), Woody (1985), Renaud (1990), Manzella and Williams (1992).

A study was conducted by Renaud et al. (1990) with the cooperation of observers on board shrimp trawlers. The goal was to evaluate certain turtle excluder devices, including the possible loss of shrimp, and analyze the bycatch from 4,159 hours of fishing from July, 1989 to September, 1990. During this study 40 marine turtles were taken, 27 from the

Atlantic coast and 13 from the Gulf of Mexico. A total of 36 survived and were released. The authors estimated that the total incidental capture in the Gulf of Mexico during 1988 was 14,112 turtles in 5 million hours of trawling effort, which was 16% higher that the previous year. Total shrimp landings were only 8% greater. They also estimated that 14,986 turtles were taken off the Atlantic coast, based on 0.5 million hours of fishing effort.

Kemp's ridley mortalities from natural causes or by incidental capture have not been evaluated yet, however the records being compiled in the U.S. by "Sea Turtle Stranding and Salvage Network" on stranded turtles may give a clearer picture of the various natural factors (diseases, climate, meteorological phenomena, etc.) or human (petroleum related activities, dredging, fishing gear, pollutants, trash, habitat destruction, etc.) along the entire area of distribution of the species. **Table 28** shows a summary on all available stranding data of both sexes of Kemp's ridleys, from juveniles to adults relative to the east coast of the U.S. Of particular interest is that the records from Texas comprise about half of the total ridleys (Odell et al., 1982; Anon, 1983, 1984, 1985; Schroeder, 1986, 1987; Schroeder and Warner, 1988; Teas and Martinez, 1989, 1992; Teas, 1992a,b).

The recapture of tagged females provides a clearer idea on the portion of the adult population affected by fishing gear. Published and unpublished capture data are noted in **Table 29** illustrating, among other fishing methods, that shrimp trawling stands out as having the greatest impact on marine turtles and secondly gill netting. Diving from a small boat to take turtles is not common in the Gulf of Mexico, as was done in the Pacific coast for the olive ridley (Marquez, 1976a). Apparently, harpoons have not been used to take turtles in the Gulf of Mexico.

6 PROTECTION AND MANAGEMENT

6.1 Regulatory Measures

Because of the unique geographic distribution of the Kemp's ridley, two nations are charged with its survival, Mexico and the United States.

Factual knowledge about the status of the Kemp's ridley did not come to light until 1962, when the Rancho Nuevo nesting beach was discovered (Carr, 1963; Hildebrand, 1963). It was not until 1966 that Mexico, through its own initiative, initiated research and conservation activities directed exclusively towards this species, and some regulatory measures such as prohibiting the extraction of eggs were implemented.

Before the 1970's the U.S. had few regulations concerning sea turtles, although a law protecting all turtles was approved by the Texas legislature in 1963 replacing an old 1895 ordinance relating to the legal minimum size of green turtles taken for commercial purposes (Anon. 1895, 1963a; Doughty, 1984; Hildebrand, pers. comm.). During that time most local and state regulations were general in nature and some were especially directed to the green turtle with the objective of protecting the

Table 28. Kemp's ridley strandings by state along the U.S. Atlantic and Gulf coasts (National Marine Fisheries Service data).

(#)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Σ
1980	16				6	5	3		9					12		51
1981	17	1	1		4	3	2	5	15			1		12		61
1982	31				7	16	8		3					6		71
1983	72				7	16	2	3	16							116
1984	68	12	1		3	2			9					9		104
1985	62	1			1	15	1	1	10		2	4	44	10		151
1986	211	94	6		11	14	8	9	6		1		34	13	1	408
1987	57	22	3	5	30	15	10	11	7			1	33	23		217
1988	43	10	6	5	80	37	6	11	13				2	4		217
1989	56	13	6	3	52	22	4	2	5			1	12	26		202
1990	164	17	6		44	45	6	15	5				13	43		258
1991	81	16	9	1	33	26	5	6	6	1		3	10	11		208
Σ	878	186	38	14	278	216	55	63	102	1	3	10	148	169	1	2164

1 = TX, 2 = LA, 3 = MS, 4 = AL, 5 = FL, 6 = GA, 7 = SC, 8 = NC, 9 = VA, 10 = MD, 11 = DE, 12 = NJ, 13 = NY, 14 = MA, 15 = ME.

Table 29. Comparative data on the capture of adult female and juvenile Kemp's ridleys.

Capture Method	Adults[1]		Juveniles[2]	
	%	N	%	N
Gill net	7.91	14	3.6	17
Shrimp trawl	71.19	126	27.6	132
Fish Trawl	1.69	3	-	-
Diving	-	-	0.8	4
Hook & line	1.13	2	5.7	27
Beach seine	1.13	2	0.2	1
Sport fishing	2.26	4	-	-
Purse seine	0.56	1	-	-
Lampara nets	-	-	1.1	5
Cast net	-	-	0.4	2
Butterfly net	-	-	0.4	2
Crab trap	-	-	0.2	1
Stranded (alive)	-	-	10.0	48
Stranded (dead)	8.47	15	24.3	116
Nesting outside area	0.56	1	-	-
Unknown	5.08	9	25.7	123
Total	100	177	100	478
Released	16.95	30		

[1] Source: INP, 1966-1991. Females tagged at Rancho Nuevo and recaptured in the Gulf o f Mexico.

[2] Manzella et al., 1988. Headstarted at the Galveston Laboratory and released in the Gulf of Mexico.

eggs, nests and females in the nesting areas. These regulations are discussed in various publications and reports: (Ingle, 1971; Rebel, 1974; NMFS, 1978, Anon., 1988).

Under the U.S. Endangered Species Act of 1973, and subsequent amendments, all U.S. marine turtles are listed as threatened or endangered. The Kemp's ridley, hawksbill, and leatherback turtles are listed as endangered throughout their ranges. The loggerhead and olive ridley turtles are listed as threatened throughout their U.S. ranges, as is the green turtle, except the Florida nesting population which is listed as endangered. The National Marine Fisheries Service has jurisdiction to protect and conserve all sea turtles in the water and the U.S. Fish and Wildlife Service has jurisdiction when the turtles are on land. Bacon (1973, 1975, 1981) and Mager (1985) summarize the extant regulatory measures, and Carr et al. (1982) published a general, revised edition which is discussed by Hopkins and Richardson (1984).

Several laws, regulations and acts have been promulgated in Mexico, for example, "Regulation for the Exploitation of Turtles, enacted in 1922, prohibiting the capture of turtles from May 1 to August 31. It also prohibits the capture of turtles under 30 cm carapace length and the sale of eggs and destruction of their nests. Laws and general restrictions were enacted later, such as "Charter of the Technical Office" of 1956, a decree which included the same closed season period but increased the minimum size limit to over 55 cm for the loggerhead turtle and 75 cm for the green turtle. The sale of eggs was prohibited during the entire year (anon, 1963b). The regulatory measures up to 1985 have been summarized by Marquez (1985a) and Marquez et al. (1990), noting that since 1965 a regulation specific for the Kemp's ridley was included. A clause in it prohibits its capture during the nesting season, from May 1 to August 31. In 1973 another regulation was enacted which prohibited the capture of the Kemp's ridley, the leatherback and extraction of eggs of all species throughout the year. In 1977, a decree was enacted which established the "Natural Reserve for the Kemp's Ridley" in the Rancho Nuevo nesting beach (Marquez, 1976b, 1978; Anon, 1977; Marquez et al., 1985a, 1990).

During that period the export and import of wild flora and fauna was regulated through the Ministry of Agriculture and Aquatic Resources. Strict regulations prohibited their international commerce. These regulations were called "Control Bases and Regulations for Export and Imports of Wildlife and By-products". Later the Ministry of Urban Development and Ecology was charged with the enforcement of all these regulations up to May 31, 1991. On this date, a decree was enacted "The Agreement By Which A Total Ban Is Placed For All Species And Subspecies of Marine Turtles In Waters Under National Jurisdiction And Caribbean Sea" (Anon. 1990a). Nonetheless, for threatened species, special permits may be issued, particularly for scientific use, exchange with museums and zoological parks (aquaria) educational exhibits (Fuller and Smith, 1984; SEDUE, 1984; Marquez et al., 1990). In December, 1991, an addition was made to the Penal Code, Article 254-bis (Anon. 1991) in which notes that whoever intentionally captures, harms, or causes the death of marine mammals, marine turtles, or collect or trade their byproducts without proper authorization, the concerned enforcing agency can impose a prison term of six months to three years.

Regardless of all the regulations enacted in both nations and conservation measures initiated in Mexico in 1966, the Kemp's ridley population continued to decrease and in 1973 was included in Appendix I of the International Convention for Commerce and Threatened Species of Flora and

Fauna (IUCN, 1973). These appendices were reconfirmed in the 1976 Resolutions of the First Meeting of the Conference, Convention for International Commerce of Threatened Species of Wild Fauna and Flora (CITES) held in Bern, Switzerland from Nov. 2 - 6, 1976 (IUCN, 1976). All the agreements related to marine turtles remained unchanged through the Conventions which followed (IUCN, 1977, 1978). The Kemp's ridley was considered to have the highest priority, among the twelve species listed, for study and conservation.

Some of CITES more important resolutions, such as the classification of species in Appendices I and II, even though Mexico had not until 1991, signed the agreements. Through national legislation however, all the turtle species were protected through a Total Ban, and since 1983 no more permits were issued for taking any of the species or their by products, excepting the olive ridley for which quota permits were issued in one state only, Oaxaca. This was continued until the Total Ban became effective, June 1, 1990 (Anon., 1990). Full protection was given to the other species through special regulations of the Ministries of Fisheries and of Social Development, which as "Federal Fishery Law" of 1986 reiterates the clauses concerned with prohibiting the destruction, collection, conservation and trade in turtle eggs and the enactment of closed seasons and capture quotas, and in 1988 "The General Law on Ecological Equilibrium and Protection of the Environment" which covers these species as well as their environment (Marquez et al., 1990; Marquez and Carrasco, 1992). With respect to the Kemp's ridley, the prohibition was more severely enforced with the installation of the camp in Rancho Nuevo in 1966, with the protection of the eggs and nesting females.

Before that date (1966) more than 90% of the nests were plundered, by both man and animals. Because of that, recruitment to the adult population for almost three decades (1950-1980), during the period when young recruits reached sexual maturity, was almost zero. It was in 1966 when extraction of eggs was stopped and the research and conservation program was established. The production and release of hatchlings at the beach was initiated and about 30,000 hatchlings per year were released through the transfer of nests to the incubation pens, as well as the protection of the nests "in situ". With the start of the 1978 U.S.-Mexico cooperative Kemp's ridley research and conservation program, nesting had increased by 90% and the number of hatchlings released was double that of the previous year. In recent years, almost all nests have been protected (95% in 1985) (Marquez et al., 1986). At present, this protection takes place between Tepehuajes Bar (34.5 km north of Rancho Nuevo) and LaBarrita (22.2 km south of La Coma). This strip is covered at least twice per day, which adds up to 20,000 km for the three months season.

Because a large number of turtles are taken incidentally during certain seasons of the year by a variety of fishing gear, especially trawls (see also Sections 4.4, 2, 5), the issue was discussed for several years in the U.S. Fish and Wildlife Service and NMFS. The result was enactment of relevant legislation and the development of trawling efficiency devices or TEDs (Taylor et al., 1985) and later called turtle excluder devices. In December, 1992, the new regulations were adopted which required all shrimp trawlers operating in coastal and high seas water from Virginia to the border with Mexico to install excluder devices in their nets. The TEDs are to be used throughout the year starting in December 1, 1994. It is noted that TEDs were required on all shrimp vessels with the exception of smaller boats fishing in shallow waters, which in January 1, 1993 were also required to use this device (Crouse, 1993).

The TED (**Figure 22**) will soon be required on all shrimp vessels operating off the coasts of several nations in the region. The date for adopting its use is May 1, 1994.

Regarding the TED Regulations of 1987, in order to initiate and expand international agreements for the conservation of marine turtles, all nations which fish for and export shrimp to the U.S. can be subject to embargo provisions unless:

a) The foreign government has adopted a plan to regulate the incidental capture of marine turtles during shrimping operations, similar to that in effect in the U.S. and

b) The rate of turtle bycatch is comparable to that in the U.S.

Several versions of TEDs (Figure 22) have been demonstrated to be effective in excluding turtles, but may also allow shrimp to escape with excessive economic loss to the fishermen. The general adoption of this device has met with considerable opposition by the shrimpers because of some shrimp loss due to the TEDs. Several authors discuss the use and effectiveness of TEDs during trawling operations, and the possibility of reducing the capture of turtles during fishing operations. Some of these discussions appear in the following: Watson and Seidel

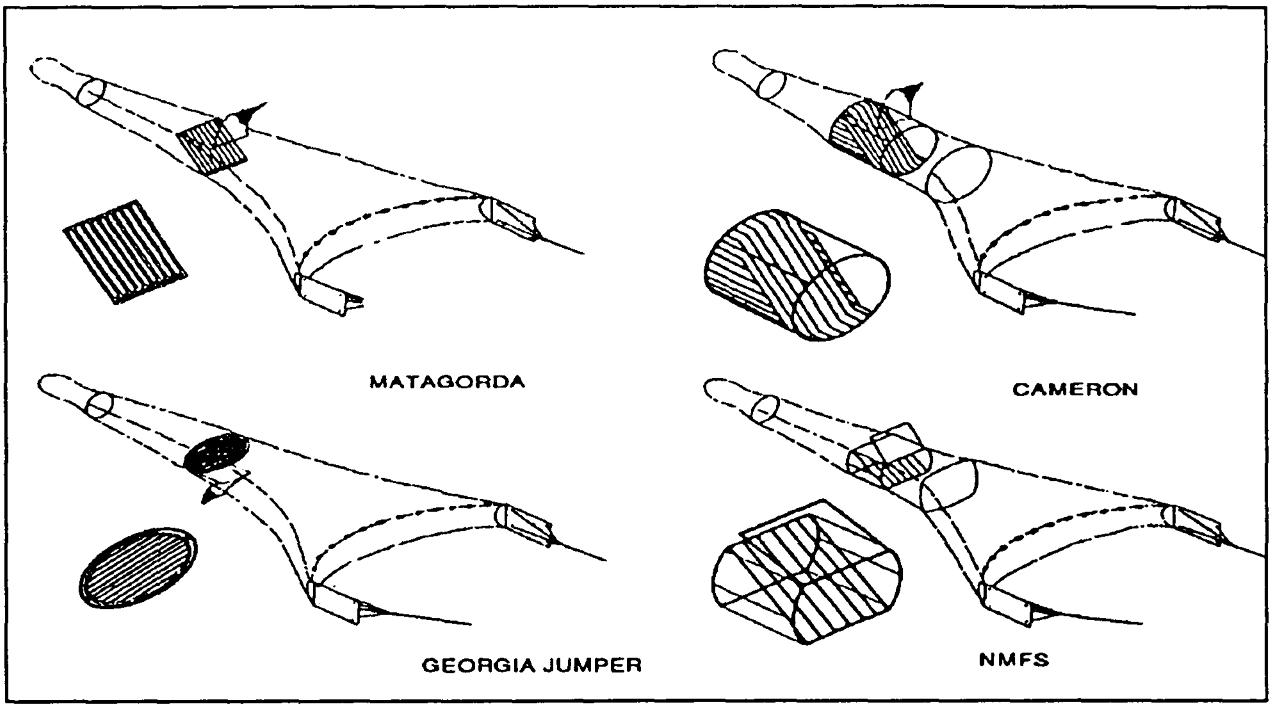

Figure 22. Examples of turtle excluder devices (TEDs) (Source: NMFS).

(1980), Seidel and McVea (1981), Hildebrand (1981), Hillestad et al. (1981) Groombridge (1982), Caillouet (1984), Hopkins and Richardson (1984), Taylor et al. (1985), Oravetz and Grant (1986). There was a number of TED models already certified by NMFS and work on new designs and experiments with other types are currently in progress. Recent developments, such as the soft TED which lacks metal bars or frames, are safer to use and also appear to exclude much bycatch, of course including turtles.

6.2 Management Strategies

Up to the 1970's, aside from the legal issues already noted in Section 6.1, no management strategies were recorded on the Kemp's ridley nor mechanisms to control its capture. In the meantime, the actions undertaken by the U.S. and Mexico were not enough to counter the many natural factors as well as human ones that were causing such drastic a drop in the nesting population (Mager, 1985).

Twenty-nine years ago the residents of Rio Grande Valley, Texas, initiated a project for transplanting eggs with the goal of re-establishing a nesting colony in South Padre Island (Adams, 1966, 1974; Francis, 1978). Historically, one or two Kemp's ridley nests were recorded from that area but there is no proof that it once was an arribada beach. Also, the terrain there shows marked differences with the Rancho Nuevo beach. One of the most obvious one being its width and slight incline, which would force the females and hatchlings to cover much greater distances to and from the nest. This would increase predation considerably as well as during incubation the nests would be impacted to a greater extent by natural phenomena such as flooding and erosion. These factors would adversely effect the survival or establishment of a colony there. However, just south across Rio Grande the outlook changes as the beach becomes narrower and the incline greater, which improves drainage and lessens humidity during the rainy season.

Until 1965, no effective work had been undertaken in Mexico. Protection of the nesting beach commenced in April, 1966 with the creation of a national program for research and conservation of marine turtles and the establishment of a turtle camp at Barra Calabazas, half way along the Rancho Nuevo nesting beach (see also Sections 4.2.1, 6.1, 6.3.7). Since 1947 the nesting population has declined drastically from an estimated arribada of 40,000 females to only 520 in 1992. If we consider a nesting frequency of 1.3 to 2.3 per season (Marquez, 1985a, 1990; Marquez and Carrasco, 1993; Pritchard, 1991) it would translate to only 93,500 eggs approximately. See also Section 4.2.1 for further information.

Since the discovery of the nesting beach in 1963, almost all management measures were directed toward conservation and none to the management of the species as a resource. This can be considered as a concern for the rapid decrease of the population (over 95% between 1947 and 1967) and therefore the imposition of a total ban on its harvest. More information on research, conservation and management activities developed at Rancho Nuevo are found in Sections 3.1.1, 3.1.2, 3.1.6, 3.1.7, 3.2.1, 3.2.2, 3.5.1, 4.2.1, 4.3.1, 4.3.2, 4.4.2, and 4.6.

Apparently, an organized fishery never existed for this species, neither in Mexico or the U. S. (see also Section 5.6.1), and since its natural distribution includes almost exclusively the coastal areas of eastern Mexico and the U.S., both nations must be charged with the conservation and restoration of turtle populations. For this reason, the management strategies in place now are directed to those aspects along the entire area of distribution. As such, various national recovery plans (for the U.S.) have been designed, such as the one by the Marine Turtle Recovery Team coordinated by Drs. Hopkins and Richardson (1984), or regional plans as the one developed at the Western Atlantic Turtle Symposium in San Jose, Costa Rica, organized by Frederick Berry (Bacon et al., 1984). Another one, more general in nature, was developed at the World Conference on Sea Turtle Conservation held in Washington, D.C. and organized by Dr. Karen Bjorndal (1981).

Nonetheless, it was early 1978 when a cooperative program was initiated between the Mexican Ministry of Fisheries, U.S. Fish and Wildlife Service, NMFS and U.S. National Park Service, as well as other state and private entities of both nations. The program was to be developed over a 10-year period (Klima and McVey, 1982; Marquez, 1983a,b, 1990; Caillouet, 1984; Marquez et al., 1985a,b; Woody, 1985; Marquez and Carrasco, 1993). The objectives and priorities as summarized by Woody (1985) follow:

> 1) Protect the natural reserve of Rancho Nuevo, the nesting beach, the adult females and optimize hatching. Considered Mexican responsibility.
>
> 2) Collect and transfer as a donation, 2,000 to 3,000 viable eggs to the U.S. for hatching and imprinting at the Padre Island National Park, Texas.
>
> 3) Undertake the experimental culture called head-start of as many hatchlings as possible at NMFS/SEFSC, Galveston, Texas.
>
> 4) Conduct relevant research and a management project, which will help to understand the species better, which should contribute to improve management and the expected restoration.

"The main goal is the restoration of the species and as second priority to establish a second nesting population in Padre Island, Texas".

The temporary confinement of marine turtle hatchlings, generally for less than a year, on a world-wide basis, is a general practice of conservation of marine turtles. Yet even after being practiced for decades the results are questionable relative to restoring populations; however, problems need to be resolved before the practice can be fully judged, whether positive, negative or useful in any manner. Experimental culture or head-starting, as well as imprinting, are considered experimental and have not demonstrated their efficiency on marine turtles. Researchers at the NMFS Galveston, Texas Laboratory Galveston Laboratory have been conducting these head-start studies (Duronslet et al., 1989). Pro and con arguments have been aired by various authors relative to maintaining hatchlings in captivity, including: Ehrenfeld (1981); Pritchard (1979b); Mrosovsky (1983); Grassman et al. (1984); Wibbels et al. (1989); Frazer (1992). Its use as a tool to improve populations in the wild has not yet been proven effective (Witzell, 1983; Frazer, 1992). Further comments on this will be made in Section 6.3.

Habitat protection as a strategy to restore the Kemp's ridley population is considered of high priority. The decree creating the "Natural Reserve of Rancho Nuevo" is considered a very useful tool, because it preserves the most important nesting area. However, with additional knowledge coming to bear concerning this coastal area, it is felt the reservation limits should be expanded both to the north and south (see Section 6.1). The decree defines a dune zone between the coastal shallows and a water depth out to 4 km, where any and all fishing activity is prohibited, including trawling (Marquez, 1976b, 1978).

A total of fifteen articles related to various aspects of "The Theories of Conservation and Techniques" were included in "Articles of the Conference on the Biology and Conservation of Marine Turtles of the World (Bjorndal, 1981). Some of these can be applied or can be adapted to the conservation strategies for the Kemp's ridley and could be used as a source for basic information.

Public education is being promoted through private and public channels, however, it is necessary to expand and extend them to new areas, especially in areas close to the reservation, coastal communities, artisan fishermen, and trawling vessel operators in both Mexico and the U.S. In this manner, the efforts spent to restore this species may bear fruit sooner.

Earlier in this section mention was made of sea turtle "recovery plans". In December, 1988 a group of turtle specialists, including the author, gathered under the sponsorship of USFWS with the objective of drafting "Recovery Plan for the Kemp's Ridley (*Lepidochelys kempi*) (FWS/NMFS, 1992). The plan was written in agreement with "Policy and Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species" (Anon., 1990b). The plan is intended to serve as a guide to delineate and program those actions which are felt necessary to restore the Kemp's ridley population, and to insure its viability within its habitat permanently. The plan mentions that many of the tasks have already been started by both nations (Mexico and the U.S.), and priority is given to those that should be continued, those that need to be expanded, and those that need to be initiated. The goal of the "Plan" is to change the status of the species from endangered (CITES Appendix I) to threatened (CITES Appendix II) keeping in mind that the adult population should reach 10,000 nesting females at Rancho Nuevo between Barra del Tordo and Barra de Ostionales. The Plan contains the necessary elements needed to achieve these goals and it is recommended that those involved in the restoration program consult it.

It is felt that the use of TEDs during shrimp trawling can be an important factor in reverting the present negative trend in marine turtle populations. The effects of trawls are observed on the adults as well as on juveniles and the present acceptance of the TEDs by the shrimp fleets of several nations cannot be accomplished in a haphazard manner. The TED designs should fit the various vessel types, and show an efficiency close to 100% for excluding turtles as well as retaining shrimp. Additional information on bycatch and excluders is found in Sections 4.4.2 and 6.1

The measures taken by Mexico relative to the different TED designs are well underway; to the extent that on February 24, 1993 an Official Emergency Rule 002-PESC-1993 was published in the Mexican Official Diary, by which the mandatory use of TEDs are required in the Gulf of Mexico and Caribbean national waters, coming into effect May 1, 1993. A turtle excluder device is understood to be a device which will improve the efficiency of shrimp trawls so as to avoid the incidental capture of turtles. Failure to abide by this mandate will be sanctioned by Article 254 of the Fishery Law which states "Whoever intentionally harms, captures, or trade them in any form, without proper authorization is subject to a prison term of six months to three years". A rule is normally in effect for six months and can be extended for another six. As its name implies "Official Mexican Emergency" is of a temporary nature when issued.

6.3 Maintenance Under Artificial Conditions

This type of activity according to Witzell (1983) "is applied to reduce predation on eggs, hatchlings and juveniles"; he notes that two basic methods are employed:

1)"Egg incubation" in turtle camps and the transfer of eggs to artificial nests is developed as well as the subsequent release of the hatchlings, and

2)"Experimental Culture" known as head-start, consists in retaining the hatchlings under artificial means, generally for less than one year, to protect them from predation and then release the juveniles.

Both methods are used for the Kemp's ridley, as noted in Sections 3.3, 3.4, 3.5, 4.3 and 4.4. Another method is discussed in Section 7 under "Farm Culture" in which turtles are kept in captivity until they reach sexual maturity and reproduce.

Since massive nesting of the Kemp's ridley occurs only in Mexico, conservation activities for the nesting females, eggs and hatchlings have been developed exclusively in that country (see also Sections 2.1, 2.2.2, 3.1.6, 3.5.1, 4.2). The results of the ongoing work have been presented at the joint meetings known as "MEXUS-Gulf" (Marquez and Berry, 1985; Marquez et al., ms) and are shown in **Table 30** and Figures 17 and 18. A summary of 27 years of work, up to 1992, with the following results: 21,657 nests transplanted, totaling 1,903,550 incubated eggs; of which 26,859 eggs were sent to Padre Island, and approximately 218,694 were protected

Table 30. Summary of Kemp's ridley conservation efforts at Ranch Nuevo resulting from the joint U.S.-Mexico program 1978-1992.

	1966-77	1978-92		Percentage	
	A (*)	B	Total	A	B
NESTS	7850	13807	21657	36.25	63.75
Estimated	3629	12919	16548	21.93	78.07
Protected	3575	280	3855	92.74	7.26
"In situ"(**)	646	582	1228	52.60	47.39
Lost by predation	?	26	+26	?	?
Stolen					
EGGS:					
Estimated total	843477	1399354	2242830	37.61	62.39
Protected	529898	1373652	1903550	27.84	72.16
Rancho Nuevo 1	380312	868893	1249205	30.44	69.56
Rancho Nuevo 2	0	255812	255812	0.00	100.00
Ostionales	0	61784	61784	0.00	100.00
El Tordo	0	15387	15387	0.00	100.00
Boxes, R. Nuevo	2500	73309	75809	3.30	96.70
Boxes, Padre Is.	4102	22757	26859	15.27	84.73
"In situ" (**)	124984	75710	218694	65.30	34.62
HATCHLINGS:					
Total protected	280005	905200	1185205	23.63	76.37
Rancho Nuevo 1	226658	627362	854020	26.54	73.46
Rancho Nuevo 2	0	139612	139612	0.00	100.00
Ostionales	0	43994	43994	0.00	100.00
El Tordo	0	11652	11652	0.00	100.00
Boxes R. Nuevo	671	43758	44429	1.51	98.49
Boxes Padre Is.	1102	26591	27693	3.98	96.02
"in situ" (**)	51574	12231	63805	80.83	19.17
Released in Mexico	278903	878609	1157512	24.40	79.60
Average eggs	106.79	101.56	103.88		
Metalic tags	1594	4156	5750	27.72	72.28

(*) Work was conducted during this time from Brazil Bar to San Vicente Bar.
(**) Data from beach scouting.

Rancho Nuevo 1 - Pen constructed south of Coma Bar. In 1967-69 the pen was built at Calabazas Bar.

Rancho Nuevo 2 - During 1979-85 and 1987-88 a second pen was built on the north of Coma Bar.

"in situ" at the Rancho Nuevo beach. Since 1966 over 1,185 thousand hatchlings were born and of these over 1,157 thousand have been released at the beach. This number includes 63,000 hatchlings born "in situ".

One of the projects that has received much support from the Ministry of Fisheries, through the INP, has been the Kemp's ridley activity in Rancho Nuevo. Beginning in 1977 the joint MEXUS-Gulf program was initiated and in 1978 the work underway at Rancho Nuevo as included in its Sea Turtle Group. Since then joint research and conservation efforts have taken place. In the same context, a project was initiated to develop a nesting colony at Padre Island, Texas, which is considered to be a prior nesting site for the subject species. For that intent it was agreed Mexico would donate 2 to 3 thousand eggs in exchange for support to the conservation activities taking place in Rancho Nuevo. The eggs for the donation were collected with special care and incubated in styrofoam boxes containing Padre Island sand (Burchfield and Foley, 1985). In order to get them imprinted, the hatchlings are exposed to the sand and waves at Padre Island and then immediately taken to the Galveston Laboratory, where they are kept for 10 to 12 months (Klima and McVey, 1981; Grassman et al., 1984; Fletcher, 1985; Fontaine et al., 1986b).

As a result of the annual donation of eggs and hatchlings (since 1989 only hatchlings) originating in Rancho Nuevo were taken to the NMFS, Galveston Laboratory, a total of 26,591 hatchlings (between 1978 and 1992) were cultured for close to one year and then released in the Gulf of Mexico. The great

Table 31. Results of experimental culture of Kemp's ridley at the Galveston Laboratory (Source: NMFS and INP, Mexico)

Year Class	Eggs (1) Donated	Hatchlings donated	Hatchlings received	Eggs (2) hatched (%)	Juveniles released	Percentage (3)
1978	2191	936	3080	88.1	2019	65.6
1979	2124		1843	85.7	1369	74.3
1980	3000		1815	84.1	1723	94.9
1981	2300		1864	83.3	1639	87.9
1982	2020		1524	77.6	1329	87.2
1983	2010		250	12.1	190	76.0
1984	2000		1441	90.7	1040	72.1
1985	2081		1684	84.1	1534	91.1
1986	2011		1759	88.3	1727	98.2
1987	2001		1437	64.3	1280	89.1
1988	1019		950	91.6	899	94.6
1989		2011	2010		1962	97.6
1990		2025	2025		1979	97.7
1991		2000	2000		1944	97.2
1992		2000	1994		1954	98.0
Totals	22757	8972	25676		22588	88.1

1) As per Rancho Nuevo records, before shipping to Padre Island and without removing dead eggs.
2) Shaver, 1989. Percentage hatched at Padre Island, after sanitizing the egg boxes in Rancho Nuevo.
3) Percentage of juveniles released for each year class.

majority of the hatchlings were born at Padre Island and imprinted there, as part of the joint project, programmed for full development in 15 years. However, since no increase in nesting females has been observed at Padre Island, that part of the project was suspended in 1989, and the annual donation of 2,000 hatchlings were sent to the NMFS Galveston Laboratory for head-starting.

Up to June, 1992, a total of 21,634 juvenile Kemp's ridleys had been released, and also 340 older than one year (**Table 31**). All of these turtles were tagged before release in the Gulf of Mexico (Fontaine et al., 1986b; Caillouet, 1986; Klima pers. comm.), and a small number are kept in U.S. aquaria (see Section 7). From 1978 to date reports have been published on the culture results, growth, behavior, disease, migration, mortality, sex ratios, maturity, reproductive physiology, tag and recaptures, etc. as a result of these joint activities on management and conservation. See also Sections 1.3, 3.1, 3.4, 3.5, 4.1 and 4.4.

Recently a group of researchers met to discuss and evaluate the Kemp's ridley culture program being conducted by NMFS and review the available data on the results achieved (Wibbels et al., 1989). Results have indicated that the culture techniques for marine turtles have been refined at the Galveston Laboratory, and tag information has shown that head-started turtles can adapt and grow after release into the oceanic environment. Also, studies on captive reproduction has shown some success. However, based on tag returns, strandings, trawling, and nesting data collected by NMFS and USFWS and INP it is impossible to determine if turtles raised in captivity are effectively recruited into the reproductive population; particularly since the mortality rate, cause by shrimp trawls, in the Kemp's ridley (wild or cultured) populations, is so high that few if any reach maturity.

This culture program has created much concern on the part of the public about the status of endangered turtle species, especially educational and conservation groups. This increased concern and interest by the public is of value to the program; however, it must be emphasized that head-starting was an experimental program and not necessarily a solution for the conservation of marine turtles.

The goal for keeping a group reproducing turtles in captivity, as a reserve, in case of a catastrophic occurrence at the only existing nesting beach of importance, is discussed in Section 7.

7 MARICULTURE

During January 23 and 25, 1988 a group of sixteen researchers from various parts of the world, met in San Jose, Costa Rica for a workshop, coordinated by Dr. Stephen Edwards of the International Union for Natures Conservancy, to evaluate the proposals on "Culture of Marine Turtles in Ranches". As a result of this workshop, two main methods were recognized (Anon. S/F., Marquez, 1991; Marquez et al., 1991, 1992; Marquez and Carrasco, 1992). They are:

a) Farms -- keep in these a sufficient number of eggs and hatchlings so as to maintain a constant and reliable production, depends initially on "wild stocks" through the capture of adults as well as the periodic introduction of eggs and hatchlings. This would be needed to create a group of reproducing turtles and start a commercial scheme with the excess produced annually. This may be expected after five years of operations. By proper selection a reproductive group can be formed and thus do away with the dependence on wild stocks; this will only occur when a sufficient number of reproductive turtles, production of eggs and hatchlings is attained.

b) Ranches -- this differs from the foregoing in that it will not be autosufficient and will depend on the excess production in wild, especially from those nests which in some manner could be destroyed, either by predation or natural phenomena (storms, floods, etc.). For this it becomes necessary to gain knowledge and follow up of the populations being exploited, with the object of not causing negative impacts.

At present only one ranch exists for the culture of marine turtles, located at Reunion Island (north of Madagascar in the Indian Ocean) and one farm, at Grand Cayman in the Caribbean.

The Kemp's ridley has never been cultured for commercial purposes. All the work taking place on this subject is for one purpose, the restoration of the Kemp's ridley populations; among these are the NMFS Galveston Laboratory, several aquaria in the United States as well as part of the Grand Cayman Turtle Farm (Caillouet et al., 1985).

Some of the justifications for keeping these turtles in captivity are to determine growth and survival rates, and for breeding. The experience gained at the NMFS Galveston Laboratory and the Grand Cayman Turtle Farm has been of great value in understanding some of the problems related to this species' biological life cycle and improve the maintenance of captive turtles (see Sections also 3.1, 3.2, 3.3, 3.4, 3.5 and 4.4). The only place at present where mariculture techniques for this species are being developed from the egg stage to nesting adults is at the Grand Cayman Marine Turtle Farm (Marquez and Carrasco, in press; Marquez et al., 1992, 1993).

Very little information is available about turtle culture in Mexico. It is known that at the end of the 1970s, some work was done by the General Directorate of Aquaculture of the Ministry of Fisheries on various sea turtles, including the Kemp's ridley. However, the results of the work was never published and after 2 or 3 years, it was halted owing to financial and logistic problems. Some data is provided by Sumano et al. (1980) who noted the number by species kept in captivity. However, when the project was terminated the surviving turtles (green, loggerhead, hawksbill) were tagged and released.

Work started at the Grand Cayman Turtle Farm (Mariculture Ltd.) during 1968. Between 1976 and 1983 it was operated as Cayman Turtle Farm, Ltd. and since April, 1983 it was purchased by the Government of the Islands of Grand Cayman and adopted the name, Cayman Turtle Farm (1983) Ltd. (Anon. 1973a,b,c; Wood, pers. comm.). The farm was installed in 1968 at an estuary called Salt Creek, where the young turtles were held in fenced enclosures, with abundant sea grasses (*Thalassia*). During the first two years, the diet consisted mostly of sea grass, pet food (for dogs or catfish) and frozen fish. In 1971, the farm was relocated to its present site in West Bay on a coral outcropping. Here cement ponds were built supplementing existing fiberglass ones; a larger pond was also constructed where the mature animals were placed. The feed used thereafter was pelletized trout food, which will remain on the water surface for several hours and therefore enhances its utilization (Anon. 1973a,b,c; Wood, 1990). Such an enterprise is able to conduct experiments that would be difficult with wild stocks. A variety of experiments have been undertaken since the beginning of culture work: disease and its treatment, feeding and nutrient requirements, age and growth, fecundity, reproductive cycles, incubation, temperatures, sex ratios (and its relationship to temperature) use and application of various tags (metallic, plastic and live) for behavior and migration studies, etc. (Wood and Wood, 1977, 1981, 1982).

In 1980, in an effort to enhance the restoration of the Kemp's ridley, INP and Cayman Turtle Farm

Ltd. reached an agreement on technical cooperation in the following general terms: "In cooperation with the Mexican INP pond space and technology shall be provided so as to maintain the largest captive Kemp's ridley turtle population in existence. It is hoped these animals will mature and reproduce in captivity in a manner that will ensure survival of the species (even if kept in a confined environment) and possibly provide hatchlings for restoration of wild stocks".

And the following particular terms:

"The Kemp's ridley turtles and their hatchlings will remain the property of Mexico".

"This is joint effort between the INP of Mexico and the Cayman Turtle Farm, Ltd. of Grand Cayman Islands and the objectives are purely of a conservationist nature without commercial intent".

Under the above agreements, and noting the precarious situation of this species, it was felt convenient to keep a genetic reserve at the Farm. Therefore, on July 4, 1980, a total of 100 juveniles cultured in the Galveston Laboratory, were air shipped to Grand Cayman, by way of Cancun, Mexico to be cultured as the initial "reproductive deposit". Another group of 500 hatchlings, year class of 1980, were included in that transfer from Rancho Nuevo, but unfortunately owing to legal impediments, the trip to Grand Cayman was delayed for three days causing a high rate of mortality. Finally, only 107 were sent, some of which were very weak so that a mere 67 hatchlings and the juveniles from Texas were shipped without further problems (Wood and Wood, 1988). Upon arrival the hatchlings were placed in rectangular concrete tanks and the juveniles (96 survivors) in circular fiberglass ones. They were fed twice per day on a high protein diet. After a few weeks they showed much variability in their rate of growth, but on the average it was higher than that for the green turtle in their natural habitat, attributed possibly to the greater portion of protein in the feed and slightly larger rations (Wood, pers. comm.).

After 12 years, the reproductive group of Kemp's ridley, at the end of 1992, consisted of 11 females, 16 males of the 1979 year class, and 3 females of the 1980 year class from Mexico and born at the farm, of the 1989 year class, there were 32 females, from 1990 year class, 152 females, from 1991 year class, 87 females and from the 1992 year class, 192 hatchlings all born at the farm (Wood & Wood, pers. comm.). The summary of the reproductive activities of the Kemp's ridley at the Cayman farm, since the beginning of the project is shown in **Table 31**.

This is the first time the Kemp's ridley has been successfully raised in captivity until maturity, and it has been proven that these experimental activities can greatly enhance conservation measures (Wood and Wood, 1988). In early April, 1984, nesting of two 1979 year class females took place, when 136 eggs were deposited producing six viable hatchlings. One female weighed 24 kg and measured 53 cm carapace length and the other 20 kg and 48 cm long (see also Section 3.1.2); in 1985 no nesting occurred at the artificial nesting area located nearby but in 1986 nesting reoccurred with eight nests which contained 526 eggs and produced 75 viable hatchlings. In 1990, when the highest number of

Table 32. Number of female Kemp's ridley (class 1979 and 1980) which nested and number of eggs and hatchlings obtained up to 1992 at the Grand Caiman Farm (J. Wood, pers. comm.).

	FEMALES		NESTS		EGGS		Total hatchlings	S %
Years	Total	Nesting	Annual	Female	Total	Average		
1984	20	2	2	1.0	136	68.0	6	4.4
1985	20	0	0	0	0	0	0	
1986	18	5	8	1.6	526	65.7	75	14.2
1987	16	7	12	1.7	877	73.1	266	30.3
1988	17	11	21	1.9	1525	72.6	45	2.9
1989	17	7	10	1.4	653	65.3	292	44.7
1990	17	10	16	1.6	1161	72.5	560	48.2
1991	15	8	17	2.1	1265	74.4	382	30.2
1992	14	11	18	1.6	1339	74.4	331	24.7

S - Survival of hatchlings with respect to total number of eggs.

hatchlings were produced, ten females deposited 1,161 eggs of which 560 hatched (**Table 32**). A portion of the hatchlings will be kept at the farm and the rest will be released as 1 or 2 year juveniles in the Gulf of Mexico, making sure they are in good health. The present low survival rate of the entire reproductive group is expected to slowly improve as well as its fecundity.

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