Abstract.— A review of previous studies on Kemp's ridley sea turtle (*Lepidochelys kempii*) diet was combined with information on the diet of the species in the coastal waters of New York State. Juvenile Kemp's ridleys occupy coastal Long Island, New York waters during the summer and early autumn months. Both fecal and intestinal samples collected between 1985 and 1989 were analyzed to obtain information on the diet of this endangered species. Fecal and intestinal sample analysis, as well as information from previous studies, indicated that juvenile Kemp's ridleys primarily consume crabs. Walking crabs of the genera *Libinia* and *Cancer* appear to be the primary food sources for the species in New York waters.

Diet of the Kemp's ridley sea turtle, *Lepidochelys kempii*, in New York waters

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The Kemp's ridley sea turtle, *Lepidochelys kempii*, was placed on the United States endangered species list in December 1970 and was listed as one of the twelve most endangered species in the world by the International Union for the Conservation of Nature and Natural Resources in 1986 (Federal Register, 1989; Marine Turtle Newsletter, 1989). Despite a recent increase in research on the Kemp's ridley, little attention has been focused on its feeding habits. An understanding of the dietary requirements and available food resources for the Kemp's ridley is a critical component in the future management and protection of this species' habitats.

While occasional glimpses into the composition of Kemp's ridley diets have been obtained, detailed quantified examinations of the species' diet have only rarely been undertaken (Table 1). In one of the earliest accounts of the diet of Kemp's ridleys, De Sola and Abrams (1933) dissected "two foot specimens" from the Georgia coast and described the main dietary component as *Platyonichus ocellatus*, later renamed the spotted lady crab, *Ovalipes stephensonii* (Williams, 1984).

Two decades later, the first published record describing the diet of the Kemp's ridley in the Gulf of Mexico was produced (Liner, 1954). In that study, gastrointestinal contents of eight *L. kempii* ranging in size from 3.2 kg to 26.6 kg were examined. All the turtles had consumed portunid crabs (*Callinectes* sp.) and occasional barnacles. Dobie et al. (1961), elaborating on the findings of Liner (1954), reported that small molluscs, plant parts, and mud were also contained in the gastrointestinal tracts of two of Liner's turtles. The molluscs included gastropods (*Nassarius* sp.) and bivalves of the genera *Nuculana*, *Corbula*, and probably *Mulinia*.

In Virginia, Hardy (1962) dissected a single specimen and found that the digestive tract contained 95% *Callinectes* sp. and one swimmerette was identified as that of the blue crab, *C. sapidus*. Research conducted in the waters of Chesapeake Bay, Virginia, by Lutcavage (1981) indicated that three Kemp's ridley carcasses had both blue crabs and Atlantic rock

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Table 1

Compilation of available diet studies of Kemp's ridley sea turtles (*Lepidochelys kempii*) published from 1933 to 1991. The studies are ordered from north to south and east to west. Marquez (1973) is cited from Pritchard and Marquez (1973).

Author(s)	Location	Diet components	Life stage
Hardy (1962)	Chesapeake Bay	Blue crabs	Juvenile
Lutcavage (1981)	Chesapeake Bay	Blue crabs	Juvenile
Belmund et al. (1987)	Chesapeake Bay	Rock and blue crabs	Juvenile
DeSola and Abrams (1933)	Coastal Georgia	Crabs (*Ovalipes* spp.)	Not given
Carr (1942)	Florida	Calico crabs	Juvenile
Liner (1954)	Louisiana	Blue crabs	Juvenile
Dobie et al. (1961)	Louisiana	Crabs, whelks, clams	Juvenile
Shaver (1991)	Texas	Various crab species	Juvenile
Marquez (1973)	Tampico, Mexico	Crustaceans, fish, molluscs	Adult

crabs (*Cancer irroratus*) in their digestive tracts.

Recently, Shaver (1991) found that Kemp's ridleys in coastal Texas waters preyed mainly on crabs. The most commonly ingested species was the speckled crab (*Arenaeus cribrarius*). Many other crab species were recorded by Shaver, including purse crabs (*Persephonia* sp.), spider crabs (*Libinia* sp.), and blue crabs (*Callinectes* sp.).

During the past decade, the role of the northeastern coast of the United States in the life cycle of Kemp's ridleys has received considerable attention (Carr, 1980; Morreale and Standora, 1990[1]; Burke et al., 1991). The northeastern coast includes the New York area which contains over 300 km of shoreline, mainly the coastline of Long Island. Long Island has a variety of marine habitats, including the shallow, enclosed waters of the Peconic and southern bays, the deeper waters of Long Island Sound, and the Atlantic Ocean (Fig. 1). Each year Kemp's ridleys begin inhabiting the Long Island area during July (Morreale and Standora, 1989[2]; Morreale and Standora, 1990[1]). To date, all Kemp's ridleys encountered in Long Island have been juveniles (straight-line carapace length from 22 cm to 42 cm $\bar{x}$=29.8 cm, SD=3.7 cm [Morreale and Standora, 1989[2], 1990[1]]). This size class of turtles represents a range of ages from 3 to 7 years (Zug and Kalb, 1989).

Between July and early October these young Kemp's ridleys are active within the estuarine waters (Long Island Sound and the Peconic Bays) and the southern bays. Kemp's ridley growth rates as high as 25% body weight per month indicate that waters around Long Island, New York, provide abundant food resources for the maintenance and growth of the juvenile turtles (Standora et al., 1989; Burke, 1990). During October the turtles begin moving out of the estuaries and into the ocean. Long distance recaptures of Kemp's ridley, green (*Chelonia mydas*), and loggerhead (*Caretta caretta*) sea turtles tagged near Long Island indicate that some turtles emigrate to the southeastern United States (Morreale and Standora, 1989[2]; Burke, 1990; Morreale and Standora, 1990[1]). Kemp's ridleys that do not emigrate by late November are likely to become cold-stunned (Burke et al., 1991). Cold-stunning, or severe hypothermia, occurs when ambient water temperatures fall below 10°C (Schwartz, 1978). Cold-stunning causes turtles to become torpid and buoyant, and eventually results in death. In Long Island, declining water temperatures usually reach 10°C during early December.

The cold-stunning phenomenon, other types of strandings, and live captures of sea turtles during commercial fishing operations can be utilized as sources of turtles for dietary studies. The goal of the current study is to provide a quantitative description of the diet of Kemp's ridleys in the northeastern United States based on gut contents from carcasses, previously preserved dietary samples, and feces from live turtles.

Materials and methods

The dietary components of the Kemp's ridley were assessed by using two separate approaches. First, fecal samples were collected from live turtles and examined for their constituents. Second, complete gastrointestinal contents were removed from dead turtles and identified. Samples were obtained from

[1] Morreale, S. J., and E. A. Standora. 1990. Occurrence, movement and behavior of Kemp's ridley and other sea turtles in New York waters. Annual report to the New York State, Dep. Environmental Conservation, April 1989–April 1990.

[2] Morreale, S. J., and E. A. Standora. 1989. Occurrence movement and behavior of the Kemp's ridley and other sea turtles in New York waters. Annual report to the New York State, Dep. Environmental Conservation, April 1988–April 1989.

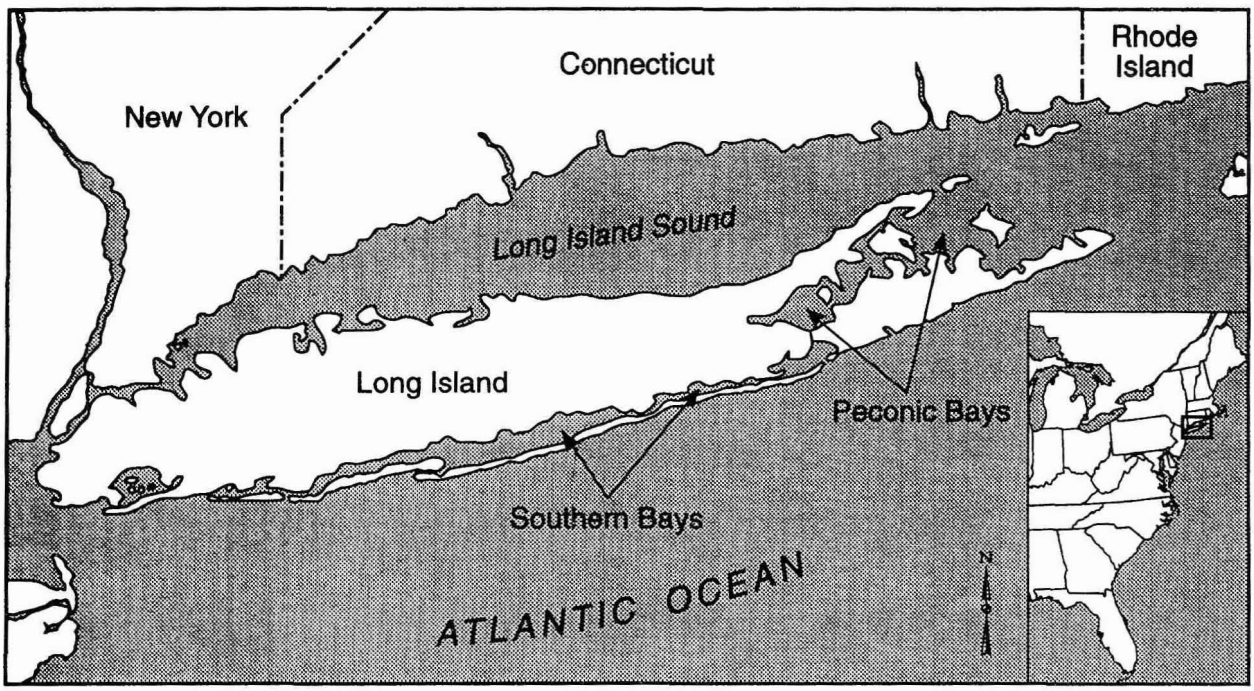

Figure 1

The waters from which Kemp's ridley sea turtles, *Lepidochelys kempii*, were obtained for this study can be divided into four habitats: Long Island Sound, where most of the stranded turtles were recovered; the Atlantic Ocean, which was the habitat of two turtles in the study; the southern bays, where one live capture and one boat-hit turtle were recovered; and the Peconic Bay system, where most of the turtles for the fecal analysis and several turtles for the digestive tract analysis wree recovered.

turtles encountered in New York waters from 1985 through 1989.

Nineteen fecal samples were obtained. Fourteen were collected during 1989, three during 1988, and two during 1987. Of these fecal samples, 17 were obtained from live turtles captured during warmer months (June to October) and two samples were retrieved from revived, cold-stunned turtles in late November. Captured turtles were obtained from local commercial fishermen who were asked to retain turtles caught incidentally in fishing gear (predominantly pound nets). After the fishermen docked, they called a 24-hour number to reach a biologist, who generally picked up the turtle while the fishermen were still unloading their catch. All noncold-stunned Kemp's ridleys received from commercial fisheries in Long Island were alive and apparently healthy.

All turtles were weighed and measured upon return to the laboratory. Each turtle was then allowed to swim freely in an individual 2100–liter tank and was offered either squid or clam meat. Most Kemp's ridleys accepted the food offerings, but many fed only after the food was dangled in front of them for as long as 2–3 hours. Feeding often induced defecation within a relatively short time.

Tanks were checked at least three times a day for the appearance of feces. Filter intakes in the tanks were elevated and covered, except for small holes, to insure against sample loss. When feces were observed, they were immediately removed and placed in individual sample jars. If a turtle did not defecate within 24 hours of being placed in captivity, it was given an enema of dioctyl sodium sulfosuccinate (Disposaject brand, Pitman-Moore Inc.). If a fecal sample was still not obtained after another 24 hours, the turtle was released.

The rate of food passage was examined during this study to insure that samples were not polluted with prey items eaten while the turtles were in the fishermen's nets. Gut passage rates were determined for two Kemp's ridleys by feeding them declawed lobsters (*Homarus americanus*). Lobster was used as a tracer because it has never been reported as a prey item and is consumed relatively readily by the turtles. By monitoring fecal output, the amount of time between ingestion of the lobster

and its first appearance in the feces was determined.

All fecal samples collected for dietary analysis were immediately placed in preservative. For fecal samples obtained during 1989, animal components were preserved as described by Zinn (1984) and algae were preserved in Transeau's solution (10 parts formalin/30 parts ethanol/60 parts distilled H_2O/25 mg $CuSO_4$/L). Feces obtained prior to 1989 were preserved in 10% formalin.

Analysis of the fecal samples was conducted in January 1990, after all the samples were collected. The samples were removed from the preservative and air dried for 24 hours on wire mesh in an enclosed hood. The samples were then placed in a U.S. standard number-5 mesh (4 mm) sieve and pieces smaller than 4 mm were separated out by shaking the sample in a Tyler RO-TAP testing sieve shaker for three minutes. Pieces smaller than 4 mm were not identified because of the difficulty of assigning them to a meaningful category. The amount of sample lost because of this constraint was never greater than 5% for any given sample.

Each fecal sample was examined under a dissecting microscope and each fragment of the sample was identified to the lowest taxon possible. Fragments belonging to the same taxonomic level were grouped. A list of components (e.g., one species of crab is one component) was compiled for each sample and the data were analyzed to determine the percentage of turtles in which each component occurred. Less than 1% of the fragments could not be assigned to a taxonomic category.

For the 1989 samples only, the relative amount of each dietary component was determined by oven drying each component from each sample for 48 hours at 60°C and weighing it. The dry weights were then used to determine the relative importance of the different dietary components in each turtle's fecal sample. Dry weight analysis was conducted by finding the percentage of each sample weight represented by each component and then determining the mean for that component. This technique of analyzing dry weights as a percentage eliminated over- or under-representation of large or small fecal samples.

A second method of determining dietary components was analysis of gastrointestinal contents from stranded, dead turtles. Stranded Kemp's ridleys died from a number of causes: cold-stunning, boat collisions, entanglement in a gill net, and natural and unknown causes. Whenever possible, each stranded turtle was weighed, measured (straight-line carapace length) and dissected. Following removal, intestinal contents were placed in 95% ethanol (1985), 10% formalin (1986–1988), or treated in the same manner as the fecal samples (1989). Identification of intestinal tract contents was performed during 1990. All components of each sample were identified to the lowest taxon possible, generally to species. These data were used to determine the percentage of turtles in which the components occurred.

Results

The food passage rate analysis indicated that lobster was retained within the digestive tracts of the two Kemp's ridleys for seven and eight days. Because fecal samples were obtained within 48 hours of receiving a turtle from a fisherman, we believe the possibility of samples having been "contaminated" by items eaten while the turtles were in the fishermen's nets is minimal.

Mean straight-line carapace length for the 19 turtles in the fecal analysis study was 32.3 cm (range=24.7 to 42.7 cm, SD=4.87). Eighteen of the 19 turtles consumed crabs (Fig. 2). Mollusc species were found in 26% of the fecal samples and algae were found in 11% of the Kemp's ridley feces. Natural and synthetic debris were present in 21% and 11% of the feces respectively.

Crab species that were identified included nine-spined spider crabs, Atlantic rock crabs, and lady crabs (*Ovalipes ocellatus*). Further examination of only the crab portion of the feces revealed that 58% of the turtles had consumed spider crabs, 36% had eaten rock crabs, and 16% had consumed lady crabs.

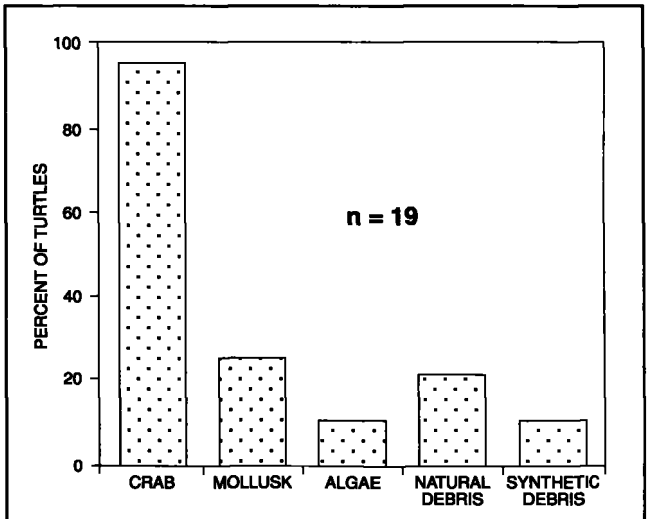

Figure 2

Percent occurrence of various prey items identified in the feces of 19 Kemp's ridley sea turtles (*Lepidochelys kempii*) that were live-captured in Long Island waters. Each bar indicates the percent of turtles in which the prey items occurred.

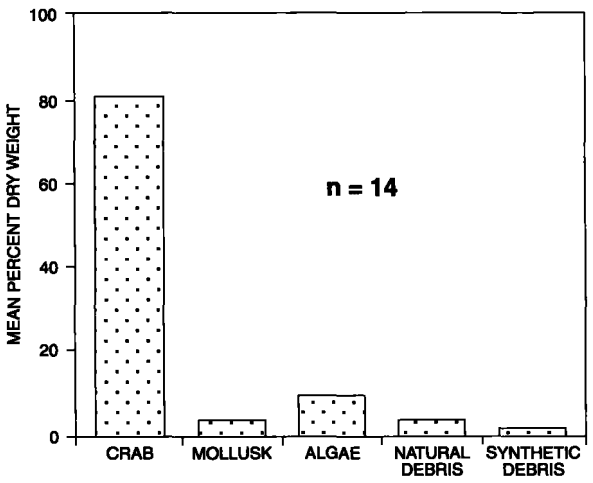

Figure 3

Mean percent of the fecal dry weight of general catergories of Kemp's ridley sea turtles (*Lepidochelys kempii*) prey items. Each area represents the mean percent of dry weight for that component of the feces (n=14). Crabs composed the predominant portion of the feces.

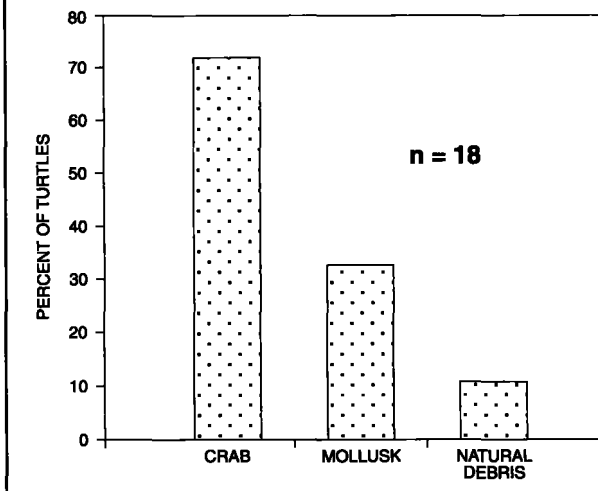

Figure 4

The percent of Kemp's ridley sea turtles (*Lepidochelys kempii*) from the digestive tract analysis that had consumed various types of ingesta. Most of the turtles had consumed crabs. Synthetics and algae were not present in the digestive tracts.

Included in three fecal samples were crab parts from which the fragments could not be identified to genus.

Mollusc species in the samples included blue mussels (*Mytilus edulis*) and bay scallops (*Argopectin irradians*). Two Kemp's ridley fecal samples contained mollusc fragments that could not be identified beyond phylum. Algal species in the samples included *Sargassum natans*, *Fucus* sp., and *Ulva* sp. A few turtles had small pieces of the macrophyte *Zostera marina* as well. Natural debris included such things as pebbles, small rocks, and bird feathers. Synthetic debris included only small pieces of polystyrene and latex.

Analysis of fecal components with dry weights (mean of percent per sample) revealed that crabs were the predominant component of all but one of the 14 fecal samples from 1989. The mean percent of crab dry weight for the samples was 80% (Fig. 3). The mean percent dry weight for each crab species revealed that spider crabs composed 60% of the identifiable crab parts. The remainder was composed of 22% rock crabs and 18% lady crabs. Thus, most of the Kemp's ridleys had consumed spider crabs, which represented a large portion of the bulk. Although more turtles consumed rock crabs than lady crabs, Kemp's ridleys that consumed lady crabs had feces composed exclusively of them.

For the period 1985 through 1989, 87 dead Kemp's ridleys were recovered from Long Island's waters. Gastrointestinal tracts were removed from 40 of the 87 turtles. Eighteen of the 40 stranded Kemp's ridleys contained identifiable diet components in the gut. All 18 turtles were juveniles. Mean straight-line carapace length for the 18 stranded turtles was 30.5 cm (range=24.8 cm to 39.7 cm, SD=3.5 cm). Thirteen of the 18 gastrointestinal tracks contained crab parts and seven contained mollusc shells (Fig. 4).

The most frequently encountered crabs in the gut content samples were spider crabs and rock crabs. Spider crab fragments were found in five of the 18 samples; rock crabs were found in four of the 18 samples. Lady crabs were found in two of the samples and the blue crab (*C. sapidus*) was found in the digestive tract of one Kemp's ridley. Two of the turtles had crab parts in their digestive tracts that could not be assigned reliably to any genus.

An additional 14 of the 40 Kemp's ridleys that were dissected had completely empty digestive tracts. All of these turtles had stranded from cold-stunning. Upon further review of necropsy data sheets from all of the Kemp's ridleys that had stranded during the study period, but from which samples were not preserved, it was noted that almost all of the cold-stunned individuals had empty or almost empty gastrointestinal tracts.

The remaining eight turtles had been collected in 1985 and 1986, and gut contents were unidentifiable because of improper preservation. These samples had been preserved for as long as five years prior to examination.

Discussion

The analysis of fecal samples from live turtles and of gut contents from dead specimens strongly suggests that crabs are the main dietary component for Kemp's ridleys in New York waters. Crab parts were present in 18 of the 19 turtles from which fecal samples were obtained and were the predominant food item by dry weight analysis. The analysis of fecal material, however, may be biased because it examines only that material which has not been fully digested. This could cause overrepresentation of less digestible components.

The gastrointestinal tract results (which are less susceptible to such bias) support the results of the fecal sample analysis. Of the 18 stranded turtles which contained identifiable food items, 13 contained crab parts in their guts. Gut contents can potentially be biased because of differential digestion. However, from our qualitative observation of the condition of the intestinal contents during dissection, we believe the components described herein are representative of the diet.

One difference between the fecal and intestinal samples was the source of the turtles. Most fecal samples were obtained from turtles captured in the Peconic Bays, but most stranded turtles were recovered on beaches adjacent to Long Island Sound. Presumably the dietary samples reflect feeding activities near the location of capture (or stranding). Thus, the observation of spider and rock crabs as the predominant components in the diets of both live-captured and stranded turtles emphasizes their importance as food items.

The dietary components observed during the study may be related to the relative abundance of the prey species in the environment. Of the four species of crab that were identified, the spider crab was both the most frequently encountered fecal component and the predominant crab identified in the gut contents of dead turtles. During the course of our studies we have noted that the nine-spined spider crab was one of the most common crabs in the waters where the turtles occurred. We have observed local commercial fishermen retrieving thousands of spider crabs while hauling in their nets. The Atlantic rock crab was also frequently encountered in the feces and gut contents of the turtles. The rock crab is also abundant in many of the areas in which the turtles occur.

Not all of the dietary make-up observed in this study can be explained by prey abundance. The green crab (*Carcinus maenus*) is very common in many of Long Island's estuaries but was not present in any of the turtles examined. This species usually inhabits shallower, rocky intertidal and subtidal habitats (Ropes, 1968; Williams, 1984), and our research on turtle behavior indicates that the Kemp's ridleys typically forage in deeper waters (Standora et al., 1990).

While we have commonly encountered lady crabs in the waters where turtles forage, this species was represented in only a few samples. Also rare in the samples was the locally and commercially harvested blue crab. Both the lady crab and the blue crab are portunid crabs, capable of swimming very quickly. This characteristic differentiates the portunids from the slower walking crabs, such as the spider and rock crabs.

The only molluscs consumed by turtles examined during this study included a few fragments of relatively thin-shelled blue mussels (*Mytilus edulis*) and bay scallops (*Argopectin irradians*), and entire shells of the small three-lined mud snail (*Nassarius trivitattus*). These mud snails are scavengers and can be found locally in association with dead fish and crabs (Long Island Shell Club, 1988). Their occurrence in four turtles, all of which had been cold-stunned, may indicate that the turtles were scavenging during periods of low water temperature.

Because sea turtles were obtained from different sources in New York waters, it was possible to obtain dietary information on a larger number of Kemp's ridleys. In many of the previous studies presented in Table 1, portunid crabs were indicated as a main dietary component for Kemp's ridleys. Although this crab family was observed in some New York turtles, it was of secondary importance to the walking crabs.

In terms of the overall life cycle of Kemp's ridleys, it appears that post-pelagic juveniles exploit the benthic environments of Long Island's estuaries, preying mainly on walking crabs. Data from our ongoing research indicate that sea turtles emigrating from New York inshore waters travel to southern coastal areas. Kemp's ridleys exhibiting this behavior may join the more southerly portion of the Atlantic population. Therefore, management plans for Kemp's ridleys should consider factors that affect benthic fauna, especially the abundant crab populations in the northeastern region. Such impacts could have far-reaching effects on a critical stage in the lives of these endangered sea turtles.

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