Breeding Status of the Hawksbill Turtle *Eretmochelys imbricata* and Green Turtle *Chelonia mydas* on Aride Island.

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Abstract: Hawksbill Turtles – 69 individuals have been tagged on Aride since 1981. Individual data reveals an inter-nesting interval of 14.7 days, with a mean of 1.4 clutches laid per season, although the maximum recorded was five. Nine tagged Aride turtles returned to nest in a season after that in which they were first seen, with a mean interval of 3.7 years. Emergence and nesting incidences increased significantly from 1976-2001, reflected in the minimum number of turtles nesting in a season increasing from four to seven. Emergences were equally likely in the morning and afternoon, and along with nests were most prevalent in beach areas four and five, which are furthest away from the settled beach section. Mean clutch size was 145 eggs, which increased with turtle carapace length measured as OCCL – tip to tip. Mean carapace length in each nesting season decreased significantly from 1992-2001. In years when hatching and emergence success was low, this was attributed to nests being flooded and nest relocation is recommended.
Green Turtles – The nesting population is extremely low with a minimum of two individuals. Turtles returned to nest on average every 1.6 years, laying a mean clutch size of 94 eggs at intervals of 12 days, with high hatching and emergence successes. Emergences tended to be located in areas with an open offshore access and exposed nesting sites.

Introduction

Aride's south beach has been monitored for turtles since 1976. This has resulted in 25 years of data that have not been fully examined. Annual reports since 1989 provide a brief summary of the respective turtle nesting season, and in-depth reports have been produced annually since the 1995-96 nesting season. Although consistent monitoring was not implemented until 1992, there is still a great deal of information on Aride's Green and Hawksbill Turtle nesting population that this paper will analyse.

Methods

The turtle nesting season in Seychelles runs from the 16th July in one year through to the 15th July in the next (Mortimer, *pers. comm.*). Aride data in the 1976-77 nesting season only covers September – November when the date of each nest and respective hatch date was recorded. From 1980-92, the date and type of all emergences were recorded, along with their location, turtle tag number and hatch date, but it is not clear how often the beach was monitored. In the 1992-2001 nesting seasons, beach patrols occurred three times a day, usually at 07:00, 12:00 and 18:00. In general beach patrols commenced at the start of September, the 12:00 watch was discarded at the end of February and beach patrols were terminated at the end of March. All emergence were noted and definite nests (laying / hatching observed, or eggs located upon excavation) were recorded. Further details of Aride's beach protocol can be found in Carty and Herzig (1995), Sheridan (1998), Raines (1999), Crowley (2000) and Hannah (2001).

Hawksbill Turtle Results

The total number of emergences and definite nests that were recorded in each nesting season are shown in Figure 1. 48% ± 19% (*n* = 20) of all emergences in a nesting season were observed. The number of emergences varied from seven in 1977-78 to 65 in 1996-97 and the number of nests ranged from two in 1984-85 to 25 in 1998-99. A mean of 27 ± 19 (*n* = 25) emergences occurred in each nesting season, of which 11 ± 7 (*n* = 22) were definite nests. The number of emergences significantly increased with time (r_s = 0.75, *n* = 23, *p* < 0.02). This is mirrored by a similar significant increase in the number of definite nests (r_s = 0.71, *n* = 23, *p* < 0.02). The minimum mean number of turtles nesting in each season was 5.6 ± 2.6 (*n* = 23, Figure 2).

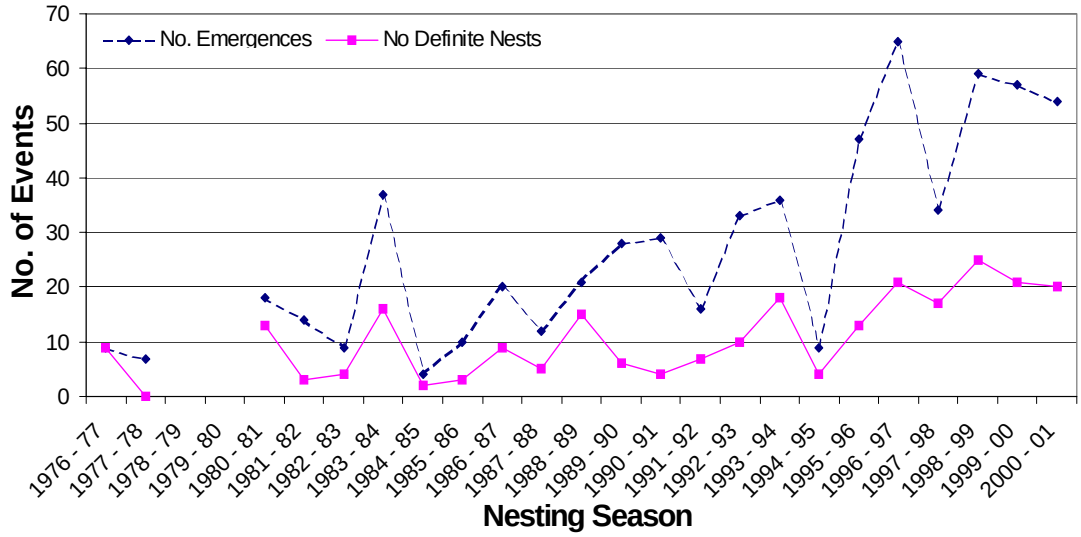

Figure 1: The number of recorded emergences and definite nests of Hawksbill Turtles in each nesting season from 1976-2001. NB: No records were made for the 1978-80 nesting seasons. The 1977-78 nesting season contains only the data from September to November and data is also missing for January and February 1992 and November 1991.

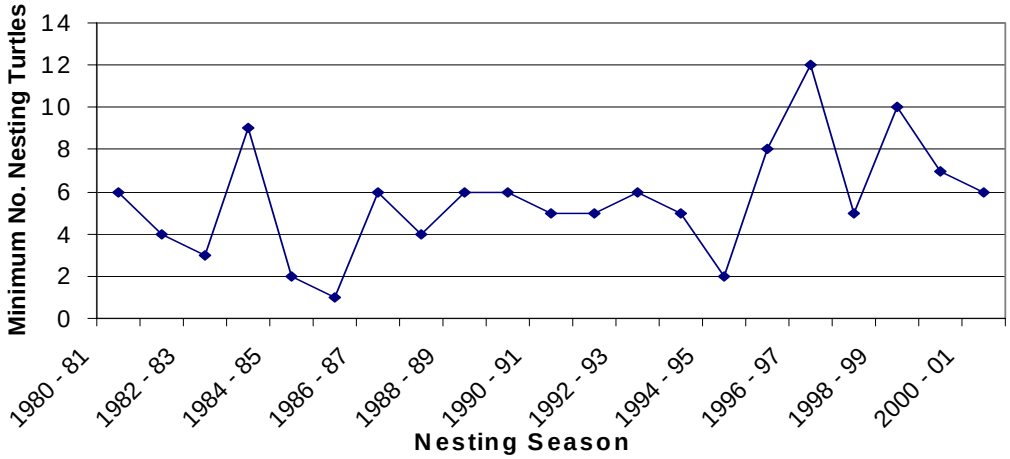

Figure 2: The minimum number of nesting Hawksbill Turtles in each season, extrapolated from the number of tagged turtles seen in a season and the interval between definite nests, assuming that re-emergences will occur on average every 14-15 days (this report), for a maximum of six clutches (Mortimer & Bresson, 1999).

Timing of Emergences

An equal number of emergences were observed during all three patrol times (χ^2 = 5.02, d.f. = 2, p > 0.05). Overall there were 237 emergences in the morning and 235 in the evening, excluding 30 overnight emergences.

Location of Nest Site

The beach areas where definite nests and emergences were recorded are noted in Table 1. The number of observed emergences (χ^2 = 181.4, d.f. = 4, p < 0.05) and definite nests (χ^2 = 71.2, d.f. = 4, p < 0.05) were spread evenly among the beach areas, with areas four and five having received more than their expected quota, whilst area 2 received less.

Beach Area	Expected % of Events	No. Emergences	No. Nests
1	10	87 (15%)	25 (11%)
2	24	79 (14%)	34 (15%)
3	39	132 (23%)	54 (24%)
4	14	138 (24%)	52 (23%)
5	13	143 (25%)	63 (28%)
Total	100	579	228

Table 1: The beach area where emergences and definite nests of Hawksbill Turtle were recorded between the start of the 1980-81 and the end of the 2000-01 nesting seasons. Expected values were calculated from the length of each beach section, assuming that emergences are equally likely along the whole length.

Tagging

Between 1976 and the end of the 2000-01 nesting season, a total of 69 turtles were tagged on Aride. Another six tagged individuals nested on Aride. Two of these were tagged on Cousin, one on Cousine, one on Curieuse and the tagging location of the other two is unknown. It is not known how many of the Aride turtles have nested elsewhere.

Of the 75 tagged turtles, nine nested in more than one season and eight of these were originally tagged on Aride. The mean number of years between nesting was 3.7 $\pm$ 1.5 (n = 9). When individual turtle data was analysed only one entry per turtle was used to avoid pseudo-replication. Of the 69 turtles tagged on Aride, two had one flipper re-tagged due to tag loss upon later emergence.

Annual Variation in Turtle Length

Size measurements taken since 1992 indicate a decrease in mean turtle length over these nesting seasons (Figure 3). Straight carapace length measurements were only taken in 1996-98, and are therefore not included. There has been a significant decrease in over the curve carapace length (OCCL) – tip to tip over the years (r_s = -0.79, n = 7, p < 0.05). Although the OCCL – midline measurements appear to be mirroring the OCCL – tip to tip measurements, there are only five data points, which is too small a number of sampling units to analyse using Spearman's Rank (Fowler & Cohen, undated).

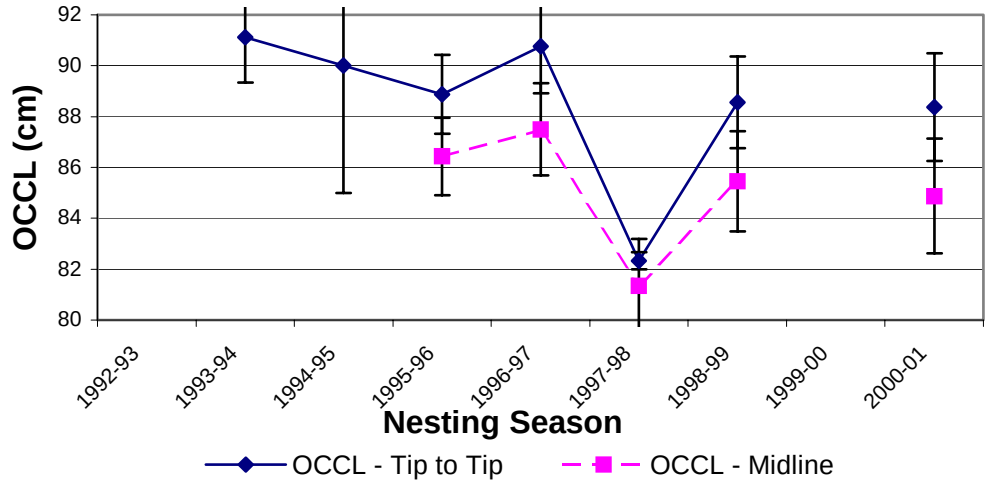

Figure 3: The mean Hawksbill Turtle over the curve carapace length or width (OCCL) in each nesting season. OCCL – mid to tip was only taken in two seasons. As this is not enough to observe any trend it is not shown. Error bars display the standard error of the mean. Data was not recorded in 1999-00.

Inter-nesting Interval

Inter-nesting interval is taken here to be the length of time that a female takes to return and lay a successive clutch. It was assumed that turtles returning to nest with an interval of > 25 days had nested undetected elsewhere (Frazer, 1984), or had aborted their eggs at sea. 14 tagged females were observed to lay consecutive nests, producing a mean inter-nesting interval of 14.7 ± 2.6 days (Table 2).

Right tag no.	Left tag no.	Inter-nesting Interval (days)					Mean Interval (days)
E056	E1932	15	17				16
E1906	E1905	14	13				13.5
E1917	E1918	14					14
E1935	E1936	17	13				15
E1940	E1942	18					18
M0021	M0022	14					14
M0023	M0024	14					14
	M2202	15					15
M2204	M2205	17	14				15.5
M2222	M2221	16	13	13	16	14	14.4
M2257	M2256	15	16	15			15.3
X3445	X3437	7					7
M0003/4	M0003/4	17					17
M0017		17	16				16.5
				Overall Mean:			**14.7**

Table 2: The inter-nesting interval between observed emergences of identified Hawksbill Turtle in the 1976-2001 nesting seasons.

Clutch Measurements

The mean number of observed clutches laid per season by an individual turtle on Aride was 1.4 ± 0.7 (*n* = 65). The maximum number observed for any individual was five. Mean clutch size was 145 ± 37 (*n* = 37), using only data from a turtle's first clutch of each season.

Clutch size increased significantly with carapace length, measured as OCCL – tip to tip, (r_s = 0.85, *n* =19, *p* < 0.01; Figure 4). There was no significant relationship between first clutch size and OCCL – midline, (r_s = -0.34, *n* =19, *p* > 0.05). There were not enough data points to calculate the relationship with other size measurements.

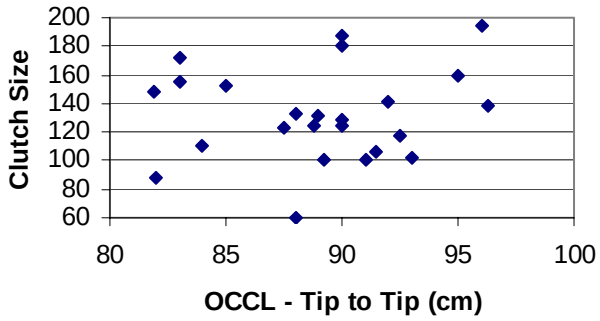

Figure 4: The relationship between OCCL – tip to tip and clutch size for the Aride nesting Hawksbill population. If a turtle laid >1 clutch in a season, the first clutch size was taken, as this is known to vary between successive clutches. If they laid in >1 season, only the first nest for each was entered. Although this uses replicated data, the turtles will probably have grown between seasons.

Hatching and Emergence Success

There was a noticeable variation between seasons in hatching and emergence success (Figure 5). Each nesting season with the exception of 1998-99 had one nest that was flooded, resulting in 0% hatching and emergence success. This greatly affected the mean for the 1995-96, 1997-98 and 2000-01 seasons where the sample size was small. The percentage of nests predated by crabs varied from 50% in 1997-98, 13% in 1998-99, 14% in 1999-00 and 0% in the remaining two seasons.

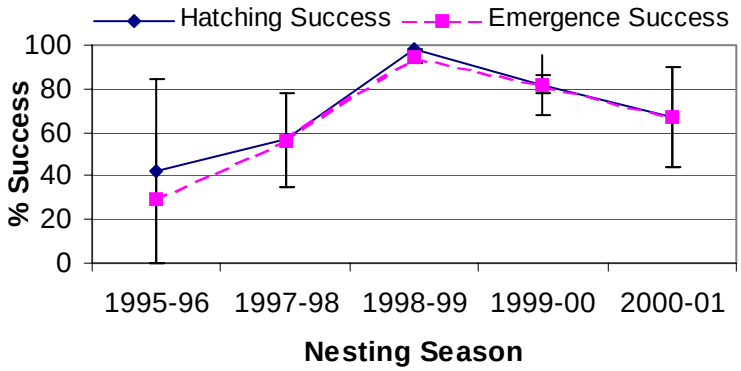

Figure 5: Mean hatching success and emergence success from the 1995-96 to the 2000-01 Hawksbill nesting seasons (*n* = 2, 4, 8, 7, 4 respectively). Data was not recorded in the 1996-97 season. Error bars display the standard error of the mean. Only data from identified individuals is shown. If a turtle laid more than once in a season only the first clutch was entered to avoid pseudo-replication.

Green Turtle Results

Green Turtle emergences were analysed in clusters, as these tended to continue over nesting seasons, making them difficult to analyse (Table 3). These clusters never had a gap of more than 35 days (but usually <14 days) between any two emergences. Emergences tended to occur between May and December (Figure 6). The mean number of years between clusters of emergences was 1.6 ± 0.8 (*n* = 9). 7.5% of emergences were observed.

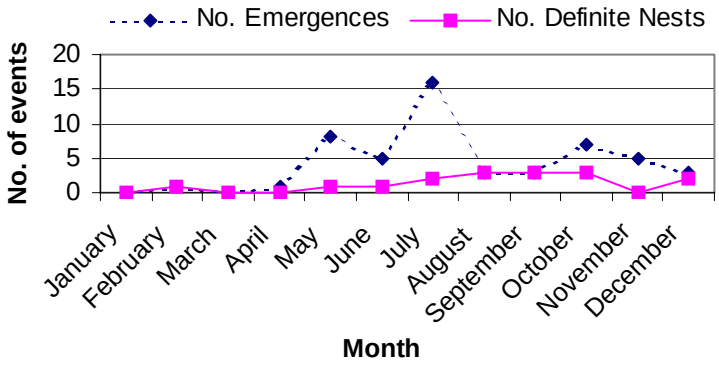

Figure 6: The number of Green Turtle emergences and definite nests that occurred in each month between 1982 and 2000. All emergences were recorded, but not all nests were stated, therefore these may be underestimated.

Year	Months of Emergences	No. Emergences	No. Definite Nests
1983	October	1	1
1984	June-July	3	1
1986	April	1	X
1989	May-August	22	X
1992	July	1	0
1993	September	1	1
1995	June	1	1
1995	December	1	0
1997	July-September	7	5
1998-99	October-February	15	5

Table 3: The number of Green Turtle emergences and nests on Aride since 1983. No emergences were recorded from 1976-82. X is used in the years where the number of nests were not stated.

The number of emergences in each beach area differed significantly from expected values (χ^2 = 20.1, d.f. = 4, p < 0.01; Table 4), but the number of nests did not (χ^2 = 3.1, d.f. = 4, p > 0.05).

Beach area	No. Observed Emergences	No. Expected Emergences
1	13	5
2	19	13
3	13	22
4	7	8
5	3	7

Table 4: The number of observed and expected Green Turtle emergences in each beach area between 1976 and 2000. Expected values were calculated from the length of each beach section, assuming that emergences are equally likely along the whole length.

As individual turtles were not identified, the following results are the mean of all of the Green turtle nests laid on Aride. This resulted in several data entries for each individual, but given the low population size this should not have too great a bias on the results. Mean clutch size was 94 ± 29 (n = 10), with a mean inter-nesting interval of 12 ± 1.5 days (n = 6). Mean: incubation duration was 59 ± 4 days (n = 6), nest depth was 79 ± 11cm (n = 5), hatching success was 94 ± 7% (n = 10) and emergence success was 91 ± 8% (n = 10).

Discussion – Hawksbill Nesting Population

The significant increase in the number of emergences and definite nests between September 1976 and June 2001 is unlikely to be purely a reflection of the intensity of beach patrols, which have been constant since 1991 and between 1989 and 1991 all emergences were recorded. Data for the 1991-92 season is incomplete (see Figure 1), but these missing emergences would only strengthen the trend. Prior to 1989 records have been taken throughout each nesting season, with the exception of the 1978-80 seasons when no data was collected. These years were therefore omitted from the analysis.

The increase in emergences and nests is also reflected by an increase in the minimum number of turtles that could have been responsible for the nests in each season. It was not possible to statistically analyse the increase in the minimum number of nesting turtles, as the number of tied ranks would have introduced too great an error for interpretation. However, when many turtles are intercepted in a season, the minimum number will be closer to the true number and may not be comparable with seasons where fewer turtles were observed. However, as only 48% of emergences were observed, it is likely that this is an underestimate of the annual nesting population size.

Patrol Times

Patrols enable track counts, which are extremely important data for establishing the nesting population size. Early morning patrols ensure that overnight tracks are encountered when they are fairly fresh and distinguishable. Evening patrols likewise ensure that all daytime emergences are accounted for. The 12:00 patrol was introduced to increase turtle encounter rate (Sheridan, 1998). Aride data indicates that emergences are equally likely in the morning and afternoon, however in depth data is not available. The greatest encounter rate with Hawksbills on Cousin was 16.00-17.59 hrs (Mortimer & Bresson, 1999), which may be a suitable patrol time on Aride if volunteers were keen. Additionally increasing monitoring 14 – 15 days after a nest is laid would increase interception rate of re-nesting turtles.

Nest Site Selection

Area two, along with the adjacent part of area three, is the section most frequented by island inhabitants. This may account for the lower than expected number of emergences and nests in this region. Likewise area four and five are furthest away from the inhabited part of the island and this may result in the large number of emergences and definite nests observed here. Offshore approach is another factor influencing beach usage, although tidal height is not thought to affect emergences on Aride (Grigg, 1993). Finally, as the beach is constantly being reshaped from year to year and even within a nesting season, the most frequented beach areas may reflect the most stable areas for nesting. Beach characteristics have not been recorded to test this.

Tagging Guidelines

Tagging records on Aride date back from 1981. 69 turtles have been tagged up to the end of the 2000-01 season, with six turtles tagged elsewhere also emerging. Of these 75 individuals nine have nested in more than one season and two tagged on Aride suffered tag loss. In the 2001-02 season it was noted that tags that had been applied to the first or second scale of the front flipper

were being pushed out. Tags should therefore be applied in the fleshy 'armpit' as close to the first scale as possible (see Mortimer, 1997). In addition, tags should always be checked after application to ensure they are fully closed.

Clutch Measurements

Larger turtles (using OCCL – tip to tip) laid larger clutches, which may be because a larger body allows greater accumulation of energy stores for use in nesting. The OCCL – midline measurement did not show any relationship with clutch size, but since the midline on Hawksbills can be difficult to define this measurement is inaccurate, which may disguise any trend. This measurement is generally no longer recorded (Mortimer, *pers. comm.*).

On Cousin, the mean number of clutches laid by a Hawksbill Turtle in a season was 3, with the most being 6 (Mortimer & Bresson, 1999). The mean number of clutches within a season by an Aride turtle was 1.4, which is comparatively low, as one individual laid five clutches in a season. Presumably this is because only 48% of emergences have been observed, hence individuals are likely to have nested unobserved. Increasing monitoring when turtles are likely to re-nest should confirm this.

Annual Variation in Turtle Length

Over the study period there has been a significant decrease in the carapace length (OCCL – tip to tip) of the nesting population. Given that smaller turtles lay smaller clutches this may impact upon the nesting population in the future, especially as the population is currently around seven individuals per season. Consistent and accurate measurements of nesting turtles need to be taken to monitor this trend in the future.

Hatching and Emergence Success

Hatching and emergence success varied markedly between 1995 and 2001, the only years when data was available. On nesting beaches hatching success is usually 80% or more unless external factors intervene (Mortimer *et al.*, 2000), which was observed in the 1998-2000 seasons. The remaining years varied between 42% and 67%. These low figures are in part due to nests being flooded. There are no records of nests being relocated, which would greatly reduce this problem. On Cousine relocation is done routinely, as crab predation completely destroys nests in some beach sections. It is strongly recommended that where nests are located below the spring tide line that they should be relocated using the guidelines found on the Aride laptop (C:\My Documents\Turtle Data\Relocation_Guidelines).

Crab predation also occurs in nests on Aride, however the extent of this is difficult to report as clutch size is often only recorded at nest excavation, when predation will already have occurred. This therefore results in lowered clutch measurements and elevated hatching and emergence success figures. Counting the number of eggs at laying will allow the extent of predation to be calculated. In addition, the presence of crab holes around the edge of the nest chamber should be noted at excavation and the number of eggshells on the surface of the nest during incubation, not just their presence, should be recorded. However, only parts of nests are lost through predation, and as predation is equally distributed along the beach relocating nests to 'crab free' areas is not an option.

Green Turtle Nesting Population

It is possible that only two Green Turtles are responsible for the nests on Aride, but this is an overly conservative estimate. Given the nocturnal habits of nesting Green Turtles, with only four out of 53 emergences observed between 1976-2001, it is not possible to provide a more accurate population size. In the current 2001-02, there have been fourteen Green Turtle emergences from 28/09/01 – 21/11/01 and all of these were by the same individual (R=E1969, L=E1972). A large fibropapilloma was present on this female's carapace, which given the low population is worrying. As the 2001-02 data set is incomplete it was not included in the analysis.

Green Turtle emergences occurred mainly between May and December, with a nesting peak in September. There were a greater than expected number of emergences in beach areas one and two. These areas have exposed nesting sites, which Green Turtles prefer to nest in (Crowley, 2000) in addition to an open offshore approach. Mean clutch size was 94, and hatching and emergence success were extremely high at 94% and 91% respectively.

Data Collection

It was not possible to analyse the Aride data at great depth as data has not been consistently recorded. A new data sheet, listing all of the data to be recorded, and highlighting the most critical aspects can be found on the laptop under 'C:\My Documents\Turtle Data\Turtle_Blank_Data_Sheets'.

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