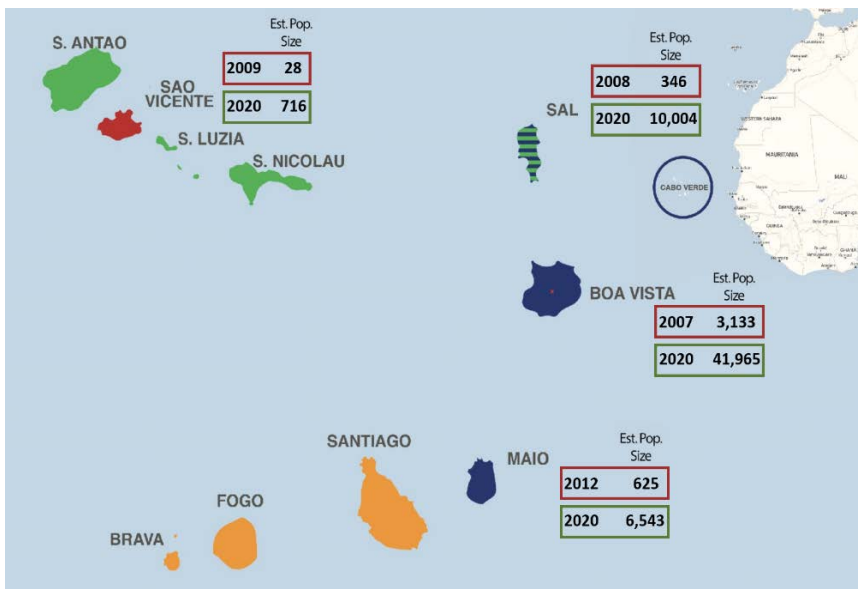


<b>Institution: Queen Mary University of London</b>		
<b>Unit of Assessment: 5</b>		
<b>Title of case study: Transforming the Conservation Strategy for one of the World's Most Significant Populations of Endangered Sea Turtles</b>		
<b>Period when the underpinning research was undertaken: 01/01/2000 - present</b>		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
1) Christophe Eizaguirre	1) Reader, School of Biological and Chemical Sciences	1) 10/2013 - present
<b>Period when the claimed impact occurred: 01/08/2013 - 31/12/2020</b>		
<b>Is this case study continued from a case study submitted in 2014? N</b>		
<p><b>1. Summary of the impact</b> (indicative maximum 100 words)</p> <p>The loggerhead sea turtles of the Cabo Verde islands in the North Atlantic represent 20-25% of the global population of this charismatic, endangered species. Queen Mary's Dr. Eizaguirre led a citizen-science project that examined the genetic and behavioural diversity of these sea turtles and discovered distinct groups within this major population. Previously, conservation efforts were focused on one large breeding site, now small groups of nesting turtles with distinct genetic diversity across multiple islands are given high protection priority. By engaging local organisations and communities, the research project has built capacity among local conservation NGOs and environmental authorities, transferred scientific knowledge to local researchers, and raised public awareness of the importance of conserving sea turtles. New measures have contributed to dramatic increases in turtle numbers on the islands, from around 4,100 in 2008 to almost 60,000 in 2020. In turn, this conservation success has created new employment and economic opportunities for the people of Cabo Verde.</p>		
<p><b>2. Underpinning research</b> (indicative maximum 500 words)</p> <p>The loggerhead turtle (<i>Caretta caretta</i>) is an icon for marine conservation and is threatened with extinction as a result of human activities, including illegal poaching, fisheries bycatch and coastal development. The loggerhead turtle population on the islands of Cabo Verde (400 miles west of Senegal in the North Atlantic Ocean) is the third largest for the species, representing around 20-25% of the global population, making it the largest population in the North East Atlantic. This means that the conservation of these turtles is of local and global importance.</p> <p>The Cabo Verde archipelago consists of ten islands (see Figure 1 below), with nesting groups of different sizes that are exposed to different pressures. The strategy for conserving the species must therefore be island specific. Research by Dr. Eizaguirre and colleagues has focused on studying: i) the population structure and the distribution of genetic diversity of the turtles across the islands; ii) the diversity of feeding strategies, an essential life history trait; iii) the risks of infection by the vector of a lethal virus; and iv) the movement and associated threats faced by hatchling turtles once in the ocean [3.1-3.4]. Since 2013, the research has taken place across nine of the islands and covers &gt;110 km of nesting beaches available to the turtles (~65% of the available habitat in Cabo Verde).</p> <p>Given that the loggerhead turtles face different threats at different life stages, Eizaguirre, in collaboration with the University of Cabo Verde (Uni-CV) and the Institute of Marine Research (IMar), conducted research that focused both on nesting females, which are the current reproductive population, and on hatchlings. These hatchlings will be recruited to the breeding population in &gt;25 years' time. To collect biological samples, the researchers established a nationwide citizen-science project that engages NGOs and local communities.</p> <p>The research has:</p> <p>i) determined the population structure of the different turtle nesting groups on the Cabo Verde islands. This was achieved by mitochondrial DNA sequencing of more than 4,000 turtle samples, generating the largest DNA database for any marine megafauna to date. With these data, Eizaguirre and colleagues reconstructed the colonisation history of the loggerhead turtle across the Atlantic Ocean and established the importance of the Cabo Verde archipelago [3.1,</p>		

EQR.1-EQR.3]. They found that Cabo Verde acted as a stepping-stone for two waves of colonisation: the first about three million years ago; and a second, later event, likely occurring after the last glaciation. These two waves of colonisation are seen in two distinct groups of genetic variants of the turtle, which are today distributed in a non-random manner across the islands. The rarer variants, linked to the more recent colonisation event, are found where nesting density is low (São Vicente) and/or where there is particular pressure from poaching (Boa Vista, Sao Vicente) [3.1, 3.2]. With the further discovery of other variants, Eizaguirre showed that, contrary to previous understanding, there is not a single homogenous loggerhead turtle population on Cabo Verde, but instead it is composed of independent nesting groups (turtles on the blue, green, red and orange islands in Figure 1) with their own genetic diversity that each require specific protection.

ii) used stable isotope analysis to establish that nesting turtles have different feeding strategies across Cabo Verde. Eizaguirre’s team showed that the nesting group at Boa Vista, the largest group in Cabo Verde (70-75% of the archipelago’s nesting population), includes turtles with three different feeding strategies, while turtles from the smaller nesting groups did not demonstrate more than two strategies [3.3, EQR.1-EQR.3]. Consequently, there is both feeding strategy diversity and genetic diversity. Conserving feeding trait diversity will increase the likelihood of population survival should food distribution and availability be affected by environmental and anthropogenic change [3.3].



iii) revealed an increasing abundance of the turtle leech *Ozobranchus margo*, a vector of the lethal virus fibropapillomas [3.3, EQR.1- EQR.3]. This finding raises concern about the spread of the virus, which is already present amongst green turtles in Cabo Verde, but has not yet moved to loggerhead turtles. Eizaguirre’s research highlighted the need to monitor the turtles to mitigate any emerging disease.

Figure 1: The Cabo Verde archipelago off the West African coast (circle) has distinct genetic populations of turtles (represented by island colours), with specific behavioural traits - a key discovery of Eizaguirre’s research. The discovery has resulted in island-specific conservation measures being enacted. The outcome is that population sizes have grown across all islands. Population size estimates are based on the number of detected nests (average 3.5 nests per turtle).

iv) used acoustic tags with high-resolution ocean modelling to determine the dispersal patterns of neonate turtles [3.4, EQR.4-EQR.5]. The results

showed that dispersal trajectories coincide with major fishing grounds. For the first time, Eizaguirre’s team quantified the swimming capacity of hatchlings and their frenzied behaviour as they escape coastal waters rapidly. The research highlighted the need to determine marine areas that need protection in order to increase hatchling survival rates and to reinforce future generations.

Overall, the researchers have generated vital new knowledge of local turtle group structures and the threats turtles face at different life stages, leading to a highly successful new strategy for protecting these populations.

**3. References to the research** (indicative maximum of six references)

[3.1] Baltazar-Soares, M., Klein, J. D., Correia, S. M., Reischig, T., Taxonera, A., Roque, S. M., Dos Passos, L., Durão, J., Pina Lomba, J., Dinis, H., Cameron, S. J. K., Stiebens, V. A. & Eizaguirre, C. (2020). Distribution of genetic diversity reveals colonization patterns and philopatry of the loggerhead sea turtles across geographic scales. *Scientific Reports*, 10, 18001. <https://doi.org/10.1038/s41598-020-74141-6>

[3.2] Cameron, S. J. K., Baltazar-Soares, M., Stiebens, V. A., Reischig, T., Correia, S. M., Harrod, C. & Eizaguirre, C. (2019). Diversity of feeding strategies in loggerhead sea turtles from the Cape Verde archipelago. *Marine Biology*, 166, 130. <https://doi.org/10.1007/s00227-019-3571-8>

[3.3] Lockley, E. C., Fouda, L., Correia, S. M., Taxonera, A., Nash, L. N., Fairweather, K., Reischig, T., Durão, J., Dinis, H., Roque, S. M., Pina Lomba, J., dos Passos, L., Cameron, S. J. K., Stiebens, V. A. & Eizaguirre, C. (2020). Long-term survey of sea turtles (*Caretta caretta*) reveals correlations between parasite infection, feeding ecology, reproductive success and population dynamics. *Scientific Reports*, 10, 18569. <https://doi.org/10.1038/s41598-020-75498-4>

[3.4] Scott, R., Biastoch, A., Roder, C., Stiebens, V. A. & Eizaguirre, C. (2014). Nano-tags for neonates and ocean mediated swimming behaviours linked to rapid dispersal of hatchling sea turtles. *Proceedings of the Royal Society, Series B*. 218 (1796). <https://doi.org/10.1098/rspb.2014.1209>

**Detailed evidence of peer-reviewed funding:**

[EQR.1] Eizaguirre, C. [PI]. (09/2010-08/2013). Interdisciplinary grant provided the resources for the long-term genetic sampling. *Leibniz Society*. EUR100,000.

[EQR.2] Eizaguirre, C. [PI]. (01/2013-12/2014). Grant provided crucial resources to the long-term sampling for both genetic and stable isotope analysis [GEFNE69]. *National Geographic*. EUR20,000.

[EQR.3] Eizaguirre, C. [PI]. (09/2014-08/2015). Grant allowed the support of capacity building and the long-term sampling for DNA and stable isotopes studies. *Centre of Public Engagement, Queen Mary*. Student Ambassador Scheme. GBP20,800.

[EQR.4] Eizaguirre, C. [PI]. (03/2013-02/2015). Grant evaluating hatchling dispersal using acoustic telemetry. *German Science Foundation (Deutsche Forschungsgemeinschaft)*. Cluster of Excellence the "Future Ocean". EUR180,000.

[EQR.5] Eizaguirre, C. [PI]. (07/2017-06/2018). Grant allowed the deployment of new accelerometers on nesting turtles. *Prince Albert II of Monaco*. "Exploration of Monaco". GBP12,750.

**4. Details of the impact** (indicative maximum 750 words)

The loggerhead sea turtles of the Cabo Verde islands represent 20-25% of the global population of this endangered species, making their protection of local and global importance to ensure the species' survival. The sea turtles face direct threats via coastal development, bycatch from fisheries, tourism and illegal poaching for meat. However, because each island is exposed to its own set of human pressures, designing an effective approach to the turtles' conservation is challenging. A citizen-science research project, led by Dr. Eizaguirre, has transformed the strategy for protecting the sea turtle populations on Cabo Verde, leading to a dramatic increase in turtle numbers on the islands, of benefit to local people, tourists from around the world and to global efforts to conserve biodiversity. By engaging local organisations and communities, the researchers have built capacity for conservation work, raised public awareness of the importance of conserving sea turtles, and created new economic opportunities for the people of Cabo Verde.

**A new strategy for conserving loggerhead sea turtles informed by research**

Eizaguirre's team identified the importance of Cabo Verde's small nesting groups through the discovery of unique genetic diversity and patterns of behaviour. This knowledge has led to a new turtle conservation management strategy - previously protection had focused on the main nesting group on Boa Vista, the island with the highest nesting density, and smaller groups were neglected. Maria Silva, Director of the Institute of Marine Research (IMar) says: "his [Eizaguirre's] nationwide genetic research has shown that the loggerheads of Cabo Verde are divided in small genetic-diverse groups, stressing that the need for the protection of small sea

turtle populations, like the one in Sao Vicente, is of national interest...This has contributed to increase the efforts and funds invested to protect the species” [5.1]. The new conservation strategy to protect all turtle groups, including small populations, has led to the deployment of night patrols to new beaches during the nesting season, involving military personnel and local communities. These night patrols are led by ‘Ambassadors’ (see below), trained by Eizaguirre with the University of Cabo Verde and IMar, working closely with local NGOs.

The Director of Cabo Verde’s National Environment Office says: “Dr Eizaguirre...has formed the first sea turtle conservation initiative in Cabo Verde to coordinate the collection of data, using standardised protocols, across all islands of the archipelago. As a result of this work and research, we now know that the Cabo Verde nesting aggregation is composed of many nesting groups that need specific protection. This knowledge has resulted in the development of local initiatives to protect those nesting groups” [5.2]. As a result of increased turtle recruitment to beaches and research-informed conservation strategies now in force across Cabo Verde, turtle numbers have soared across all islands (Figure 1). For example, in 2007 there were estimated to be 3,133 turtles on Boa Vista, but by 2020 this had risen to 41,965. Indeed across all islands, populations are growing fast, including the small, rare and most threatened unique nesting groups on Sao Vicente, where nesting turtle numbers have risen from 28 turtles in 2009 to >700 in 2020 [5.1].

In 2017, Eizaguirre’s research attracted interest from ‘Explorations de Monaco’, an initiative led by Prince Albert of Monaco, which improves knowledge, management and conservation of the oceans. At a meeting in September 2017, Prince Albert, Dr Eizaguirre, the Director of the National Directorate of Environment and all NGO leaders working to protect turtles in Cabo Verde, discussed new strategies for sea turtle conservation in Cabo Verde informed by Eizaguirre’s research [5.3]. At the meeting, a joint report was presented to Prince Albert of Monaco and discussed with the President of the Republic of Cabo Verde, Mr. Fonseca [5.4]. The report is now the guideline for conservation of sea turtles in the country, with the initiative being the first to produce national standardised protocols in sea turtle conservation [5.2].

#### **Building capacity in sea turtle conservation work**

In 2013, Eizaguirre established a community-based citizen-science conservation programme to help protect the loggerhead turtles. Being one of the largest conservation programmes for marine megafauna in the world, it has engaged with 24 coastal communities, recruited more than 300 local volunteers and trained 36 Cabo Verde University students (“Ambassadors”) in sea turtle conservation. Of these Ambassadors, 24 have subsequently been employed by NGOs and 10 have permanent management roles in conservation [5.1, 5.5, 5.6]. The Director of the National Environment Office says: “The coordinated efforts across islands has built local capacity and empowered a team of national students and conservationists that have now become leaders of conservation initiatives or have found a professional career within conservation-related organisations. Nowadays, being a sea turtle conservationist is recognised as a professional opportunity for many young people” [5.1]. The programme was a finalist at the UK National Coordinating Centre for Public Engagement awards in 2016.

#### **Establishing an alternative economic model for the people of Cabo Verde**

As well as helping to reduce poaching, the citizen-science programme has enabled local people to find alternative sources of income to poaching. Specifically, on the island of Maio, 11 coastal communities have generated income through conservation and employment, amounting to ~EUR70,000 between 2016-2019. These are substantial sums, given an average salary is GBP250 per month. Thus the new income alleviates poverty [5.5].

Now that poaching has decreased and nesting populations are growing, eco-tourism has been established as an alternative economic model for local people, helping to further secure the sustainability and growth of turtle populations. In 2019, two agreements were signed between a local conservation group and two eco-tourism companies, enabling tourists to visit nesting beaches on the island of Sao Vicente. These beaches now have larger numbers of turtles and predictable turtle activity, so tourists can enjoy observing this animal in its natural habitat [5.1].

### Enabling local NGOs to access new international conservation funds

Eizaguirre and colleagues' discovery that the distribution of genetic diversity and population structure of the Cabo Verde turtle aggregation is not uniform contributed to the International Union for the Conservation of Nature's (IUCN) decision to adjust its assessment of the Cabo Verde population in 2015. At a global level, the status of the loggerhead turtle is 'Vulnerable', but locally this status was elevated to 'Endangered', which means that Cabo Verde NGOs can continue to access vital international conservation funds. For example, the US Fish and Wildlife Service and the MAVA foundation protects small nesting groups with strategic funding [5.5, 5.6] and provides new financial support worth >GBP805,000 to fund the night patrols on nesting beaches [5.1, 5.5, 5.6].

### Increasing knowledge transfer in sea turtle conservation

To provide a reliable census of sea turtles and their nesting on Cabo Verde, Eizaguirre developed a field protocol that allows the status of nesting groups on different islands to be compared [5.5, 5.7]. The director of Project Biodiversity, an NGO operating on the island of Sal, says: "Standardising the field protocols...for the first time made possible country-wide comparisons facilitating knowledge transfer which was previously impossible" [5.6]. In 2019, Project Biodiversity presented a report drawing on evidence of the spatial distribution of turtles that challenged a new Tourism Land Use Management Plan [5.6]. The report showed that loggerhead turtles were using a small coastal area that was not protected and was therefore vulnerable to development plans. The report highlighted the importance of this local population, leading to a review of the Tourism Land Use Management Plan. Eizaguirre's data are summarised in a publicly available database, *TurtleBase* [5.8], the largest database of a marine megafauna to date, with data on >6,000 individual tagged turtles, genomic resources and stable isotope information. This resource is providing accurate information that can be used to inform nationwide strategies for the conservation of sea turtles. As of 31 December 2020, *TurtleBase* has been viewed 1,898 times and generated 231 downloads.

### Engaging young people to secure the future of loggerhead sea turtles

Eizaguirre and colleagues have used their research for diverse public engagement activities. In 2017 and 2018, 2,000 booklets for children about turtle conservation, funded by Explorations of Monaco, were distributed by conservation NGOs in Cabo Verde to primary schools on Boa Vista, Maio, Sal and Sao Vicente [5.9]. These booklets explain the societal value of turtles over their economic value gained by poaching. In 2019, with the UK company Wolf in Motion, Eizaguirre developed a research-based virtual reality experience, called *Atlantis*, which simulates the experience of swimming with a turtle [5.10]. More than 3,000 children and adults in the UK, Spain and Cabo Verde have experienced *Atlantis* [5.1, 5.5].

### 5. Sources to corroborate the impact

- [5.1] M. O. S. D. Silva. Director. *Institute of Marine Research*. (testimonial letter, 4 May, 2020). [Corroborator 1]
- [5.2] A. N. Rodrigues. Director. *National Directorate of Environment* (testimonial letter, 7 May, 2020). [Corroborator 2]
- [5.3] G. Bessero. Chief Operating Officer. *Monaco Explorations* (testimonial letter, 28 August, 2020). [Corroborator 3]
- [5.4] Eizaguirre, C. (2018). *Diversity, ecology and threats of loggerhead turtles nesting in the Cape Verde archipelago*. Explorations of Monaco. [Presented by Prince Albert of Monaco to the President of Cabo Verde](#).
- [5.5] R. Moreno. Director. *Foundation Maio Biodiversity* (testimonial letter, 8 August, 2020). [Corroborator 4]
- [5.6] B. Renom. Executive Director. *Project Biodiversity* (testimonial letter, 29 February, 2020). [Corroborator 5]
- [5.7] Standardised marine-turtle conservation protocol shared across organisations.
- [5.8] [TurtleBase](#), a public online database of the sea turtles of Cabo Verde.
- [5.9] [Public engagement booklet](#) offered to children in Boa Vista, Maio, Sal and Sao Vicente after various activities (school in Nature, Beach clean-up, Carnival).
- [5.10] [Atlantis Virtual Reality experience](#), which simulates the experience of swimming with a turtle, drawing on data from real dive and swimming patterns recorded by the researchers.