Pre-Project Inwater Survey of Marine Turtles
Brevard County FL Shore Protection Project, Mid Reach

Prepared by[1]:
East Coast Biologists, Inc.
P.O. Box 33715 | Indialantic, FL 32903 | 321-432-5545
eastcoastbiologists.net | kgha@earthlink.net
June 2015

INTRODUCTION

Boat surveys to document the presence of marine turtles within inter- and subtidal regions of the Mid Reach in Brevard County, Florida were conducted in summer of 2013 as a preparatory monitoring requirement prior to future beach nourishment construction activities along the Mid Reach shoreline. Abundance, distribution, life stage, and activities of marine turtles were recorded along the proposed project fill, designated buffer, and reference-area shorelines, in addition to the proposed mitigation reef areas. Data from similar monitoring conducted during previous survey periods (2005-2012) are also included in this summary report, along with measurements of sea turtle size in 2004-2014. These additional data allow a more comprehensive evaluation of marine turtle presence in the Mid Reach and demonstrate the extent of variability in the presence and detection of marine turtles under nearshore environmental conditions in Brevard County.

The Mitigation and Monitoring Plan for the Brevard County Mid Reach Beach Restoration (FDEP Permit #0254479-001-JC) includes the requirement for the equivalent of 5 survey transects (or survey days) to describe the in-water abundance, distribution, life-stage, and activity of marine turtles within the water along the shoreline of the Mid Reach and adjacent buffer/reference area of southern Patrick Air Force Base, as well as the area(s) in which the project's nearshore mitigation reefs are to be built. These monitoring surveys are to be conducted for conditions of (i) pre-construction, (ii) during-construction, (iii) post-construction, and (iv) at 1-, 2-, 3-, and 5-years after initial construction. The during-construction surveys are to be conducted with the objective of 1 survey day (2 transects) per month, seas permitting. This report describes the results of the pre-construction monitoring survey.

[1] This investigation and report was prepared for Brevard County Natural Resource Management Department, Vierra FL, under subcontract to Olsen Associates, Inc., Jacksonville, FL.

METHODS

Study Area

The reference, buffer, and fill areas of the Mid Reach shoreline project extend approximately 14.65 linear kilometers (9.1 miles) of nearshore waters of Brevard County coastline. The project area is bounded to the north within Patrick Air Force Base at latitude 28.230, longitude -80.597 and to the south within the city of Indialantic at latitude 28.103, longitude -80.568 (Figure 1). The area lies within FDEP R-monuments 68 and 119 [R-monument numbers are herein referred to as R*nn*] or more precisely, between R75.3 and R118.3 (Figure 2).

Transect surveys

Boat survey methods and ocean condition parameters--Systematic visual transect surveys used to estimate the abundance of marine animals (Dawson et al. 2004, Bresette et al. 2010) were conducted to standardize marine turtle abundance and distribution within the study area. Research crews of two observers and a boat driver, trained in the identification of marine turtles, conducted surveys from a 24' Carolina Skiff boat equipped with a 150-hp engine and a sighting tower. Observers were stationed side-by-side in the tower and scanned the waters for turtles from the side of the boat they were closest to, out to approximately 50 m distance, while the boat driver maintained a traveling speed between 9 and 11 km/hour. When a turtle was observed, the boat driver entered a time-stamped GPS waypoint, recorded the turtle species and life-history stage (juvenile or adult) as reported by the observer(s). Water depth and visibility (water clarity) estimates were documented during surveys and updated as conditions changed during each visual transect survey. Water depth was measured via a Hummingbird (Matrix 10) depth/fishfinder. Water clarity was measured by submerging a pre-measured boat hook towards the seafloor to the depth where the submerged hook was no longer visible. The following data were recorded for turtles sighted during surveys: (1) location of the turtle in relationship to the transect track (inside, outside or on the transect line), (2) location of the turtle within the water column (top, middle, or bottom), and (3) the turtle's behavior (swimming, breathing, resting, foraging). While ocean conditions are highly dynamic along this coastal region, efforts were made to conduct transect surveys under as similar conditions as possible, targeting days with relatively "ideal" conditions (i.e., >1.0 meter visibility, calm seas, clear skies).

Nearshore hardbottom (NHB) transects--At least one shore-parallel transect was conducted per survey day along the NHB. Depending on inshore swell activity, surveys were conducted approximately 25 to 90 m from shore in 0.9-1.8 m water depth. Transects were haphazardly selected to begin at either the designated reference location R68 (PAFB; Figure 2) and progress south, or begin at the southernmost Fill Area 4 (R119) and proceed north.

Mitigation reef site (MIT) transects--The footprint of the designated construction site for the total MIT is approximately 98,800 m^2, of which 19,450 m^2 (4.8 acres) is to be reef substrate, and

located in 4.5-5.5 m water depth. Surveying for marine turtles within the proposed MIT site consisted of conducting transects that crossed through the area and covered 0.5 km linear distance altogether.

Data analysis

Marine turtle spatial distribution--Coordinates (lat/long) from GPS waypoints collected for turtles observed during surveys were superimposed on a geo-referenced map (©Google Inc. 2013) with the designated FDEP R-monument coordinates. Turtle locations were assigned to the lower R-monument number. For example, if the lat/long of a turtle observation was between R94 and R95, the turtle was assigned to R94. Marine turtle sightings were ultimately assigned to 6 discrete segments (blocks; Figure 2) or the mitigation reef (MIT; not shown) of the project area between the following R-monuments:

Reference Area (R68-R75) = 2.0 km

Buffer Area (R75-R78) = 0.85 km

Fill Area 1 (R78-R88) = 3.0 km

Fill Area 2 (R88-R99) = 3.0 km

Fill Area 3 (R99-R110) = 3.3 km

Fill Area 4 (R110-R118) = 2.5 km

MIT section (located ~275 m east of R105) = 0.5 km

Density estimates--Marine turtle observations were calculated based on the number of turtles: (1) per transect, (2) per total km area surveyed, and (3) within each segment or MIT section of the project area (Figure 2). In addition, results of turtles per segment area from this pre-construction monitoring period were compared with previous marine turtle surveys utilizing the same methods and conducted in the same location since 2005.

Other marine turtle data

Mean size of juvenile green turtles--From 2004 to 2014, juvenile green turtles were captured using both tangle and dip net capture methods. The average annual straight carapace lengths (SCL) of green turtles captured within the study area during the past 11 years were compared to examine potential changes in the mean size of turtles utilizing the NHB within the Mid Reach project area.

RESULTS

Survey conditions

Temperature, visibility, and sea state parameters during surveys--Five transect survey days met the criteria for weather and water conditions for data collection and the equivalent of 6.5 transects were conducted between July 13 and August 31, 2013 (Table 1). Air temperatures ranged from 27.8-28.3°C (average 28.2 ± 0.2°C) and water temperatures ranged from 23.3-28.9°C (26.5 ± 2.0°C) (Table 1). The clearest water (4.0 m visibility) was encountered on July 27 and the lowest visibility (1.0 m) occurred during the August sampling periods (Table 1). Seas ranged between 0.0 and 1.3 m.

Transect Surveys

Nearshore hardbottom (NHB) surveys--Five full and 3 partial transects were conducted within the project area covering a total distance of 95.3 km. A total of 50 green turtles (*Chelonia mydas*) and 1 loggerhead (*Caretta caretta*) were observed during transects. Marine turtle density was greatest (1.87 average number of turtles per km distance surveyed) during the second transect performed on July 27 (16 turtles observed in 8.55 km; Table 1, Figure 3). Spatially, turtle density within the Buffer segment was highest [1.85 turtles/km (± 2.34 SD)] followed by Fill-1 and Fill-2 segments [0.88 and 0.81 turtles/km, respectively; Appendix Table 1A(ii), Figure 4]. No marine turtles were observed in the southern section of the project area between R97 and R119 which represents Fill-3 and 4 segment areas [Appendix Table 1A(ii), Figure 4].

Mitigation reef (MIT)--Surveys of the proposed mitigation reef area near R105 were conducted 5 times covering a total of 2.5 km (0.5 km per survey). No marine turtles were observed within this area [Appendix Table 1A(ii), Figure 4].

Historic marine turtle survey data

Transect surveys--A total of 35 transects have been conducted since 2005 (Table 2, Figure 5). The numbers of visual transect surveys conducted by boat per year ranged between 0 (in 2006) and 11 (in 2005). Surveys were predominantly in spring and summer; however, one survey was conducted in winter (February 2, 2008) and one in fall (November 4, 2012) (Table 2). Juvenile green turtles were observed in the winter transect, but not the fall transect; however, stationary transect data from shoreline surveys (not presented here) indicate turtles were present every season. During the past 9 years (2005-2013), one loggerhead (*Caretta caretta*) and 491 juvenile green (*Chelonia mydas*) turtles were observed in boat transect surveys within the Mid Reach (Table 2).

Density--The mean number of turtles observed per kilometer survey area for all study years combined was 61.5 ± 98.1 [492 turtles/8 years; Appendix Table 2A(i)]. Observations of turtles by year ranged from 0 in 2011 surveys (n = 2 transects) to 298 in 2008 surveys (n = 4 transects)

[Appendix Table 2A(i)]. While the Buffer segment (0.9 km) was the shortest distance within the project shoreline survey area [28.9 km; Appendix 2A(ii)], it had the highest density of marine turtles [2.5 turtles per km; Appendix Table 2A(iii), Figure 6]. Only one juvenile green turtle was observed within the Fill-4 segment, noted during the survey conducted May 24, 2008 [Appendix Table 2A(i), Figure 6].

Water column location and activity--Green turtles were more frequently observed in waters shoreward of the boat transect position (in), taking a breath at the surface (Figure 7). Exceptional water clarity during the transect conducted July 3, 2008 allowed an abundance of turtles to be observed throughout the entire water column. On this day, a large percentage of turtles were observed resting or swimming near the bottom (Figure 7).

Mean size class--The number of turtles captured (excluding recaptures) per year varied from 0 in 2011 and 2012 to 23 in 2014. Mean straight carapace length was largest in 2004 (37.0 ± 9.6 cm SCL; Holloway-Adkins and Provancha 2005) and smallest in 2014 (27.2 ± 1.9 cm SCL; Figure 8). The mean SCL of juvenile green turtles in 2014 was significantly smaller in comparison to turtles captured in previous years (p value adjusted pairwise t-test, $t = 36.96$, $p < 0.001$; Figure 8).

DISCUSSION

Transect surveys

2013 Nearshore hardbottom (NHB) transect surveys--Green turtle abundance was concentrated in the rock-dense region of the Mid Reach (Fill-1 and 2; R78-R98) as well as the project Reference and Buffer segments (R68-R77). No turtles were observed in Fill-3 and 4 segments which contains comparatively little hardbottom habitat than the more rock-dense areas to the north.

Mitigation Reef Site--No marine turtles were observed in transects over the proposed mitigation reef site. However, this is not surprising since it is strictly a sand bottom habitat at this time, void of forage and/or shelter resources for marine turtles, especially green turtles that generally forage macroalgae growing on hardbottom in nearshore waters.

Historic marine turtle survey data

Marine turtle transects--Differences in the number of transect surveys conducted among years were primarily due to weather conditions and, secondarily due to targeted study activity during that year, and/or available funding (unrelated to the Mid Reach project). Differences in water clarity most likely influenced the number of observed turtles. On adequate survey days with good-to-excellent water clarity (>3.0 m), population estimates based on the number of turtles observed at the surface, may be calculated with confidence. When visibility varied considerably or when the clarity of entire transects were ≤1.0 m, the density of marine turtles was likely a

conservative estimate of the actual number of turtles within those areas/transects (see comments from aerial surveys in: Bayliss 1986, Benson 2007). Natural conditions and characteristics of this region (east central Florida coast) produce high variability in water clarity and conditions along the Mid Reach shoreline.

Mean size class of juvenile green turtles--Capture data continue to indicate that marine turtles utilizing the nearshore reefs in Brevard County are primarily green turtles and the mean size of turtles is at the smaller end of the juvenile size class (Hirth 1997). In 2014, the size range of juvenile green turtles captured (23.0-30.4 cm SCL) indicate these turtles have newly recruited from oceanic to neritic habitats.

CONCLUSION

During the past decade, knowledge of juvenile green turtles use of NHB habitat has greatly expanded through capture, tagging, measuring, foraging analyses, and acoustic tracking activities as well as the assessment of turtles' spatial distribution through transect surveys. The continuity of data collection during and after the completion of the Mid Reach shoreline project will be critical to examining the extent in which shoreline alterations influence the distribution of green turtles in the area. At this time, there are no data on juvenile green turtle use of mitigation reef sites within high energy shorelines. Monitoring of these activities will also be important to agencies assessing the materials used in artificial reef construction as well as the challenges and success of deploying structures along highly dynamic shorelines.

REFERENCES

Bayliss P 1986. Factors Affecting Aerial Surveys of Marine Fauna, and Their Relationship to a Census of Dugongs in the Coastal Waters of the Northern-Territory. Wildlife Res 13(1):27-37.

Benson SR, Forney KA, Harvey JT, Carretta JV, Dutton PH. 2007. Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990− 2003. Fish Bull 105(3):337-347.

Bresette MJ, Witherington BE, Herren RM, Bagley DA, Gorham JC, Traxler SL, Crady CK, Hardy R. 2010. Size-class partitioning and herding in a foraging group of green turtles *Chelonia mydas*. Endanger Sp Res 9:105-116.

Dawson S, Slooten E, DuFresne S, Wade P, Clement D. 2004. Small-boat surveys for coastal dolphins: line-transect surveys for Hector's dolphins (C*ephalorhynchus hectori*). Fish Bull 102(3):441-451.

Hirth HF. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). Washington D.C.: Fish and Wildlife Service, U.S. DOI. Biological Report

Holloway-Adkins KG, Provancha JA. 2005. Abundance and foraging activity of marine turtles using nearshore rock resources along the Mid Reach of Brevard County, Florida. Jacksonville, FL: Dynamac.

Table 1. Surveys conducted in 2013 for pre-construction monitoring of sea turtles within the Brevard County Mid Reach project area. Surveys were conducted under as similar conditions as possible since weather, sea state, and water clarity strongly influence the ability to detect sea turtles in surveys. Full surveys included the reference, buffer, and fill areas. The proposed mitigation reef site (MIT), seaward of Canova Beach (R105), was surveyed with cross transects that equaled 0.5 km distance through the area. The shaded rows are individual days which frequently had more than one transect or area surveyed.

Date	Transect by day	Air temp (°C)	Average wind (mph)	Wind direction	Seas (m)	Average water temp (°C)	Water clarity range (m)	*C. mydas* observed	*C. caretta* observed	Transect distance (km)	*C . mydas* per km	*C. caretta* per km
13-Jul-13	1-FULL	28.3	5	SSE	0-1.3	23.3	1.0-1.5	0	0	14.65	0	0
27-Jul-13	1-PART	28.3	4	SSW	0-1.3	28.9	4.0	2	0	4.0	0.5	0
27-Jul-13	2-PART	28.3	4	SSW	0-1.3	28.9	4.0	16	0	8.55	1.87	0
28-Jul-13	1-FULL	28.3	4	SSW	0.3-0.6	26.6	1.0-3.0+	20	1	14.65	1.37	0.07
28-Jul-13	MIT	28.3	4	SSW	0.3-0.6	26.6	1.0-3.0+	0	0	0.50	0	0
28-Jul-13	2-PART	28.3	4	SSW	0.3-0.6	26.6	1.0-3.0+	7	0	9.50	0.74	0
17-Aug-13	1-FULL	27.8	9	SE	0.3	26.6	1.0	0	0	14.65	0	0
17-Aug-13	MIT	27.8	9	SE	0.3	26.6	1.0	0	0	0.50	0	0
17-Aug-13	2-FULL	27.8	9	SE	0.3	26.6	1.0	4	0	14.65	0.27	0
17-Aug-13	MIT	27.8	9	SE	0.3	26.6	1.0	0	0	0.50	0	0
31-Aug-13	1-FULL	28.3	8	SSW	0-0.6	27.2	1.0	1	0	14.65	0.07	0
31-Aug-13	MIT	28.3	8	SSW	0-0.6	27.2	1.0	0	0	0.50	0	0
31-Aug-13	MIT	28.3	8	SSW	0-0.6	27.2	1.0	0	0	0.50	0	0

Table 2. The number of marine turtles observed in transect surveys that were conducted between April 22, 2005 and August 31, 2013. No transect surveys were conducted in 2006. Excludes mitigation reef (MIT) surveys conducted in 2013 (see Table 1).

Transect Date	*Chelonia mydas*	*Caretta caretta*	Transect length (km)
22-Apr-05	3	0	12.65
13-May-05	0	0	12.65
23-May-05	0	0	12.65
24-May-05	2	0	12.65
30-May-05	6	0	12.65
16-Jun-05	0	0	12.65
19-Jun-05	14	0	12.65
7-Jul-05	9	0	14.65
17-Jul-05	6	0	14.65
24-Jul-05	15	0	14.65
6-Aug-05	10	0	14.65
23-Jun-07	20	0	14.65
9-Feb-08	6	0	11.5
24-May-08	5	0	14.65
3-Jul-08	245	0	14.65
2-Aug-08	42	0	14.65
31-May-09	3	0	12.0
2-Jul-09	7	0	12.0
30-Aug-09	3	0	14.65
19-Jun-10	38	0	12.65
10-Jul-10	0	0	14.65
18-Jun-11	0	0	12.0
4-Jul-11	0	0	12.0
6-Jul-12	3	0	8.55
29-Jul-12	0	0	12.0
18-Aug-12	4	0	12.0
4-Nov-12	0	0	12.0
13-Jul-13	0	0	14.65
27-Jul-13	2	0	4.0
27-Jul-13	16	0	8.55
28-Jul-13	20	1	14.65
28-Jul-13	7	0	9.5
17-Aug-13	0	0	14.65
17-Aug-13	4	0	14.65
31-Aug-13	1	0	14.65
Total km surveyed	491	1	447.1

Figure 1. Study area location on the east coast of Florida between the south end of Patrick Air Force Base (PAFB) and north end of the city of Indialantic (approximately 14.65 km or 9.1 miles). The study area extends from latitude 28.230, longitude -80.597 south to latitude 28.103, longitude -80.568.

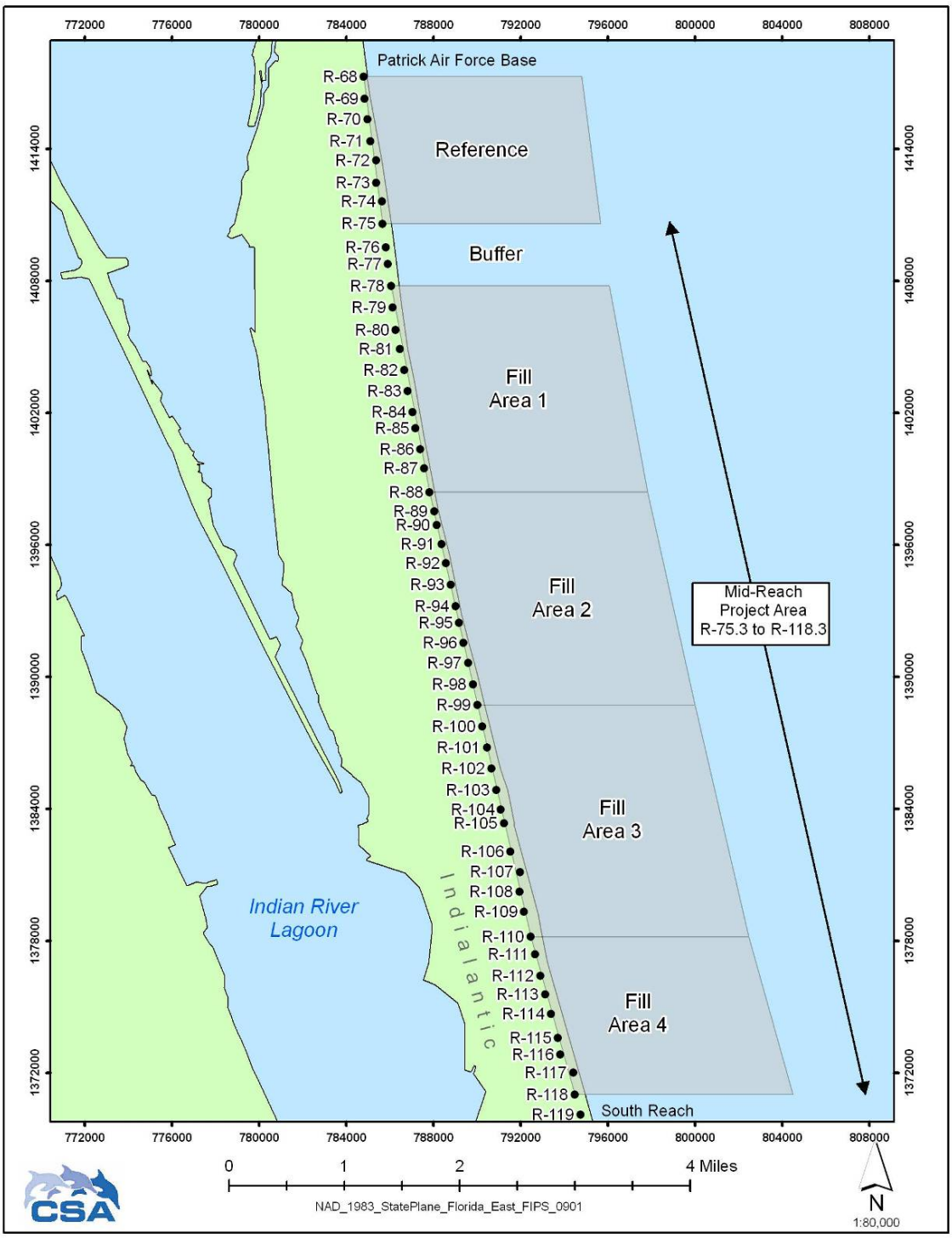

Figure 2. Fill area and reference-area segments along the natural nearshore hardbottom of the project area and adjacent shorelines. Segments of the project area were different sizes and were located between the following FDEP R-monument numbers: Reference (R68-75; 2.0 km), Buffer (R75-78; 0.85 km), Fill-1 (R78-88; 3.0 km), Fill-2 (R88-99; 3.0 km), Fill-3 (R99-110; 3.3 km), and Fill-4 (R110-119; 2.5 km).

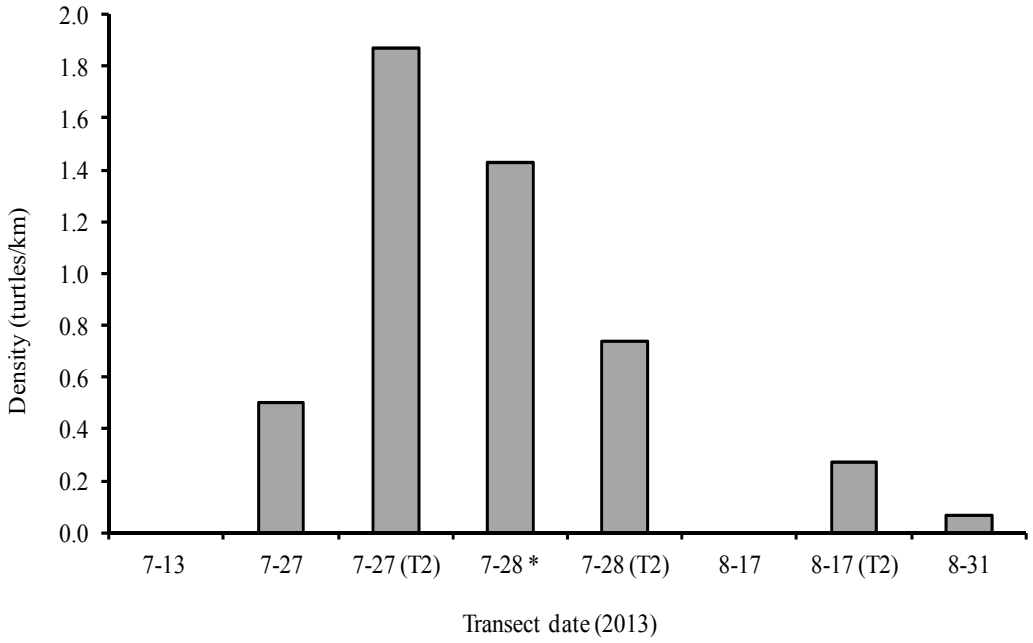

Figure 3. Density of marine turtles per kilometer in pre-construction monitoring surveys conducted during the summer of 2013 (see Table 1). Juvenile green turtles were the dominant species over nearshore reefs; however, one loggerhead sea turtle (*Caretta caretta*) was sighted in the first transect conducted on July 28, 2013 (*). Does not include data from MIT (proposed mitigation reef area).

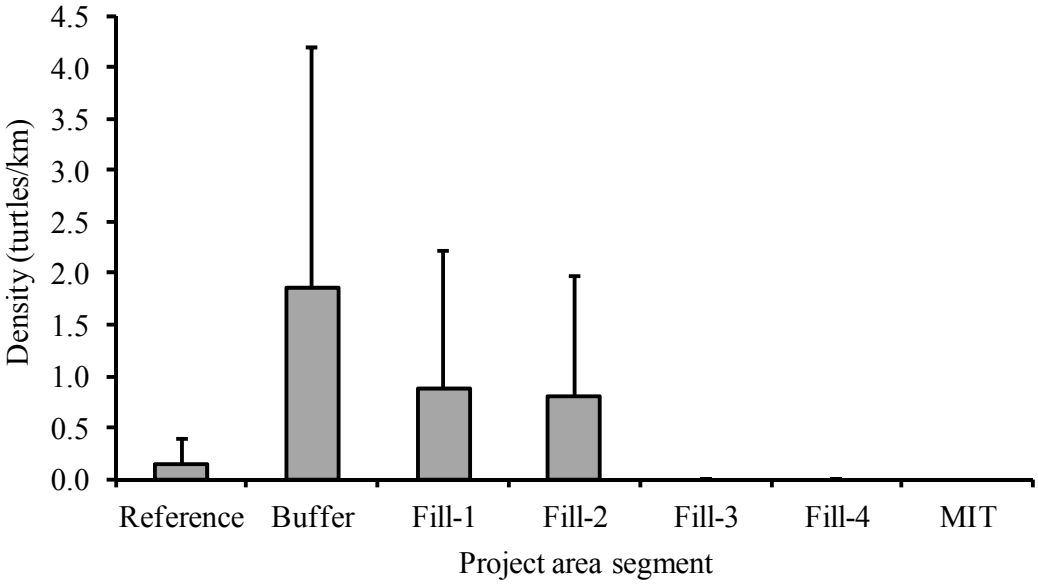

Figure 4. Marine turtle density (whiskers are + standard deviation) per kilometer of shoreline within project area segments and proposed mitigation reef site (MIT). Data are from visual transects surveys conducted in summer of 2013 [see Appendix, Table 1A] for pre-construction monitoring of the Mid Reach shoreline project.

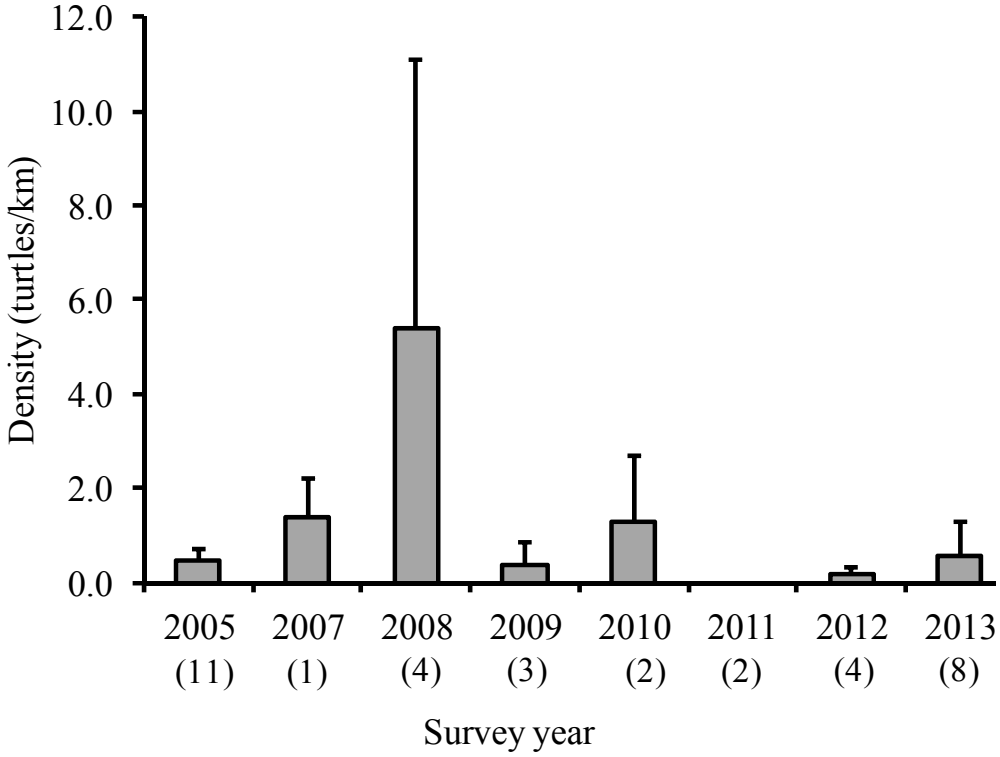

Figure 5. Density of marine turtles in the Mid Reach project area based on the mean number of turtles observed (whiskers are + standard deviation) per kilometer in transect surveys conducted during 2005-2013 (see Table 3, Appendix Table 2A). Values in parentheses are the number of transects conducted during the survey year. No transects were conducted in 2006.

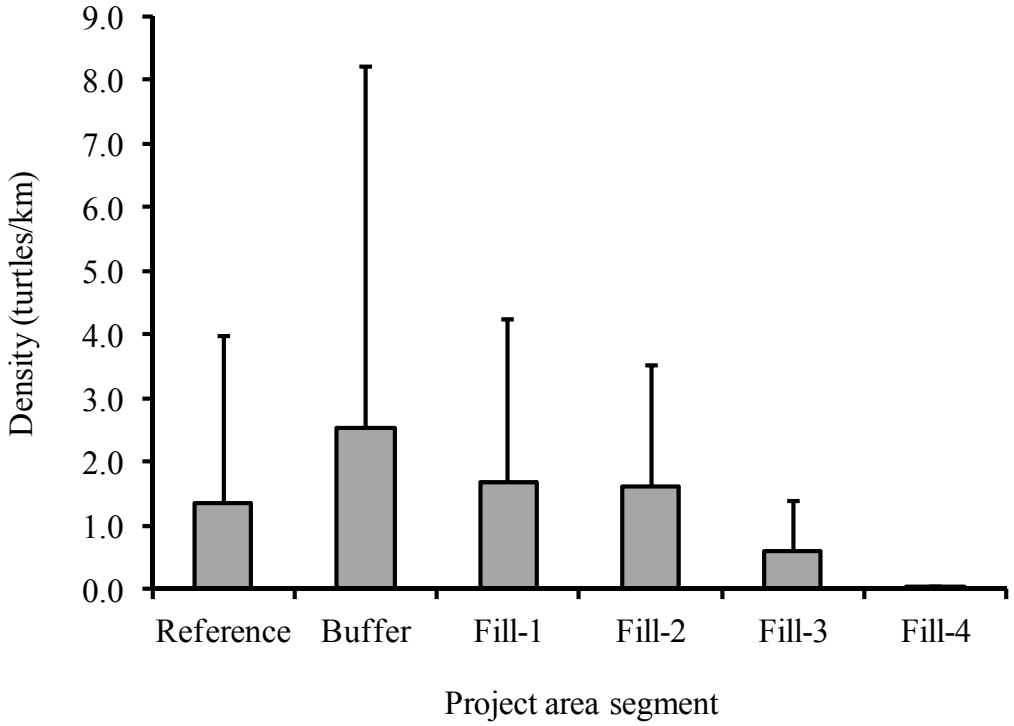

Figure 6. Density of all marine turtle observations (whiskers are + standard deviation) from 2005-2013 within the Mid Reach shoreline project segments (see Appendix Table 2A). No transects were conducted in 2006.

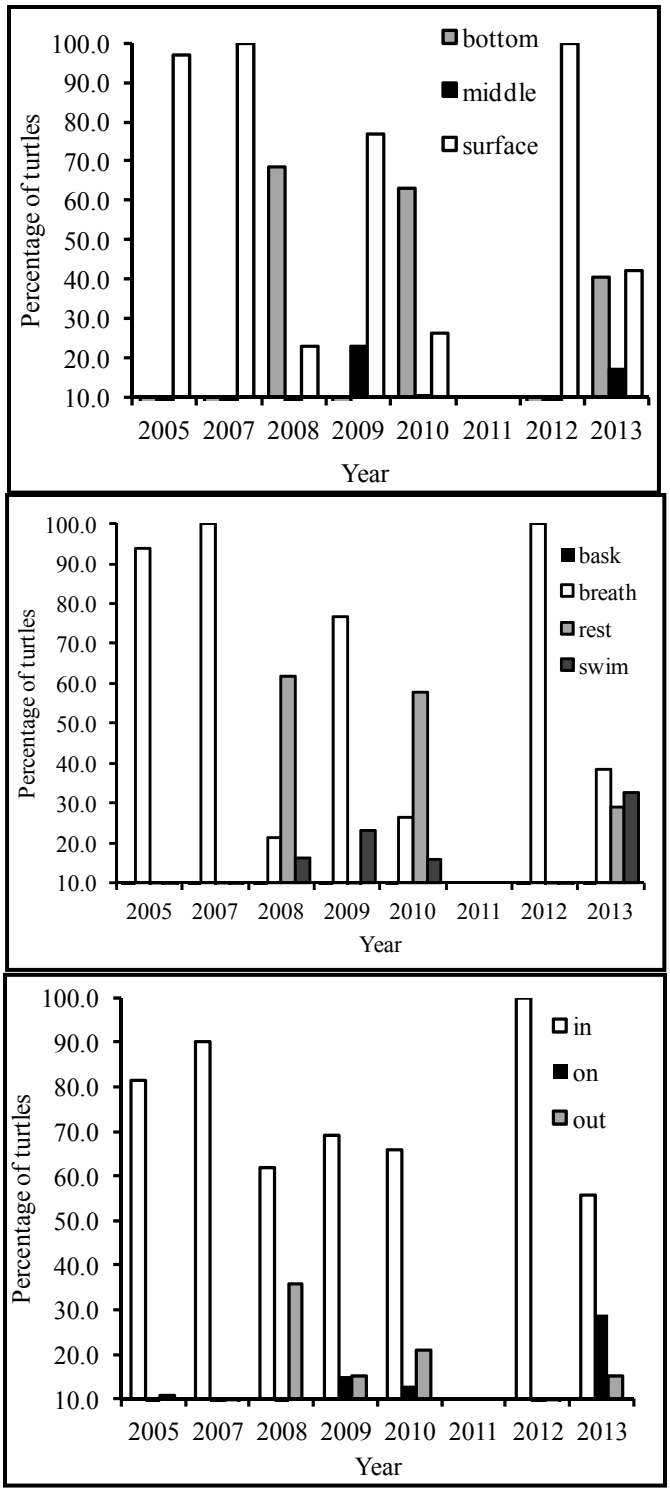

Figure 7. Percentage of turtles observed at positions within the water column (surface, bottom, middle; top graph), their activity (basking, breathing, swimming, resting; center graph), and position from the transect line (or boat; bottom graph) during visual transects. Surveys were conducted primarily in summer between 2005 and 2013. No transects were conducted in 2006 and no turtles were observed on the 2 transects conducted in 2011.

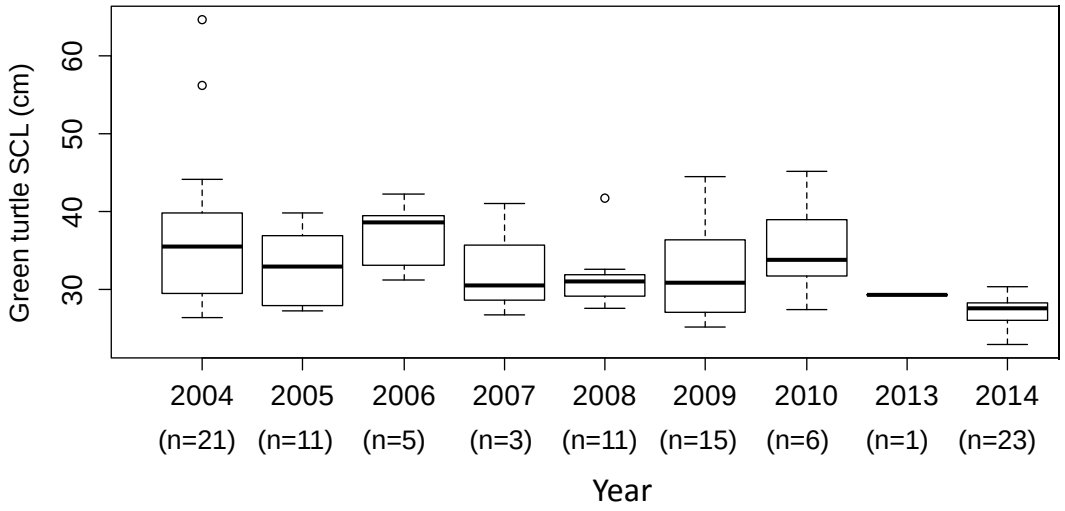

Figure 8. Box and whisker plot of straight carapace lengths (SCL cm; ± SD) of juvenile green turtles captured over nearshore reefs within the Mid Reach project area (2004-2014).The bottom and top of the boxes are the 1st and 3rd quartiles and the dark middle band = median size. The "whiskers" are the 2nd and 98th percentile and the open circles are the extreme outliers. Green turtles captured in 2014 were significantly smaller when compared with turtles captured in previous years (p value adjusted pairwise t-test, t = 36.96, p <0.001).

APPENDIX

Table 1A. Area surveyed (km distance) in transects by segment and mitigation reef area (MIT) for 6.5 transect surveys conducted in 2013 (i). Mean number of marine turtle observations per project segment (km) (ii). T2 = is the second transect conducted on the same survey day. One survey of MIT area = 0.5 km. Segments or areas (i.e., MIT) that were not surveyed during a transect are indicated by "-" symbol.

(i) area surveyed (km) by project segment and mitigation reef

Date	REFERENCE	BUFFER	FILL-1	FILL-2	FILL-3	FILL-4	MIT	Total distance by survey
13-Jul-13	2	0.85	3	3	3.3	2.5	-	14.65
27-Jul-13	-	-	3	1	-	-	-	4.00
27-Jul-13 (T2)	2	0.85	3	2.7	-	-	-	8.55
28-Jul-13	2	0.85	3	3	3.3	2.5	-	14.65
28-Jul-13 (T2)	2	0.85	3	3	0.66		0.5	10.0
17-Aug-13	2	0.85	3	3	3.3	2.5	-	14.65
17-Aug-13 (T2)	2	0.85	3	3	3.3	2.5	1.0	15.65
31-Aug-13	2	0.85	3	3	3.3	2.5	1.0	15.65
Total survey distance by segment	14.00	5.95	24.00	21.70	17.16	12.50	2.50	97.8

(ii) Density of turtle per project segment or mitigation reef (turtles/km)

Date	REFERENCE	BUFFER	FILL-1	FILL-2	FILL-3	FILL-4	MIT	Average turtles/km
13-Jul	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
27-Jul	-	-	0.33	1.00	-	-	-	0.50
27-Jul (T2)	0.50	3.53	2.67	1.48	-	-	-	1.87
7-28*	0.50	0.00	3.33	3.33	0.00	0.00	-	1.43
28-Jul (T2)	0.00	4.71	0.33	0.67	0.00	-	0.00	0.74
17-Aug	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
17-Aug (T2)	0.00	4.71	0.00	0.00	0.00	0.00	0.00	0.27
31-Aug	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.07
Average density per segment	0.14	1.85	0.88	0.81	0.00	0.00	0.00	0.61

Table 2A. The total distance of transects surveyed (km) within Mid Reach project segments conducted during 2005-2013 (i), the number of marine turtle observations per year (ii), and the density (marine turtle observations per km) within project segments (iii). Transects across the proposed MIT (mitigation reef) site conducted in 2013 are not included. No transect surveys were conducted in 2006.

(i) Number of turtles observed by project segment by year

Year	REFERENCE	BUFFER	FILL-1	FILL-2	FILL-3	FILL-4	TOTAL/ YEAR
2005	4	7	14	24	16	0	65
2007	2	1	6	7	4	0	20
2008	57	56	93	61	30	1	298
2009	7	0	5	0	3	0	15
2010	1	0	10	22	4	0	37
2011	0	0	0	0	0	0	0
2012	0	0	4	3	0	0	7
2013 *	2	11	21	17	0	0	50
Total turtles per segment	73	75	152	134	57	1	492

(ii) Total distance of transect area surveyed by year within project segments

Segment surveyed by year (km)	REFERENCE	BUFFER	FILL-1	FILL-2	FILL-3	FILL-4	TOTAL/ YEAR
2005	8.0	9.4	33.0	33.0	36.3	27.5	147.2
2007	2.0	0.9	3.0	3.0	3.3	2.5	14.7
2008	7.4	3.4	12.0	12.0	13.2	7.5	55.5
2009	6.0	2.6	9.0	9.0	9.6	2.5	38.7
2010	4.0	1.7	6.0	6.0	6.6	3.0	27.3
2011	4.0	1.7	6.0	6.0	6.3	0.0	24.0
2012	8.0	3.4	12.0	11.7	9.5	0.0	44.6
2013	14.0	6.0	24.0	21.7	17.2	12.5	95.3
Total distance surveyed	53.4	28.9	105.0	102.4	102.0	55.5	447.1

Table Continued next page

(iii) Density of marine turtles per project segment (km)

Turtle density/ (km) by year	REFERENCE	BUFFER	FILL-1	FILL-2	FILL-3	FILL-4	MEAN DENSITY
2005	0.5	0.7	0.4	0.7	0.4	0.0	0.4
2007	1.0	1.2	2.0	2.3	1.2	0.0	1.4
2008	7.8	16.5	7.8	5.1	2.3	0.1	5.4
2009	1.2	0.0	0.6	0.0	0.3	0.0	0.4
2010	0.3	0.0	1.7	3.7	0.6	0.0	1.4
2011	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.3	0.3	0.0	0.0	0.2
2013*	0.1	1.8	0.9	0.8	0.0	0.0	0.5
Average density per segment	1.4	2.5	1.7	1.6	0.6	0.0	1.2

* includes one loggerhead (*Caretta caretta*) in FILL-1