

FINAL REPORT

Population Study of Diamondback Terrapins of the Lower Housatonic River

Submitted 30 April 2000

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Executive Summary of Research:

The nesting habitats and adult population structure of diamondback terrapins (*Malaclemys terrapin*) on Milford Point and in Nell's Island marsh on the lower Housatonic River were examined, to expand baseline information on this important estuarine species. Measurement and mark and recapture techniques were used in tidal creeks of the 800-acre wetland to determine the spatial distribution and assess the potential for maintenance and/or growth of the terrapin population that now has been studied for two consecutive field seasons. To summarize these data, 252 terrapins have been trapped over the past two field seasons, including 182 original captures and 70 recaptures. Of the 252 total, 162 were males and 90 were females (with 28 of these gravid). The range in "ages" (loosely based on number of rings on scutes) was from 3 to 14 years. Terrapins were captured in three separate creeks (labeled "turtle creek", "boat ramp" and "median" on spreadsheets) and there was no overlap in recapture locations, i.e., terrapins caught in one creek were always recaptured in that same creek. Roughly one-fourth of all terrapins captured exhibited shell anomalies (extra laminae, divided scutes, etc.), suggestive of developmental alterations prior to hatching. A smaller number of terrapins were scarred or were missing limbs owing to predation and/or accidents as juveniles or adults. Attempts to track the success/failure of specific nests on Milford Point using GPS were thwarted by high rates of initial predation on terrapin eggs immediately after laying; despite documenting extensive movements of female terrapins on the beaches of Milford Point, the student on the project never saw a female actually laying eggs in a nest. The population monitoring program for terrapins at Milford Point and in the adjacent wetlands of the lower Housatonic River has provided a clearer picture of the current status and management potential of diamondback terrapins in an urbanized estuaries where restoration of coastal habitat is proposed.

POPULATION STUDY OF DIAMONDBACK TERRAPINS OF THE LOWER HOUSATONIC RIVER

A. INTRODUCTION

The Nell's Island wetland complex at the mouth of the Housatonic River is home to the diamondback terrapin (*Malaclemys terrapin*), a unique estuarine species of turtle harvested to very low numbers at the turn of the century (Garber 1989). Although the turtle has slowly recovered from this decimation, recent loss of feeding and nesting habitat and other environmental impacts may threaten the terrapin's ability to maintain healthy populations in the Housatonic River and elsewhere in the region (Seigel and Gibbons 1995). Little scientific information exists, however, regarding the actual size and structure of existing populations of terrapins along the river, and the successful use of the recently restored section of Milford Point for terrapin nesting has not been documented. A population study of terrapins from the lower portion of the Housatonic River would provide a clearer picture of the current status and management potential of diamondback terrapins in an urbanized estuary.

The objective of the completed research was to complete a population study of diamondback terrapins of the lower Housatonic River during summer 1999. Diamondback terrapins are a species of management concern in Connecticut and elsewhere along the eastern seaboard (Garber 1989; Roosenburg 1992; Seigel and Gibbons 1995), yet data on the population status of terrapins in different coastal environments is lacking. Large populations occur in the expansive barrier island marshes of southern New Jersey (Roger Wood, pers. comm.), but smaller populations are more typical in New York (Morreale 1992) and coastal Connecticut (Victoria 1994). Although a general survey of terrapin use of habitats in the state of Connecticut recently has been completed (Victoria 1994), no population studies from the western part of the state have been attempted (Seigel and Gibbons 1995). No information is available regarding the home ranges of terrapins, and whether they migrate long distances between marsh habitats.

Diamondback terrapins do use the Nell's Island marsh/upland complex for feeding and/or nesting, but the size and structure of this terrapin population is not completely known (Chambers 1999). Small collections of terrapins have been made by various investigators here (Bob Mueller, pers. comm.), and many terrapins have been observed swimming in the marsh creeks; terrapin tracks have been observed on shore (R.M. Chambers, pers. obs.). Terrapins nest primarily in open, sandy environments above the high water mark (Burger and Montevecchi 1975; Roosenburg 1994). Informal surveys of existing habitat surrounding the marsh complex suggest that nesting habitat is poor, owing to ongoing development and a general lack of undisturbed and unvegetated sandy soils (R.M. Chambers, pers. obs.). In New Haven County where the marsh is located, predation by raccoons could also influence nest success (Seigel 1980). The current presence of adult terrapins in and around Nell's Island Marsh, however, indicates the importance of the marsh either as a current refuge and/or feeding habitat, or as a historical nesting habitat.

In light of ongoing development of residential areas surrounding Nell's Island Marsh, it is worthwhile to determine the current nesting behaviors of diamondback terrapins

inhabiting the marsh. Also, efforts by US Fish & Wildlife in 1997 to restore nesting habitat by clearing and grading open barrier beach environments on Milford Point have provided a unique opportunity to examine terrapin use of high quality nesting habitat.

B. METHODS

Site Description. The study was completed during summer 1999 in Nell's Island Marsh in New Haven County, CT; the marsh is part of the Charles E. Wheeler Wildlife Area (Figure 1). The marsh is dominated by *Spartina alterniflora*, although *Phragmites* appears to be expanding (Chambers 1997).

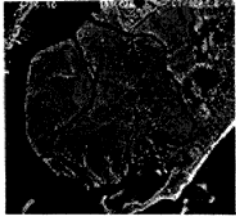


Figure 1. Aerial photograph of Nell's Island Marsh (DEP 1990), located at the mouth of the Housatonic River where it empties into Long Island Sound. Milford Point is the sand spit peninsula south of the marsh complex; the western end of Milford Point is the site of barrier beach habitat restoration by USF&W. CT Audubon Coastal Center is also located on Milford Point, which will allow for rapid and near-continuous access to the marsh during the sampling season.

Nesting Habitat Survey. Roosenburg (1994) suggests that general habitat suitability index models for terrapin nesting such as that constructed by Palmer and Cordes (1988) are not applicable to all locations, so that the nesting habitat surveys of necessity must be site specific. The upland areas adjacent to the marsh complex that may serve as nesting habitat for terrapins include some sections managed by the U.S. Fish and Wildlife Service, by the CT Audubon Coastal Center at Milford Point, plus some sections undergoing intense developmental pressures (residential building along Milford Point and surrounding the marsh). In May, before the nesting season began in June and July, upland sites were surveyed for their potential as nesting habitat, considering site characteristics of overall size, relative elevation, proximity to open water, general soil type, proximity to human development, and percent of open space. These characteristics are thought to influence the use of potential nesting sites by adult terrapins (Roosenburg 1994) and the sex determination of hatchlings (Roosenburg 1996).

Throughout the summer, a standard surveying strategy was used to record terrapin use of those habitats, noting presence and behaviors of nesting females and/or occurrence of terrapin tracks to and from the water's edge. Identified terrapin nests and test-hole locations were to be sited using GPS; each nest was to be re-visited many times through the summer and fall to track its success or to document predation. A student researcher (James Tabery) lived on-site at the Connecticut Audubon Coastal Center, Milford Point, and conducted daily walks through the nesting habitats to complete the surveys.

In 1997, U.S. Fish & Wildlife employees completed a re-grading and re-structuring of barrier beaches at Milford Point, on property that is part of the Stewart B. McKinney National Wildlife Refuge (Figure 1). These large-scale changes were completed to restore open upland habitat and enhance nesting opportunities for plovers and terns,

federal- and state-listed species, respectively. The nesting habitats for birds are also thought to be prime nesting habitats for terrapins. Nesting surveys therefore were concentrated in and around this site, where terrapins are known to come ashore during the nesting season (pers. obs.). Because terrapins, plovers and terns all use the restored section of Milford Point, the proposed monitoring of terrapins allowed for complementary monitoring of bird nesting on-site. Initially, a live-trap was proposed to be set in the restored section of Milford Point to capture potential nest predators (skunks, raccoons, opossums, feral cats, dogs), with capture management according to recommendations of the Town of Milford Animal Control Department. However, U.S. Fish and Wildlife Service, as property managers of the Milford Point Unit, asked us not to set traps on their property. Thus, no control of terrapin or bird predators was attempted during summer 1999.

Population Study. The primary method of sampling adult terrapins in the Nell's Island marsh was via net capture, using 50' and 75' trammel nets strung across sections of creeks where terrapins were observed by canoe survey. At total of 16 different dates between May and August were successful in trapping terrapins; on 8 other dates no terrapins were captured. On all dates, nets were placed across the creeks, then sampled by canoe on an hourly basis for 4-5 hours. Terrapins become entangled in the net and were removed long before they experienced hypoxic stress. By-catch was immediately released after removal from the net. All collected terrapins were held in boxes in the canoe until the end of the sampling interval, a maximum of 4 hours. Past experience with this technique indicated that the terrapins were not harmed by trapping or subsequent processing procedures (Gallowitsch and Chambers 1998).

At the end of the trapping period, all captured adult terrapins were sexed; immature terrapins (0-2 years) are not sexually differentiated and were too small to be captured in the net mesh. Each captured terrapin was weighed using a hanging tube scale; standard measurement of shell dimensions (maximum length and width) was accomplished with tree calipers. Females were palpated for presence of eggs. Terrapin age was estimated by counting the number of growth rings on the plastron as a proxy for years; growth rings were sometimes obscured on older terrapins (> 7 years). Shell condition (physical damage or disease) was noted. Adult terrapins were marked before release using a file to notch the marginal scutes in unique "codes", allowing for individual identification upon recapture. The filing procedure is essentially non-invasive and does not harm the terrapins. Recaptured terrapins were noted for their location, change in weight or physical appearance since previous capture, and for females, change in reproductive status (gravid or not).

Before the 1999 field season, we had completed one summer of terrapin monitoring in the Nell's Island marsh complex (seed money for one year of funding from the Long Island Sound License Plate Fund, CT Department of Environmental Protection). Prior to the present study, over 100 marked terrapins were in the marsh, their ages ranging from 3 to 12 years (Figure 2).

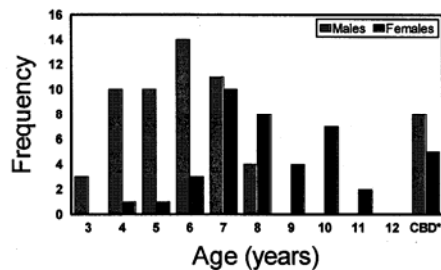


Figure 2. Frequency distribution of terrapin age (based on growth rings), from captures during the summer 1998 field season at Nell's Island marsh.

For that 1998 study, all of the terrapins were collected from the same tidal creek; based on the number of re-captures (Schnabel method; Krebs 1998) the population was estimated as 185 +/- 45 terrapins. Males outnumbered females roughly 2:1, and females exhibited a broader range of sizes (Figure 3).

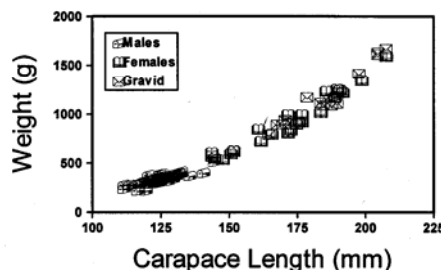


Figure 3. Length-weight relationship for diamondback terrapins captured during the summer 1998 field season at Nell's Island marsh. Males tends to remain small, whereas females grow much larger in size and weight.

Results and Discussion

Nesting Surveys

A compilation of notes taken during daily walks of the Milford Point Unit of the Stuart B. McKinney National Wildlife Refuge is included as Appendix A at the end of this document. These notes document the more extensive use of the south shore of Milford Point as an upland access point for terrapins (i.e., oriented toward Long Island Sound), relative to the north shore (oriented toward the Nells Island Marsh). Nesting activity by terrapins was observed starting on 8 June and lasting through most of July. During the entire summer nesting season, however, only two adult females were observed nesting on the beach, and neither of these terrapins were from the marked population in Nells Island Marsh. In other words, we still do not have clear documentation that female terrapins living in the marsh complex are using Milford Point as a nesting site.

Owing to the lack of nesting observations, we were unable to complete nest tracking using GPS. Many of the nests established at Milford Point, however, were destroyed by nest predation, but all of these nests were located only after the eggs had been destroyed. Tracks of nest predators were obvious as footprints in the sand and probably included

skunks and raccoons. Additionally, feral cats were observed on the site, and some people were observed walking the Point with their dogs during the summer. Because no controls on nest predators were attempted this year, the toll on terrapin eggs was substantial. Also, in the single piping plover nest that contained a clutch of three eggs, only one of the three eggs presumably fledged. Other birds (e.g., seagulls) may have preyed on young plovers or eggs, but the presence of terrapin nest predators in the same area of Milford Point suggests these same predators were responsible for plover nest predation.

Population Ecology

A total of 108 terrapins were caught during the 1999 study, including 81 original captures and 27 recaptures. Terrapins were captured in three different sections of the Nells Island Marsh, designated Turtle Creek, Median, and Boat Ramp, respectively (Figure 4). Sampling from the previous year had captured terrapins only from the Turtle Creek section of the marsh, so sampling in 1999 expanded the local geographic range in captures.

Of the 48 terrapin captures at Turtle Creek during 1999, 25 were recaptures of turtles that had been marked the during a previous study in 1997 and 1998. One turtle was recaptured twice in 1999; another turtle was recaptured three times. Of 19 individual terrapins recaptured at Turtle Creek roughly one year after original capture in 1998, the average increase in carapace length was small and variable (1.47 +/- 0.33 mm S.E.), and the increase in weight was 26.3 +/- 9.5 g S.E. Two other female terrapins were notable for their growth: one increased in size by 26 mm and 200 g over a single year and the other (initially captured in September 1997 and recaptured in August 1999) increase in size by 13 mm and 350 g.

Age estimates based on growth rings should have documented a 1-year increase, but rarely were these year-to-year estimates close to one another. It appears that age determination based on numbers of growth rings is highly subjective; because the discrepancies between age evaluations from 1998 and 1999 did not vary in a systematic fashion, we suspect that growth rings cannot be used as a valid indicator of terrapin age.

The low total number of captures at the Median and Boat Ramp sites preclude the use of standard models to estimate population size. The size of the population from Turtle Creek based on 1998 data was approximately 185. Since one-half of all terrapins captured at Turtle Creek in 1999 were recaptures (i.e., a high percent recapture rate), this estimate of total population size is quite reliable.

One interesting outcome of sampling at three different locations in the marsh was that the movement of terrapins between sampling locations could be determined. For instance, a terrapin sampled from one location and recaptured at another location would document the distances that adult terrapins moved in the marsh. We found, however, that terrapins were never recaptured at any location other than the site where they initially were captured. It appears that adult terrapins do not venture far from their "home" creeks and instead exhibit a strong fidelity to those locations. Clearly the adult females must move out of their creeks to seek upland locations to nest; further, tidal water flushes in and out of these creeks on a diurnal basis, suggesting that a passive turtle's location in the marsh

would change dramatically unless it maintained its position in an active fashion. All three sampling locations are interconnected by tidal creeks so there are no apparent barriers to flow of water and terrapins among sampling locations. The spatial separation of adult terrapin sub-populations in Nells Island marsh, therefore, suggests that population dynamics in terms of marsh-wide recruitment of juveniles must be quite intricate, and that social structures within populations may also exist.

Taking into account data both from 1998 and 1999, the relationship between carapace length and terrapin weight demonstrates the large sexual dimorphism in adult terrapins (Figure 5). Females generally are larger than males and they tend to increase in size throughout their lives. Males stay smaller; in this plot, the “male” designation probably includes a number of immature female terrapins that could not be distinguished from males. Males rarely exceed 0.5 kg in weight, whereas females may be three times as large. The implication of this size difference is that adult male and female terrapins may have access to different food resources, with larger prey items available to females.

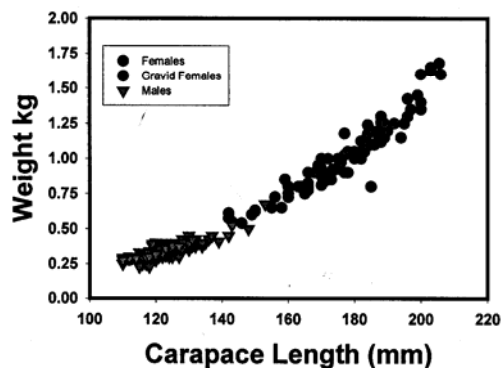


Figure 5. Plot of terrapin weight as a function total carapace length in millimeters. Data are from two years of collection (1998 and 1999). “Males” include all male terrapins plus immature female terrapins that were not distinguishable from males.

Based on total captures from 1998 and 1999, the sex ratio of terrapins in the Nells Island marsh complex is approximately 1.6:1 (males:females), although this ratio may be skewed artificially towards males due to our inability to distinguish immature females from males (that we designated as males).

Roughly one-fourth of all terrapins captured during the past two years of study exhibited developmental anomalies in their shells, with either extra laminae, split scutes or asymmetrical scute formation. It is unknown whether this frequency of developmental anomaly is typical of terrapin populations or indicative of a sub-lethal response to environmental conditions either in the adult female terrapin or in the soils where she laid

her eggs. A host of environmental contaminants are known from the Nells Island marsh, including extremely high sediment concentrations of copper and mercury. Because of its location at the mouth of the Housatonic River, the marsh and its terrapin inhabitants are exposed to an abundance of potential contaminants that could influence egg development. Comparison of the occurrence of anomalies in the Nells Island marsh populations with the frequency of occurrence in populations from more pristine environments would be necessary to determine whether a search for a proximate environmental cause should be initiated.

Conclusion

The most important aspect of this work is that we have demonstrated the persistence of individual terrapins in the same tidal creeks over at least two years, and that terrapins exhibit a strong fidelity to these tidal creeks. To this end, the estimate of a “marsh-wide” terrapin population size cannot be made because all possible “home” creeks have not yet been sampled. A marsh-wide estimate would only be reliable if all possible terrapin creeks were sampled, i.e., estimates would have to be made for individual tidal creeks and then summed to yield the marsh-wide estimate. Because our numbers of recaptures are sufficiently high only at the Turtle Creek site, we cannot state with any confidence the size of the marsh-wide population. Given the population size in Turtle Creek is approximately 200 and that additional sub-populations are known to exist in Median Creek and Boat Ramp Creek, we suspect the total population size may be 500 or so.

Do adult terrapins in the Nells Island marsh move upstream in the Housatonic River to the power plant or across the river to the Great Meadows marsh in Stratford, CT? We have no data from these other locations to document such movement, but know that terrapins are abundant in these areas. Research during the summer 2000 field season will include continued sampling in the Nells Island marsh complex and new sampling in the Great Meadows marsh. Additionally, we plan to initiate molecular marker studies to determine the extent of genetic similarity of terrapins living in different geographic areas. Given their strong fidelity to home creeks that persists over years, we may find small genetic differences among metapopulations.

We see no evidence in our two years of data to indicate that terrapin populations in the Nells Island marsh are suffering from reduced juvenile recruitment as a consequence of extensive nest predation by upland predators. Clearly these predation events could function as a fine environmental sieve, permitting only a small number of nests to provide hatchlings to the marsh population. To date we do not see this effect in terms of quantity of terrapins in the marsh population, but such strong selective pressures could influence the genetic quality of the populations. For instance, if fewer nests yield hatchlings, then presumably the overall genetic diversity of terrapins will be reduced as well. Continued studies of terrapin population sizes and population genetics are warranted to document these potential impacts of nest predation on terrapin ecology.

Management Implications

The historical "threat" to terrapin populations was overharvesting of adults a century ago; when harvesting pressure decreased, terrapin populations slowly recovered. Now, however, terrapin populations increasingly are susceptible to predation at another stage of their life cycle, as eggs. As human populations continue to develop coastal environments, the quantity and quality of terrapin nesting habitats will almost certainly decrease. Further, with human populations come an abundance of associated nest predators, including raccoons, skunks, dogs and cats. As terrapin nests become concentrated in the few adequate nesting sites remaining, the focusing and amplification of nest predation will occur. Eventually the result will be decreased recruitment of juveniles to existing populations and subsequent decreased sizes of those populations.

We still have no data documenting the importance of Milford Point to nesting by terrapins from the Nells Island marsh complex, but obviously large numbers of terrapins are using Milford Point to nest. Unfortunately, large numbers of terrapins are also unsuccessful in their attempts to seed the next generation of terrapins. More active management of Milford Point is necessary to preclude potential nest predators. Because nesting is time-sensitive, the focus of management efforts to trap/exclude nest predators can and should be concentrated during the short terrapin nesting season (June and July) and hatching season (September-October). These efforts would also enhance the nesting success of plovers and terns and make Milford Point more attractive to these species.

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Appendix A

Summary of Milford Point Observations, Summer 1999

By James Tabery '00
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14 May 1999 (10AM): Jim Tabery and Randy Chambers walked Milford Point and saw two fishermen at the tip of the point, a man walking his dog on the south shore (adjacent to Long Island Sound), and a CT-DEP representative scanning the point for plover nests (none yet found but a pair of plovers observed in the area).

2 June 1999 (1PM): Common birds (gulls, pigeons, mallards, swans and red-winged blackbirds) dominate the marsh and point area. Salt spray rose bushes in pink and white bloom, providing refuge for sparrows. Plover nest with fencing observed on south side of point. Nest contains 2-3 eggs; parents lead Jim away from nest. No signs of turtle activity.

3 June 1999 (2:30PM): Common birds abound (red-winged blackbirds, mallards, pigeons, gulls), plus a few great egrets and snowy egrets. Rotting egret carcass found on north side of point. Human and other animal footprints found along north and south shores. Plover nest has 3 eggs, 2 adults. A third plover (different species, darker) also seen nearby. Large numbers of birds seen on sand bars out in Long Island Sound, but no identifications possible owing to distance.

8 June 1999 (7:30AM): Turtle seen swimming on north side in marsh; 5 sets of turtle tracks and some test holes seen on the south side beach. Twelve egrets in marsh; 2 least terns feeding in marsh creeks. Plover nest still with 3 eggs.

9 June 1999 (11AM): Two great egrets and a number of mallards seen. Willets (?) and unknown sandpiper species seen along shore. Fresh turtle tracks seen all over the south side beach, especially near the path. Plover nest still with 3 eggs.

13 June 1999 (5:30PM): Yellow-crowned night heron in marsh. Plover nest with 3 eggs; adult male seen but female not seen for the first time. The south side beach is "littered" with evidence of turtles (tracks, test holes). First nesting peak for terrapins?

14 June 1999 (1230PM): Gravid terrapin found walking on south side beach near the plover nest, but terrapin was not marked and was not observed laying eggs. Plover nest still with three eggs. Rat seen running into rose bush on north side

15 June 1999 (430PM): More fresh terrapin tracks on south side. Plover nest still with three eggs. Night heron seen in marsh.

18 June 1999 (230PM): Old and new terrapin tracks everywhere, but no adults on the beaches. Three eggs in plover nest.

19 June 1999 (10AM): Same as 18 June.

21 June 1999 (8AM): Ten fresh sets of turtle tracks on south side beach, but also a plethora of "other" animal tracks and signs of nest predation. Plover nest may have 4 eggs in it now. A pair of night herons in the marsh.

24 June 1999 (630AM): Three plover chicks running the beach with parents, plus another pair of adult plovers nearby. Animal tracks other than terrapins dominate the south beach shore. Extreme high tides this past week may have drowned plover nests (if any occurred) out on sand bars in Sound.

25 June 1999 (3PM): Only one plover chick seen with parents.

26 June 1999 (1130AM): Only one plover chick seen with parents.

28 June 1999 (8PM): Fewer terrapin tracks relative to the number observed two weeks earlier, apparently the major nesting period for terrapins this year (approximately two weeks earlier than observed the previous 2 years). Only one plover chick remains; the other two chicks probably were eaten by gulls. The fourth egg, if it existed, did not hatch.

29 June 1999 (930AM): Piping plover chick growing nicely. Third adult was on the beach again near original nest. On the north side beach was seen a pair of semi-palmated plovers with two or three chicks, plus three night herons in marsh.

30 June 1999 (5PM): Piping plover chick and semi-palmated chicks observed again today, plus several least terns feeding in the marsh.

1 July 1999 (8PM): Two predated terrapin nests seen. Plovers as yesterday.

3 July 1999 (730AM): No new sights. Plovers as previously, no new terrapin activity, no new nest predation.

6 July 1999 (8PM): Adult female piping plover has flown the nest, apparently, leaving male and single chick. Predators (raccoons, skunks, etc.) are thought to be wreaking havoc with terrapin nests, according to Jason from USFWS.

7 July 1999 (530PM): More predated terrapin nests found.

9 July 1999 (8AM): Only single adult male plover seen; chick is missing. No new terrapin nest predation.

10 July 1999 (830PM): Only single adult male plover seen. No new terrapin nest predation.

12 July 1999 (830AM): Plover chick is back. Eight additional terrapin nests have been predated.

13 July 1999 (1130AM): No sign of piping plovers, but semi-palmated plover family still on north side. An unmarked, gravid female terrapin was seen on the fishermen's path but she ran back into the water before laying eggs. Two more predated nests. Dead baby terrapin found near Coastal Center, possibly a hatch from previous year. Still too early for this year's hatchlings.

14 July 1999 (1130AM): One more predated terrapin nest. Chick and adult plover seen near fishermen's path.

16 July 1999 (430PM): Plovers still near fishermen's path.

18 July 1999 (10AM): Two plovers near fishermen's path. Gull with wounded leg out near point. The plover chick is now 27 days old, so government surveillance of activity will now cease.

19 July 1999 (4PM): Plovers active, wounded gull not.

20 July 1999 (10AM): Plovers active, least terns feeding in marsh. Another pair of plovers seen along north side shore.

3 August 1999(1130): No evidence of terrapins, no new nests destroyed. No signs of plovers.

4 August 1999 (9AM): No evidence of terrapins, no new nests destroyed. No signs of plovers. Prior to going missing, the plover chick was seen flying. Perhaps chick and adult male have moved on.