GLOBE Investigation

Gozo College Middle School 2020-2021

Title – What are the ideal environmental conditions for a successful turtle nest?

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Optional Badges: I am a Data Scientist, I am a Collaborator, I am a STEM professional

Abstract

On Friday 29th May, at around 10pm, a loggerhead turtle was noted laying eggs on Ramla Bay in Gozo. The turtle came out of the sea at around 10pm and left around 11.30pm. This was the first recorded and confirmed nest in Gozo after 70 years. GLOBE students attending Gozo College Middle School started collecting data from the turtle nest site at Ramla Bay, Gozo. The purpose of this study was to investigate the ideal environmental conditions which result in a successful hatching rate. This study investigated the turtle nest site, sand temperature, weather conditions and cloud cover. The students measured air temperature, humidity and barometric pressure and the GLOBE Observer App and Observation Cloud chart to measure the cloud cover following the steps of the GLOBE Protocols (GLOBE, 2014). The main objective was to find out the sand temperature around the nest and how it affects the hatchings during the incubation period. Using an Infra-Red thermometer and 3 data loggers students measured sand temperature at a depth of 20cm and 80cm, surface temperature, air pressure, humidity and air temperature. Cloud type and cover were also observed and recorded through the GLOBE Observer App.

Key words: loggerhead turtle (*caretta caretta*), Mediterranean Sea, sandy beach, coastal areas, sand temperature, surface temperature, hatchlings, turtle nest

Research Questions

What are the ideal environmental conditions for a successful turtle nest?

Does climate change affect turtle hatchlings?

The turtle nest site at Ramla Bay gave the students the opportunity to collect data themselves. Using two digital probes, the students measured sand temperature installed in the sand at two different depths. They carried out data collection and used it to investigate if sand temperature effects the success rate of the nest. The students measured sand temperature during the incubation period between June and August. Readings were taken from two spots: one probe at a depth of 20cm and another at a depth of 80cm, one metre away from the actual nest (in order not to harm the eggs). At first only one probe was used, at a depth of 80cm. After 12 days of observations (morning, afternoon, evening) it was noticed that there wasn't any fluctuations in the sand temperature. Thus it was decided to add another probe, this time at a depth of 20cm from the surface. The probes were installed at a depth of 20cm and 80cm following the advice given by experts assuming that those depths would mark the top and bottom of the nest.

From the study of the weather conditions, cloud cover, and the observation of sand temperature at different depths, the students discussed and came up with their own conclusions.

Is there a relationship between physical conditions of the beach, weather conditions and the number of hatchlings?

What is the effect of a change in sand temperature to hatchlings and the number of hatched eggs?

Climate change is causing an increase in air temperature, the amount of sunny days in the Maltese Islands with a drastic drop in rainfall totals and thus a higher sand temperature. Supported with the knowledge obtained by the students during their science and geography lessons together with the research conducted on loggerhead turtles, it was concluded that climate change really effects turtle hatchlings with a significant greater proportion of female hatchlings. This will result in an imbalance in the gender of the loggerhead population which will result in a decline in their numbers.

Introduction

A loggerhead turtle was spotted nesting at the Ramla Bay in Gozo on Friday 29th May 2020. The loggerhead turtle was spotted coming on the bay from the sea at around 10pm and returned to the sea at around 11.30pm. This was the first time in the past 70 years that a turtle nest has been registered and confirmed on Gozo. The last time that turtle nests were recorded on the island of Malta was in 2012, 2014 and 2018. In the 2018 nest, 111 out of 112 eggs had hatched.

The loggerhead turtle, scientifically known as *caretta caretta* is a long-living, slowly maturing marine species that inhabits tropical to warm temperate areas. This species is classified as globally endangered by the World Conservation Area (IUCN) and is also protected by various national and international legislation. The nest site at Ramla Bay was guarded day and night by volunteers in order to preserve the site from trampling, predators and excessive noise and vibrations.

The aim of the study is to find out what makes a turtle nest successful. In this study we used the experimental method, where the sand temperature at a depth of 20cm and 80cm was measured. Two temperature probes were placed in the sand for consistency and to have accurate readings on each visit.

From this study it was found that the nesting season, location of nest, amount of sand and sand temperature have an effect on the success rate of a nest. This study contributes significantly to the importance of protecting the nest and that a marked nest has much better chances of successful incubation.

Research Methods

Study site (*Latitude 36.0342, Longitude 14.1709, Elevation 9m, SITE_ID: 203775)****:***

- Ramla Bay (locally referred to as *Ir-Ramla l-Ħamra*) is located along the northern shore of Gozo, between the two towns of Nadur and Xaghra, at the mouth of a valley.
- The area is characterized by a sandy beach and sand dunes surrounded by gently sloping hills and exposed cliffs on either side of the bay.
- A running temporary stream divides the beach during the rainy season, with a freshwater pool forming a marshland community.

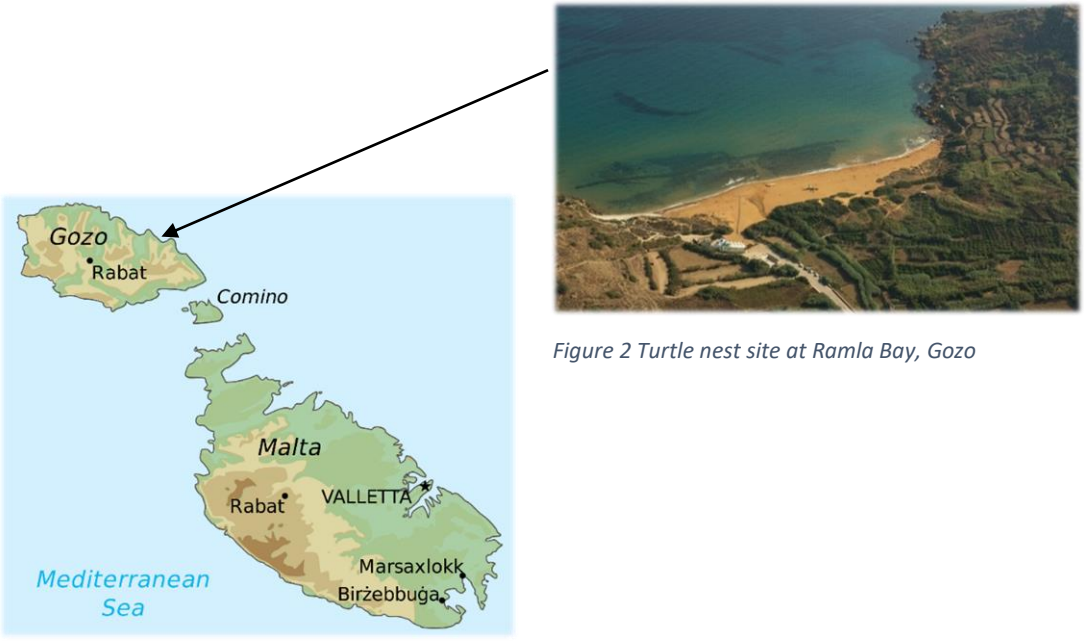


Figure 1 Map of the Maltese Island and study site

Figure 2 Turtle nest site at Ramla Bay, Gozo

Methodology:

Surface and ground sand temperature from and around nest site were recorded. Air temperature, humidity and barometric pressure were also measured and the GLOBE Observer App and Observation Cloud chart to measure the cloud cover following the steps of the GLOBE Protocols (GLOBE, 2014). Data was collected from the turtle nest site 3 times daily (morning, afternoon, evening) throughout the whole incubation period between June and August.

Figure 1 Students collecting data from turtle nest site

Apparatus used:

- 2 temperature probes (buried in sand at a depth of 20cm and 80cm respectively)
- Data logger to read sand temperature
- Data logger to measure air temperature, humidity and air pressure
- GLOBE Observer App to record cloud type and cover
- Infrared Thermometer to measure surface sand temperature

Data Analysis

All sand temperature data gathered was analysed and plotted along the time to verify the changes between temperature at 20cm and 80cm depth during the morning, afternoon and evening. It was noted that during incubation period, when the gender of hatchling is determined, sand temperature never exceeded 31° Celsius. Usually, for loggerhead turtles, a nest temperature higher than 29 Celsius produces more females, whilst a nest temperature lower than 29 Celsius produces more males. The time in which the temperature determines the sex is between Day 20 and Day 30 of incubation.

Results

The screenshots below show data uploaded on GLOBE website during observation period between June 2020 and August 2020 (Figures 4, 5, 6 and 7). The students collected daily readings of air temperature, barometric pressure, humidity, sand surface temperature, sand temperature at a depth of 20cm and 80cm, cloud cover and type together with surface conditions following GLOBE Protocols guide.

Air Temperature

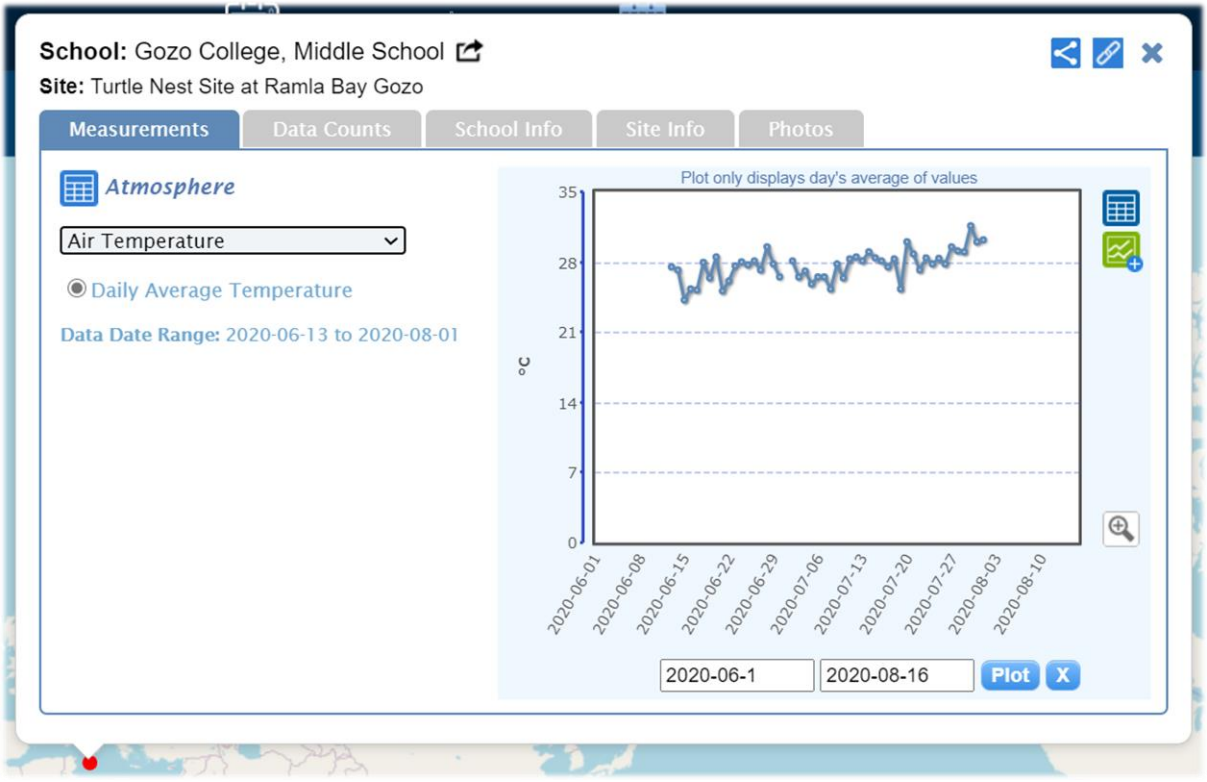


Figure 4 Air temperature plot of VIZ GLOBE

Barometric pressure

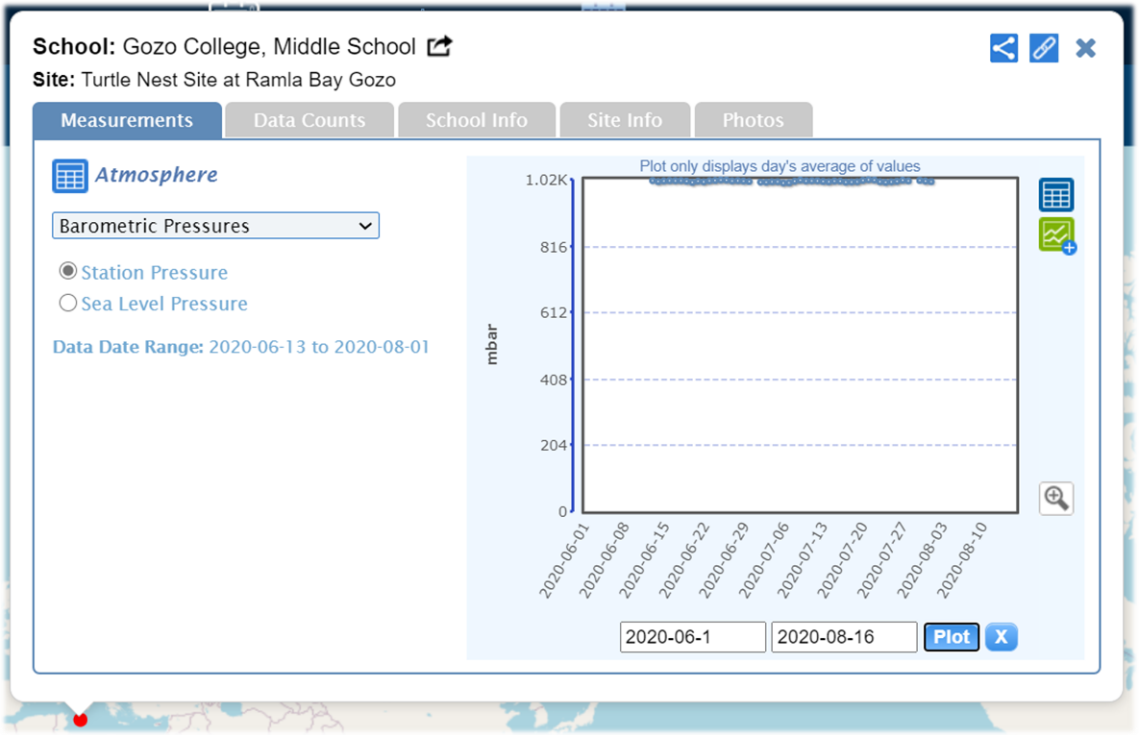


Figure 5 Barometric pressure plot of VIZ GLOBE

Relative humidity

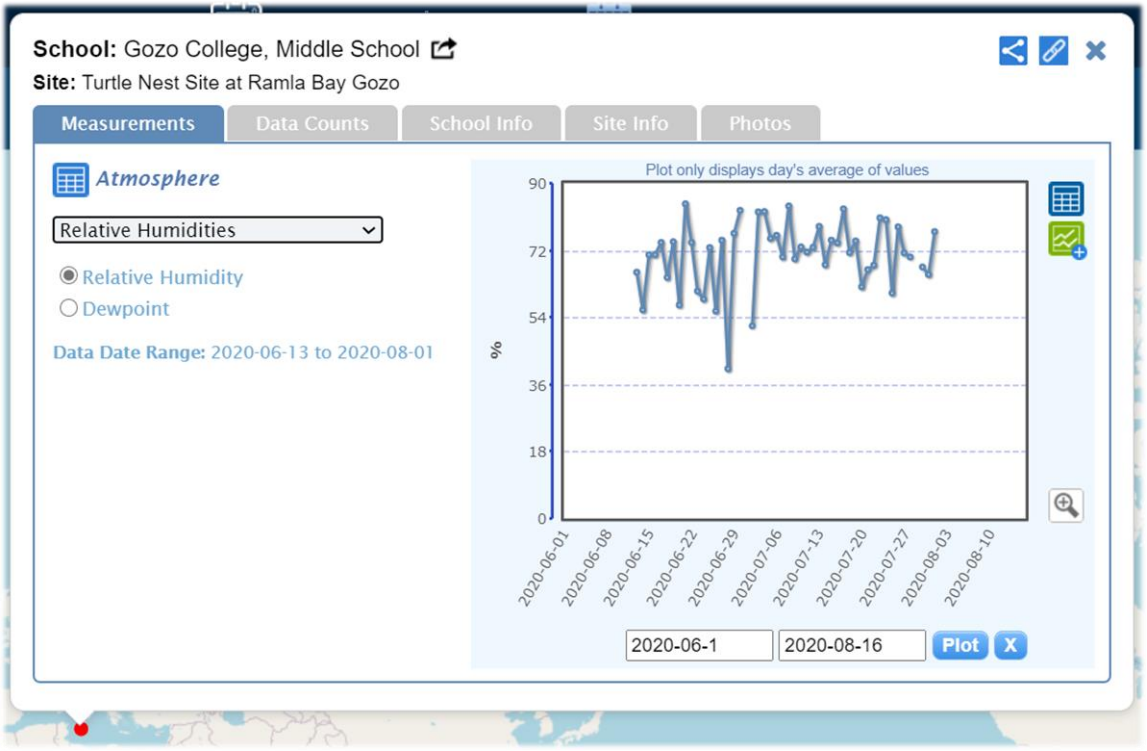


Figure 6 Relative humidity plot of VIZ GLOBE

Surface Temperature

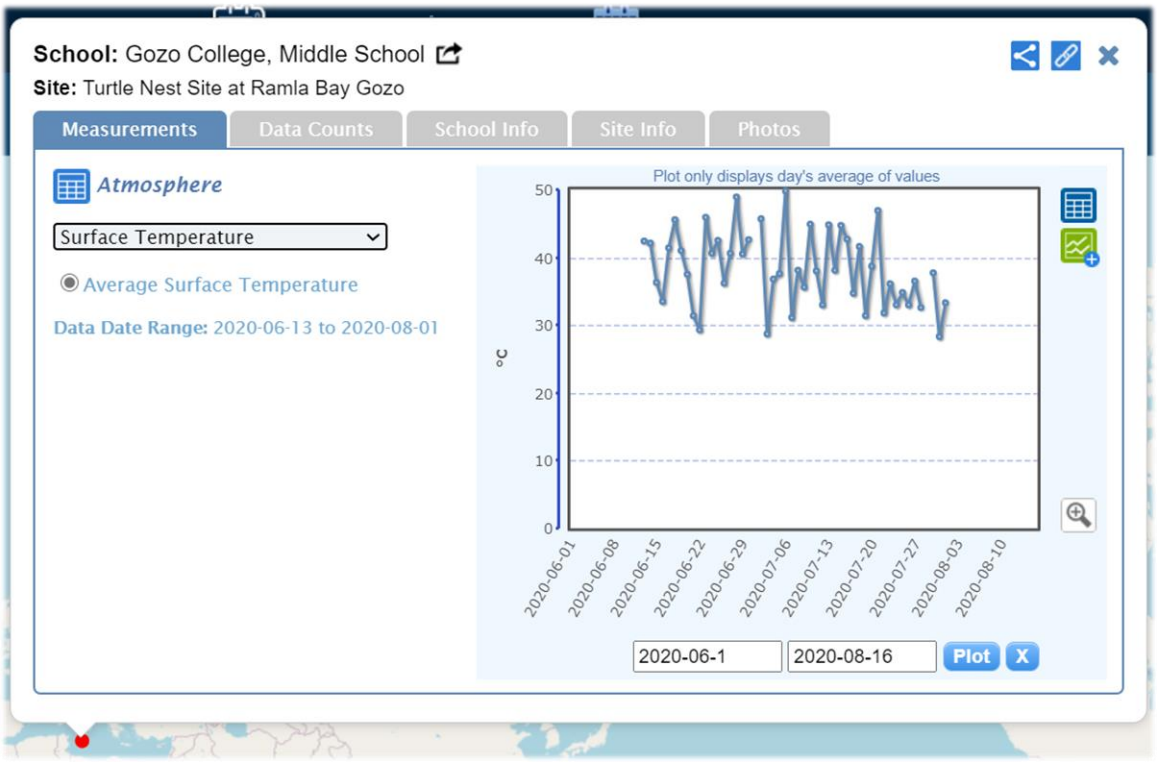


Figure 7 Surface Temperature plot of VIZ GLOBE

Screenshots from observer.globe.gov showing different cloud types and surface conditions for three particular days from the observation period, one in June (Figure 8), one in July (Figure 9) and one in August (Figure 10).

Figure 8 Clouds and surface conditions on 15th June 2020

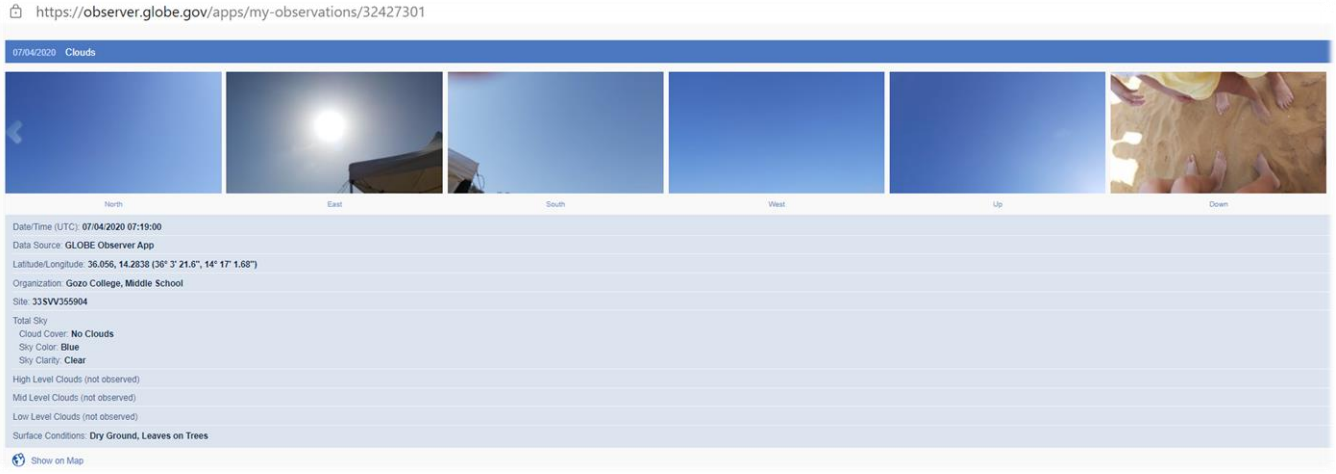
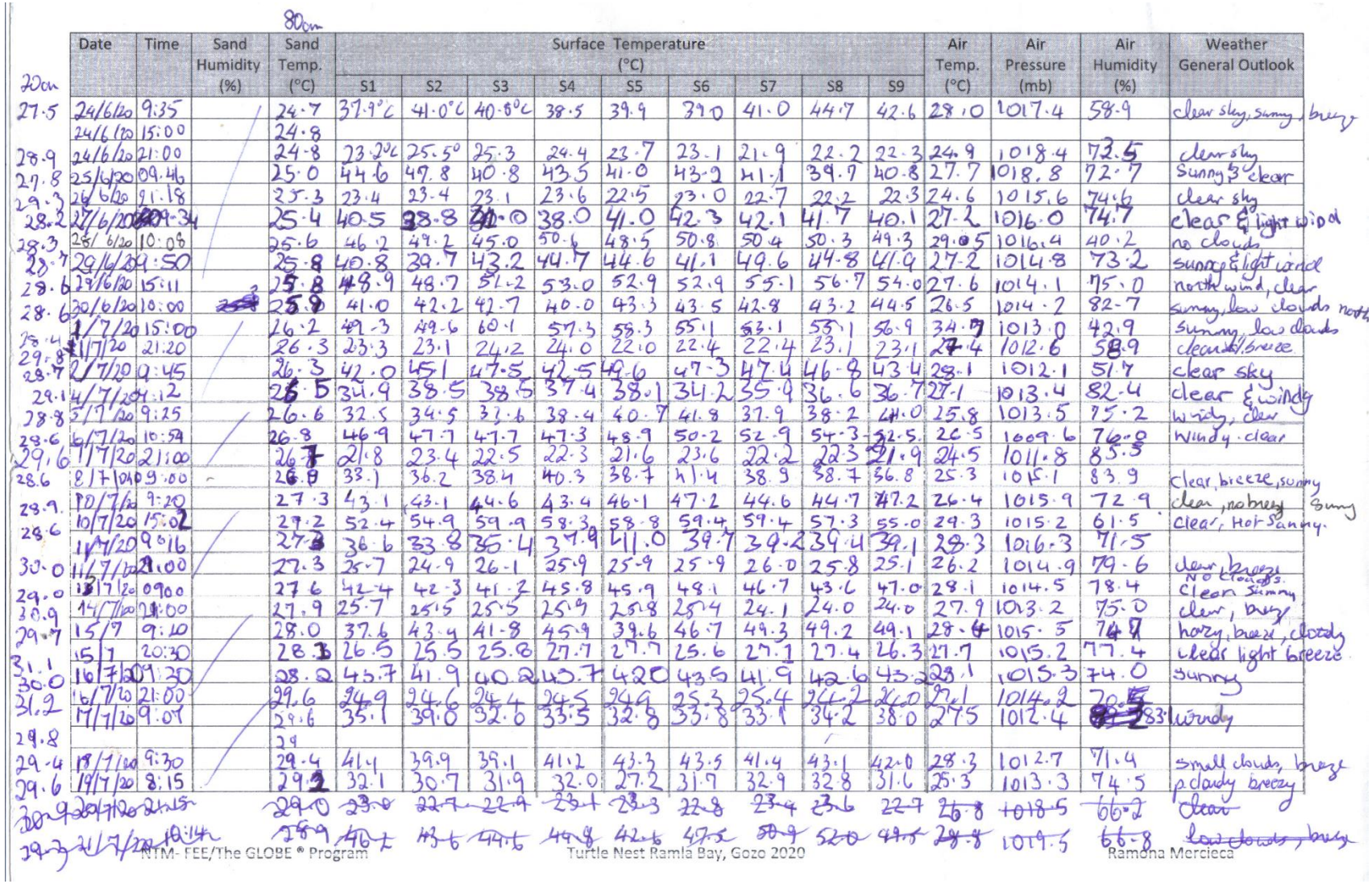


Figure 9 Clouds and surface conditions on 4th July 2020

Figure 10 Clouds and surface conditions on 1st August 2020

Table 1: Sample of Data Sheet 2 of 6



20cm	Date	Time	Sand Humidity (%)	80cm Sand Temp. (°C)	Surface Temperature (°C) S1	S2	S3	S4	S5	S6	S7	S8	S9	Air Temp. (°C)	Air Pressure (mb)	Air Humidity (%)	Weather General Outlook
27.5	24/6/20	9:35		24.7	37.9°C	41.0°C	40.8°C	38.5	39.9	39.0	41.0	44.7	42.6	28.0	1017.4	58.9	clear sky, sunny, breezy
	24/6/20	15:00		24.8													
28.9	24/6/20	21:00		24.8	23.2°C	25.5°	25.3	24.4	23.7	23.1	21.9	22.2	22.3	24.9	1018.4	72.5	clear sky
27.8	25/6/20	09.46		25.0	44.6	47.8	40.8	43.5	41.0	43.2	41.1	39.7	40.8	27.7	1018.8	72.7	Sunny & clear
29.3	26/6/20	21.18		25.3	23.4	23.4	23.1	23.6	22.5	23.0	22.7	22.2	22.3	24.6	1015.6	74.6	clear sky
28.2	27/6/20	09.34		25.4	40.5	38.8	40.0	38.0	41.0	42.3	42.1	41.7	40.1	27.2	1016.0	74.7	clear & light wind
28.3	28/6/20	10:06		25.6	46.2	49.2	45.0	50.6	48.5	50.8	50.4	50.3	49.3	29.05	1016.4	40.2	no clouds
29.7	29/6/20	9:50		25.8	40.8	39.7	43.2	44.7	44.6	41.1	49.6	44.8	41.9	27.2	1014.8	73.2	sunny & light wind
28.6	29/6/20	15:11		25.8	48.9	48.7	51.2	53.0	52.9	52.9	55.1	56.7	54.0	27.6	1014.1	75.0	north wind, clear
28.6	30/6/20	10:00		25.9	41.0	42.2	42.7	40.0	43.3	43.5	42.8	43.2	44.5	26.5	1014.2	82.7	sunny, low clouds north
28.4	1/7/20	15:00		26.2	49.3	49.6	60.1	57.3	58.3	55.1	53.1	53.1	56.9	34.7	1013.0	42.9	sunny, low clouds
29.8	1/7/20	21.20		26.3	23.3	23.1	24.2	24.0	22.0	22.4	22.4	23.1	23.1	27.4	1012.6	58.9	clear sky, breeze
28.7	2/7/20	9:45		26.3	42.0	45.1	47.5	42.5	49.6	47.3	47.4	46.8	43.4	28.1	1012.1	51.7	clear sky
29.1	4/7/20	9:12		26.5	34.9	38.5	38.5	37.4	38.1	34.2	35.9	36.6	36.7	27.1	1013.4	82.4	clear & windy
28.8	5/7/20	9:25		26.6	32.5	34.5	37.6	38.4	40.7	41.8	37.9	38.2	41.0	25.8	1013.5	75.2	windy, clear
28.6	6/7/20	10:59		26.8	46.9	47.7	47.7	47.3	48.9	50.2	52.9	54.3	52.5	26.5	1009.6	76.8	windy, clear
29.6	7/7/20	21:00		26.7	21.8	23.4	22.5	22.3	21.6	23.6	22.2	22.3	21.9	24.5	1011.8	85.5	
28.6	8/7/20	9:00		26.8	33.1	36.2	38.4	40.3	38.7	41.4	38.9	38.7	36.8	25.3	1015.1	83.9	clear, breeze, sunny
28.9	10/7/20	9:20		27.3	43.1	43.1	44.6	43.4	46.1	47.2	44.6	44.7	47.2	26.4	1015.9	72.9	clear, no breez Sunny
28.6	10/7/20	15:02		27.2	52.4	54.9	59.9	58.3	58.8	59.4	59.4	57.3	55.0	29.3	1015.2	61.5	clear, Hot Sunny.
	11/7/20	9:16		27.8	36.6	33.8	35.4	37.9	41.0	39.7	39.2	39.4	39.1	28.3	1016.3	71.5	
30.0	11/7/20	21:00		27.3	25.7	24.9	26.1	25.9	25.9	25.9	26.0	25.8	25.1	26.2	1014.9	79.6	clear breeze NO clouds.
29.0	13/7/20	0900		27.6	42.4	42.3	41.2	45.8	45.9	48.1	46.7	43.6	47.0	28.1	1014.5	78.4	clear sunny
30.9	14/7/20	21:00		27.9	25.7	25.5	25.5	25.9	25.8	25.4	24.1	24.0	24.0	27.9	1013.2	75.0	clear, breez
29.7	15/7	9:10		28.0	37.6	43.4	41.8	45.9	39.6	46.7	49.3	49.2	49.1	28.6	1015.5	74.8	hazy, breez, cloudy
	15/7	20:30		28.3	26.5	25.5	25.8	27.7	27.7	25.6	27.1	27.4	26.3	27.7	1015.2	77.4	clear light breeze
31.1	16/7/20	09:30		28.2	45.7	41.9	40.2	43.7	42.0	43.5	41.9	42.6	45.2	28.1	1015.3	74.0	sunny
30.0	16/7/20	21:00		29.6	24.9	24.6	24.4	24.5	24.9	25.3	25.4	24.2	24.0	27.1	1014.2	70.5	
31.2	17/7/20	9:09		29.6	35.1	39.0	32.0	33.5	32.8	33.8	33.1	34.2	38.0	27.5	1012.4	83	windy
29.8				29													
29.4	18/7/20	9:30		29.4	41.4	39.9	39.1	41.2	43.3	43.5	41.4	43.1	42.0	28.3	1012.7	71.4	small clouds, breeze
29.6	18/7/20	8:15		29.2	32.1	30.7	31.9	32.0	27.2	31.7	32.9	32.8	31.6	25.3	1013.3	74.5	p.cloudy breezy
30.9	20/7/20	21:15		29.0	23.0	22.9	22.4	23.1	23.3	22.8	23.4	23.6	22.7	26.8	1018.5	66.2	clear
29.3	21/7/20	10:14		28.9	46.1	43.6	44.6	44.8	42.6	47.5	50.9	52.0	49.5	29.8	1019.5	66.8	low clouds, breez

Table 2: Sample of Data Sheet 6 of 6

Date	Time	Sand Humidity (%)	Sand Temp (°C)		Surface Temperature (°C)									Air Temp. (°C)	Air Pressure (mb)	Air Humidity (%)	Weather General Outlook
			20cm	80cm	S1	S2	S3	S4	S5	S6	S7	S8	S9				
20/7/20	21:15		30.9	29.0	23.0	22.7	22.9	23.1	23.3	22.8	23.4	23.6	22.7	26.8	1018.5	66.2	clear
21/7/20	10:14		29.3	28.9	46.2	43.6	44.6	44.8	42.6	47.5	50.9	52.0	49.5	28.8	1019.5	66.8	low cloud breeze
23/7/20	08:53		29.6	29.0	35.9	34.0	37.0	35.8	38.1	38.1	37.2	32.4	36.4	28.4	1013.6	80.7	sunny, clear
24/7/20	8:52		29.8	29.0	29.4	34.2	32.8	33.2	35.1	33.5	30.4	33.9	34.4	27.8	1011.9	80.2	sunny, light wind
25/7/20	15:10		29.5	29.0	52.3	49.7	51.4	50.9	52.7	49.9	50.6	50.8	51.2	28.9	1015.3	67.2	windy, sunny WNW
26/7/20	9.00		30.0	29.3	31.2	36.2	27.2	31.1	37.0	34.8	31.9	33.1	34.3	27.8	1014.7	78.3	clear, sunny breeze
29/7/20	21:00		31.8	29.9	26.4	26.4	26.7	27.1	27.5	27.1	26.6	25.7	25.5	28.1	1015.7	81.1	clear, cold
28/7/20	9.00		29.6	29.4	26.4	29.8	31.2	31.9	33.6	35.7	38.1	37.2	29.9	29.1	1016.2	70.2	clear, sunny
31/7/20	9:00		30.8	30.0	27.2	26.5	27.0	29.3	30.2	28.7	29.5	27.9	28.1	30.0	1015.6	65.5	clear sun
1/8/20	8.49		30.0	30.3	35.4	32.8	28.6	34.4	35.3	30.9	34.5	32.3	35.4	30.2	1013.8	77	windy, clear

Once all data was collected the students presented it in a graph and analyzed it. They considered all data (morning, afternoon, evening) both for the sand temperature at a depth of 20cm and 80cm.

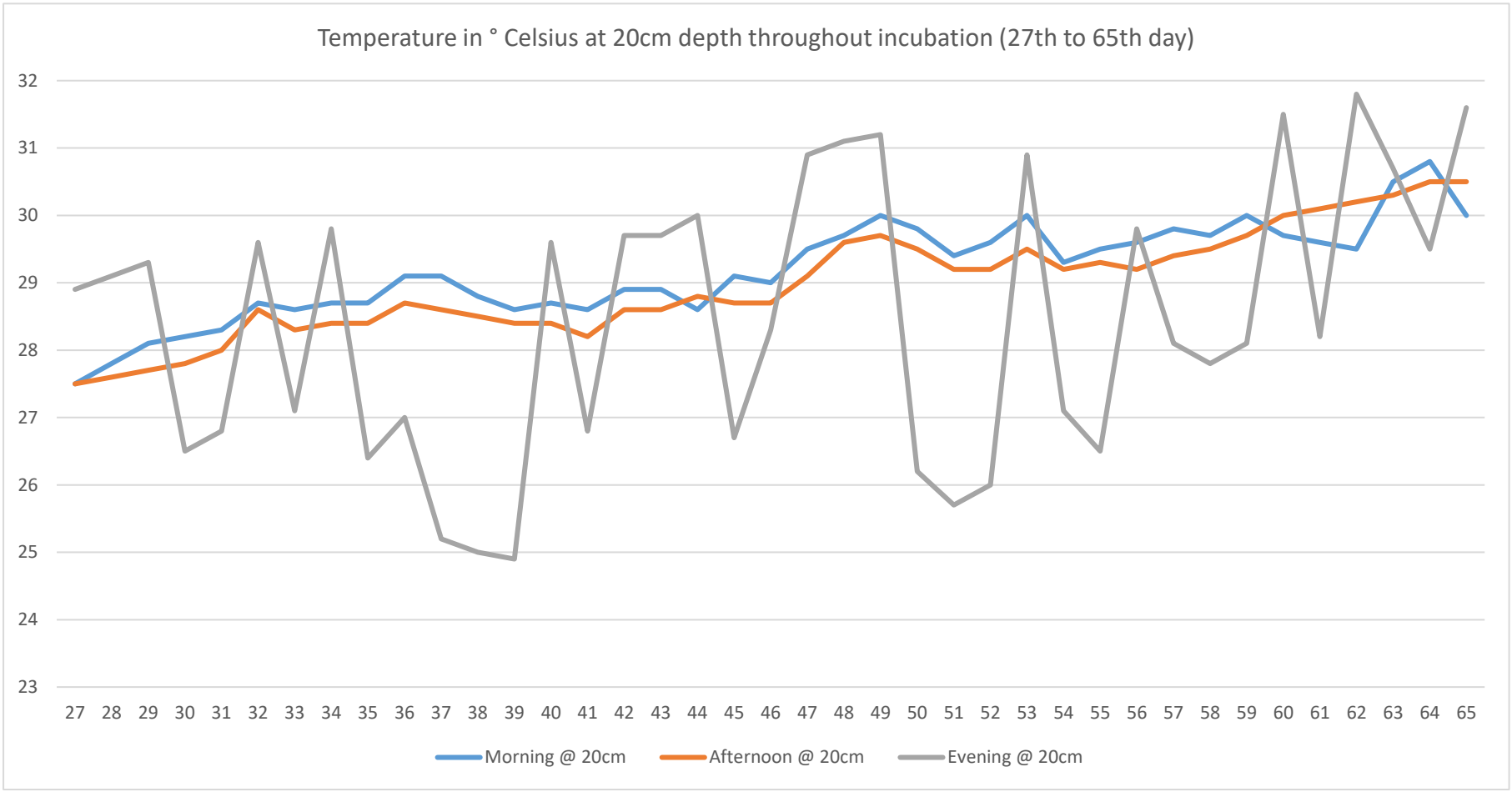


Figure 11 Sand temperature (morning, afternoon, evening) at a depth of 20cm

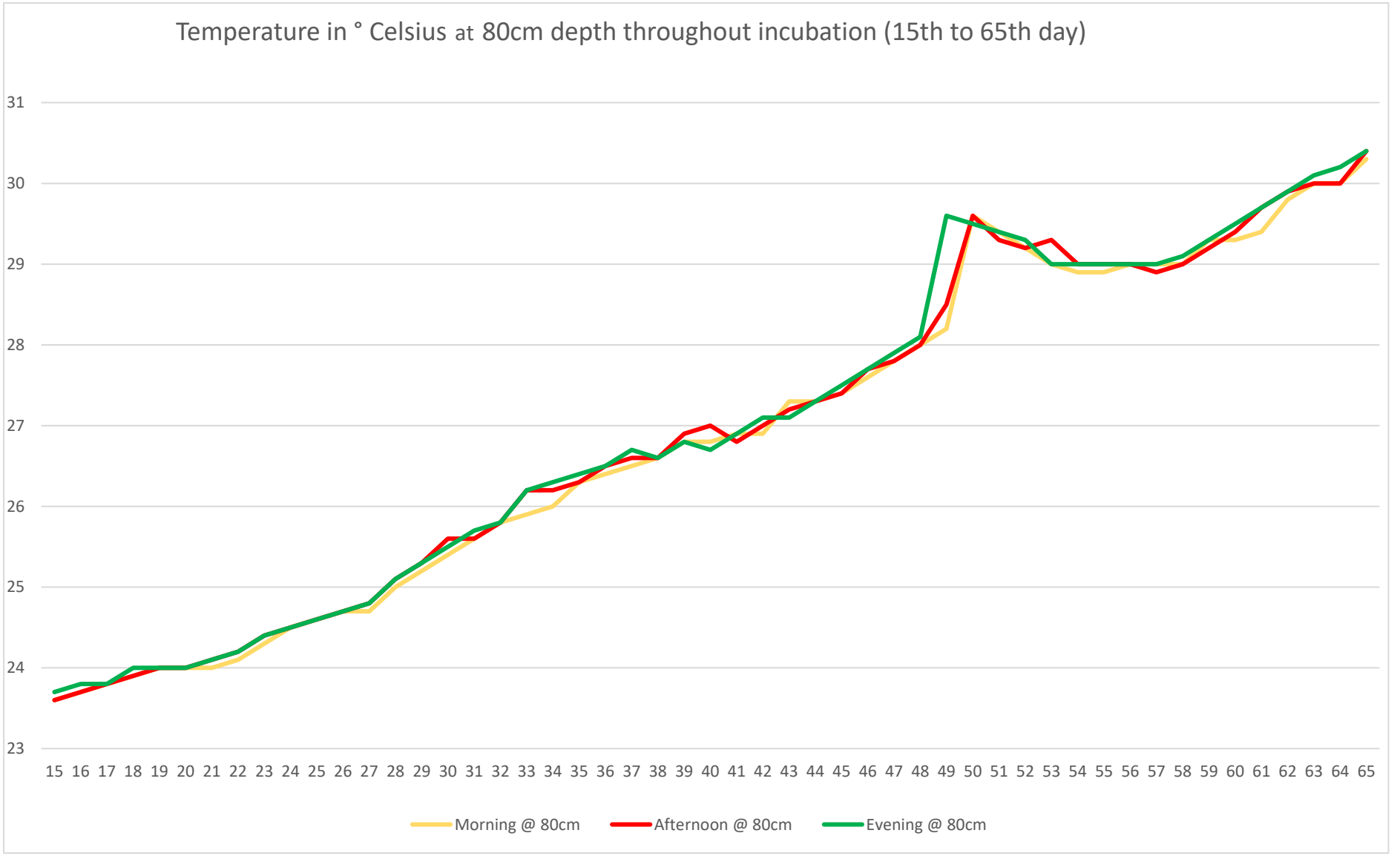


Figure 12 Sand temperature (morning, afternoon, evening) at a depth of 80cm

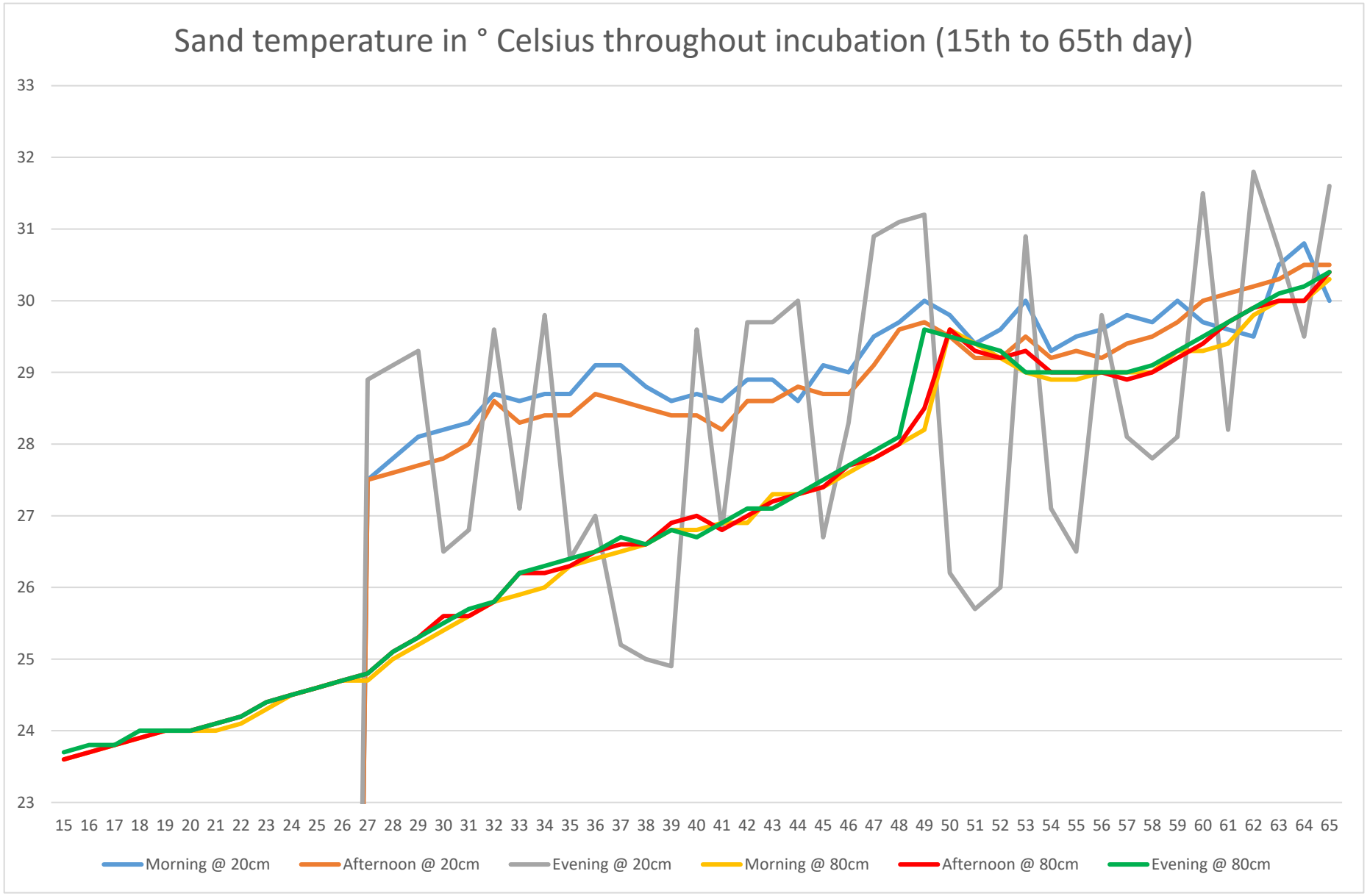


Figure 13 Graphs overlaid to show significant difference between top and bottom temperatures

Discussion

A total of 83 hatchlings hatched and made it to the sea. When the nest was uncovered after the hatching, there were a total of 104 eggs and two hatchlings were found dead inside the nest, with the first egg being found at a depth of 16.5cm and the last egg at 45cm from the surface. The turtle nest at Ramla Bay had a success rate of 80%. Table 3 gives a detailed insight of all the turtle nests that were registered during the nesting season for the year 2020 provided by the Environment and Resource Authority and Nature Trust FEE Malta who also gave us a special permission to be able to do this research and collect data from the turtle nest site.

Table 3: Data of the 7 turtle nests for year 2020

Nest Location	Egg Laying Date	Days taken for the nest to hatch	Nest Dig Up Date	Total Eggs in nest	Total hatched eggs	Unhatched eggs	Partially hatched eggs	Hatchling Corpses	First egg/last specimen depth (cm)
Ramla il-Ħamra	30/05/20	65	04/08/20	104	83	21	Nil	2	16.5/45
Golden Bay (Ramla tal-Mixquqa)	04/07/20	50	26/08/20	96	77	13	6	Nil	27/38
St. Thomas Bay (Ta' Fajtata)	Not known	-	03/09/20	80	31	28	21	21	NA
Ramla il-Ħamra (unknown nest)	Not known Possibly 16/07/20	52/53*	09/09/20	102	58	42	2	Nil	27/46
Għadira Bay (Mellieħa bay)**	Not known	-		-	10	-			NA
Għadira (Mellieħa bay)	29/07/20	53	25/09/20	83	17	63	3	Nil	25/42
Għadira (Mellieħa bay)	10/08/20	58	9/10/20	90	71	14	5	Nil	29/40

What made this nest successful?

1. Location

The turtle nest was located in a sheltered part of the beach. The site where the loggerhead turtle laid eggs had deep sand and hardly any pebbles.

2. Nesting Season and Weather Conditions

Nesting season for loggerhead turtles in the Mediterranean Sea peaks in June and July. Being an early nesting, during the incubation period the sand temperature only exceeded 30° Celsius at the end of the incubation when the gender of the hatchlings is already decided so most hatchlings were males. This is because research shows that if a turtle's eggs incubate below 28° Celsius, the turtle hatchlings will be male. If the eggs incubate above 31° Celsius, however, the hatchlings will be female. Temperatures that fluctuate between the two extremes will produce a mix of male and female baby turtles. Researchers have also noted that the warmer the sand,

the higher the ratio of female turtles. As the Earth experiences climate change, increased temperatures could result in skewed and even lethal incubation conditions, which would impact turtle species and other reptiles.

3. Protection

Loggerhead turtles are protected under Maltese law. As soon as the turtle was spotted laying eggs on the beach, volunteers from Nature Trust FEE Malta were on site followed by officials from the Environment and Resource Authority. An enclosure was put up around the nest surrounded with sand bags to stop sea water from strong waves and/or surface runoff from heavy rainfall. A mesh was also buried 1 metre deep all around the perimeter of the enclosure, three metres away from the nest, to protect the eggs from the possibility of ghost crabs digging tunnels to the nest and signs were placed along the beach informing people about the nest and required behaviour such as avoiding loud noises and using objects causing vibrations close to nest. Studies show that a marked nest has much better chances of successful incubation, as in this case.

Conclusion

Through the observations and data collected from the turtle nest site, it was concluded that the physical environment, weather conditions and sand temperature do have an effect on the success rate of a turtle nest. Moreover, the fact that turtle nest was marked and protected during the incubation period contributed significantly to its success rate.

During site visits the students noticed, on many occasions, that the beach was full of litter especially cigarette butts and microplastics. To back up the educational process and support wildlife, the students took the initiative and went a step further. They came up with the idea of organising a beach clean-up event. Volunteers from Nature Trust FEE Malta and the general public joined the event. Besides lots of cigarette butts, bottle caps, straws and cotton bud sticks, thousands of small pieces of plastic including nurdles were collected from the sand through sieving (Figure 14). The students wanted to set the example and be part of the change and take action to get closer to reach the Sustainable Development Goals mainly SDG 14 (Life below water) and SDG 11 (Sustainable cities and communities).

Figure 14 Collecting microplastics and nurdles through sieving during clean-up event

Bibliography

GLOBE teacher guide https://www.globe.gov/ (Accessed October 2020)

GLOBE Observer https://observer.globe.gov/ (Accessed February 2021)

http://earth-sea-sky-global.org

Badge Descriptions/Justifications:

I am a Data Scientist

Students analysed their own data (from their measurements). They were able to analyse line graphs to interpret the data. They also became aware of the limitations of the data and could only draw conclusions from the samples studied. From the data analysis, the students answered their research questions and made suggestions for future research.

I am a Collaborator

GLOBE students from Gozo College Middle School participated in 2 online meeting with students from the University of Lima. They spoke about their experience with The GLOBE Program, how interactive the program is and the opportunities it offers. Last by not least they shared the results of their investigation on marine litter and data collected from turtle nest site in Ramla Bay with 1st year General Ecology students attending Universidad Nacional Agraria La Molina in Lima, Peru. GLOBE Malta students shared their findings and together they discussed the ideal conditions for a turtle nest to be successful.

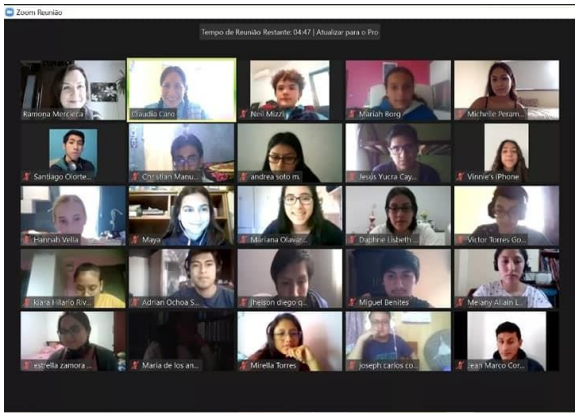


Figure 15 Screenshot from 1st online meeting held on 15th January 2021

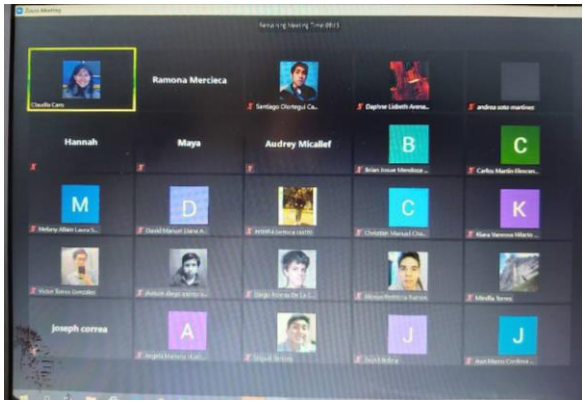


Figure 16 Screenshot from 2nd online meeting held on 26th February 2021

I am a STEM Professional

This research was developed with some suggestions and feedback of the biologist Ms Claudia Caro, from Peru. She suggested some questions and sent us some information to improve the discussion of our results.