TERRAPIN MONITORING AT POPLAR ISLAND ENVIRONMENTAL RESTORATION PROJECT

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BACKGROUND

The Poplar Island Environmental Restoration Project (PIERP) is a large-scale project that is using dredged material to restore the eroding island in the Middle Chesapeake Bay formerly known as Poplar Island. As recently as 100 years ago, the island was greater than 400 hectares and contained upland, mid- and low-level wetlands. During the past 100 years the island had eroded and only three, small (<4 hectares) islands remained before the project commenced. In a large-scale project, the United States Army Corps of Engineers (USACE) and the Maryland Port Administration (MPA) are rebuilding and restoring Poplar Island. A series of stone-covered dikes facing the windward shores prevent erosion. Dredged material from the Chesapeake Bay Channels will fill the areas within the dikes, ultimately restoring the island to a size similar to what existed over 100 years ago. The ultimate goal of the project is to rebuild and restore the habitat for the wildlife that once existed on Poplar Island.

One of the wildlife species targeted in the restoration project is the diamondback terrapin, *Malaclemys terrapin.* These emydid turtles were probably common in the Poplar Island archipelago. However, the persistent erosion of Poplar and nearby islands has greatly reduced the nesting and juvenile habitat of the terrapin. Thus, the local terrapin population in the archipelago may be below their former levels. Terrapin populations likely declined due to emigration of adults, which combined with the reduction of available high quality nesting habitat, reduced recruitment. By restoring the island and providing nesting and juvenile habitat, terrapin populations utilizing the PIERP and the surrounding wetlands could significantly increase and potentially repopulate to their former levels. The restoration also could provide the resources that would allow terrapin populations to increase. Terrapin nesting habitat includes accessible sandy areas that are above the mean high tide. Juvenile terrapin habitat includes the salt flats and fringe marsh common along the Chesapeake Bay shoreline.

PIERP is a unique opportunity to understand how large-scale ecological restoration projects affect terrapin populations and turtle populations in general. In 2002, a long-term terrapin-monitoring program began to monitor terrapin nesting on the PIERP. By monitoring the terrapin population on the PIERP, resource managers can learn how creating new terrapin nesting and juvenile habitat affects terrapin populations. This information will contribute to understanding the ecological quality of the restored habitat on the PIERP, as well as understanding how terrapins respond to large-scale restoration projects.

Beginning in 2002, Ohio University terrapin researchers identified major terrapin nesting beaches at the PIERP, quantified nest and hatching success rates, and marked and released over 500 hatchlings (Roosenburg and Allman, 2003). A continuing concern is that some nesting beaches are not located in close proximity to suitable hatchling and juvenile habitat, potentially resulting in reduced hatchling survivorship. In 2002 the researchers released hatchlings in a small marsh habitat located between Coaches Island and the PIERP. This was the only natural marsh habitat available to hatchling and juvenile terrapins near the PIERP during those years. It is unknown whether this small area can support a large hatchling and juvenile population; therefore, the researchers released marked hatchlings collected in the 2003 and 2004 studies in Cell 4DX, a recently constructed demonstration marsh. Terrapin researchers will determine the suitability of hatchling habitat in Cell 4DX by future surveys of marked individuals in the area.

As stated in the 2006 PIERP Framework Monitoring Document, the purpose for Terrapin Monitoring is to: quantify the use of nesting and juvenile habitat by diamondback terrapins on Poplar Island. This includes monitoring the responses to change in habitat availability throughout the progression of the project; determining hatchling viability, recruitment rates, and sex ratios to evaluate the suitability of the island for terrapin nesting; and determining if the project is affecting terrapin population dynamics by increasing the amount of juvenile and nesting habitat on the island.

METHODS

Identification of terrapin nests:

From 15 May to 1 August 2005, the Ohio University researchers surveyed nesting areas daily (figure 1); beaches in the notch area (near Cell 4), areas between Coaches Island and the PIERP (outside of Cell 5), inside the open upland cell (Cell 6) and the beach outside the dike in Poplar Harbor (outside Cell 3). The researchers occasionally searched the periphery of Cell 4DX for signs of terrapin nesting on the surrounding dikes. Geographic positioning system (GPS) recorded nest position and survey flags identified the specific nest locations. Upon discovering a nest, researchers examined the eggs to determine the age of the nest. If the eggs were white and chalky, they considered the nest greater than 24 hours old and no further excavation was conducted. Researchers excavated recent nests (less than 24 hours old) to count the number of eggs and weigh the individual eggs.

Monitoring hatching success:

After 45 to 50 days of incubation, researchers placed an aluminum ring around each nest to prevent emerging hatchlings from escaping. Anti-predator cages also were placed over nests to prevent avian predators from preying on emerging hatchlings within the ring. Beginning in late July, the researchers checked ringed nests at least once daily for emerged

Figure 1. In red are the areas on the PIERP that were monitored for terrapin nests by the research team.

hatchlings. Researchers brought newly emerged hatchlings to a storage shed onsite where they measured and tagged the hatchlings.

Researchers excavated nests ten days after the last hatchling emerged. For each nest, they recorded the number of live hatchlings, dead hatchlings, and eggs that appeared to be incompletely developed. To estimate hatching success, researchers compared the number of surviving hatchlings to the total number of eggs from only the nests for which total clutch size was known . Additionally, researchers determined if the nest was still active – eggs that appeared healthy and had not completed development. The researchers allowed nests containing viable eggs or hatchlings that had not fully absorbed their yolk sac to continue to develop; however, researchers removed fully developed hatchlings from nests.

Capture of hatchlings:

Researchers collected hatchlings from ringed nests and from un-ringed nests that were discovered by hatchling emergence. Additionally, researchers found a small number of hatchlings on the beach, which they collected and processed. Because a significant number of the 2005 nests over-wintered (hatchlings remaining in the nest until the spring of the following year), researchers traveled to the PIERP on 3 April 2006 to excavate and monitor over-wintering nests.

Measuring, tagging, and release of hatchlings:

Researchers brought all hatchlings back to the Maryland Environmental Service (MES) trailer onsite where they placed hatchlings in plastic containers with water until they were processed. Researchers marked hatchlings by notching the 11^{th} right marginal scute and 11^{th} left marginal scute establishing the cohort ID 11R11L for 2005. Researchers implanted individually marked binary coded wire tags (CWTs, Northwest Marine Technologies®) in all hatchlings. The CWTs were placed subcutaneously in the right rear hind limb using a 25-gauge needle. The CWTs should have high retention rates (Roosenburg and Allman, 2003) and in the future researchers will be able to identify terrapins originating from the PIERP for the lifetime of the turtle by detecting tag presence or absence using Northwest Marine Technologies' V-Detector.

Researchers measured plastron length, carapace length, width, and height (± 0.1 mm) and mass (± 0.1 g) of all hatchlings. Additionally, they checked for anomalous scute patterns and other developmental irregularities. Following tagging and measuring, researchers released all hatchlings in either Cell 4DX or Cell 3D, with the exception of one individual that they released in the north corner of the notch. The researchers held many of the hatchlings for several days prior to release. On several occasions, they released large numbers (>50) of hatchlings simultaneously. Eight hatchlings that emerged from a nest in late October were held over winter and released the following spring. These hatchlings were remeasured at the time of their release to monitor any growth while in captivity.

Arlington Echo Education Program:

In a program coordinated by MES for the USACE and MPA, 105 hatchlings were provided to the Arlington Echo Outdoor Education Center (AE) for a terrapin education / environmental outreach program. In May 2006, researchers traveled to AE to PIT (spell out, first time using) tag and determine the sex of these animals using laparoscopy. Researchers also measured and weighed all animals at this time. In late May and early June 2006, the AE animals were returned to the PIERP for release in the notch.

Researchers summarized and processed all data using Microsoft Excel®. Institutional Animal Care and Uses Committee (IACUC) at Ohio University approved animal use protocols and Maryland Department of Natural Resources (MD DNR) – Fisheries Division issued a Scientific Collecting Permit to Willem M. Roosenburg (WMR).

RESULTS

Nest and Hatchling Survivorship:

During the 2005 terrapin nesting season (May-August), the researchers located 261 nests on the PIERP. They located 21 more nests after the nesting season as the hatchlings emerged from their nests (raw nest data provided in Appendix 1). This represents a 57% increase compared to the nesting that occurred in 2004. Researchers found nests on the beach, on the outside of Cells 5 and 3, inside of Cell 6 and in the notch area. Additionally, researchers found one nest inside Cell 5 on one of the bird nesting islands. The female turtle apparently got through a washed out portion of the fence and was able to get inside Cell 5. Predators destroyed 45 nests and partially destroyed 30 additional nests. The majority of the predation occurred opposite Coaches Island in the notch and on the outside of Cell 5. It is suspected that birds, particularly in the case of partially depredated nests, did the majority of the predation. At least three of the depredated nests appeared to have been destroyed by foxes as indicated by the manner the nest was dug and foot prints around the nest. Additionally, 11 nests were washed away during high tides because the females laid their eggs too close to the high tide line. Eight nests had either all or a portion of the eggs thinly shelled. There were three instances in which females dug up either part or all of a previously laid nest. Additionally, three nests were accounted for because the ring caught almost twice as many hatchlings as there were eggs in the original nest, indicating the presence of a previously undiscovered nest. Of the remaining 282 nests, 189 of these produced hatchlings either as evidenced by live hatchlings or hatchling tracks emerging from the nest, which indicated that they had escaped. This resulted in an overall nest success of 67.0% including depredated nests and 83.2% of the nests that survived predation.

Table 1. Summary of the number, location and predation of diamondback terrapin nests discovered on the PIERP during the summer of 2005.

Location	**Nests Discovered**	**Depredated**	**Washed Away**	**Nests Hatched**
Cell 5	94	31	0	59
Cell 3 Beach	36	3	11	17
Notch	130	35	0	64
Cell 6	22	6	0	17
Total	282	75	11	157

The researchers also recorded data of clutch size, total clutch mass and egg size. These data are summarized in Table 2. Because clutch size data was collected for most nests, the average within clutch survivorship was calculated to be 66.7% (SD = 29.8%, n = 157, Table 2).

Table 2. Summary of average clutch size, clutch mass, egg size, and numbers of hatchlings per nest from the PIERP.

	Clutch Size	Number of Hatchlings	Clutch Mass	Egg Size
Mean	13.57	9.05	133.5	9.91
Standard Deviation	2.656	4.69	28.772	0.986

Hatchlings:

Researchers captured 1,526 hatchlings on the PIERP between 10 August 2005 and 3 April 2006. All hatchlings except for 4 were caught at the location of the nests. These include the ringed nests and the 21 nests that were found as the hatchlings emerged. This finding suggests that there was thorough coverage of the nesting areas and a high percentage of the nests were located during the study period.

The mean PIERP hatchling measurements are summarized in Table 3 (raw data provided in Appendix 2). Hatchlings had a mean plastron length of 27.4 mm and a mean carapace length of 31.0 mm. The average weight of hatchlings was 7.5 g. Four hundred ninety-five (32.4%) had shell scute pattern anomalies. The scute anomalies

Table 3. Summary of hatchling metrics caught on the PIERP

	Plastron Length (mm)	Carapace Length (mm)	Carapace Width (mm)	Height (mm)	Mass (g)
Mean	27.4	31.0	27.7	16.2	7.5
Standard Deviation	1.9	2.2	1.9	1.0	1.1

included extra marginal, vertebral, and pleural scutes. One hatchling was discovered that had a developmental defect that resulted in an abnormal shell; due to this abnormality the terrapin was not able to pull its head into its shell.

Over-wintering:

In mid-October 2005, researchers went to the PIERP to excavate nests that had produced hatchlings and to identify nests that might over-winter. Twenty-nine over-wintering nests produce hatchlings. On 3 April 2006, researchers returned to the PIERP to excavate the remaining over-wintering nests and recovered 165 live hatchlings. Because of warmer than anticipated temperatures during the winter of 2005/2006, nine of the over-wintering nests emerged and these hatchlings died in the rings. Procedures have been implemented to keep this from occurring in the future. Over-wintering hatchlings did not differ in plastron length (ANOVA, $F_{1,1514} = 1.59$, $P > 0.20$, Table 4) or mass (ANOVA, $F_{1,1335} = 0.0$, $P > 0.96$, Table 4)compared to hatchlings that emerged in the fall.

Table 4. Summary statistics of terrapin size comparing hatchlings from nests emerged in the fall and those that over-wintered in the nest on the PIERP.

Fall Emergers	**Plastron Length (mm)**	**Carapace Length (mm)**	**Width (mm)**	**Mass (g)**	**Height (mm)**
Mean	27.4	31.0	27.7	7.5	16.2
S.D.	1.7	1.9	1.7	1.1	1.1
Spring Emergers					
Mean	27.6	31.3	27.8	7.4	16.4
S.D.	1.5	1.7	1.5	0.9	0.8

Adult and Juvenile Terrapins: The researchers and MES personal assisted in the capture of 10 adult females on the PIERP during the 2005 nesting season. Researchers marked all females with PIT tags and a monel metal tag in the 9^{th} marginal scute on the right side. Data of these animals can be found in the Appendix, Table 3. The researchers also collected data from 28 hatchlings that were captured in 2004 and were held over the winter in the MES offices onsite. Researchers measured, marked with CWTs and released these terrapins in Cell 4DX (Appendix 3). Researchers also PIT tagged terrapins that were part of the AE Terrapin Education Program. Researchers tagged, sexed, and processed 105 terrapins in early May (Appendix 4). The students released 104 of these on the PIERP in late May and early June. One of the terrapins died following laparoscopy to determine sex.

CONCLUSIONS

Terrapin nesting on the PIERP continues to increase and the 120 nest increase from 2004-2005 indicates a clear trend. This is the second year in a row that the number of nests has increased by more than 100 nests. The nesting activity on the island most likely is increasing because more females are discovering the nesting areas on the PIERP vs. other nesting areas on Coaches and Jefferson's Islands and possibly the mainland. Because this is the second year of thorough daily nesting surveys, the research team is confident that a part of this increase is real. However, the research team does acknowledge that proficiency at locating nests can vary from year to year. Because it takes female terrapins a minimum of 8 years to reach maturity, the nesting increase is not because of recruitment from the PIERP in the previous 4 years. The female terrapins are either immigrating to the Poplar Island archipelago or they are choosing to nest on the PIERP after previously nesting on Coaches or Jefferson's Island. During 2005, the researchers continued their daily surveys and under optimal nesting conditions, twice daily surveys of the nesting areas. This was possible because Sean Sullivan was dedicated full-time to locating terrapin nests. Interestingly, 21 nests were discovered by hatchlings emerging, suggesting that some nests remained undetected despite the thorough nesting beach surveys. Most of these nests were probably laid over the weekend when nesting surveys were not completed.

The PIERP has resulted in providing excellent nesting habitat since the completion of the perimeter dike. While nest survivorship remains high on the PIERP relative to the mainland, it continues to decrease, primarily because nest predators are discovering the high-density terrapin nesting. During 2004 researchers began to notice increased predation of nests, primarily by a small mammal that was preying on the nests as the hatchlings were emerging. In 2005, the researchers noticed that crows had learned how to locate terrapin nests and excavate them. The crows depredated a large number of nests in Cell 5 and the notch area. Interestingly, most of the avian predation did not destroy all of the eggs in the nest, however, the excavation and exposure of the remaining eggs to higher than normal temperatures may have resulted in killing some of the remaining embryos. Whenever possible, researchers reburied exposed nests in the hope that the eggs had not gotten too hot. Both nest and hatchling survivorship remains high on the PIERP relative to the mainland. During 2003 nest survivorship was 71% (Roosenburg et al., 2004) compared to 72% in 2004 (Roosenburg et al., 2005) and this decreased to 67% in 2005 because of the increase in predation. Hatchling survivorship has fluctuated among years from 93% in 2003 (Roosenburg et al., 2004) to 71% in 2004 (Roosenburg et al., 2005) and decreased in 2005 to 66.2%. The decrease in 2005 is most likely a result of the partial predation of many nests that still produced hatchlings.

Although predation rates of nests are low compared to mainland terrapin nesting sites, predation rates are increasing on the PIERP. The foxes that colonized the island during 2004 clearly destroyed three of the nests. The presence of their tracks near the excavated nest and the manner in which the nests were dug (similar to the digging of a dog) identified foxes as the predator. It was interesting that the foxes did not destroy more terrapin nests, and it is likely that the fox removal efforts by the United States Fish and Wildlife Service (USFWS) personnel (covered under the site's depredation permit) can be credited for keeping the predation rates low. Researchers also confirmed crows preying on terrapin nests through the presence of bird tracks and direct observation of the predation. Crows either completely or partially depredated a large number of nests in the notch and Cell 5. Researchers reburied partially destroyed nests and many of these still produced hatchlings. Other researchers have observed birds excavating terrapin nests and noted that they frequently do not destroy the entire clutch of eggs (Wood and Butler, 2004, pers. comm.). Several times during the 2005 season, researchers identified small mammal tracks inside nest rings. These mammals may have preyed upon hatchlings that were held in the ring. Frequently, the research team discovered small tunnels leading into nest suggesting a small burrowing mammal. Researchers could not confirm what kind of mammal was visiting these rings or whether they indeed consumed hatchlings, however Draud et al., (2005) found that rats prey on hatchling terrapins in New York.

The absence of efficient nest predators such as raccoons results in high nest survivorship rates that are much greater than other nesting areas that have been studied. As observed in 2002 - 2004 (Roosenburg and Allman, 2003; Roosenburg et al., 2004, Roosenburg et al., 2005), the survivorship of known nests was much higher than normally encountered for terrapins because of the lack of nest predators on the PIERP. Raccoons, foxes, and otters are known terrapin nest predators and contribute to low nest survivorship in areas where predators occur, sometimes depredating 95% of the nests (Roosenburg, 1994). Additionally, the lack of raccoons on the PIERP minimized the risk to nesting females that also may be depredated by raccoons (Seigel, 1980; Roosenburg pers. obs.). Thus, the PIERP is successfully creating terrapin nesting habitat.

As observed in summer 2002 - 2004 (Roosenburg and Allman, 2003; Roosenburg et al., 2004), terrapin nesting on the PIERP occurred in areas where terrapins could easily access potential nesting sites. These areas are outside of Cells 3 and 5, and inside of Cell 6 and the notch. In 2004, the erosion fence along the dike around Cell 5 was extended to include the entire notch. The erosion fence prevented terrapins from crossing the road and nesting within Cell 4 as they did last year. Although this fence is effectively preventing terrapins from nesting in Cell 4 and 5, it also is causing many females to lay their nests at the base of the fence. Therefore, it is recommended that the effect of the fence on terrapin nesting be carefully monitored. Throughout the remainder of the PIERP, the stone face of the surrounding retaining dike is a barrier that prevents terrapins from accessing potential nesting sites. As wetland cells are completed, and the exterior dikes are breached to provide water flow, terrapins are likely to follow and begin nesting on interior parts of the island.

The large number of nests combined with the high nest survivorship resulted in a record 1,526 hatchlings captured on the PIERP. Hatchlings started emerging from the nests on 10 August 2005; the last hatchlings emerged in 3 April 2006. Researchers released all of the hatchlings in Cell 4DX and Cell 3D, however, it was noted that many of the hatchlings, particularly those released in September and October, headed to shore as opposed to heading to the water. Recent data of hatchling terrapins in New York suggests that they spend their first winter in terrestrial vs. aquatic habitats (Draud, 2004 pers. comm.). This may be a mechanism to avoid predation and to avoid freezing in shallow marsh sediments. Researchers witnessed many of the PIERP hatchlings distinctly heading away from the water. This behavior is interesting and potentially problematic because these hatchlings may be entering cells that are targeted for filling in the upcoming fall and winter.

The hatchlings produced on the PIERP were similar in size and weight to those captured during previous studies in the Patuxent River in Maryland (Roosenburg, 1992) and in previous years on the PIERP. The frequency of shell scute anomalies and cranial developmental anomalies, 32%, is higher than the average for terrapin populations, approximately 10% (Herlands et al., 2002). A high frequency of shell scute anomalies was also observed in 2002 - 2004 (Roosenburg and Allman, 2003, Roosenburg et al., 2004, Roosenburg et al., 2005). Warmer incubation temperatures cause higher frequencies of shell scute anomalies in terrapins (Herlands et al., 2002). The high frequency of shell scute anomalies in the PIERP hatchlings could be due, in part, to the limited vegetation on the PIERP that could provide shaded, cooler incubation environments (Jeyasuria et al., 1995). Although shell anomalies have been associated with higher incubation temperatures, there is no evidence to suggest that these anomalies have any detrimental effects on terrapins or other turtle species. Anomalies occur at higher frequency in female terrapins than in males and may be linked to temperature-dependent sex determination (TSD). For terrapins, warmer incubation temperatures produce females, and cooler conditions produce males (Jeyasuria et al., 1995; Roosenburg and Kelly, 1996). The higher frequency of anomalies may be indirect evidence that the PIERP may be producing a higher than average number of female hatchlings. Continued monitoring of the PIERP terrapins will be able to confirm this hypothesis.

During the winter of 2005/2006 a significant number of nests over-wintered successfully. The recovery of 165 hatchlings from 29 over-wintering nests continues to indicate that this is a successful strategy used by some terrapin nests. Interestingly, during 2004 over-wintering hatchlings were lighter and smaller than hatchings that emerged in the fall (Roosenburg et al., 2005), but in 2005 there was no difference between fall and spring emerging hatchlings. In addition to the over-wintering of the nests, researchers also noticed that hatchlings released after processing clearly preferred to stay on land as opposed to remaining in the water. These hatchlings actively left the water and sought higher ground. These observations are similar to terrapin populations in New York where the hatchlings that emerge from their nests in the fall spend their winters in terrestrial environments below the surface, sometimes buried up to 10 cm

(Draud, 2004 pers. comm.). The PIERP offers a wonderful opportunity to study terrapin over-wintering because of the large number of nests that survive predation.

The educational program conducted in collaboration with the AE Outdoor Education Center was a success. Students significantly increased the size of the hatchlings they raised to sizes that are characteristic of 2-3 year old terrapins in the wild. Additionally, researchers were able to get some of the first sex ratio data from the hatchlings because they had obtained sizes that were large enough to allow for laparoscopic surgery. Additionally, because these hatchlings were PIT tagged the researchers hope to be able to follow the fate of these hatchlings over the years. An integral part of this project will be to compare survivorship of naturally released hatchlings vs. those that have been given a head start for 9 months.

The initial success of terrapin use of the PIERP predicts that similar projects may have success in creating terrapin nesting habitat. One of the major factors threatening terrapin populations throughout their range is the loss of nesting habitat to development and shoreline stabilization (Roosenburg, 1991; Siegel and Gibbons, 1995). Projects such as the PIERP that combine the beneficial use of dredged material and ecological restoration have the potential to create habitat similar to what has been lost to erosion and human practices. With proper management, areas such as the PIERP may become areas of concentration for species such as terrapins and thus become a source population for the recovery of terrapins throughout the Bay.

The PIERP Monitoring Framework identifies three hypotheses for the terrapin monitoring program. The first hypothesis evaluates changes in nesting activity from year to year. During 2005 nesting activity increased by more than 100 discovered nests thus the hypothesis that there is no difference between years in the number of nests is rejected. However, the increase in the number of nests is a positive sign that the PIERP is resulting in good terrapin nesting habitat. The second hypothesis evaluates the nest and hatching survivorship. Nest survivorship continues to be high on the PIERP, significantly higher then on mainland nesting areas where predation rates of nests range from 70 to 100%. The continued absence of the traditional predators (raccoon and fox) on the PIERP continues to result in lower than mainland predation rates. Hatching success continues to be high on the PIERP, although the partial predation of many nests by smaller predators such as birds and a small unidentified mammal have resulted in decreasing nest success over the past four years on the PIERP. The second hypothesis is rejected but once again the difference favors the successful use by terrapin of the PIERP. Finally, the number of nests si the only data that can test the third hypothesis, which evaluates changes in the terrapin population around the PIERP. The dramatic increase in the number of nests during 2005 suggests that the terrapin population in the Poplar archipelago is increasing. This indirect method of evaluating the population suggest an increase, however in future years we hope to obtain a more direct evaluation of this hypothesis by using mark-recapture techniques. Based on the evaluation of terrapin activity on the PIERP the research team concludes that the project is having a positive effect on terrapins in the archipelago by providing high quality nesting habitat.

Recommendations

As the PIERP continues, terrapins will continue to use the habitat for nesting. There are some short-term measures that can be taken to improve nesting habitat on the island. First, a suggestion that nesting areas devoid of vegetation be provided as terrapin nesting habitat. During 2005, engineers initiated tidal flow into Cell 3D that may have contributed to the erosion and loss of most of the nesting habitat outside of Cell 3. This was optimal habitat because it was devoid of vegetation and in the sheltered PIERP harbor. Because terrapins avoid nesting in areas with dense vegetation (Roosenburg 1996), providing open, sandy areas on the seaward side of the dikes should reduce efforts by terrapins to enter into cells under construction to find suitable, open areas. Second, predator control on the island will be paramount to the continued success of terrapin recruitment. Keeping raccoon and fox populations to a minimum will maintain the high levels of nest survivorship observed in 2002 - 2004. Consideration of crow removal is a potential option to reduce nest predation. Finally, efforts to promote the use of by-catch reduction devices (BRDs) on crab pots fished in and around the PIERP archipelago will increase adult survivorship. Crab pots drown terrapins and can have dramatic effects on their populations (reviewed in Roosenburg 2004). Promoting or requiring the use of BRDs in the PIERP archipelago could greatly reduce the mortality of juvenile female and male terrapins. The recommendations offered herein will contribute to the continuing and increasing use of the PIERP by terrapins. As terrapin monitoring continues, evaluating the success of these measures, if implemented, will be conducted.

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