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IS THE 2018 LOGGERHEAD NEST REALLY ANOTHER EXCEPTIONAL SEA TURTLE NESTING RECORD FOLLOWING THE 2012 AND 2016 PREVIOUS NESTING CASES IN MALTA?

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We report another nesting event by a loggerhead turtle in Ġnejna (Malta), in June 2018, with an extraordinary hatching rate of 99.1%. This follows the previously reported nesting in 2012 in the same bay, and the 2016 event in a nearby beach at Golden Bay, both beaches located in the NW of Malta. Before the 2012 record, scientifically recorded turtle nesting in Malta dated back some 100 years, although in one paper it is alleged that turtles may have been nesting in Malta up until some 50-60 years ago. Noting that loggerheads have an average remigration interval of 2 years, it is possible that the same turtle that nested in 2012 came back to Ġnejna to nest again in 2018. It is hoped that DNA analysis, which ideally follows at a later stage, will determine whether it was the same turtle.

Campaigns are currently ongoing to solicit greater reporting of nesting. Relocation of eggs is discussed. In this paper we also describe conservation measures that were set-up in this bay and in Golden Bay, including measures during hatching. Emergency conservation orders were issued in all the three nesting events, to protect the beaches in question from any major and potentially harmful activities. The sites were also surrounded and physically protected with a 24 hour monitoring scheme being set-up with the help of volunteers from Nature Trust Malta and government officials.

Keywords: *Caretta caretta,* sea turtle, nesting, Mediterranean, Malta, exceptional and sporadic nesting

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U radu donosimo podatke o novom gniježđenju glavate želve na plaži Ġnejna (Malta) u lipnju 2018., s izuzetnim omjerom izlegnutih kornjača od 99.1%. Taj događaj slijedi nakon prethodnih gniježđenja u istoj uvali 2012. i na obližnjoj plaži Golden Bay 2016.; obje plaže se nalaze na sjeverozapadu Malte. Prethodno podatku iz 2012., jedino znanstveno opažanje gniježđenja kornjača na Malti bilo je zabilježeno prije 100-tinjak godina, iako se u jednom radu spominje njihovo gniježđenje na Malti do prije 50-60 godina. S obzirom na interval prosječnog povratka glavate želve od dvije godine, moguće je da se ista kornjača, koja se gnijezdila 2012., vratila ponovno gnijezditi u uvalu Ġnejna 2018. godine. Nadamo se da će uslijediti DNA analiza kojoa bi utvrdila radi li se o istoj kornjači.

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* The views expressed here do not necessarily reflect the views of the Environment Resource Authority

Trenutno se provode kampanje za poticanje boljeg izvještavanja o gniježđenju. U radu se raspravlja u premještavanju jaja. Također opisujemo mjere zaštite poduzete u ovoj uvali i uvali Golden Bay, uključujući mjere tijekom gniježđenja. Hitne mjere zaštite poduzete su u sva tri gniježđenja da bi se dotične plaže zaštitile od potencijalno štetnih događaja. Lokacije su i fizički zaštićene i ograđene tijekom 24-satnog monitoringa, uz pomoć volontera iz Nature Trust Malta i upravnih tijela.

Ključne riječi: *Caretta caretta,* morske kornjače, gniježđenje, Sredozemlje, Malta, izuzetno i sporadično gniježđenje

INTRODUCTION

Species conservation requires an understanding of the population, life histories, and behavioural patterns of the target species. Although the Mediterranean subpopulation of the Loggerhead turtle (*Caretta caretta*) has recently been categorised as 'Least Concern' (LC) on the IUCN Red List of Threatened Species 2015 (IUCN, 2015), this change in category from a previous threatened status is entirely conservation-dependent, because the 'current population is the result of decades of intense conservation programs, especially at nesting sites (Casale & Margaritoulis, 2010) and the cessation of these programs would be followed by a population decrease'. Survival of this species thus depends primarily on implementation of conservation measures based on conservation priorities, like population ecology, biogeography, their reproductive biology and by curbing, as much as possible, threats (including anthropogenic ones) directly to the species and to their habitats, both on land (nesting) and at sea.

The main current threats to the Mediterranean subpopulation are represented by fishery bycatch and nesting habitat degradation due to coastal development (Casale & Margaritoulis, 2010), as also outlined in the conservation and research priorities by Casale in 2018 (Casale *et al*., 2018).

The Mediterranean loggerhead population exhibits limited gene flow with that in the Atlantic (Shamblin *et al*., 2014; Carreras *et al*., 2011) and thus represents a Regional Management Unit for conservation (Wallace *et al*., 2010). Annual adult female population nesting in the Mediterranean is estimated at 2,000 for *C. caretta* (Grommbridge, 1990) with over 7,200 nests per year in the whole Mediterranean (Casale & Margaritoulis, 2010; Casale *et al*., 2018). Major nesting sites are found in Greece, Turkey, Libya (unquantified nesting) and Cyprus (Baran & Kasparek, 1989; Groombridge, 1990; Kasparek, 1995; Broderick & Godely, 1996; Kuller, 1999; Laurent *et al*., 1999; Margaritoulis, 2000; Clarke *et al*., 2000; Casale & Margaritoulis, 2010). Minor sites or scattered nesting occur in several other countries in the eastern basin, including Italy Egypt, Lebanon, Israel, Syria and Tunisia (Casale & Margaritoulis, 2010).

It is interesting to note that initially, Italy was not known to host any major nesting sites (Argano & Baldari, 1983; Argano *et al*., 1992) but a recent review reported many recent nesting reports (Mingozzi *et al*., 2007, Bentivegna *et al*., 2008; Senegas *et al*., 2008). In Sicily, there are potential coasts for sea turtle nesting, and nests have occasionally been reported there by tourists or local people (Mingozzi *et al*., 2007). This is quite noteworthy considering the close proximity of Sicily to Malta. In 2011, Casale reported 11 nests, which in comparison to past records was a relatively high number possibly, due to the 'awareness campaign carried out in 2011 to solicit such reports'. This also inferred that Sicily (Casale, 2011) and possibly other minor islets nearby may host a much higher nesting activity than previously thought. It is also crucial to note that nesting events in the central and western Mediterranean (Tomás *et al*., 2002; Delaugerre & Cesarini 2004; Bentivegna

et al., 2008; Senegas *et al*., 2008; Tomás *et al*., 2008; Bentivegna *et al*., 2010; Carreras *et al*., 2018) have been increasing greatly in the last decade.

MATERIALS AND METHODS

The main aim of this work was to acquire important clues for better conservation, on local nesting events (Mifsud *et al*., 2007), all of which had been reported to authorities or NGOs by people on the beaches in question. Since this was quite an exceptional phenomenon in the Maltese Island (Mifsud, 2010), the best conservation measures possible were set up and further awareness-raising with the public was carried out to stimulate the population to make such reports.

Both Ġnejna bay and Golden Bay (Fig. 1) are important beaches in Malta, with large numbers of tourists and locals visiting daily. Ġnejna is 228.2 metres long and about 50 metres wide at its widest point (MSFD Initial Assessment Report on Habitats; based on the 2008 aerial photos). Golden Bay is 317 metres long and 82 m wide (MSFD Initial Assessment Report on Habitats; based on the 2008 aerial photos). These beaches are amongst the very few sandy beaches present in the Maltese Islands. Sandy (particle size 0.063-2mm), shingle (particle size 2-256 mm) or mixed sand and shingle shores are

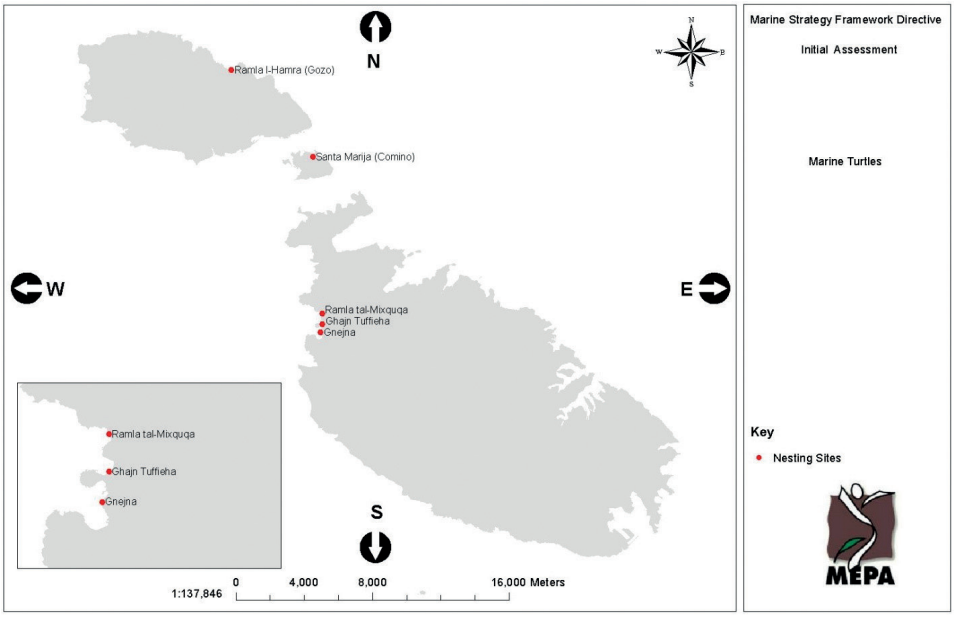

Fig. 1. Location of the sporadic recent and historic recorded nesting of *Caretta caretta* – extracted from the Malta Environment and Planning Authority (2013). MSFD Initial Assessment - Reptiles. Retrieved from https://era.org.mt/en/Documents/MSFD-InitialAssessment- MarineTurtles.pdf
Ad-hoc nesting events reported from Malta for 2012, 2016 and 2018 in Gnejna, Ramla Tal-Mixquqa and Gnejna respectively. Before the 2012 record, scientifically recorded turtle nestings in Malta were sporadic dating back some 100 years, though one paper carried hearsay reports about turtles that may have been nesting up till some 50-60 years ago in Ghajn Tuffieha (see map). Other sporadic nesting beaches historically recorded were from Gozo (Ramla l-Ħamra) and from Comino (Santa Marija), as marked in the above map.

restricted to only small pockets along the Maltese coast occupying circa 2.5% (Axiak & Sammut, 2002) of the Maltese coastline or an estimated 6.5km.

On the side of Ġnejna Beach, there is a small kiosk and the owner also has a number of other commercial beach/sea related activities, including renting of kayaks, paddle boats and speed boats. Overlooking Golden Bay, there is a large five-star hotel and a small part of the beach is also privately operated by this hotel. A large kiosk is present on the hill above the beach and a number of other operators and kiosks are present near or on the beach with activities related to hiring of paddle boats, deck chairs and umbrellas. Golden Bay forms part of Il-Majjistral Nature and History Park and both bays are Natura 2000 protected areas.

These nesting events were reported by a person or persons on the beach. For the 2012 (Mifsud *et al*., 2015) and 2016, the report received was during the actual oviposition, when there were several barbecues lit on the beach. This is very common practice on Maltese beaches during summer evenings. For the 2018 case, the person in question reported such nesting to NTM (Nature Trust Malta-an e-NGO) the next day. Date of nesting was conventionally assigned as the day after the night when the clutch was laid i.e. 21st June for 2012, 2nd August for 2016 and 25th June for 2018 (see Tab. 1). Following such reports, a number of Government officials from the Environment Authority as well as staff from Nature Trust Malta, visited the area immediately − for 2012 and 2018, it was done early the next day after nesting and for 2016, officials were present during or right after the actual nesting. In 2012, the nest was some 5 meters (or less) away from the sea on the lowest part of the beach, easily subject to covering by waves, hence it was decided to relocate the eggs, into a dug-out egg chamber some 60-100 m away from the original nest. For the 2016 and 2018, no relocation was necessary, as the nest was more than 8-10 meters away from the water's edge. The decision for the 2018 event was quite difficult in view of the previous prognostications of the effect of the clay on the 2012 nest. However, following the advice of NTM, which had 'gently' dug the nest to confirm its presence; it was decided not to relocate, since the area where the nest was, did not seem to contain clay.

In 2012 (Mifsud *et al.*, 2015), the relocation was done as per standard procedures and the number of eggs was recorded. The artificial nest was dug out as closely as possible, in terms of depth, diameter and shape (flask shaped), to the natural nest.

Close collaborations were established in all cases with the commissioner of the Police and with the Administrative Law enforcement officials. Press releases were immediately drafted and issued through the help of the National Affairs Office (and PR office) of the Environment Authority and by NTM.

In all the nesting cases on the day of or a few days after nesting, an Emergency Conservation Order (ECO), banning barbecues, and other harmful activities like the use of cars in the adjacent area, were issued. A large area of about 4m x 4m around the nesting was cordoned off with green shallow mesh plastic in each case. In these ECOs, the use of caravans and camping was prohibited in the area adjacent to the cordoned-off area. In Ġnejna, vehicles were forbidden to get closer than 20 m to the nest and in Golden Bay such a prohibition was not necessary as vehicles do not normally drive on the sandy beach itself. Large catering and other activities were also banned close to the cordoned off area. Nearer to the hatching time, the southern part of the mesh was opened to give free access to the hatchlings, in case of unnoticed emergence.

A 24 hour surveillance was set up in all the nesting cases, with government officials also from the department of Works Division, and with Volunteers from NTM. In these nesting events, the Maltese officials immediately contacted the regional and international experts on the subject in view of the lack of direct experience on nesting in the Maltese coast and their advice was followed. An aluminium cage was placed around the nest in every case, for the further protection of the nest as per the advice from the Cypriot author of this paper. *'Marine Turtles Encounter Guidelines'* (short versions and long version) were written as well as 'what one should do if one encounters a nesting turtle coming up the beach…again'. The latter was done in case of the eventuality of multiple nesting by the same turtle. These guidelines were issued on the Authority's website and the leaflets were appended to the cordoning mesh and to other beaches.

In 2012, a local notice to mariners was also issued to pre-advise that when the eggs hatched (issued 3 weeks prior to the expected hatching date), the maritime traffic and fishing in the bay would be prohibited during the hatching time frame. Signage with this information and details of a call line for emergencies, were also appended in the area prior to the stipulated date of hatching. For the 2012, however, since the nest had failed, these regulations were then not eventually put into force.

In the ECO of 2016 and 2018, the above-mentioned clauses re maritime traffic, were incorporated in the actual ECO. All the lights (for all nesting cases) in the adjacent areas overlooking the beach, were either turned off and/or had red filters put on them. Warning signs were put up all around the beach (stipulating activities not permitted during that time) and a number of FAQ and other information posters were also appended all around the cordoning mesh.

In all cases, on a number of occasions, sand bags had to be used to lessen the effect of waves coming up near the nest. In the 2018 nesting, since it had been noted how rain water would behave following the 2012 nest and storm, measures were taken to mitigate this by placing sand bags to help divert the currents during heavy rain. This worked well as there were a number of small storms and sand bags helped to divert the water flow.

A protocol was also drafted for the eventuality of hatching, in order to control the people potentially attending the hatching event. Another protocol (both in Maltese and in English) was also drafted for the surveillance personnel. Security officials and volunteers were advised to check the nest every 20 minutes even during the night when the hatching time was getting closer. For Ġnjena, an agreement had also been made with the nearby five star hotel to switch off the lights facing the bay when hatching was noted to have started. A number of radio and TV programmes were also attended by key members and all the conservation measures were featured on the evening news. A number of media releases were also issued to alert about the government notices.

In 2012, in the last 2 weeks prior to the stipulated hatching the then Maritime Authority was notified to remove the swim zone (which has a line and a number of floating buoys), since it was understood that this might interfere with the swimming hatchlings. In 2016 and 2018, weights were positioned on various points on the swim zone line, for the same reason.

RESULTS

For the 2012 nest on the 79th day (7th September) we excavated the nest (Tab. 1); the top layer (some 5 eggs) had eggs with fully developed embryos inside (at the latest stages of development). 1 embryo of these 5, had a yolk sac which was undergoing absorption, implying the embryos died some 2-3 days prior to hatching. This embryo was about 5 cm long. Eggs beneath were less developed showing mid-stages of development whilst the lowest layers of eggs had embryos in either the initial stages of development or with no discernible embryo at all. 7 embryos were quite big (late stages of development) between 4.2 to 4.8 cm and about 18 embryos were between 3.0 to 4.0, 4 embryos were between 2.4 - 2.8 and 8 embryos between 1.5 - 2.2 cm. Some (approximately 23) were at very early stages, and approximately 8 eggs seemed to have no discernible embryo at all.

When the chamber was dug out, it was noticed that the lowest layer was very wet and the bottom of the nest had either embedded water and/or been inundated with rain water in the previous weeks and the nest had not drained. A lot of blue clay material at this level was also found in the nest.

For the 2016 nest (Tab. 1), hatching happened on the 26th September with 56 days of incubation (nesting on 2nd August). Exhumation was done on the 29th September. After analysis of the remnant egg shells and all nest contents, it was discovered that 79 (max 80) eggs had hatched (hatching was most probably in one episode on the 26th September) and 13 eggs remained unhatched, with 1 hatchling which had not made it out of the nest. It was thus calculated that the initial nesting clutch was of 93 or 94 eggs. The success rate was thus about 86 %. Out of the 13 eggs, 7 were opened for examination. 2 had no discernible embryo (not even at early stages as not even an embryonic disc was observed), 1 was at the very initial stage of development, 3 were at the middle stage of development and 1 was at late stage of development (possibly a few days before it would have hatched).

For the 2018 nest (Tab. 1), hatching occurred on the 22nd August after 59 days of incubation. The nest was exhumed on the 28th August. It was discovered that the nest had 112 eggs of which only 1 had not hatched. Thus in 2018, 99.1 % hatching success was expe-

Tab. 1. Depiction of the recent sporadic nests from 2012-2018 with details on nest parameters

Year	Name of location	Nesting	Number of eggs	Hatching date	Incubation days	Exhumation date	Fertility	Hatchling success
2012	Gnejna Bay (eggs relocated within 24hrs)	21st June	79	n/a	n/a	7th September	7 embryos @ late stages of development & ~ 18 embryos were mid stages, 12, mid but smaller, 8 mid and smaller embryos and 23 were at very early stages. 8 eggs seemed to have no discernible embryo.	0 %
2016	Golden Bay- ir-Ramla Tal-Mixquqa	2nd August	93/94	26th September	56	29th September	13 eggs unhatched; 1 hatchling died in nest; 7 opened for examination: 2 no discernible embryo; 1 very initial stage of development, 3 were @ mid stage & 1 was at late stage of development	86 %
2018	Gnejna	25th June	112	22nd August	59	28th August	Only 1 egg did not hatch	99.1 %

rienced. As in the 2016 case, it appeared that all hatchlings emerged on the same night and for 2018, all had hatched in one very quick wave of emergence, as the event did not take more than about 15 to 20 mins, according to the volunteers who were on site.

DISCUSSION

As previously discussed, it seemed probable that the huge amount of clay present in the nest of the 2012, had led to the failing of this nest. This was evident from the high clay content which was subsequently found in the nest after exhumation and the fact that the underside of the nest was found inundated by seawater and/or the ineffective draining of the heavy rainfall of the last weeks before the expected hatching time. This water or wetness was probably the cause of the death of embryos in the bottom layer at the early stage whilst the upper ones got lost at a much later stage (since the upper embryos were either middle stage or fully formed). These embryos might have got damaged, due to the high demand on the air that the developing embryos were placing on the already limited air in the nest chamber. The waves and rain had inundated the nest on several occasions in the end of August and beginning of September, despite the sandbags placed around the nest. The latest 'torrential' rains in the area had been recorded between the 2-3 Sept, though it is speculated that at this stage most of the embryos might have already been dead with the exception of possibly the topmost 2.

In 2016, most of the eggs hatched, with an 86 % success rate, quite comparable to the good hatching success in Cyprus and Greece (and unlike in Sicily), though there are even higher success rates in certain areas (Demetropoulos, pers. comm). The good results were probably due to the good sand present in Golden Bay and since the rain experienced in the previous few weeks was not torrential and anyway the 'good' porous sand provided very good water drainage, all combined with the good conservation measures established during the incubation time.

In 2018, the exceptional record of 99.1 % was quite an astonishing result. Though the initial decision was quite challenging, in view of the 2012 failed nest, the immediate area around the nest seemed to lack clay particles and the nest was not too near the sea, hence the decision was made not to relocate and keep the nest in its natural place.

According to Margaritoulis & Rees (2008), from a study ongoing since 1982, reproductively older turtles produce more nests (multiple nesters) and lay more eggs than the reproductively younger turtles. It can thus possibly be postulated that the Maltese case, can be a case of neophytes that may have started nesting for the first time in Malta in 2012 with an inadequate initial place (this initial nest was too near the sea and the area was completely inundated with sea water the next day) and which nest had to be relocated. The initial nest only had 79 eggs. In 2016, 93/94 eggs were deposited, whilst in 2018, 112 eggs were laid. The hatching success also increased over time. In all cases, no other nesting was found in the same year, although these can be cases of missed nesting or non-observed nesting in the Maltese Islands, which would then possibly have succumbed in view of sand compaction by mechanical removal of the *Posidonia* banquettes which is a common practice in summer. Nesting events in the central and western Mediterranean (Tomás *et al*., 2002; Delaugerre & Cesarini, 2004; Bentivegna *et al*., 2008; Senegas *et al*., 2008; Tomás *et al*., 2008; Carreras *et al*., 2018) have been increasing during

the last decade, and seem to be associated with ongoing colonisation, which is favoured by global warming. This recurrent nesting in Malta also points in this direction.

It is important to note that as postulated by Carreras *et al*. (2018), colonisation of appropriate new habitats is crucial for species survival at the evolutionary scale under changing environmental conditions. Mafucci *et al*. (2016) further state that the loggerhead turtle has begun to nest steadily beyond the northern edge of the species' range in the Mediterranean basin.

The hypothesis that it was the same turtle that was involved in all the Maltese recent nesting cases reported can only be proven through DNA analysis of these eggs and embryos. Analysis from all these nesting episodes will need to be followed up to check the rookery provenience of the mother and if it was the same turtle in all these nesting cases. Similar studies to those undertaken by Carreras *et al.* (2018) would need to be undertaken to prove this point.

The huge efforts to increase public awareness because of the overall goal of sea turtle protection, which is crucial to the survival of the species, was seen to be imperative in all the cases of these nesting events. The outreach program in which the local people, tourists and the general public were targeted was created and done throughout all the nesting periods and afterwards. Turtle conservation ultimately depends largely on awareness of the issues by the public. We cannot guarantee conservation but we are sure it goes a long way.

Relocation of Sea turtle nests to protect them remains a commonly used strategy around the world (Blanck & Sawyer, 1981; Wyneeken *et al*., 1988) and in 2012 no other option was available, because of the proximity of the nest to the sea. However, in 2018 this was not the case, and despite the failed hatching in 2012, the right decision was made to keep the nest in its original position.

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To all Nature Trust volunteers as well as Government officials from the Works Department and from the environment authority who kept constant watch on a 24 hours basis. These volunteers and officials were all the time giving information and updates to the people and tourists who were present. The NTM volunteers were also conducting other very important volunteer measures during such times like clean-ups of the beaches and giving information on other species and other nature issues as well and as necessary. To all the Enforcement and Compliance Unit and Biodiversity officials who enabled the overall coordination and drafted and enforced the legislative frameworks. Thanks are also due to the Mgarr local council mayor, Mr. Paul Vella and his colleagues and to the regional and international experts for their valuable advice during these nesting episodes. A huge thank-you also to the Kiosk owners and the owners of all the other outlets and particularly to the management of the five star hotel in Golden Bay who fully collaborated and were prepared for the huge task of switching off all the outside lights as necessary during hatching. Also thanks are due to numerous other people who helped in one way or another. The authors would also like express their gratitude and appreciation for the interventions suggested by the anonymous reviewer/s of this paper.

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SUMMARY

Is the 2018 loggerhead nest really another exceptional sea turtle nesting record following the 2012 and 2016 previous nesting cases in Malta?

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We report another nesting event by a loggerhead turtle in Ġnejna (Malta), which happened on the 25th June 2018, with an extraordinary hatching rate of 99.1% on the 22nd August 2018. This follows the previously reported nesting in 2012 in the same bay, and the 2016 event in a nearby beach at Golden Bay (ir-Ramla Tal-Mixquqa), both beaches located in the NW of Malta. Before the 2012 record, scientifically recorded turtle nesting in Malta had only been reported by Despott, dating back some 100 years, although in one paper, it is alleged that turtles may have been nesting in Malta up until some 50-60 years ago. Noting that loggerheads have an average remigration interval of 2 years, it is possible that the same turtle that nested in 2012 came back to Ġnejna to nest again in 2018. Even the 2016 nest in Golden Bay, may have been by the same turtle, since the beaches are in close proximity. Any 'missed' nesting in 2014, may have been due to nesting elsewhere, noting that Malta only has 2.5 % of its beaches that are sandy, or it may have been the case of an unobserved nesting resulting later in a failed nest due to sand compression from mechanical beach cleaning. It is hoped that DNA analysis, which ideally follows at a later stage, will determine whether it was the same turtle. Campaigns are currently ongoing to solicit greater reporting of nesting through more meticulous monitoring for sporadic nesting prior to beach cleaning which is carried out daily in summer in the early mornings. Following the unsuccessful hatching of the 2012 nesting, it was suggested that the high amounts of clay material in this sandy beach, together with the huge rainfall event during the last phase of the nest, may have contributed to the failed nest. It had been previously suggested that Ġnejna beach may not be optimal for development of the turtle's embryos, resulting in either low emergence success or none at all. Despite this, in 2018 a decision was taken not to relocate the eggs in Ġnejna to Golden Bay, where a high hatching emergence had been sustained in 2016. The decision not to relocate was based on the fact that the nest was not close to the waterline, as the 2012 nest and that digging in the nest area to confirm nesting showed that clay seemed not to be present in this small zone. In 2012, relocation was done in the same beach in the 12 hour period after nesting. In this paper we also describe the conservation measures that were set-up in this bay and in Golden Bay, including measures during hatching. Emergency conservation orders were issued in all the three nesting events, to protect the beaches in question from any major and potentially harmful activities. The sites were also surrounded and physically protected with a 24 hour monitoring scheme being set-up with the help of volunteers from Nature Trust Malta and government officials.