



A Galapagos giant tortoise hatchling © Sam Rowley

FINAL REPORT TO THE
BRITISH CHELONIA GROUP

Conserving the Galapagos giant tortoise:
steps towards lifetime tracks



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Conserving the Galapagos giant tortoise: First steps towards lifetime tracks

A Final Report by the Galapagos Conservation Trust & the Giant Tortoise Movement Ecology Programme (GTMEP) prepared for the British Chelonia Group

Reporting Period: March 2015 – March 2016

Project Dates: March 2015 – March 2016

Project Lead: Dr Stephen Blake (GTMEP)

Project Partners:



**GALAPAGOS
TORTOISE
MOVEMENT
ECOLOGY PROGRAMME**



**Galapagos
Conservation
Trust**



BCG
BRITISH CHELONIA GROUP



Parque Nacional
GALÁPAGOS
Ecuador



**HOUSTON
ZOO**



fundación
Charles Darwin
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LIVING CONSERVATION



ECOLOGY PROJECT
INTERNATIONAL

Max Planck Institute for Ornithology
Migration and Immuno-ecology



Saint Louis Zoo

Institute for Conservation Medicine

Healthy Animals. Healthy People.



—WHITNEY R.
HARRIS
WORLD ECOLOGY CENTER
at the University of Missouri-St. Louis

Introduction

Thanks to the generous support of British Chelonia Group, we have been able to significantly progress the Galapagos Tortoise Movement Ecology Programme (GTMEP) in the grant period between March 2015 and March 2016. This final report describes activities undertaken and results obtained during the first year of funding for the “First steps towards lifetime tracks” project of the Galapagos Tortoise Movement Ecology Programme (GTMEP). The GTMEP has been active for over six years and has grown from a small and simple research programme on one of the Galapagos Islands with one tortoise species, to a programme that now focuses on tortoise movement ecology across three islands including several tortoise species. The insights provided so far have been critical to our understanding of how environment, physiology and life history interact to determine movement behaviour in these iconic animals – information that is critical to ensure robust conservation strategies are developed and implemented.

Executive Summary: Taking our ‘First steps towards lifetime tracks’...

The ‘First steps towards lifetime tracks’ project is a study focused on giant tortoise nesting behaviour, hatchling survival and movements on Santa Cruz island. A major gap in our knowledge about giant tortoises are the life history stages from egg to juvenile where mortality rates are highest and a serious population bottleneck exists. These stages are often called “the lost years” because few data exist on

growth, mortality rate and causes of death of infants and juveniles. This is the first study of its kind in Galapagos.

Tracking young tortoises over the first year of this study has revealed that mortality rates of eggs can exceed 50% due to predation by non-native feral pigs and fire ants. The elevation at which the nests are laid also has a significant impact on egg weight, survival, growth and home range size. Such differences may play a key role in tortoise population dynamics and may be negatively impacted by future climate change and increasing human impacts. The results of this project have provided the first ever quantitative data around key parameters of Galapagos giant tortoise reproduction and hatchling survival.

In the grant period, we have also been able to continue our joint outreach and education programme to translate and disseminate research results to local people, decision makers in Galapagos and an international audience. The project team are working closely with Galapagos National Park Rangers to ensure that this information can be utilised to improve management strategies and over the last year, this has resulted in a brand new protocol for data sharing and improving communications that is due to be implemented later in 2016.

Objectives for the “First steps towards lifetime tracks”

The overall **research objective** of this study is to answer the following research questions on tortoise nesting behaviour:

- What are the patterns of seasonal abundance and behaviour of adult female Galapagos tortoises at known nest aggregation sites and do nesting females display strong site fidelity?
- Do environmental conditions influence the timing of nesting?
- Do elements such as incubation temperature, egg size, clutch size, hatching success, hatchling survival, hatchling growth rates and movement patterns vary by nest aggregation site?
- Is this due to a variation in environmental conditions?
- If so, what does this mean for possible future changes in these conditions with increasing human impact and climate change?



Field Assistant Fredy Villamar measures a hatchling – if this tortoise makes it to adulthood, it could live for up to 150 years! © GTMEP

The methodology and some results relating to this objective were covered in detail in the interim report submitted in November 2015. This report contains a summary of the findings included in the interim report but focuses on the subsequent analysis and discussion of any implications or questions raised.

Our **conservation objective** is to increase the survival of eggs and hatchlings on Santa Cruz by developing a closer collaboration with the Galapagos National Park to harmonise data collection and analysis of monitoring data collected by park rangers. Attempts are made to protect large numbers of nests from predation by pigs, however protection methods are rarely successful at saving nests from predation and better systems need to be put in place. Robust documentation of the high failure rate of protection methods is a first step toward generating the will to develop more efficient alternatives. This activity is an ongoing priority for the project.

The **outreach objective** is to build on the previous work of the GTMEP and GCT to inspire conservation ethics and scientific enquiry among young people both in Galapagos and internationally.

We proposed to:

- (a) directly engage 150 local Galapagos high school students into our research programme through a long standing collaboration with the Ecology Programme International (EPI),
- (b) hold a workshop for educators from the Galapagos National Park and teachers from the local community on Galapagos toward the integration of our research into their curricula
- (c) develop similar tools with GCT's "Discovering Galapagos" initiative and the education department of ZSL London Zoo for visitors to the zoo and international users through internet applications
- (d) finish a 30 minute film with the National Geographic Channel on the GTMEP that will use tortoise borne video via the Crittercam system.

Achievements and activities during the project period are summarised below.

1. Research Activity Outcomes

Tortoise Reproduction: Nest characteristics by nesting zone

Since the start of this project, a total of 29 tortoise nests have been closely monitored along varying elevations of Santa Cruz island; nine in the lower nesting zone, and ten in each of the middle and upper nesting zones (Figure 1). 294 eggs were counted, measured, weighed and marked before being returned into the nest in the exact order in which they were removed. Temperature logging "i-buttons" were placed in 24 of these nests to record temperature every four hours. Nests were checked regularly over the following months, particularly when hatching and eruption of the nest was expected.

The results of the "i-button" study show a clear decrease in mean nest temperature (measured from the centre depth of nests) with increasing elevation (Figure 2). There is a mean temperature difference of 2°C over just a 140m elevation range (10-149m). Given the critical role of incubation temperature on sex selection and survival, such differences may play a strong role in tortoise population dynamics.

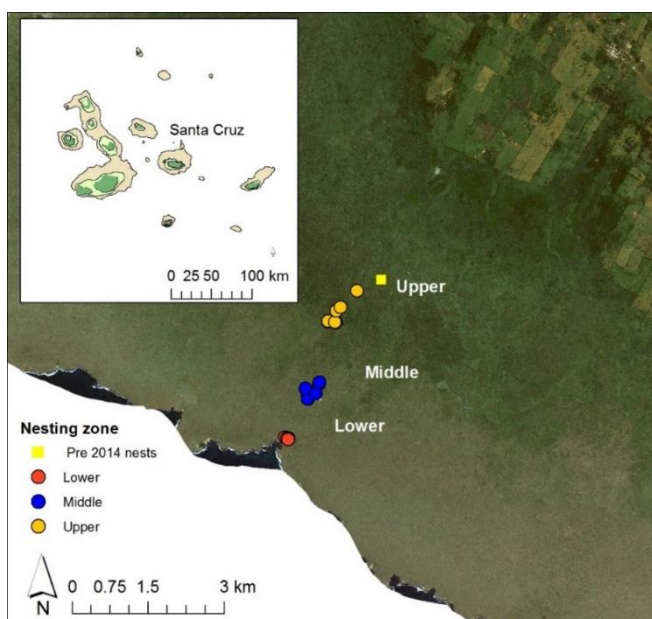


Figure 1. Nests monitored during this reporting period.

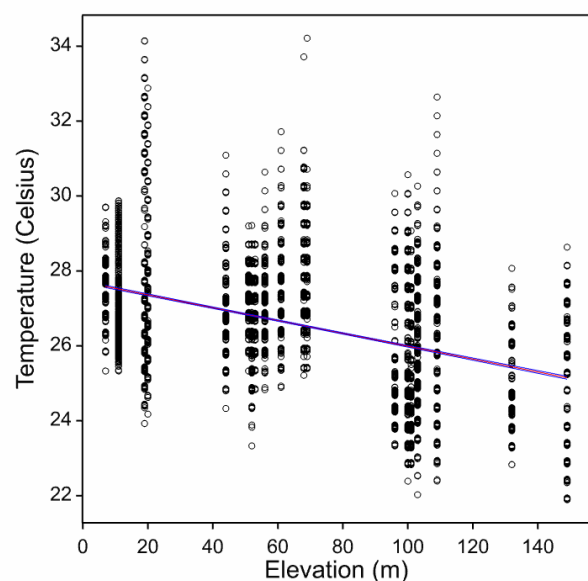


Figure 2. Nest temperature decreases significantly with elevation (all data pooled for illustrative purposes)

Hatchling success, growth, and movements

We have made significant progress towards understanding the biology of nesting, the last years and the impact of environment. The data collected has demonstrated that nest location on the elevation gradient really matters. From a sample of >80 nests, and >680 eggs we have shown that elevation appears to have little effect on clutch size, but mid elevations have heavier eggs compared to lower and upper elevations.

Egg mortality and growth rates of hatchlings shows an increase with elevation (Table 1). We have insufficient data to assess mortality rates of hatchlings with elevation, however our small sample suggests that mortality is lowest at mid elevations (Table 1). During the hatching season in 2016, it was observed that heavy rainfall due to the current El Niño event had resulted in a higher instance of nest flooding than in previous years, particularly in the upper nesting zone. This could be a concern for the future where El Niño events are forecast to become stronger and more frequent.

Table 1. Egg and hatchling mortality 2015 (data)

Nesting Zone	N Eggs	N Failed Incubations	% Egg Mortality	N Hatchlings	N Hatchling Deaths	% Hatchling Mortality
Lower	63	18	28.57	15	5	33
Middle	95	46	48.42	13	2	15.3
Upper	131	90	68.70	15	7	46.6
Overall	289	154	53.29	43	14	32.6

Pooled growth rate data indicate that mortality is highest in the first days and weeks of life, and after ca. 150 days drops to low levels (Figure 3).

As well as considerable differences in survivorship, we have found that growth rates also change with elevation. Growth varies seasonally with a peak from February to March during and after the rainy season in the lower and middle zones. Overall, growth is markedly slow in the upper nesting zone compared to the lower and middle zones.

During this reporting period, we deployed VHF tracking tags on 20 new hatchlings, bringing our total of currently tagged tortoises to 36 individuals. Radio transmitters are attached to the shell using superglue and are <5% of hatchling body weight. For each tortoise fitted with a tag, we know the nest location, incubation temperature and clutch characteristics. The location, length, width, and weight of each infant tortoise is recorded bi-weekly thereafter.

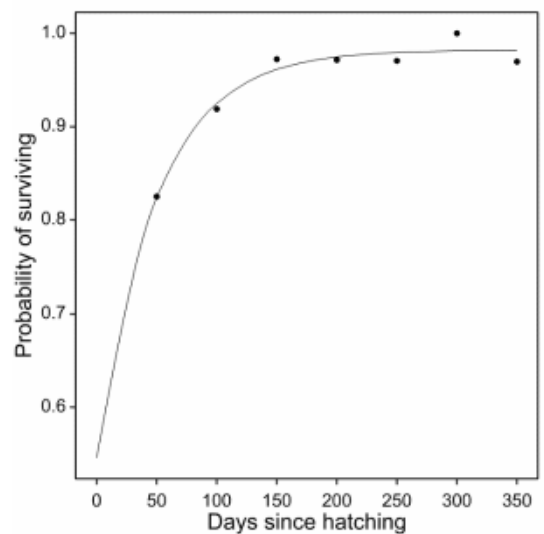


Figure 3. Probability of hatchling survival over time. This confirms that the first 150 days of life are the most risky for giant tortoises.

Newly hatched tortoises appear to disperse rapidly from the nest usually within the first 60 days after hatching. They then move between 100 - 600m from the nest, most likely as an anti-predator defence. This is a useful adaptation on Santa Cruz where introduced predators (e.g. pigs and dogs) are numerous. Initial long distance movements are characterized by directional persistence, and may achieve >30m per day (Figure 4). This may not sound like "long distance dispersal", but for an 80g tortoise moving over

lava rocks it represents a huge energetic effort. After their rapid dispersal, hatchlings settle into tiny home ranges.

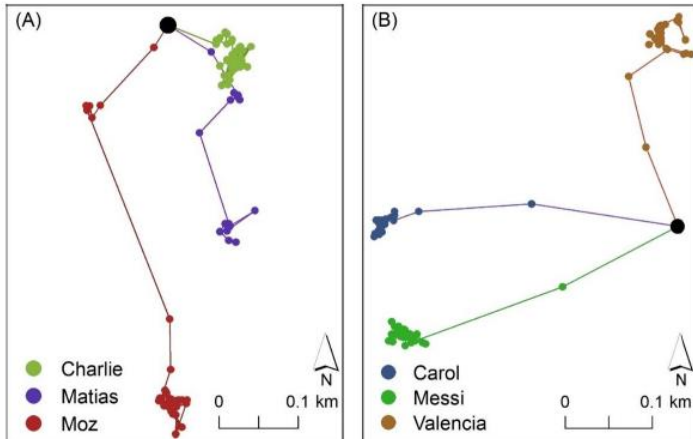


Figure 4 Illustrations of early dispersal from the nesting site for hatchlings in the lower (A) and middle (B) nesting zones, © GTMEP



A Galapagos giant tortoise hatchling is weighed and fitted with a VHF transmitter © GTMEP

Adult tortoise movement ecology

During the first year of this project we have monitored the movements of over 60 juvenile, sub-adult and adult tortoises from four species on three different islands: Santa Cruz, Espanola and Isabela (Alcedo volcano). These data (for which collection began in 2009) have provided the key dataset for most of our scientific papers either submitted or published so far this year (see next section). Our telemetry project continues throughout the year in the field with regular downloads of data from GPS tagged tortoises. Our post-doctoral student, Guillaume Bastille-Rousseau, funded primarily through the National Science Foundation (USA), has made excellent progress in the analyses of telemetry data for several papers, either submitted to journals or near completion. His addition to the team has significantly improved the rate at which papers can be produced.

Papers published and submitted:

1. The Dominance of Introduced Plant Species in the Diets of Migratory Galapagos Tortoises Increases with Elevation on a Human-Occupied Island. *Biotropica*. 47: 246-258

This paper received considerable press internationally and nationally in Ecuador and the Galapagos Islands. Notably it was featured on the National Geographic News, Reuters World Press, and the Discovery Channel News, as well as being selected as Editor's Choice by the journal *Biotropica*.

2. Walking with giants: Allometric and temporal scaling of movement characteristics in Galapagos tortoises

Submitted to the *Journal of Animal Ecology*. Abstract available.

3. A Bioenergetics Model Explains Size-Biased Partial Migration in Giant Galapagos Tortoises

Submitted to *Ecology Letters* (Ranked second in ecology journals). Abstract available.

4. Flexible characterisation of animal movement behaviour using net squared displacement in a mixture distribution framework

Submitted to the *Journal of Movement Ecology*. Abstract available.

In addition to the above, work is ongoing on at least five more papers that cover a range of subject matter from movement characteristics across the three Islands on which we have tagged tortoises, to

tortoise seed dispersal mechanisms in the face of climate change and, of course, a preliminary paper on tortoise nesting and the lost years. By the end of 2016, three of the four should be in review.

2. Conservation Activity Outcomes

Our focus during the latter part of the grant period has been on the conservation activity objective. This is centred on harmonising data collection methodologies on tortoise nest characteristics between the Galapagos National Park Service and the GTMEP to ultimately improve both nest protection and tortoise survival rates. After a number of false starts, we held a constructive meeting with Galapagos National Park in early 2016 explaining the problems identified during the nesting study and the need for a unified approach to data collection and sharing. The Park is supportive of our initiative and a proposed protocol has been developed outlining procedures for sharing data and nest surveillance. We hope that this will be formally adopted in July 2016. Once this protocol is agreed, we can utilise the resulting data to put forward a strong argument for increasing local support for eradication of feral pigs – something that we have not been able to do in this grant period as we had originally anticipated. The outcome of this would hopefully be increased reproductive success and better protection of nests.



The implementation of a new protocol to monitor giant tortoise nests in collaboration with the Galapagos National Park will mark a real step-change in how we can protect nests and really evaluate the efficacy of invasive species management activities. © GTMEP

We are also currently working with both the Galapagos National Park Service and the Charles Darwin Foundation on zonal planning for the Galapagos National Park. Although there are potential risks concerning this discussion, as it could pave the way for negotiations on park limits (which may signify an increase of the agricultural or urban zones), we will remain engaged to ensure that there is a strong voice for conservation present. A closely related project, regarding applied research on conflict and solutions between farmers and tortoises in the highlands, has seen us again partner with Charles Darwin Foundation at the request of the Director of the Galapagos National Park. A briefing document that will serve as the basis for this project was drafted and further work will take place in this space over the next few months.

The lack of concrete outcomes in this area of the project during the grant period has been disappointing but we have put in place a great foundation to build on over the coming year as we continue to work closely with the local authorities.

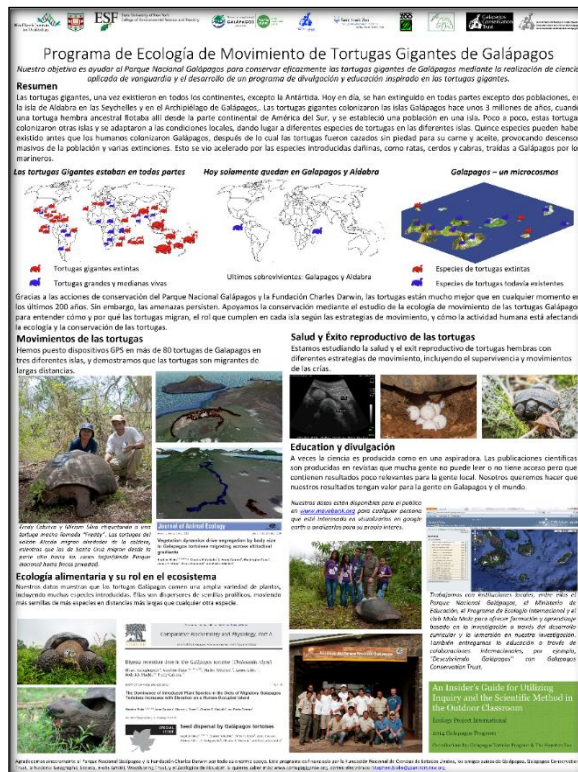
3. Outreach Activity Outcomes

Our joint outreach and education programme is developing strongly and we are really encouraged by what has been achieved over the grant period – expectations have certainly been exceeded.

Key Achievements:

1. Completion of the GTMEP programme web site in Spanish for an Ecuadorian audience.

- The compilation of Spanish versions of recent reports provided to decision makers in the Galapagos National Park Service.
- Provision of support to the Mola Mola Ecology Club (ran by Ecology Project International). The Mola Mola Club is a group of young conservation and ecology enthusiasts based on Santa Cruz. We have developed various activities within the club to teach awareness and understanding of tortoise movement ecology and its implications for conservation. Some 20 students were involved in a multi-week activity entitled "Mapping your Community" in which they mapped the distribution of their activities, favourite and outstanding places, and other areas of interest. The principles of space use and movement between important areas of each student's habitat were related to how tortoises and other animals move within their environment. These exercises have now been adapted for the Discovering Galapagos educational programme that is linked to both the UK and Ecuadorian curricula (both the English and Spanish sites regularly receive over 2,500 hits per month). We are expecting to replicate this activity on San Cristobal island with another group of young conservationists later in 2016.



Informative poster in Spanish that describes the work of the GTMEP for Galapagos school groups
© GTMEP

- We coordinated and implemented a workshop on Experiential Learning Techniques for teachers across Galapagos. The workshop was over three days and involved 11 teachers from three islands. Other delegates included environmental educators from Ecology Project International (EPI), Houston Zoo, Jen Jones from GCT and three PhD students from the UK. Follow up evaluation revealed that teachers found the workshop valuable and rewarding, and strongly felt that the materials covered would help them to develop and implement effective science club activities in their schools. We will be following the progress of the clubs throughout the coming year and upon securing funding, hope to support them further with more teaching resources.



Educational booklet cover for World Turtle Day at ZSL London Zoo © GCT

- We hosted an open day in the Galapagos National Park to celebrate World Turtle Day on 23 May 2015. Students from the Mola Mola Club constructed a 3D model of the Galapagos Islands and used it to describe and explain the fundamentals of tortoise movement ecology on Galapagos. Posters illustrated the plight of tortoises and turtles around the world, and the important role Galapagos can play as ambassadors for tortoise conservation. The event was open to the public and was well attended by Santa Cruz residents, mostly families, who despite a heavy thunderstorm came to participate in the event.

- Continuing our partnership with ZSL London Zoo, we produced an educational leaflet for World Turtle Day and conducted several UK school visits. In addition to the activity undertaken in Galapagos, there were also events held in the USA – a truly international outreach collaboration using an iconic species to raise awareness of large scale conservation issues.

Since the interim report in November 2015, we have also delivered:

- A 10 session “education package” for schools and after school clubs incorporating lesson plans and activity ideas produced in Spanish for a local audience. In the coming months, we are aiming to trial these sessions at 6 Galapagos schools and will incorporate evaluation into future education and outreach activities.
- A new brand for the programme. Local designer Alejandra Camacho was brought on board in December 2015 to renew the GTMEP logo, produce designs for a website revamp and to produce attractive resources for the after school group education package (see Appendix 1 for a summary report of products produced). In addition, she also produced a social media promotional plan.
- A collaboration with the National Geographic Society’s “Cittercam” (a research tool designed to be worn by wild animals) also continues to develop. GTMEP was featured on a National Geographic Society (NGS) broadcast on the NG Wild Channel on 27 June 2015 and again in the National Geographic magazine in February 2016. Although the content used was shot several years ago, the footage and exposure was very relevant to our current programme since Cittercam will be returning to Galapagos to work with us in November 2016.

Summary Budget

A full budget breakdown is available on request.

Line Item	Budget	Actual
Research & Field Costs		
Project coordinator salary	£3,000	£2,000
Local research assistant salary (12 months)	£15,200	£15,200
Communication	£825	£751
Field equipment & supplies	£11,190	£11,321
Food and lodgings	£3,630	£3,616
Printing	£0	£78
Travel (field teams)	£3,500	£5,641
Total Research & Field Costs	£37,345	£38,607
Outreach & Education Costs		
Part time education coordinator salary (12 months)	£10,000	£10,000
Outreach workshop and materials in Galapagos	£2,300	£1,171
Outreach resource development (UK & Galapagos)	£5,000	£5,000
Total Outreach & Education Costs	£17,300	£16,171
Administrative Costs		
Bank fees	£0	£217
Grand Total	£54,645	£54,995

The £10,000 grant from the British Chelonia Group was hugely appreciated to support this essential work over the last year. The remaining funding was sourced via GCT’s Lost Years Appeal that launched in winter 2014 and from grants from the Ernest Kleinwort Charitable Trust and The Woodspring Trust.

Conclusion

The ecological importance of giant tortoises in Galapagos is well known; as key ecosystem engineers, they are essential for regulating vegetation and many species depend on their presence. We are delighted with the outcomes of this programme to date but there is still work to be done - the Galapagos Conservation Trust are keen to continue supporting this essential work into the future.

The project team has made sound progress during the first year of funding for the "First steps toward lifetime tracks" project of the Galapagos Tortoise Movement Ecology Programme – the first study of its kind. The research activity continues to shed new light on the secret lives of Galapagos giant tortoise hatchlings and tortoise movement ecology on a wider scale. We have published several papers to broadcast our findings to a wider scientific audience and have tailored outreach materials to a variety of audiences ranging from local Galapagos schoolchildren to GCT's UK membership base.

Progress has been made towards our conservation objectives but this has been slower than anticipated – we are keen to continue building a close relationship with the Galapagos National Park and it is our priority to secure funding to ensure that the aforementioned protocol is agreed and implemented over the coming years. During the hatching season in 2016, the heavy rainfall due to the current El Niño event threatened a higher than normal instance of nest flooding than in previous years. This is a concern for the future where El Niño events are forecast to become stronger and more frequent.

We would like to take this opportunity to thank the British Chelonia Group for their generous support as a funder for the Galapagos Tortoise Movement Ecology Programme as we continue to take our first steps towards a long-term and sustainable conservation plan for these iconic animals of the Galapagos Islands. Please do not hesitate to get in touch if you would like any more information on any elements of this report.

