Assessing the Reproductive Output of the Northern Diamondback Terrapin, *Malaclemys terrapin terrapin*, on North Sedge Island after a Post-Tropical Cyclone

Annalee Tweitmann

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Mentor: Dr. John Wnek

Abstract:

The northern diamondback terrapin, *Malaclemys terrapin terrapin*, is one of seven subspecies of the diamondback terrapin, the only turtle to live in brackish waters in the Western Hemisphere. The northern diamondback terrapin is a species of special concern in New Jersey, meaning that the population shows evidence of decline. In October 2012, Superstorm Sandy hit New Jersey and caused extensive damage. At this time, the terrapin population was preparing for hibernation. This interruption could have forced the terrapins to appropriate their energy differently, thus negatively affecting their reproductive output, in terms of clutch size and egg size. Additionally, terrapins could have been displaced by the storm, injured, or killed. North Sedge Island in Barnegat Bay is home to many nesting female terrapins. This year, nesting season extended June 9th-July 23rd. As terrapins came up to nest, they were captured by hand, marked if new, measured, and released after being sprayed with paint and numbered. Eggs were measured and then moved to an enclosed hatchery to prevent predation. This season, only sixty-six terrapins were marked and only twenty-eight nests were recovered, much lower than in the past seven years. There were no significant differences in egg length, clutch size, or egg mass amongst years. Although these factors didn't change, the loss of nesting females to N. Sedge Island did have a negative impact on the overall reproductive output for 2013.

Introduction:

The Northern Diamondback Terrapin, *Malaclemys terrapin terrapin*, is one of seven subspecies of the diamondback terrapin. The diamondback terrapin is the only species of turtle that lives in brackish waters, like Barnegat Bay ("Northern Diamondback Terrapin". In New Jersey, the diamondback terrapin is a species of special concern in New Jersey, meaning that they "warrant special attention because of some evidence of decline" ("Northern Diamondback Terrapin". Terrapins have been and are still harvested in New Jersey. Anthropogenic habitat alteration has forced terrapins to new, less appropriate nesting locations where the eggs are more available to predators ("Northern Diamondback Terrapin"). Nesting females face threats from motor vehicles when attempting to cross roads to lay eggs. Additionally, terrapins can become stuck and drown in crab pots without turtle excluder devices ("Northern Diamondback Terrapin"). During the winter, terrapins bromate (or hibernate) and bury themselves in mud. In New Jersey, terrapins lay their eggs between late May and late July. Female usually lay 8-12 eggs; the number of eggs is called the clutch size. Eggs hatch approximately 61-104 days later ("Northern Diamondback Terrapin").

In late October 2012, post tropical cyclone Sandy hit the Jersey Shore. Sandy's unusual path and arrival with a cold front among other factors led to one of the most damaging storms New Jersey has seen in years. Some even consider Sandy to be the second most-destructive US hurricane (Plumer). Hurricanes have been known to wash away sea turtle nests, and Sandy's appearance in October could have easily washed away late-hatching terrapin nests. However, another impending question is how the rest of the terrapin population fared. The possible displacement of the terrapins came at a time where they should have been preparing for hibernation. The stress of the hurricane could possibly mean that less energy was allotted for reproduction. J. Bernardo found that larger eggs usually represent a larger investment (1996). If less energy is available to invest, there may be smaller eggs after a significant storm like Sandy. Food sources for terrapins could have been affected as well impacting energy allotted for reproduction. Additionally, the storm surge may have injured or killed terrapins. Litzgus et al. found a positive relationship between spotted turtles with better body conditions and higher clutch mass and egg size (2008). Lastly, Ocean County, New Jersey lost over 5 million cubic yards of sand due to Superstorm Sandy. Terrapins nest in sandy soils and experienced habitat loss due to the storm (Stockton 2012).

N. Sedge Island is the perfect location to test the effects of Hurricane Sandy on reproductive output. Data on terrapin nests have been collected since the spring of 2002 and there is a 75-90% return rate for all nesting females (Wnek, pers, comm.). Located in the middle of Barnegat Bay, the island is relatively untouched by humans except for small groups that stay overnight on the island. This season, few day groups visited the island due to building damage on Sedge Island. Sedge Island has caretakers, Jackie and Tony Raniero who helped in the constant watch for nesting female terrapins.

Figure 1. Left is the hatchery on Sedge Island before Superstorm Sandy. Right is the same nesting area at Sedge after the storm and the loss of 38 cubic yards of sand.

Figure 2. Left is Sedge Island before Superstorm Sandy. The yellow dots indicate nesting locations. Right is after the storm. Notice the sand washed out on the nesting area next to the education facility. The sand was washed back into the cove.

Methodology:

The island was surveyed from 7:00 am to 8:00 pm every day from May 20th to July 20th. As female terrapins came up onto N. Sedge Island to nest, they were captured, and the day and time of capture was recorded. The tide and weather were also noted. Female terrapins were scanned for passive integrated transponder (PIT) tags. If they did not already have a PIT tag, they were injected with one. If their shells were not notched, or marked on certain marginal scutes

with an individualized code, they were notched with a file. Size measurements, including plastron length (mm), carapace length (mm), carapace width (mm), carapace height (mm), and weight (g), were recorded. Before being released, females were sprayed with white spray paint on their carapace and numbered so that we could easily identify them when they nested, and allowed researchers to identify already measured (processed) terrapins (Wnek, pers. comm.). The paint would wash off after two to three weeks.

After a female dug her nest, the nests were carefully excavated, and collected within hours of oviposition. Eggs were counted to determine clutch size and weighed (g) on a scale. Then, the length (mm) and width (mm) were measured using digital calipers (Figure 3). Eggs were then moved to a designated hatchery on the southwest end of the island. Here, new nests were dug and covered with galvanized hardware cloth in order to protect them from predators. Once the eggs hatch, the hatchlings will be measured and let go. We will be able to determine hatch success.

Figure 3. Measuring a newly laid egg from a clutch.

Results:

Sixty-six female terrapins were captured on North Sedge Island this past nesting season (Figure 4). Nine of the sixty six females were new to the island, meaning that they were sexually mature and joining the reproductive population (Figure 5). This is 14% of the females were new this year, and indicates an 86% return rate (Figure 6). There were 28 known, non-predated nests. There were three unknown and one known but predated nest (Figure 8). In the 2013 season, each landing averaged 5.6 eggs (Figure 7). The average egg mass was 8.4 grams and the average egg length was 31.74 mm (Figure 9). The average clutch size or number of eggs per nest was 13.1 (Figure 10). Forty-two percent of females that landed on the island nested this season (Figure 11). This year, there were five double nesters and no triple nesters (Figure 12). The average egg mass for the double nesters were 8.28 grams (Figure 13), which was slightly lower than the means of their first clutch egg masses.

Discussion:

Last year, the 2012 nesting season started much earlier than expected possibly due to an extremely warm spring. There were reports that some terrapins started nesting as early as late April (Wnek, pers. comm.). However, we were not able to begin assessing the 2012 nesting season until late May. Therefore, up to two weeks of nesting were missed on N. Sedge Island. In 2011 and 2013, an average of 17% of total terrapins caught came up in the first week. In order to more accurately this year's nesting results to the past years, the 2012 season's number of terrapin landings were estimated to be 81, rather than 67 captured. The "81" is a better indication of what we would have captured in 2012.

After calculating an ANOVA (an alpha of 0.05 or less was used for significance), it was determined that there were significantly less terrapin landings this year in comparison to the last three years ($p<0.001$). This could mean that less terrapins are in the area, which would indicate many factors including: displacement, death, choice of other nesting areas, or that females did not put energy into reproductive output, which is evident in other turtles. Sometimes when resources become scarce, turtles may not reproduce (in western ponds turtles, Pires 2011). Additionally, after running another ANOVA comparing nests among the past three years, there were significantly less nests on North Sedge Island this season ($p<0.001$). This supports the idea that there are less terrapins in the area or that they cannot reproduce this season. This season, however, the number of new nesting females was as expected and not significantly different than past seasons. This shows that, despite a major natural disaster, young females were recruited into the reproductive population. This may be a result of the females being displaced from another location then coming to N. Sedge Island to nest.

The average amount of eggs per landing and the ratio of nests to landings were both significantly lower than past seasons. This indicates that the terrapins did not choose to nest on Sedge Island. It may be the result of lost nesting substrate or changes in the nesting soil. Across their range, habitat loss is a serious threat to the terrapins. Barnegat Bay is already known as one of the most anthropogenically altered estuaries in the United States; over 35% of Barnegat Bay's shoreline is bulkheaded ("Effects of Artificial Shoreline"). The amount of sand washed away by Superstorm Sandy may have forced the terrapins to find more suitable nesting areas.

There was no significant difference in the egg mass, egg length and clutch size this season compared to the past three years. While the storm did affect the number of turtles nesting, this aspect of the reproductive output was not significantly altered. This year, there were

significantly less multiple nesters; those terrapins that would come back two or three times in one nesting season. This may indicate that the terrapins that did not return were predominantly multiple nesters or that there may have been some impacts on their energetics. Thus, they may expended great amounts of energy in the late fall to survive the storm, find a proper brumation area, or travel greater distances to a brumation area. This may mean that terrapins would not have enough energy to produce multiple clutches. Energy allocation to reproduction in animals is constrained by the animal's physiology, the environment, and resource limitations (Dunham et al. 1989). Pires also found in Western Pond turtles that resource availability is indicative of clutch frequency in Southern, California (2001).

It is important to look at next year's nesting season as well. There may be a lag effect in which the reproductive output may be significantly altered next year. There may be a considerable lag in response time when the habitat is altered, which was evident in painted turtles in altered habitats (Eskew et al. 2010). Additionally, it is important to replenish habitat. Terrapins choosing less appropriate nesting sites could mean increased predator access and compromised temperature and moisture. Although speculative, these factors should be looked at in more detail as the ecosystem continues to recover from Sandy.

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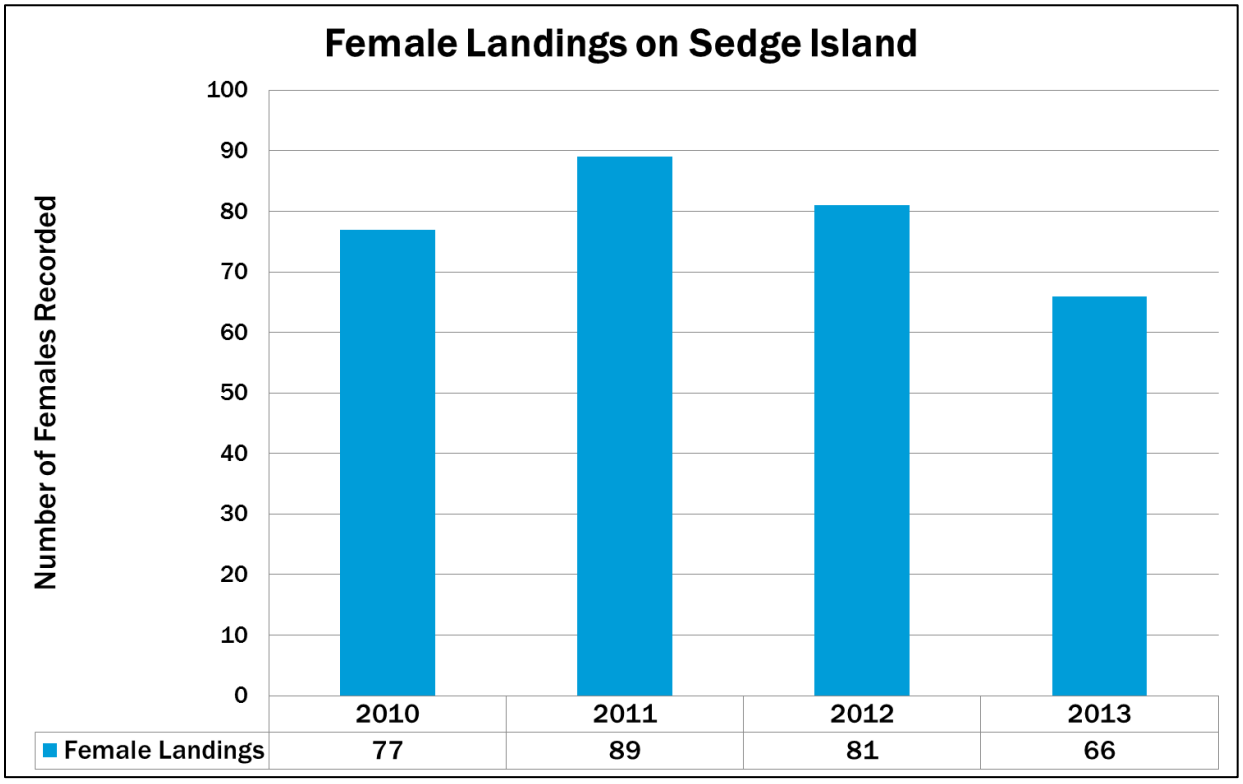

Figure 4. Number of female terrapins that were captured and processed.

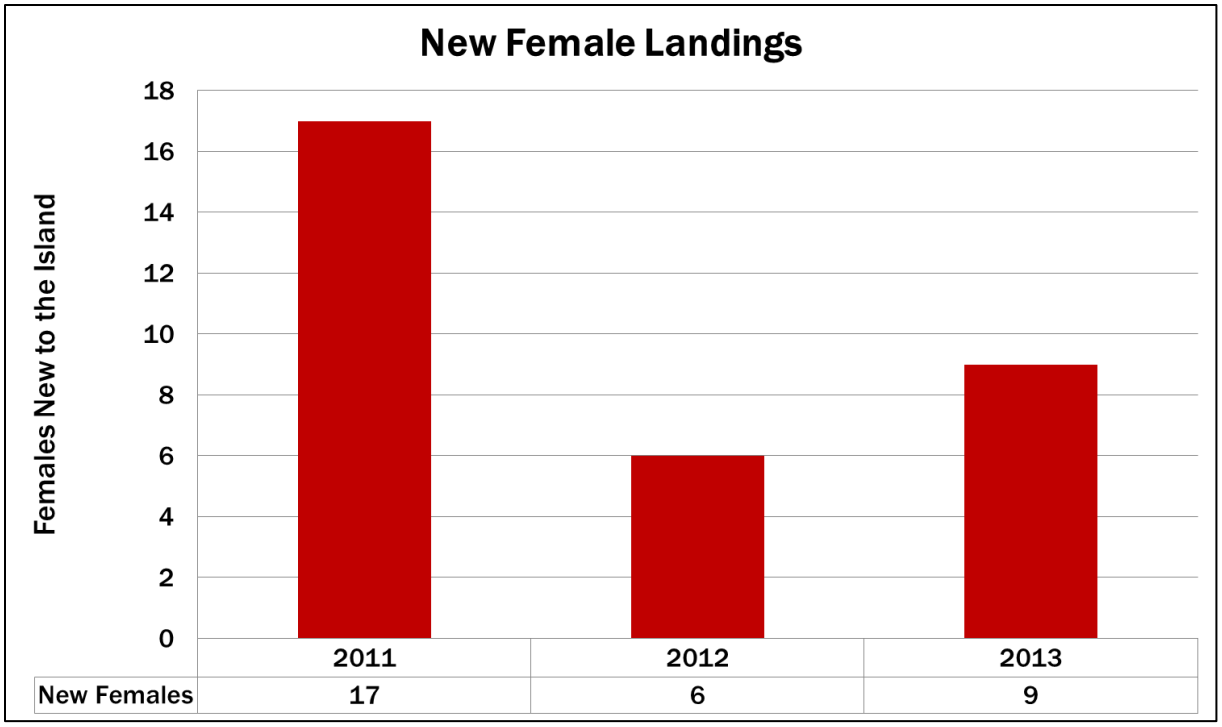

Figure 5. Number of new nesting female terrapins at N. Sedge Island.

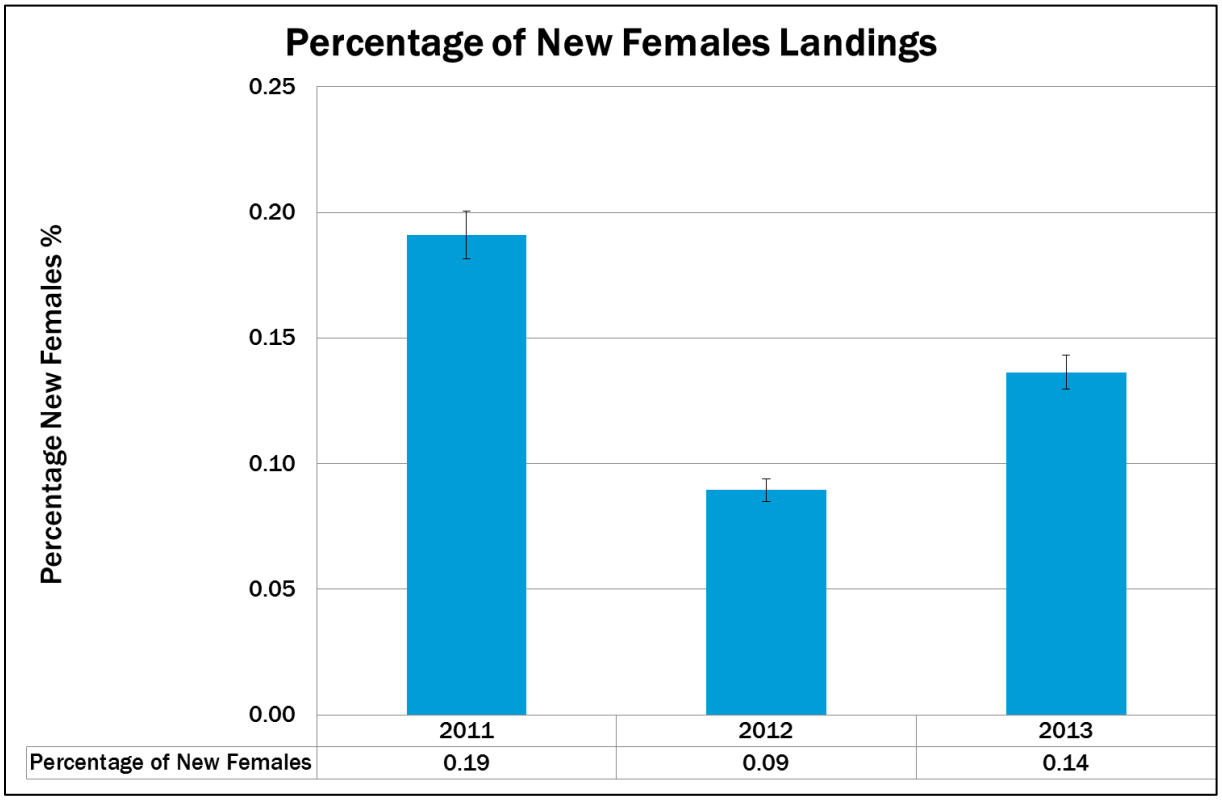

Figure 6. Percentage of landings that are new females at N. Sedge Island.

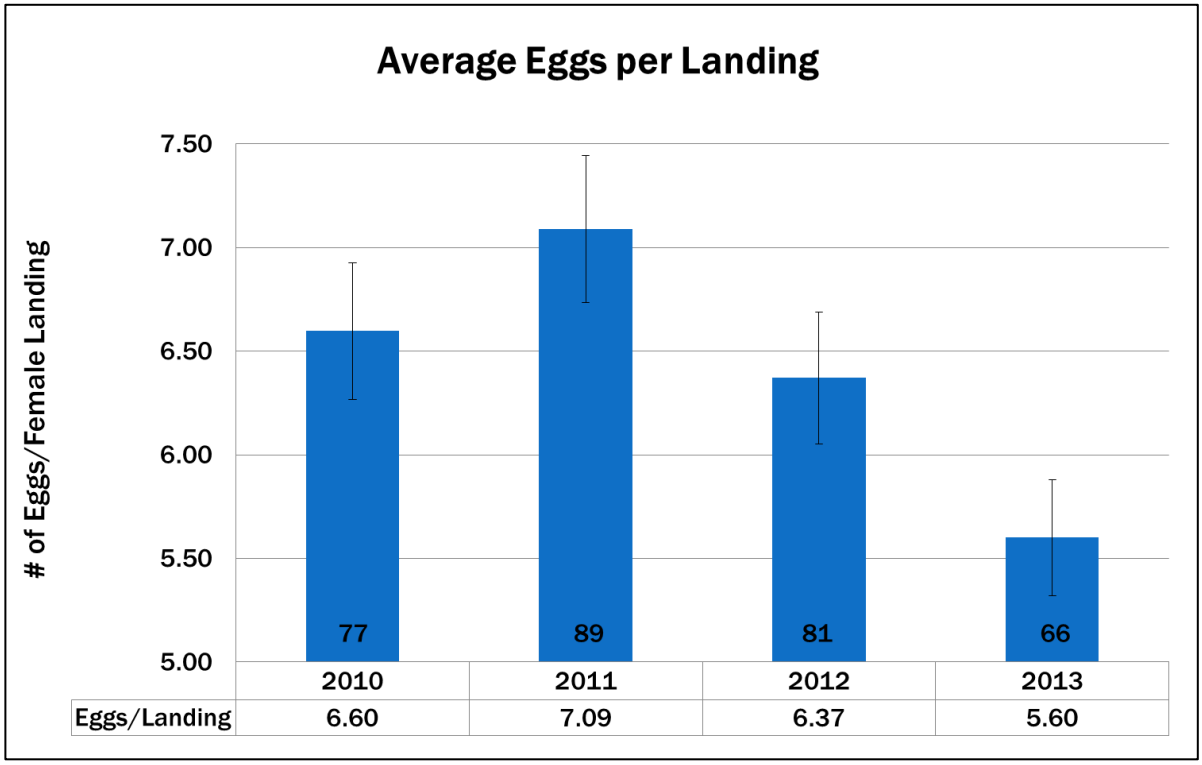

Figure 7. Average number of eggs per landing on N. Sedge Island.

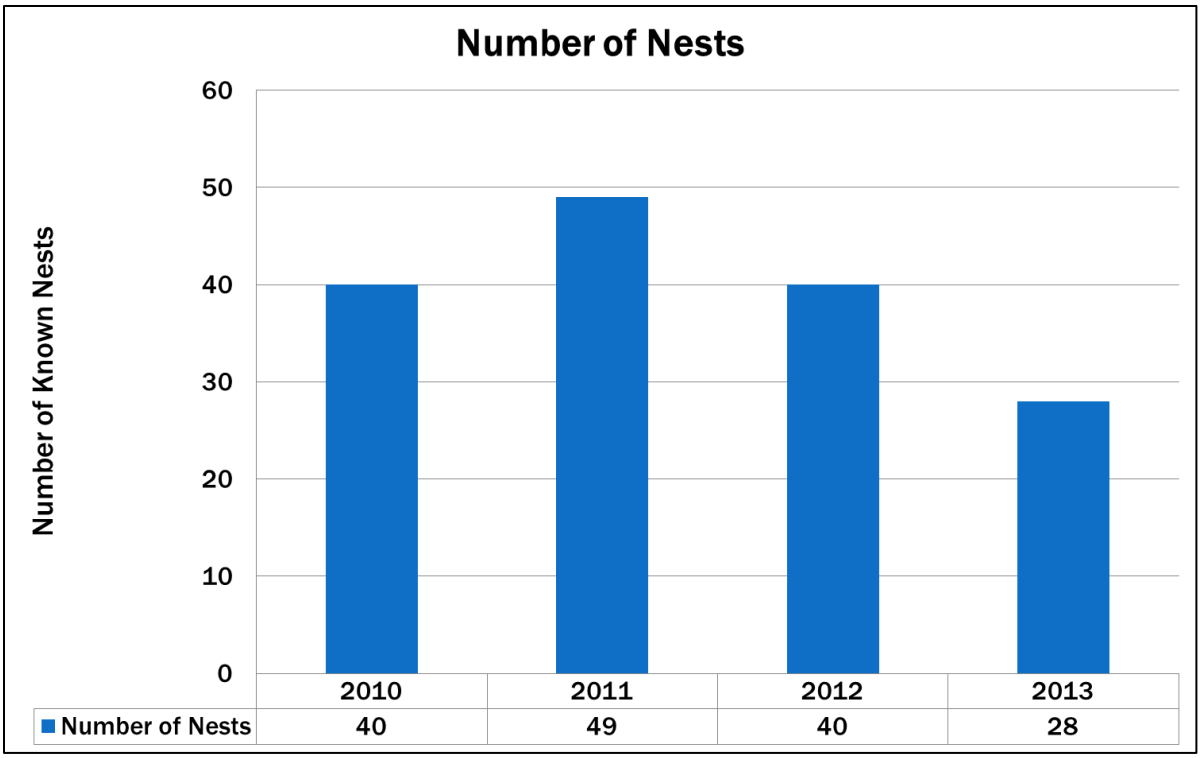

Figure 8. Number of known, non-predated nests on N. Sedge Island.

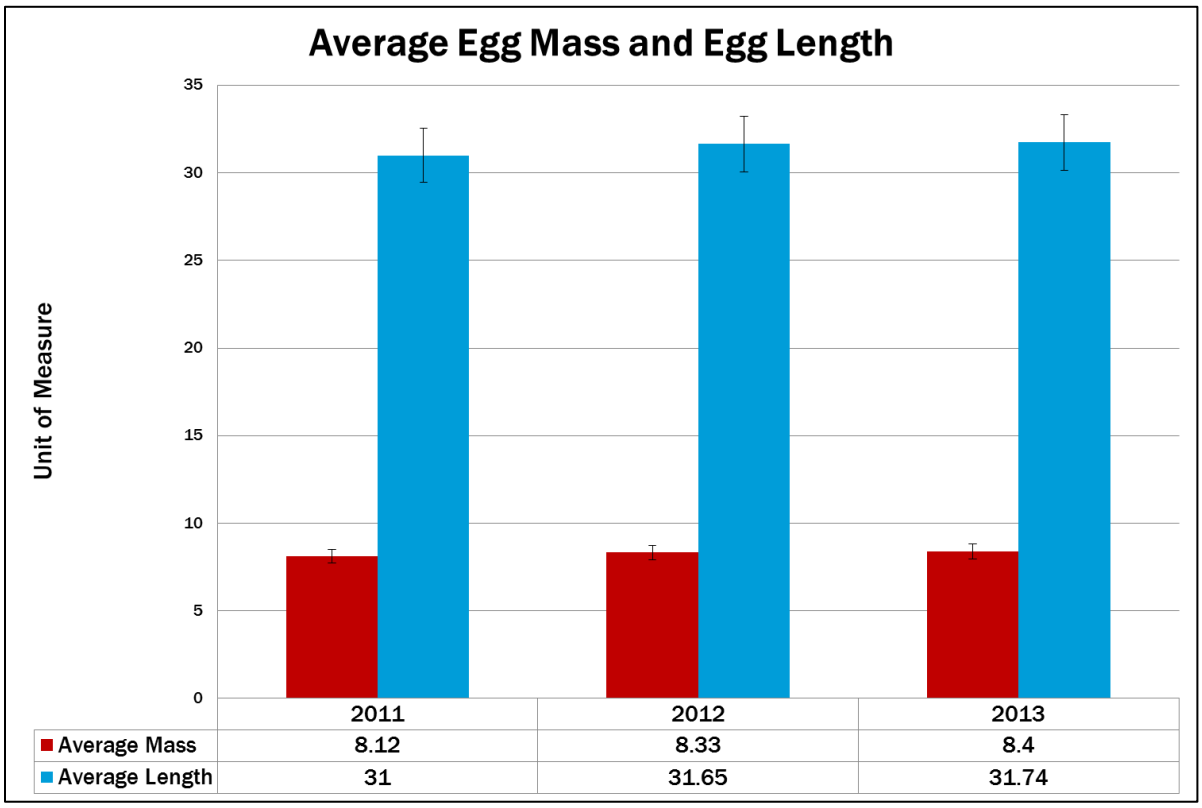

Figure 9. Average egg mass (g) and egg length (mm) at N. Sedge Island.

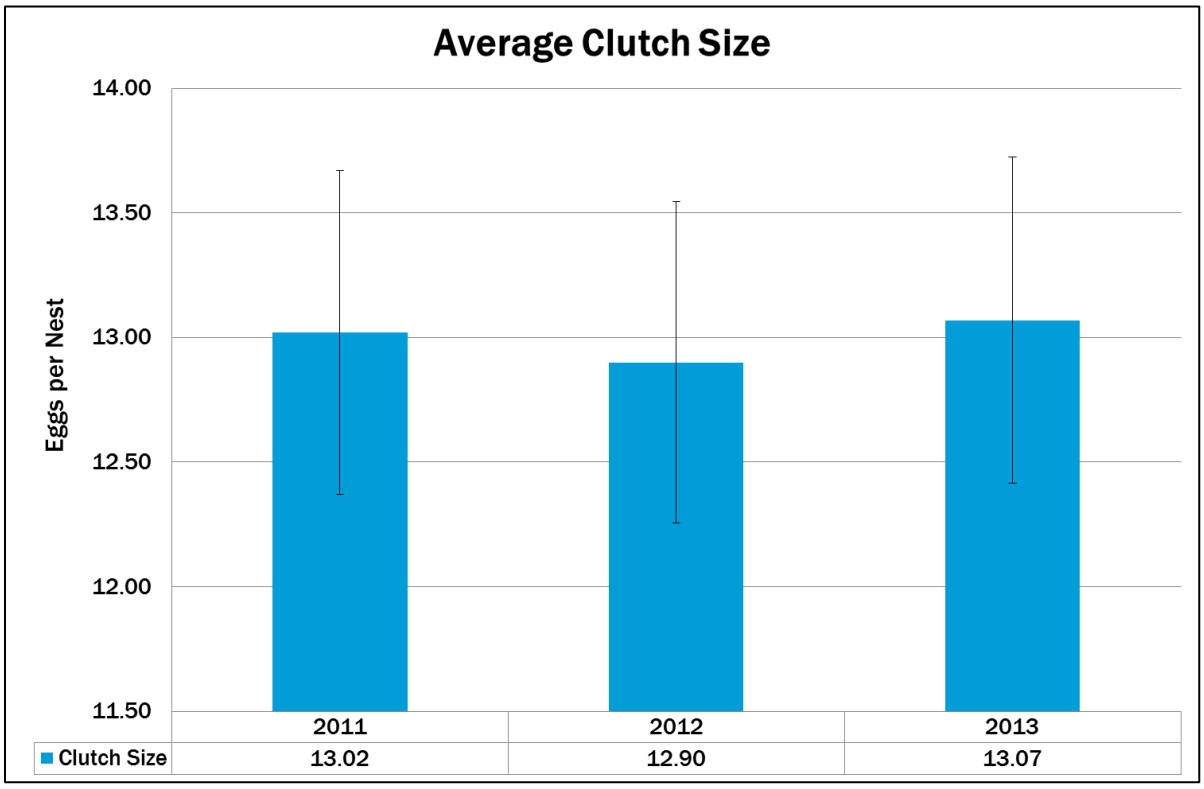

Figure 10. Average number of eggs per nest at N. Sedge Island.

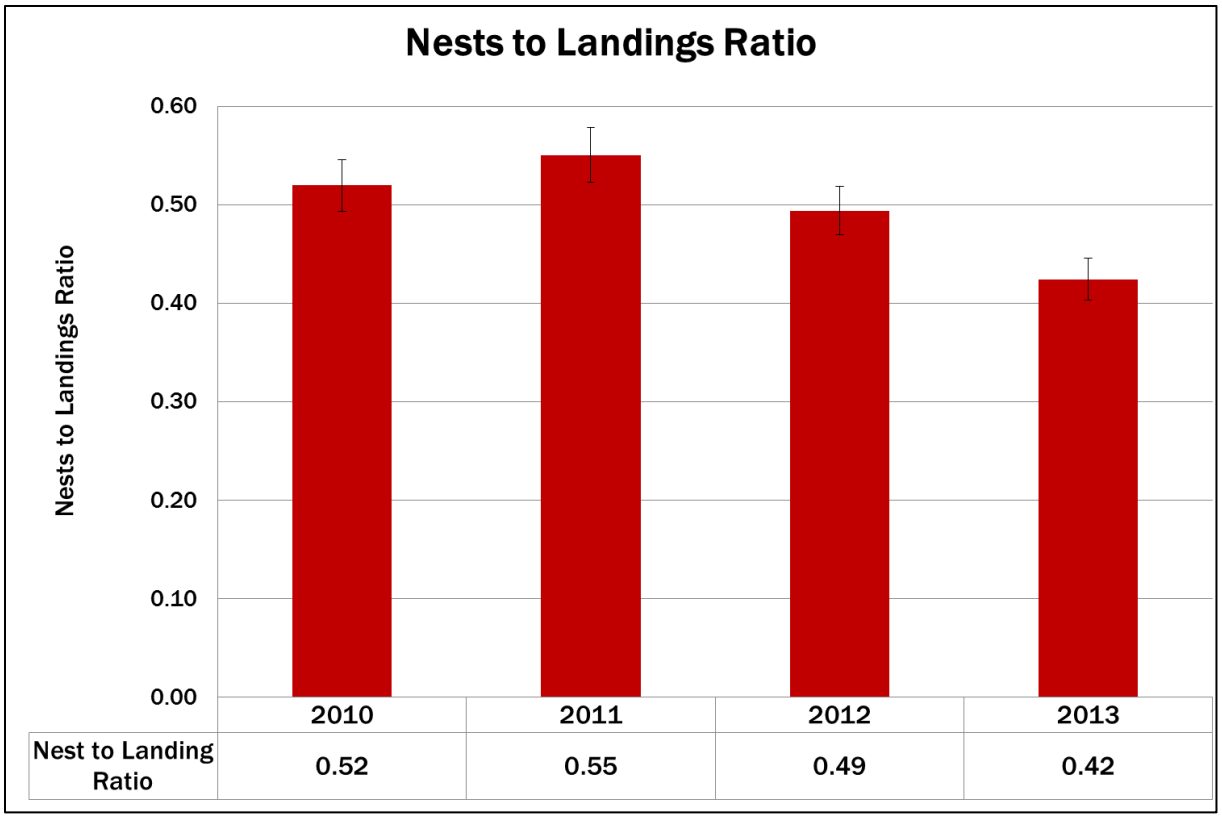

Figure 11. Percentage of landed females that nested at N. Sedge Island.

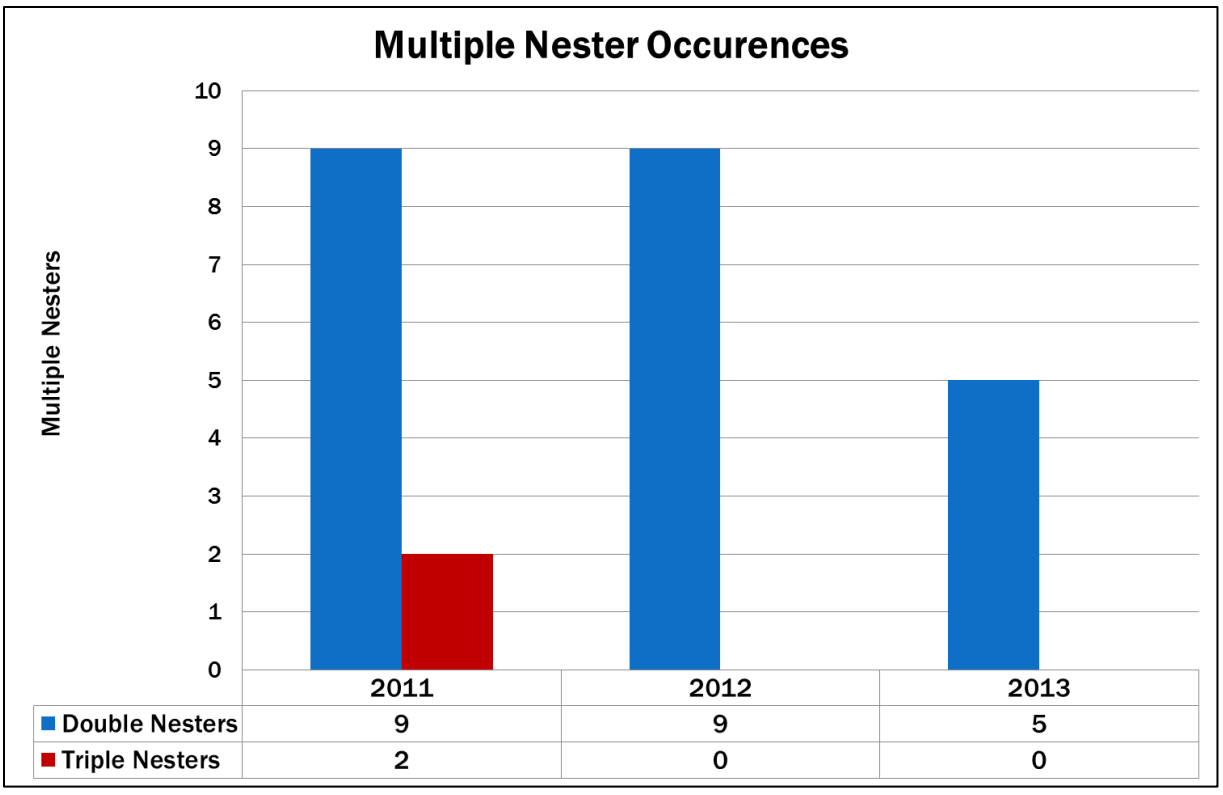

Figure 12. Number of females that nested more than once at N. Sedge Island.

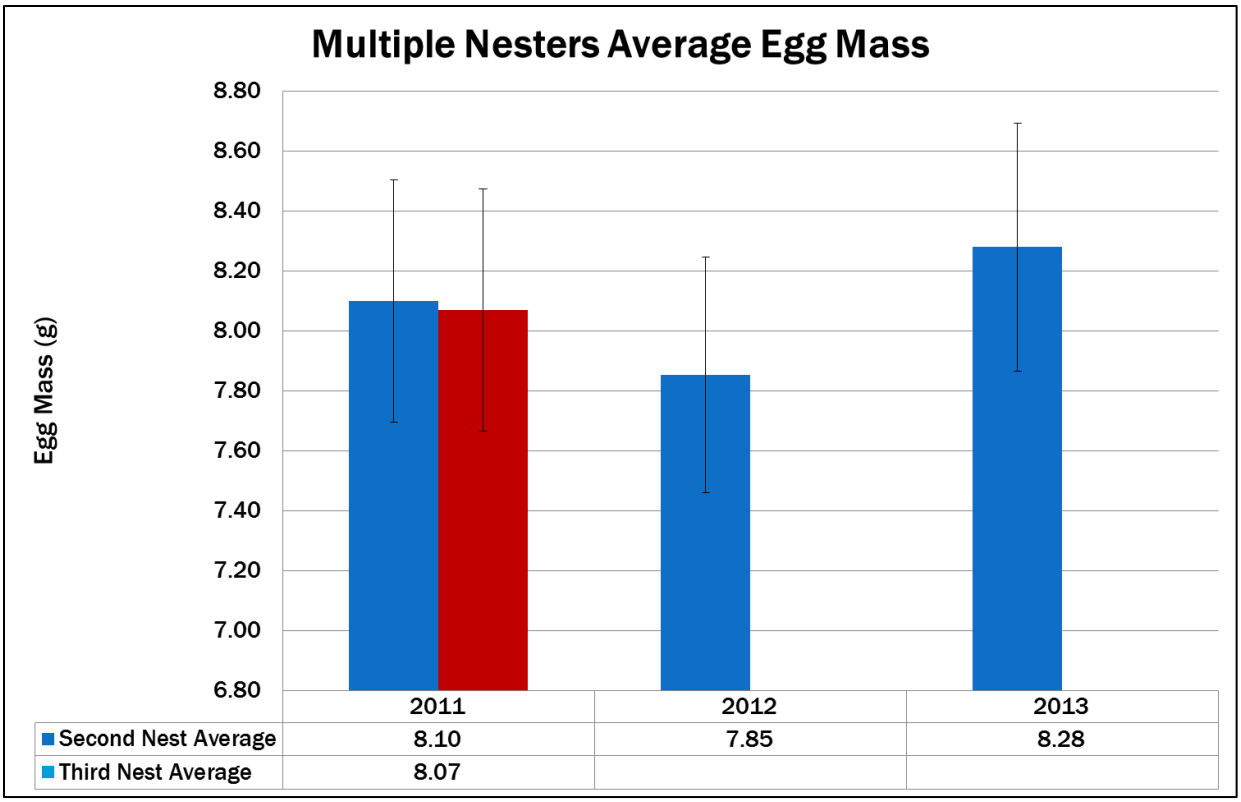

Figure 13. Average egg mass (g) of second and third nesters at N. Sedge Island. Note, that there were no third nesters in 2012 (indicating that we missed the first two weeks of the season). There were no triple nesters in 2013.