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Selection of nesting habitat of hawksbill turtle (*Eretmochelys imbricata*) in two coral islands of Qeshm and Hengam in the Persian Gulf, Iran

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Abstract

The Persian Gulf islands are the nesting regions for the severely endangered hawksbill turtle (*Eretmochelys imbricata*) species. Therefore, the selection of the nesting habitat of this species in the two islands of Qeshm and Hengam was studied by a five-member working group in the spring of 2013 - 2015. Ultimately, 23 and 17 nests were identified in the south of Qeshm Island and in the south and south-west of Hengam Island over two consecutive years, respectively. The habitat variables were measured around 24 nests (12 selected in Qeshm Island and 12 in Hengam Island) and compared with absence points. The results showed that the nests in the two islands were established in wide and deep beaches with a low slope near light sources. Due to its wider and deeper beaches, Qeshm Island is more favorable for the nesting of this species compared with Hengam Island. There was no significant difference in terms of average weight, diameter, and the number of normal eggs of the 12 nests selected in Hengam Island (31.10±0.30 g; 38.19±0.14 cm; 87±4) compared with those in Qeshm Island (30.59±0.29g; 38.09± 0.17 cm; 79.07±5.39), respectively.

Keywords: Habitat selection, Hawksbill turtle, Qeshm Island, Hengam Island, Iran

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Introduction

Hawksbill turtles inhabit coral reefs, mangrove estuaries, and other hard-bottom habitats (Bolten, 2010; Gaos *et al*., 2012). Female turtles return annually in their native beaches to nest (Lohmann *et al.,* 2013). It was ranked as the critically endangered species in 1996. Of the factors threatening this species, one can name tortoise shell trade, egg collection, slaughtered for meat, destruction of foraging and entanglement, hybridization of hawksbills with other species, destruction of nesting habitat, oil pollution, and ingestion of marine debris including fishing gear (IUCN, 2014). Turtles are particularly vulnerable to human exploitation during nesting (Humber *et al.,* 2014). Numerous studies have been conducted on hawksbill turtle in different regions of the world. The selection of nesting regions in dynamic beaches in mangrove estuaries and local adaptation of the adult females to different nesting habitats were studied (Liles *et al*., 2015). Of other studies performed, one can refer to breeding in coral islands as the key points in breeding seasons and the effectiveness of water temperature in breeding time intervals (Walcott *et al*., 2013). Successful hatching in protected hatcheries due to prevention of the effect of sea waves, tides, other turtles, and predators was compared with that of the main habitat (Pazira *et al*., 2015). The successive selection of a site by the female turtle as well as flexibility in habitat selection behavior in Galapagos are among other studies performed (Kamal and Morsovsky, 2005). The important effect of the sea currents and swimming behavior of the hawksbill turtle (Putman *et al*., 2014) along with the effect of the physiochemical factors of beach soil such as temperature, moisture, and rate of oxygen on incubation of the eggs (Matsuzawa *et al*., 2002) and selection of open-coast beaches near coral beaches for nesting in Caribbean and Indian-Pacific Oceans with the effect of genetic factors on the selection of hatching sites are other important factors for the selection of the breeding site for this species (Liles *et al*., 2015). Regions with high vegetation cover in dynamic beaches of mangrove estuaries and the local adaptation of female turtles are effective in nesting regions selected by hawksbill turtle (Liles *et al*., 2015). The study of nesting habitat selection of this species in macro-scale and recognition of its local adaptation will be more effective in the more accurate recognition of its ecology. The goal of this study is the identification of the factors effective in the selection of the nesting sites by hawksbill turtle in Qeshm and Hengam Islands. With regard to inadequate information of this species in Iran, the results can contribute to the codification of protective and effective strategies in Iran and the world.

Materials and methods

Study area

The two coral islands of Hengam and Qeshm in the south of Iran were studied (Fig. 1). These two islands were selected for the study from among several islands in the Persian Gulf for their easy accessibility and their sandy beaches for egg laying. The geographic coordinates of Hengam Island are 26°, 36' to 26°, 41'N latitude and 55°, 51' to 55°, 55'E longitude with an area of 33 square kilometers, and those of Qeshm Island are 26° and 57' N latitude and 56 ° 16'E longitude with an area of 1504 square kilometers in the south of Iran.

Figure 1: Qeshm Island (right) and Hengam Island (left).

Data collection

Identification of the regions for laying eggs was initially performed through field observations along with the study and examination of former researches done in spring seasons of 2013 through 2015 on the beaches of Hengam and Qeshm Islands by a 5-member team. A field study was performed by entering the passable beaches, using telescopes and binoculars in impassable regions as well as collecting information from the fishermen and coastal natives to determine random transects on the map, establish and survey the sandy coasts of the two islands over the egg laying season to identify the nests. Accordingly, 23 and 17 nests were identified on the southern beaches of Qeshm Island and the west-south of Hengam Island, respectively and their geographic coordinates were registered by GPS. The location of the nests is shown in Fig. 2.

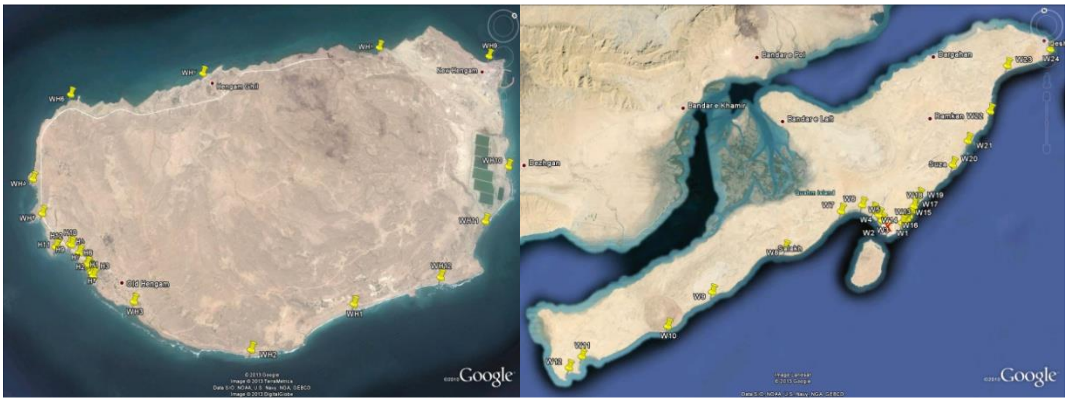

Figure 2: Location of nests of Hawksbill Turtles in Qeshm and Hengam.

After locating the nests, the biometry of the egg-laying female turtles was also performed and some parameters such as length and width of carapace were measured by a large caliper and plastic meter. The body weight was obtained by a spring balance with an accuracy of about 0.1 g (Fig. 3).

Figure 3: Biometry of hawksbill turtles and eggs in Hengam and Qeshm Islands, 2014 (photo by: A. Askari).

Figure 4: Marking nest for plot conduction, 2015 (Photo by: A. Askari).

To find the habitat variables effective in the selection of nesting regions of hawksbill turtles, some plots with dimensions of 10×10 square meters were established in the center of the nest after nesting so as to observe protective laws concerning this species; some habitat parameters within the nest boundary such as the width and slope of the beach, depth of the nest, determination of the type of the particles in the nest by soil sampling (Fig. 4), the distance of the nest to the nearest road, presence of seaweeds alongside the beach where egg laying is done along with water turbidity and the presence of the holes created around the nests by crabs were measured. A few kilometers away from the nesting regions and in different directions from the absence or control points, it was found that there was no trace of the hawksbill turtle at these points and the absence plots were established according to the number of the presence plots and the above habitat variables in these points were also measured to be compared with the presence points.

Data analysis

The normality of the data was first examined by the use of Kolmogorov-Smirnov test and homogeneity of variances was studied by Leven's test. The data were not normal and they were transformed by the use of a base-10 logarithm and square root. Data analysis was performed by SPSS software (version 23). The independent t-test was administered to compare the mean of habitat variables between presence and absence regions in each of the islands and between these two islands. The principal component analysis and logistic regression tests were employed to specify the important variables effective in hawksbill turtle nesting. The diagrams were plotted by the use of Excel software.

Results

Comparison of habitat effective variables between the presence and absence regions in Hengam and Qeshm.

The results of the t-test obtained from the study of the habitat variables showed that there was a meaningful difference in the soil depth between the presence and absence regions in Qeshm Island unlike Hengam Island and the nests were dug in deeper soils ($p \leq 0.001$). While the data obtained from the soil texture in the two islands did not show any meaningful differences between the presence and absence regions ($p > 0.05$), there were meaningful differences between the nesting and control points in the two islands in terms of the mean slope; the slope of the nesting was meaningfully lower than that of the absent points ($p < 0.001$). Furthermore, the nesting points were meaningfully nearer to light sources compared with those of the control points in the two study areas ($p = 0.01$). There were also meaningful differences between the presence and absence regions of the two islands in terms of the width of the beach ($p \leq 0.001$). In fact, the nesting points meaningfully enjoyed a wider width (Table 1).

Table1: Comparison between habitat variables of present and absent plots in Hengam and Qeshm Island.

Variables	Hengam Presence (n=12) Mean (SE)	Random (n=12) Mean (SE)	*p*	Qeshm Presence (n= 12) Mean(SE)	Random (n= 12) Mean (SE)	*p*
Soil deep (cm)	103(2.56)	101(4.74)	0.64	150(0.00)	72.92(3.81)	<0.001**
Sand Soil (%)	0.51(0.05)	0.47(0.00)	0.06	98.50(0.15)	0.96(0.87)	0.1
Slope of Beach	2.25(0.13)	3.83(0.24)	0.04*	0.04(0.00)	0.06(0.00)	<0.001**
Turbidity (mg L^{-1})	9 (2.00)	6 (0.24)	0.001**	5.92 (0.05)		
Distance to the nearest light source(m)	400(89.19)	1091(301)	0.01*	116.67(19.53)	292.25(53.65)	0.01*
Number of crab hole	1(0.00)	17(11)	0.001**	3(1.00)	6(2.00)	0.1
Beach width (m)	60(4.51)	14 (15.15)	0.001*	70(0.00)	8.42 (0.83)	<0.001*
Number of algae	20(8)	9(1)	<0.001	5(1.00)	3(0.5)	0.20

To specify the most important variables effective in the selection of nesting habitat of hawksbill turtle species in Hengam and Qeshm Islands, the principal component analysis was used. This test showed that of the habitat variables of the two islands of Hengam and Qeshm, slope and beach width were the two important variables for this species in selecting the nesting regions. According to the principal component analysis test administered in Hengam Island, the base of the first axis of this test was on two variables of the beach slope and presence of seaweeds and the base of the second axis was the width of the beach. The eigen value was larger than one and the total value of the cumulative variance was 72.50%. In addition to the slope and width of Qeshm beach, the depth of soil was also an important variable in selecting the nesting habitat for this species. The eigen value was more than one and the percentage of cumulative variance was 72.43% approximating 100%. It can be said that nesting has been done in beaches with more width and less slope near light sources in the two islands. Over the two-year work period, 23 and 17 nests were identified in Qeshm and Hengam Islands, respectively. Sandy beaches with more slope and width exist throughout Qeshm Island, while these favorable conditions exist only in the south-west of Qeshm Island where the nests are observed in colonies (Fig. 2).

The results of our study showed that a type of local adaptation existed in selecting nesting regions for this species in that the soil depth and the presence of seaweeds alongside width and suitable slope were the important factors in selecting the nesting regions in Qeshm and Hengam Islands, respectively. On the whole, it can be said that Qeshm Island enjoys higher mean soil depth, slope, and beach width compared with those of Hengam Island (Table 2).

Table 2: The principal components analysis test with 2 major axes based on 6 measured habitat variables in burrowing regions of hawksbill turtle, Hengam and Qeshm Islands 2015.

Variables	1	2	3
Deep slope	0.64	-0.55	**0 .96**
Beach slope	**0.79**	-0.55	0.84
Turbidity(mg L^{-1})	0.44	0.60	-0.84
Distance to the nearest light (m)	**0. 86**	0.11	**-0.94**
Beach width(m)	-0.65	**0.68**	**0.96**
Number of *Algae*	**0.85**	0.12	0.23
Number of crab holes	0.77	0.23	0.45
Eigen value	3.71	1.35	4.34
Percent of total variance (%)	53.10	19.39	72.43
Percent of cumulative variance (%)	53.10	72.50	72.43

Comparison of Qeshm and Hengam Islands for their biometric results of hawksbill turtle and its eggs

The data collected from 12 nests selected in both Hengam and Qeshm Islands is presented in Tables 3-6. The mean weight, diameter, and the number of normal eggs in Hengam Island were (30.8±0.29 g; 38.09±0.14 cm; 79.07±5.39); and in Qeshm Island it was (31.1±0.3g; 38.19±0.17 cm; 88±4).

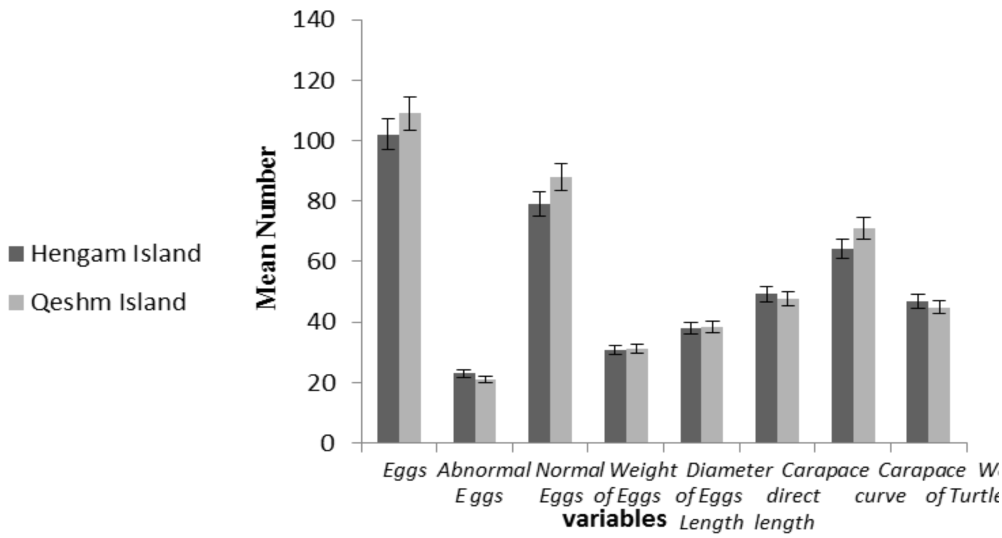

Figure 5: The Mean number of abnormal and normal eggs, weight of eggs, diameter of eggs length, carapace direct length and carapace width in Qeshm and Hengam.

Table 3: Biometry of egg hawksbill turtle in Hengam, 2015, Iran.

Number	Mean Diameter of egg(mm)	Mean weight of egg (g)	Mean number of normal egg	Mean number of Abnormal egg
1-	38.42	30.80	90	11
2-	38.18	29.30	75	18
3-	39.18	31.70	51	16
4-	38.17	32.80	88	22
5-	37.71	29.70	38	15
6-	38.56	31.50	89	9
7-	37.82	29.90	112	31
8-	36.81	27.50	99	22
9-	38.23	28.40	79	11
10-	39.16	29.20	70	9
11-	38.22	30.80	135	16
12-	36.73	29.80	98	18
13-	37.72	30.50	82	12
14-	39.15	33.20	112	21
15-	39.12	33.10	105	9
16-	38.56	29.90	80	26
17-	36.79	30.60	65	26
18-	38.17	32.50	57	28
19-	39.18	33.30	84	35
20-	38.75	32.80	114	24
21-	37.63	29.80	48	28
22-	38.22	33.20	90	25
23-	37.80	32.50	115	35
24-	39.16	30.70	94	29
25-	39.23	30.9	125	16
26-	36.85	29.80	83	36
27-	38.42	29.50	86	16
28-	37.38	33.50	68	25
29-	37.42	32.80	118	12
30-	39.19	33.20	86	39

Table 4: Biometry of egg of hawksbill turtle in Qeshm, 2015, Iran.

Number	Mean diameter of eggs(cm)	Mean weight of egg (g)	Mean number of normal egg	Mean number of abnormal egg
1-	37.96	28.70	73	23
2-	37.56	29.30	79	26
3-	38.39	27.90	25	33
4-	38.56	31.60	83	27
5-	39.14	30.50	115	20
6-	36.69	30.60	69	29
7-	37.71	33.70	128	14
8-	38.56	29.90	56	28
9-	39.15	32.60	38	31
10-	38.89	29.70	94	29
11-	39.17	33.50	128	21
12-	37.82	31.40	96	8
13-	38.13	28.30	79	14
14-	36.73	31.20	83	45
15-	38.23	32.70	89	46
16-	39.25	29.40	64	24
17-	39.19	28.30	79	32
18-	36.53	30.60	56	23
19-	36.44	31.30	64	29
20-	37.90	29.60	96	35
21-	39.13	30.90	134	12
22-	38.27	33.10	94	11
23-	39.23	29.30	68	21
24-	39.71	29.80	8	11
25-	37.64	31.40	53	22
26-	38.41	32.30	102	18
27-	37.28	28.40	86	13
28-	38.17	30.40	117	14
29-	36.88	32.60	61	18
30-	36.45	29.30	53	22

Table 5: Biometry of hawksbill turtle in Hengam, 2015. Iran.

Number	Mean weight of Turtle (kg)	Mean length of carapace curve (g)	Mean width of carapace curve(cm)	Mean direct length of carapace (cm)	Mean direct width of Carapace (cm)	Mean length of lower carapace (cm)
1-	45.00	73.00	69.50	50.00	46.50	54
2-	43.50	72.50	67.50	48.50	44	52.50
3-	32.00	62.00	58	39.50	36.50	42.50
4-	48.00	73.50	71.50	49.50	47	54.00
5-	41.50	65.50	62.50	42	40	45.50
6-	52	76	72	53	50	56.00
7-	50	74.50	72	52	49	55.50
8-	46.50	73	70	49	46.50	54.00
9-	34.60	62.50	59	40	38	44.00
10-	46	73	70.50	49.50	46.50	54.00
11-	45.50	73	69.50	49	46.50	54.00
12-	51	75	71.50	52	49	56.00
13-	49	73.5	71	49	47	54.50
14-	38	64	61	42	39.50	46.00
15-	41	65.50	63	45	42	49.00
16-	50	75	71.50	52	49	56.00
17-	36	63	59.50	40	38.50	45.00
18-	46	73	70	49	47	54.50

Table 5 continued:

19-	50.50	75	72	52	49	56.00
20-	49.00	74.50	71	51.50	48.50	55.50
21-	51.50	75	71	52	50	55.00
22-	46.00	72	69.50	48.50	46	52.50
23-	39.00	64	61.50	42	40	46.00
24-	50.00	73	70.50	51.50	48.50	55.00
25-	45.00	74.50	70	49	47	54.00
26-	46.50	73	70.50	48.50	46.50	53.00
27-	52.00	73.50	71.50	52	49	55.00
28-	39.00	65.00	62.00	44	41.50	48.00
29-	38.50	64.00	61.50	42	40.00	46.00
30-	44.50	73.00	69.00	49	46.00	54.00

Table 6: Biometry of hawksbill turtle in Qeshm, 2015. Iran.

Number	Mean weight of Turtle (kg)	Mean length of carapace curve (g)	Mean width of carapace curve(cm)	Mean direct length of carapace (cm)	Mean direct width of Carapace (cm)	Mean length of lower carapace (cm)
1-	56.00	77.50	74.00	54.00	51.50	60.00
2-	45.00	73	69.50	49.50	47	4t.50
3-	38.00	66.50	63.00	43.00	40.50	47.00
4-	42.00	71	67.50	49.50	45.00	52.50
5-	59.00	78.50	75.00	56.50	52.50	61.00
6-	45.50	73.50	71.00	48.50	46.50	53.50
7-	41.50	71	67.50	49.50	45.00	52.50
8-	55.00	77	74.50	53.50	51.50	56.50
9-	39.00	66	63.50	43.50	41.00	47.00
10-	50.00	75.50	73.00	53.50	50.00	56.00
11-	46.00	73.00	71.00	48.50	47.00	53.50
12-	52.00	76.50	72.50	53.00	50.00	56.50
13-	39.50	66.00	64.00	43.50	41.50	47.00
14-	45.50	73.00	70.00	49.00	47.00	54.50
15-	58.50	79.00	75.50	56.50	53.00	60.00
16-	43.50	71.00	67.00	49.50	45.50	52.00
17-	32.50	63.00	57.00	40.50	35.00	45.00
18-	51.50	75.00	73.00	52.50	49.50	56.00
19-	34.50	62.50	58.50	41.00	37.00	45.00
20-	48.00	73.50	72.00	50.00	47.50	54.50
21-	51.50	51.50	71.50	52.50	49.00	56.00
22-	53.00	53.00	72.00	53.00	50.50	56.50
23-	55.50	55.50	74.00	53.50	52.00	57.00
24-	45.00	45.00	70.00	50.00	47.00	54.50
25-	37.50	37.50	62.00	42.50	39.50	46.50
26-	42.00	42.00	63.50	45.50	41.50	48.50
27-	59.00	59.00	75.50	55.50	52.00	61.00
28-	48.00	48.00	71.00	49.50	47.00	54.00
29-	39.50	39.50	62.50	43.50	39.50	47.50
30-	49.00	49.00	71.50	49.00	47.50	53.50

Discussion

The results showed that nesting was done in beaches with more width and less slope near light sources in the two islands. More beach width provides more areas for digging the nests while protecting the eggs against sea waves. Less sloped beaches facilitate egg laying and the return of the infants. Comparing the beaches of the two islands, nesting in Qeshm Island was more and done in deeper regions than in Hengam Island. The deeper depth of the beach facilitates digging holes leading to more egg survival. Additionally, the eggs are in optimal conditions in terms of temperature and humidity; it is therefore concluded that the features of the beach, i.e. the presence of a sandy beach with more width and suitable slope as well as light sources attract female turtles to lay eggs; in this regard, Qeshm Island enjoys more favorable conditions compared with Hengam Island. These results overlap with those of Mortimer's study performed in 1981 that showed that an accessible and sloped beach with coarse grading and high moisture was important for the sea turtles to select a region for laying eggs. Qeshm and Hengam beaches, especially Qeshm Island enjoy accessibility, slope, and sandy beaches that contribute to the nesting of hawksbill turtle. Also, the results obtained by Scale *et al*., in Belize in 2010 showed that the number of hawksbill turtles was more in lagoons than in coral regions; furthermore, the study performed by Walcott in 2013 was in congruent with the above study in that it specified that coral islands were used as the key points in breeding seasons. The islands of Qeshm and Hengam are both coral islands and considered as the egg laying sites for this species. According to the results obtained in the Caribbean, the nesting regions of hawksbill turtle were located in regions with high plant cover on dynamic beaches with local adaptation in selecting the nesting regions (Liles *et al*., 2015). The presence of seaweeds in this research has also been an effective parameter in the feeding of this animal in breeding seasons and the dynamics of the beach has also been evident due to tides as there is behavior flexibility in the establishment of the nests between the two islands of Hengam and Qeshm. The coral islands in the Persian Gulf are of the few remaining habitats for hawksbill turtle breeding. An increase in ecotourism in these two islands and construction of villas especially in beaches of Qeshm Island followed by pollution and destruction have affected the breeding of hawksbill turtles. Tight control of these beaches and education of indigenous people and eco-tourists can play an effective role in the protection of these key beaches.

Comparison of the nesting regions in the two different islands with regard to their beach structure shows that nesting in the two islands has been done in beaches with more width and less slope near light sources. Qeshm Island has lodged more nests due to its sandy beaches with suitable slope and more width compared with the rather rocky beaches of Hengam Island. There is a local adaptation in the behavior of hawksbill turtle so that the nests are established in regions with more seaweeds and deeper depth in Qeshm Island compared with those in Hengam Island.

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References

Bolten, A.B., 2010. The biology of sea turtles. *CRC Press, Boca Raton*. pp. 243-257.

Gaos, A.R., Lewison, R.L., Yañez, I.L., Wallace, B.P., Liles, M.J. and Nichols, W.J., 2012. Shifting the life-history paradigm: discovery of novel habitat use by hawksbill turtles. *Biology*, 8, 54–56.

Humber, F., Godley, B.J. and Broderick, A.C., 2014. So excellent fisheries: a global overview of legal marine turtle fisheries. *Diversity and Distributions*, 20, 579-590.

IUCN, 2014. Red List of Threatened Species, IUCN. http://www.IUCNredlist.com.

Kamal, S.J. and Morsovsky, N., 2005. Deforestation: Risk of sex ratio distortion in hawkbill sea turtles. *Ecological Application*, 16, 923-931.

Liles, M.J., Peterson, M., Seminoff, J. A., Altamirano, E., Henriques, A., Gao, A., Gadea, V., Urteaga, J., Torres, P., Wallace, B. and Peterson, T.R., 2015. One size does not fit all: Importance of adjusting conservation practices for endangered hawkbill turtles to address local nesting habitat needs in the eastern Pacific Ocean. *Biological Conservation*, 184, 405-413.

Lohmann, K.J., Lohmann, F. and Brothers, J.R., 2013. Natal homing and imprinting in sea turtles. The biology of sea turtles. *CRC Marine Biology Series, CRC Press*. pp. 59-78.

M**atsuzawa, Y., Sato, K., Sakamoto, W. and Bjorndal, K., 2002.** Seasonal fluctuations in sand temperature: effects on the incubation period and mortality ofeloggerhead sea turtles (*Caretta caretta*) pre- emergent hatching in Minabe. Japan. *Marine Biology*, 140, 639-646.

Mortimer, J.A., 1981. Reproduction ecology of the green Turtle *(Chelonia mydas*) at Ascension Island, Ph.D. Thesis University of Florida.

Pazira, A., Moshtaghi, M., Tollab, M. A., Ahmadi, F., Rashidi, m., Faghihi, H., Ghorbanzadeh-Zaferani, G., Mirshekar, D., Shamsaie, M. and Malekpouri, P., 2015. Hatching success of hawkbill sea turtle (*Eretmochelys imbricata*) in a protected hatchery site in Nakhilo Island, Persian Gulf. *Reginal Studies in Marine Science*, 3, 216-224.

Putman, N.F., Abreu- Grobis, F.A., Broderick, A.C., Cifi, C., Formia, A., Godley, B.J., Stroud, S., Pelembe, T., Verley, P. and Willimas, N., 2014. Numerical dispersal simulations and genetics help explain the origin of hawkbill sea turtles in Ascension Island. *Journal of Experimental Marine Biology and Ecology*, 450, 98-108.

Walcott, J., Eckert, S. and Horrocks, J.A., 2013. Diving behavior of hawkbill turtles during the inter-nesting interval: strategies to conserve energy. *Journal of Experimental Marine Biology and Ecology*, 448, 171-178.