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EXPEDITION REPORT

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Latin American Sea Turtles

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Abstract

Monitoring of sea turtle nesting activities took place from 24 February - 15 November 2016 in Pacuare Beach (Caribbean coast of Costa Rica). Monitoring was conducted by Latin American Sea Turtles (LAST) and assisted by Biosphere Expeditions citizen science volunteers from 2 – 19 May 2016. 414 nesting activities of leatherback turtle (*Dermochelys coriacea*), 525 of green turtle (*Chelonia mydas*) and 22 of hawksbill turtle (*Eretmochelys imbricata*) were recorded. 220 clutches were relocated to the custom-built hatchery, three were left in situ. None were relocated on the beach, because of the very high local poaching rate.

From clutches moved to the hatchery, 12,755 neonates emerged (4,147 leatherback, 8,266 green, 342 hawksbill turtle) and were successfully released to the ocean. The percentages of emergence recorded were 51% (SD=30.31, n=112) for leatherback, 81% (SD = 21.33, n = 95) for green and 66% (SD = 37.82, n = 4) for hawksbill turtle.

The average nest poaching rate recorded for each species was 40% for leatherback, 23% for green and 43% for hawksbill turtle. In addition, 40 green sea turtles and two hawksbill turtles were recorded to have been killed by poachers.

The data recorded in 2016 (and since 2012) indicate clearly that Pacuare beach is one of the most important nesting sites for the leatherback turtle in Cost Rica. Nevertheless, very high levels of poaching continue, predominantly perpetrated by transient and criminal poachers who frequent the beach during the nesting season. There is currently little support and attention from government authorities tasked with nature conservation and law enforcement, which means that NGOs such as LAST and Biosphere Expeditions, with the critical help from national and international volunteers and citizens scientists, by and large struggle against poachers unaided. Even with the very positive nest and turtle protection, as well as neonate hatching rates reported here, this means that conservation activities by NGOs alone are unlikely to go beyond preventing the extinction of local turtle populations. Whilst this is in itself a vital contribution to sea turtle survival, help by government authorities, which are after all tasked with nature protection and law enforcement, could transform efforts from extinction prevention to population recovery with concomitant benefits for the local population through sustainable, turtle-based ecotourism in a safe area free from criminal poachers.

LAST and Biosphere Expeditions therefore strongly recommend that the project continues in order to prevent local turtle extinction, to gather sufficient scientific information that will allow the creation of conservation tools such as protected areas, and to build partnerships with government and other agencies that will lead to a recovery of the populations of sea turtles on the Caribbean coast of Costa Rica.

Resumen

El monitoreo de las actividades de anidación en Playa Pacuare (Costa Caribe de Costa Rica) se realizó entre el 24 de febrero y el 24 de noviembre 2016. El monitoreo fue coordinado por Latin American Sea Turtles (LAST) y apoyado por voluntarios ciudadanos del 2 -19 mayo 2016. 414 actividades de tortuga baula (Dermochelys coriacea), 525 de tortuga verde (Chelonia mydas) y 22 de tortuga carey (Eretmochelys imbricata) fueron observadas. 220 nidadas fueron relocalizadas en el vivero de tortugas marinas, tres se dejaron in situ y ninguna nidada fue reubicada en la playa por el problema de saqueadores furtivos.

De las nidadas relocalizadas en el vivero, 12,755 neonatos emergieron (4,147 tortugas baula, 8,266 tortuga verde y 342 tortuga carey) y fueron liberadas al mar. Los porcentajes de emergencia registrados fueron 51% (SD=30.31, n=112) para la tortuga baula, 81% (SD = 21.33, n = 95) para la tortuga verde y 66% (SD = 37.82, n = 4) para la tortuga carey.

El promedio de saqueo ilegal registrado fue de 40% para la tortuga baula, 23% para la tortuga verde y 43% para la tortuga carey. Además, 40 tortugas verde y dos tortugas carey fueron matadas por cazadores furtivos.

Los datos registrados en 2016 (y desde 2012) demuestran que Playa Pacuare es uno de los sitios de anidación más importante para la tortuga baula en Costa Rica. Sin embargo, la tasa de saqueo ilegal sigue siendo muy alta, involucrando principalmente saqueadores transitorios quien se apoderan de la zona durante la temporada de anidación. Presentemente, se observa poco apoyo y atención de parte de las autoridades gubernamentales responsables del reforzó de las leyes ambientales; eso significa que ONGs tal como LAST y Biosphere Expeditions, con la ayuda critica de voluntarios nacionales e internacionales y científicos ciudadanos, se enfrentan a una lucha desbalanceada con los saqueadores ilegales. A pesar de la protección positiva de las nidadas y de las hembras, además de la tasa alta de emergencia de los neonatos reportados aquí, es poco probable que las ONGs logran más allá que la prevención de la extinción de las poblaciones locales de tortugas marinas. Aunque es una contribución vital a la supervivencia de las especies de tortugas marinas, la ayuda de las autoridades gubernamentales podría transformar el esfuerzo contra la extinción de las poblaciones a un esfuerzo de recuperación de las poblaciones junto con beneficios hasta la población local a través de un eco-turismo responsable basado en las tortugas marinas, en una zona libre de saqueadores furtivos.

LAST y Biosphere Expeditions recomiendan que las actividades de investigación y protección se mantienen en fin de prevenir la extinción de las tortugas marinas y acumular suficiente información científica para la creación de herramientas de conservación tal como áreas protegidas, y creer colaboraciones con el gobierno y otras agencias, las cuales ayudaran a la recuperación de las poblaciones de tortugas marinas en la costa Caribeña de Costa Rica.

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1. Expedition review

M. Hammer
Biosphere Expeditions

1.1. Background

Biosphere Expeditions runs wildlife conservation research expeditions to all corners of the Earth. Our projects are not tours, photographic safaris or excursions, but genuine research expeditions placing ordinary people with no research experience alongside scientists who are at the forefront of conservation work. Our expeditions are open to all and there are no special skills (scientific or otherwise) required to join. Our expedition team members are people from all walks of life, of all ages, looking for an adventure with a conscience and a sense of purpose. More information about Biosphere Expeditions and its research expeditions can be found at www.biosphere-expeditions.org.

This expedition report deals with an expedition to Costa Rica that ran from 2 to 19 May 2016 with the aim of assisting Latin American Sea Turtles (LAST) in their mission to protect and research critically endangered leatherback and other sea turtles along one of the world's most beautiful and biodiverse coastlines. LAST's aims are to reduce poaching through patrols and through relocating nests to a hatchery, and to determine population parameters of nesting sea turtles in order to improve the conservation status of the various species. The emphasis of the May period is on leatherback turtles, which predominantly come to nest during this time. Leatherback turtles are listed as Critically Endangered on the IUCN (International Union for the Conservation of Nature) Red List and the combination of direct conservation action paired with the research by this programme will assist with the recuperation of this iconic species, ensuring its survival into the future.

Humans have always used the products and sub-products of sea turtles as a source of nutrition and handicrafts (Groombridge and Luxmoore 1989). However, as the human population increases, the demand for these products also rises, creating a black market and huge pressure on the sea turtles – primarily for the consumption of the meat and eggs (Chacón 2002). Since the first studies on nesting sea turtles on the Caribbean shores of Costa Rica in the 1970s (Troëng and Rankin 2005), it is clear that human demand is at unsustainable levels, threatening the survival of all seven species of sea turtles (Chacón 2002).

The leatherback sea turtle is the largest of all living turtles and is the fourth-heaviest modern reptile behind three crocodilians. It can easily be differentiated from other modern sea turtles by its lack of a bony shell. Instead, its carapace is covered by skin and oily flesh. The leatherback turtle is the sea turtle species with the widest global range, spanning all oceans as far as the arctic circles (Eckert et al. 2012). Scientists have tracked a leatherback turtle that swam from Indonesia to the U.S. in a 20,000 km foraging journey over a period of 647 days (Benson et al. 2012). Leatherbacks follow their jellyfish prey throughout the day, resulting in turtles preferring deeper water in the day time, and shallower water at night (when the jellyfish rise up in the water column). Leatherback turtles are known to pursue prey deeper than 1,000 m - beyond the physiological limits of all other diving animals except for beaked whales and sperm whales (Eckert et al. 2012).

The three major, genetically distinct populations occur in the Atlantic, eastern Pacific, and western Pacific Oceans. Whilst the species as a whole is classed as Vulnerable on the IUCN's Red List, the Atlantic subpopulation of this project is considered to be Critically Endangered. Recent estimates of global nesting populations are that 26,000 to 43,000 females nest annually, which is a dramatic decline from the 115,000 estimated in 1980 (Eckert et al. 2012).

Direct utilisation of turtles or eggs for human use (consumption and commercial products) is one of the major threats (Chacón 2002) and as such is the focus for this project through direct conservation action such as nest and nesting ground protection and ensuring hatchling success.

The project involves community members alongside international citizen scientist in its conservation activities, recruiting local people as research and conservation assistants, and giving them an alternative income to poaching. This is urgently needed in what is a very isolated and vulnerable community, with very few educational and employment opportunities.

Through the construction of an uncontaminated hatchery as a safe incubation zone for each nest laid on Pacuare beach, the project collects data from eggs and hatchlings and protects nests from predation and poachers. The leatherback turtle nesting season runs from February to July, with peak nesting activity in April and May. The project is made possible by the cooperation of the local community – The Environmental Association of Nuevo Pacuare – and the local coastguards, and meets the standards and protocols set by MINAET (Ministerio de Ambiente y Technologia) for handling turtles and their eggs.

1.2. Research area

Costa Rica is a small country in Central America. The country has coastlines on both the Atlantic and the Pacific and is home to nearly 5% of the planet's biodiversity. Despite its small size, it is considered one of the planet's top 20 countries in terms of biodiversity. Indeed, Costa Rica is known for its progressive (environmental) policies, having disbanded its army and being the only country in the world to meet all five criteria established to measure environmental sustainability. It was ranked fifth in the world and first in the Americas in the 2012 Environmental Performance Index. It was twice ranked the best-performing country in the New Economics Foundation's (NEF) Happy Planet Index, which measures environmental sustainability, and was identified by the NEF as the greenest country in the world in 2009. In 2007, the Costa Rican government announced plans for Costa Rica to become the first carbon-neutral country by 2021. In 2012, it became the first country in the Americas to ban recreational hunting.

When Colombus discovered Costa Rica in 1502, the first indigenous people he saw wore gold bands in their noses and ears – which later led to the name of the country – The Rich Coast – or Costa Rica. In those days, there were four main indigenous tribes, which after the arrival of the Spanish were decimated by small pox. Today a remarkable 98% of Costa Ricans are of Spanish descent.

The project's study site, Pacuare beach, is located in the province of Limon, in the district of Matina. The project site is only accessible by boat, through the canals of Tortuguero. It is a very remote and isolated area – rich in wildlife and nature.

Figure 1.2a. Map and flag of Costa Rica with study site.

An overview of Biosphere Expeditions' research sites, assembly points, base camp and office locations can be found at Google Maps.

1.3. Dates

The expedition ran from 2- 19 May 2016 and was composed of a team of international research assistants, guides, support personnel and an expedition leader (see below for team details).

1.4. Local conditions & support

Expedition base

The expedition base was a remote and rustic research station with cabins for sleeping, shared bathroom and shower blocks, a kitchen, hatchery and various other utility buildings. Participants shared cabins, with between one to three people of the same sex (except couples) to a cabin. All meals were prepared for the team and special diets were catered for.

Weather

Costa Rica has a tropical climate and the sun shines throughout the year. Day temperatures during the expedition were between 16 and 30° C with slightly lower temperatures at night and humidity around 80% (www.weatherbase.com). There have also been many non-seasonal rain events in recent years, so participants needed to be prepared to work in varied weather conditions.

Field communications

Mobile phones worked intermittently on the beach. In the field, two-way radios and mobile phones were used for communication between research teams.

The expedition leader also posted an expedition diary on Biosphere Expeditions' social media sites such as Facebook, Google+ and the Wordpress blog.

Transport and vehicles

Team members made their own way to the San José assembly point. From there onwards and back to the assembly point all transport and vehicles were provided.

Medical

The expedition leader was a trained first aider, and the expedition carried a comprehensive medical kit. Further medical support was provided by a clinic in Bataan, about 40 minutes by boat and 40 minutes by taxi. There is also a main hospital in Limon, 45 minutes from Bataan by car. Safety and emergency procedures were in place, but did not have to be invoked.

1.5. Scientist

Magali Marion was the head scientist for this expedition. Magali is the on-site biologist at the Pacuare site. She has nine years of experience working in research of marine ecosystems and coastal management and has coordinated four different sea turtle conservation projects in Costa Rica, as well as being a biology teacher in the city. Magali has a Bachelor of Science in Environmental Sciences obtained from University of South Brittany and a Masters Degree in Engineering of Coastal Ecosystems, obtained through the University of La Rochelle, both in France. Magali is committed to the protection of the turtles of Pacuare and firmly believes in community involvement to change mindsets about poaching. She has been active in conservation projects as far as the Maldives. She is a qualified PADI divemaster and speaks three languages.

1.6. Expedition leader

Catherine Edsell was born in the UK into a family of mountaineers, skiers and adventurers. With wanderlust in her blood she left England in 1997 and set off to the jungles of Central America and Indonesia, lived in the Himalaya with locals, trekked through the Namib desert in search of elusive elephants and dived the oceans surveying coral reefs. Her passion for conservation grew as she sought out and trained with expedition organisations that echoed her ecological beliefs, and for seven years straight her feet barely touched British soil as she lived the expedition life in all manner of terrains. In 2014 Catherine was awarded a fellowship of the Royal Geographical Society for her continued contribution to conservation through expedition work. She is also a mountain leader, PADI Divemaster, coral reef ecologist and Reef Check trainer, and has led in the Azores, the Maldives and Musandam for Biosphere Expeditions. When not on expedition, Catherine teaches yoga, rock-climbs and dabbles in the flying trapeze.

1.7. Expedition team

The expedition team was recruited by Biosphere Expeditions and consisted of a mixture of ages, nationalities and backgrounds. They were (in alphabetical order and with countries of residence):

2 – 9 May 2016

Keiner Jimenez Alvarado (Costa Rica)*, Theresa Bowman (Germany), Alan & Janet Hoffberg (USA), Carol Powell (UK), Irmtraut Schumann (UK), Sheila Tucker (UK). Also present: Biosphere Expeditions staff members Matthias Hammer (Germany), Tessa Merrie (UK), Ida Vincent (expedition leader in training, USA).

12 – 19 May 2016

Theresa Bowman (Germany), Rex Gunderson (USA), Terry James (UK), Janet James (UK), Holly Kirkwood (press, UK), Carol Powell (UK), Jessica Mora Salas (Costa Rica)*, Brad Styner (Canada), Tyler Styner (Canada), Dustin Styner (Canada), Gordon Thomson (UK). Also present: Ida Vincent (expedition leader in training, USA).

*placement kindly sponsored via a GlobalGiving fundraising campaign

1.8. Partners

Our partner on this project is Latin American Sea Turtles (LAST) who represent WIDECAST (the Wider Caribbean Sea Turtle Network in Costa Rica). LAST has over 28 years of experience in sea turtle management and research and has attracted various strategic partners thanks to their contribution to this field (Whitley Award for Nature, The Nature Conservancy and WWF). LAST has initiated projects to monitor reefs, trained national park rangers in monitoring turtle nesting, and educated hundreds of local students on the importance of marine and coastal conservation. They also act as environmental advisors to the government on marine environments, participate in several local, national and international networks, and publish articles to improve public knowledge about the ocean and its life. In order to reduce threats to sea turtles, and to restore population levels, LAST has implemented a series of sea turtle management programmes on many of the Caribbean beaches in Costa Rica – including Pacuare beach. When the Pacuare project started in 2004, it was just for egg protection and no data were collected. WIDECAST took over the investigation in 2007 and LAST have become the sole researchers since 2012.

1.9. Expedition budget

Each team member paid a contribution of £1,480 per seven-day slot towards expedition costs. The contribution covered accommodation and meals, supervision and induction, all maps and special non-personal equipment, and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs, etc., or visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how these contributions were spent are given below.

Income	£
Expedition contributions	16,580
Expenditure	
Staff includes local & international salaries, travel and expenses	6,243
Research includes equipment and other research expenses	1,483
Transport includes car hire, fuel, taxis and other local transport	1,185
Base includes board and lodging at the research station	2,752
Administration includes local sundries, fees and miscellaneous expenses	7
Set-up costs to set up the expedition (staff travel, expenses, time, equipment, etc.)	3,830
Team recruitment Costa Rica as estimated % of PR costs for Biosphere Expeditions	6,430
Income – Expenditure	**-5,350**
Total percentage spent directly on project	**132%***

*This means that in 2016, the expedition ran at a loss and was supported over and above the income from the expedition contributions and grants by Biosphere Expeditions.

1.10. Acknowledgements

This study was conducted by Biosphere Expeditions, which runs wildlife conservation expeditions all over the globe. Without our expedition team members (listed above) who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The same is true for all LAST volunteers, helpers and research assistants, whom we thank too. Thank you also to the support team and staff (also mentioned above), who were central to making it all work on the ground. Biosphere Expeditions would also like to thank the Friends of Biosphere Expeditions for their sponsorship and/or in-kind support, Thomas Douglas of Hotel Santo Tomas in San José for his support and advice in Costa Rica, Nicki Wheeler and Daniela Möller of LAST for being ever helpful and reliable in setting things up and keeping them running, Robert Adeva of La Tortuga Feliz for help and advice in Pacuare. Finally, thank you to the anonymous reviewers for helpful comments on the various draft versions of this report.

1.11. Further information & enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Copies of this and other expedition reports can be accessed via at www.biosphere-expeditions.org/reports. Enquires should be addressed to Biosphere Expeditions via www.biosphere-expeditions.org/offices.

Please note: This report details the results of an entire nesting season from February to November 2016. The bulk of the work during this period was conducted by LAST, with Biosphere Expeditions assisting during the leatherback nesting season in May.

2. Annual report of the nesting activity of sea turtles in Pacuare beach, Costa Rica

2.1. Introduction and background

For centuries, humans have been using sea turtle products and subproducts, mainly as a food resource, but also for the production of handicrafts (Chacón 2002). Along with the demographic increase of the population of Costa Rica, the anthropogenic pressure on sea turtle species has intensified, leading to the development of a black market in the entire country, targeting mostly eggs and meat from the reptiles.

In order to reduce these threats and to help to re-establish the population of sea turtles, a large number of conservation projects have been implemented on the Caribbean coast of Costa Rica. One of them is the Pacuare Beach Project established in 2012 by LAST (Latin American Sea Turtle) in association with WIDECAST (Wider Caribbean Sea Turtle Network) and the Asociación para el Ambiente de Nuevo Pacuare.

The community is involved in the different activities of the conservation project, such as guarding the hatchery or working as research assistants on beach patrols. The community of Pacuare is located in a highly remote and rural area of the country, which is prone to a low employment rate, vulnerable to the use and traffic of drugs, and seldom visited by the police. Moreover, during the nesting season, a significant number of homeless persons settle by the beach and dedicate themselves to the illegal extraction of eggs and the slaughter of marine turtles, significantly increasing the pressure on the species that already exists in this area.

Given this situation, monitoring, assessment and efficient conservation tools are all essential in order to restore and protect the four species present on this site, namely the hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) (Fonseca and Chacón 2012, Marion and Chacón 2013). The first hawksbill is classified as Critically Endangered, whereas the green and the loggerhead turtles are classified as Endangered (IUCN 2014). The leatherback was classified as Critically Endangered until 2013, when it was downgraded to Vulnerable by the Sea Turtle Experts Group of IUCN, due to higher numbers observed mainly in Guyana, Panamá and Surinam (IUCN 2014).

The main objective of the Pacuare Beach Project is to improve the conservation status of the species present in the area by involving local communities, national and international volunteers and governmental agencies. This is achieved through the consolidation of institutional agreements that allow the standardisation of conservation activities, all of which ultimately assist in the reproductive success of sea turtle nests and the protection of the nesting females.

The success rate of the project is directly linked to the number of volunteers present on the beach in order to compensate the number of poachers present on a daily basis. In addition, the volunteers provide crucial help in assisting with data recording, beach and hatchery maintenance.

The lack of manpower and financial resources have been described in a large number of conservation projects and seem to be a general consensus in the science field (e.g. Hodgson 1999). However, volunteers can make important contributions to the project, since they contribute both labour and funding. Indeed, they have already made significant contributions to scientific knowledge through their participation in a range of studies, particularly ones that have been guided by experienced scientists (Foster-Smith & Evans 2003).

2.2. Methods

From the month of February until November, daily nightly patrols were organized to monitor the 7.1 km of beach administrated by LAST – WIDECAST. National and international volunteers were involved in data recording, measurement of nesting females and hatchlings, as well as nest relocation and maintenance of the hatchery. Such involvement is a key element of the project, since none of the nests can be left in situ due to the high poaching activities in the area. Volunteers are trained upon arrival and then conduct most activities under the supervision of a trained staff member in order to reduce bias and errors in data recording. Evans et al. (2000) and Birchenough et al. (2001) have demonstrated that, given training, volunteers can perform straightforward tasks as competently as more experienced scientists.

Study site

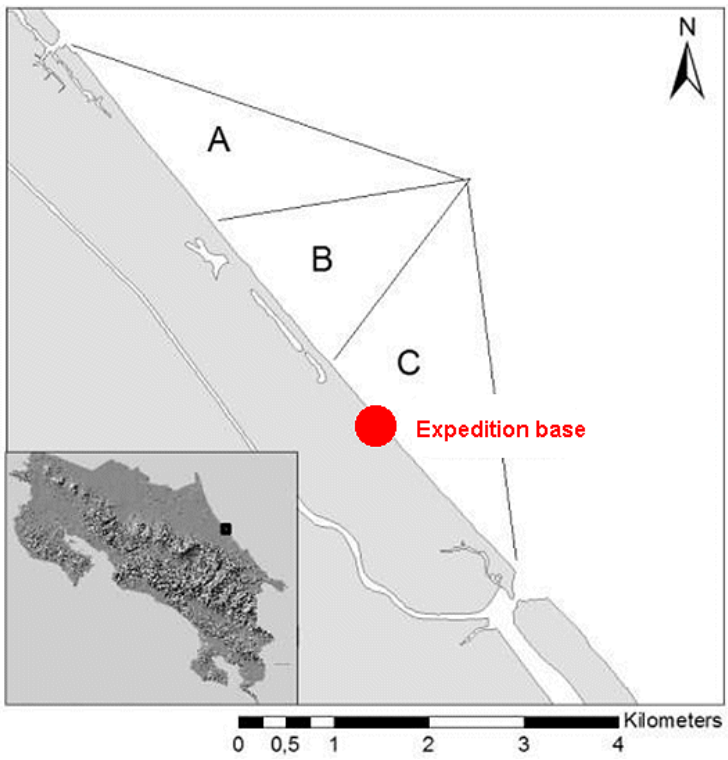

Figure 2.2a. Pacuare beach study site and sectors.

Pacuare Beach (10°18’48.66’’N, 83°21’17.25’’W – 10°13’25.37’’N, 83°16’47.12’’W) is located in Costa Rica’s Bataan district within the canton of Matina, in the province of Puerto Limon (see Fig. 2.2a). The beach is 7.1 km long and delineated by the Parismina River mouth in the north and the Pacuare River mouth in the south. It is a dynamic beach, susceptible to erosion during high tides. The beach study site is geographically divided into three sections known for the project as:

Sector A (2.3 km): This section has parts of the beach close to the vegetation because so much sand has been washed away. However, this section sees a lot of nesting activity due to its isolation. Sector B (2.3 km): This straight, open section of beach is an important nesting area – but also the area where most poachers reside. Sector C (2.5 km): This sector is the most inhabited and also has the most driftwood, making nesting activities very challenging for the turtles.

In order to facilitate accurate localisation of nesting activities, the beach is further divided into sectors of 50 metres following a parallel line to the sea. In each site, a wooden marker carrying a consecutive number is set. Numberung runs from the northern (Laguna Perla at the Parismina River mouth) to the southern limit (Pacuare River mouth).

Training

Training of the local research assistants was completed during the third week of February. Assistants participated in three days of lectures on ecology, biology, threats, sea turtle conservation strategies and monitoring protocols on nesting beaches. All the lectures were coordinated within the LAST biological station. Afterwards, assistants attended seven days of practical training in tagging techniques, hatchery duties, data collection and nest relocation.

Biosphere Expeditions citizen scientists received similar, albeit abridged, training sessions, lasting 1.5 days, during the month of May. All training was conducted by the expedition scientist. On patrols, all activities and data collection was supervised by a trained assistant or the expedition scientist. Hatchery duty was conducted independently.

Figure 2.2b. Training session.

Hatchery

A hatchery was built at wooden marker #104, on the vegetation line, in an area subject to little erosion and without risk of flooding. The hatchery was delimited by a 1.25 m high metal fence to prevent the intrusion of predators or turtles. During construction, sand was removed down to a metre depth in the whole area to remove roots, wood and other elements that could damage the eggs. Later, sand from the low tide line, naturally sterilised by the sea, was filtered through a sieve of 0.25 cm mesh and placed in the selected area. The hatchery was then divided into 270 squares of 80 x 80 cm. Once constructed, the hatchery was guarded around the clock to prevent poaching, to check on egg condition at regular intervals, and to prevent ant and other pest infestations.

Figure 2.2c. Hatchery.

Nightly patrols

Staggered patrols of a maximum of five persons per patrol started from 19:00, with the last patrol leaving the station at midnight. Each nightly patrol was guided by a trained staff member and lasted an average of four hours, depending on nesting activity. The distance usually covered during a patrol was 10 km.

Patrols walked in a line parallel to the shoreline and behind the patrol leader in order not to miss out on any activity. Only red lights and dark clothing were used while recording biometrics, tagging nesting females, relocation of clutches and release of neonates.

If a patrol found a poacher who was already with a turtle, and in line with LAST's strict non-confrontation policy, the patrol either waited until the oviposition was over in order to record data, or kept on patrolling, depending on the leader's decision.

Nest protection

Because of the very high poaching pressure, all eggs found during oviposition were relocated to a guarded hatchery (category 'relocated'). In this case volunteers caught the eggs in a bag as the turtle was laying them and carried the bag to the guarded hatchery for deposition in nests dug by humans to match turtle nest dimensions. Patrols that found nests as they were being laid or had just been laid, removed them from their original location and also relocated them to the guarded hatchery.

Nests category 'in situ' were nests that were left in the location chosen by the turtle at the time of the oviposition. This is usually the result of a nest that could not be localised in time by patrols. In this case, the turtle tracks leading to the nest and back to the beach were camouflaged in order to limit detection of in situ nests by poachers.

Collection of eggs

When a turtle was found and no poacher was present, the patrol leader approached the turtle and decided when the group could approach safely without disturbing the turtle. Once the turtle had dug an egg chamber, a sterile plastic bag was placed under the turtle's ovipositor and eggs were collected in the bag as the turtle laid them. Measurements of the depth and width of the nest were also taken. Once the turtle started to cover the egg chamber, the egg bag was pulled out gently and placed in a safe place so that the volunteers had enough space to record the turtle's biometrics.

Figure 2.2d. Egg collection.

Biometrics

After oviposition, the carapace width and length of the nesting female was measured as shown in Fig 2.2d. Each measurement was repeated three times and dictated clearly to the volunteer in charge of writing down the data.

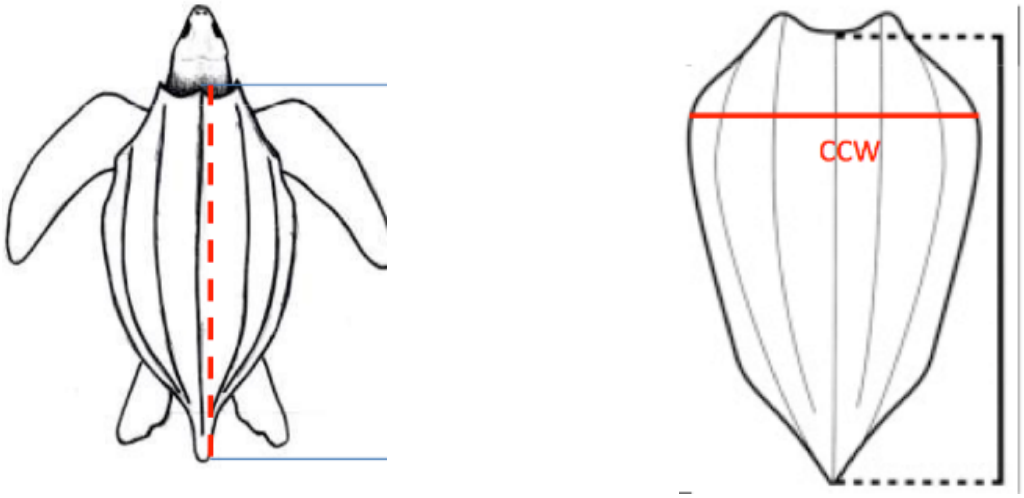

Figure 2.2e. Carapace length (left) and width measurements (right).

Tagging

Before tagging, all turtles were checked for Evidence of Previous Tagging (EPT) and all information was recorded onto the data sheet in accordance with protocol R-055-2007 (Chacón et al. 2007) as recommended by SINAC (Sistema Nacional de Areas de Conservación). Nesting female without tags, or those who were about to lose tags, were tagged with metal tag Monel #49 (leatherback turtle), as well as PIT tags (passive integrated transponders). Tags were applied by a trained staff member holding a valid scientific tagging licence issued by MINAE (Ministry of Environment of Costa Rica).

Figure 2.2f. Placement of the metal tags in the uropigeal area of a leatherback turtle.

Clutch relocation

Once a clutch of eggs was collected and measuring and tagging of a turtle was completed, the patrol walked back to the hatchery to relocate the nest. During transport it was important for the handler to carry the eggs steadily to avoid movements that could harm embryonic development. Once at the hatchery, one of the 270 squares was chosen, following a rule that each square that takes a nest must be followed by an empty one to avoid adjacent nests affecting each other (temperature, bacteria, oxygen).

Visibly normal eggs were relocated and counted first, followed by yolkless or infertile eggs. A mesh basket was placed on the nest to prevent access by predators and to contain the neonates at their emergence (Fig. 2.2b).

Figure 2.2g. Clutch of eggs next to a leatherback turtle, ready for relocation.

Neonates

Hatchery shifts lasted six hours maximum at night and shifts of two hours were organised during daytime. Nests were checked every 20 minutes round the clock to remove crabs, flies and ants, but also to take notice of any hatchling emergence. Only empty squares were walked on to avoid stepping on the nests and compacting them.

Once neonates started to emerge from the nests, 15 hatchlings were picked randomly and both length and width of the carapace were measured with a calliper. Weight was also recorded with 50 g Pesola balance. Handling of the hatchling was done with latex gloves and as carefully as possible in order to avoid stress and disorientation.

Hatchlings were released in various areas of the beach to avoid congregation of predators and at a minimum distance of 10 metres from the high tide line so that they could imprint on the beach.

There was a ban on lights during night time releases to prevent hatchling disorientation. Day time releases took place after 17:00 when the temperature was lowering, except on cloudy or rainy days, when daytime natural hatching was observed.

Figure 2.2h. Measuring a hatchling.

Exhumations

After a nest had fully hatched, an exhumation was conducted to estimate the percentage of hatching and emergence. The exhumations were done within 48 hours after the first emergence or, in case no emergence was observed, 70 days after the nesting date.

From each nest, the number of egg shells, dead neonates and live neonates was recorded and the eggs that did not hatch were opened to estimate the embryonal development. The development stages are classified according to the space used up in the eggs by the embryo and divided into four categories: I (1-25%), II (26-50%), III (51-75%) and IV (76-100%) (Fig. 2.2i).

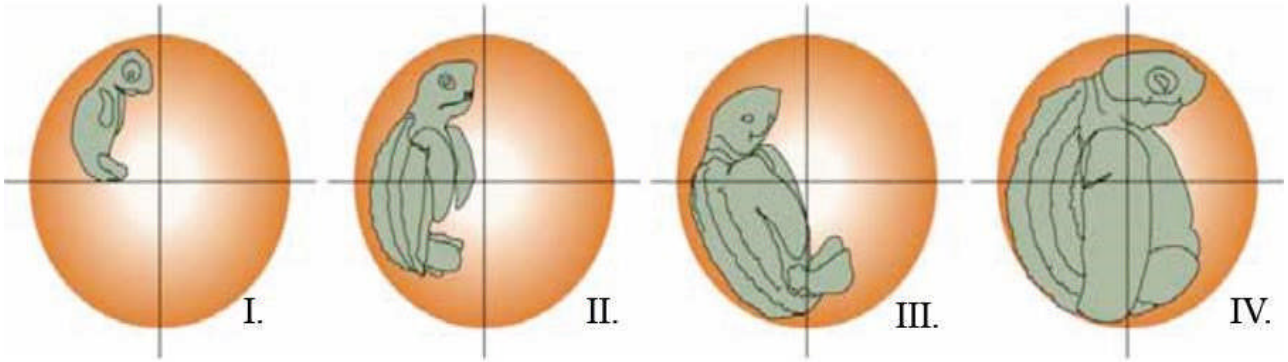

Figure 2.2i. Development stages of the embryos in non-hatched eggs (Chacón et al. 2007).

The percentage of hatching and emergence were calculated following the formula:

$$PE = \frac{C}{N} \times 100$$

$$PEM = \left(\frac{C}{TM}\right) \div N \times 100$$

Where PE = percentage of hatching, PEM = percentage of emergence, C = shells, N = total number of eggs and TM = number of dead hatchlings present in the nest or its surrounding.

Figure 2.2h. Conducting an exhumation count.

Research permits

On 22 January 2016, LAST submitted their application for the research permits required from the Áreas de Conservación La Amistad-Caribe (ACLAC) to monitor the three species of sea turtles nesting in Pacuare. On the 17 February 2016, the application was granted and permits were delivered under resolution code SINAC–ACLAC-PIME-R-003-2016, signed by Jorge González Villalobos.

2.3. Results

2.3.1. Leatherback turtle

Nests and false crawl activity

A total of 414 nesting activities were recorded on Pacuare Beach. 210 of these activities led to a successful oviposition. The remaining 204 activities were classified as false crawls, i.e. the female emerged from the sea, no nest was built and/or no eggs were deposited.

In comparison with the four previous seasons, during which LAST monitored the beach, 2016 is slightly below average, but the pattern observed corresponds to the inter-annual fluctuations described previously by several authors (Troëng et al. 2004, Chacón-Chaverri and Eckert 2007).

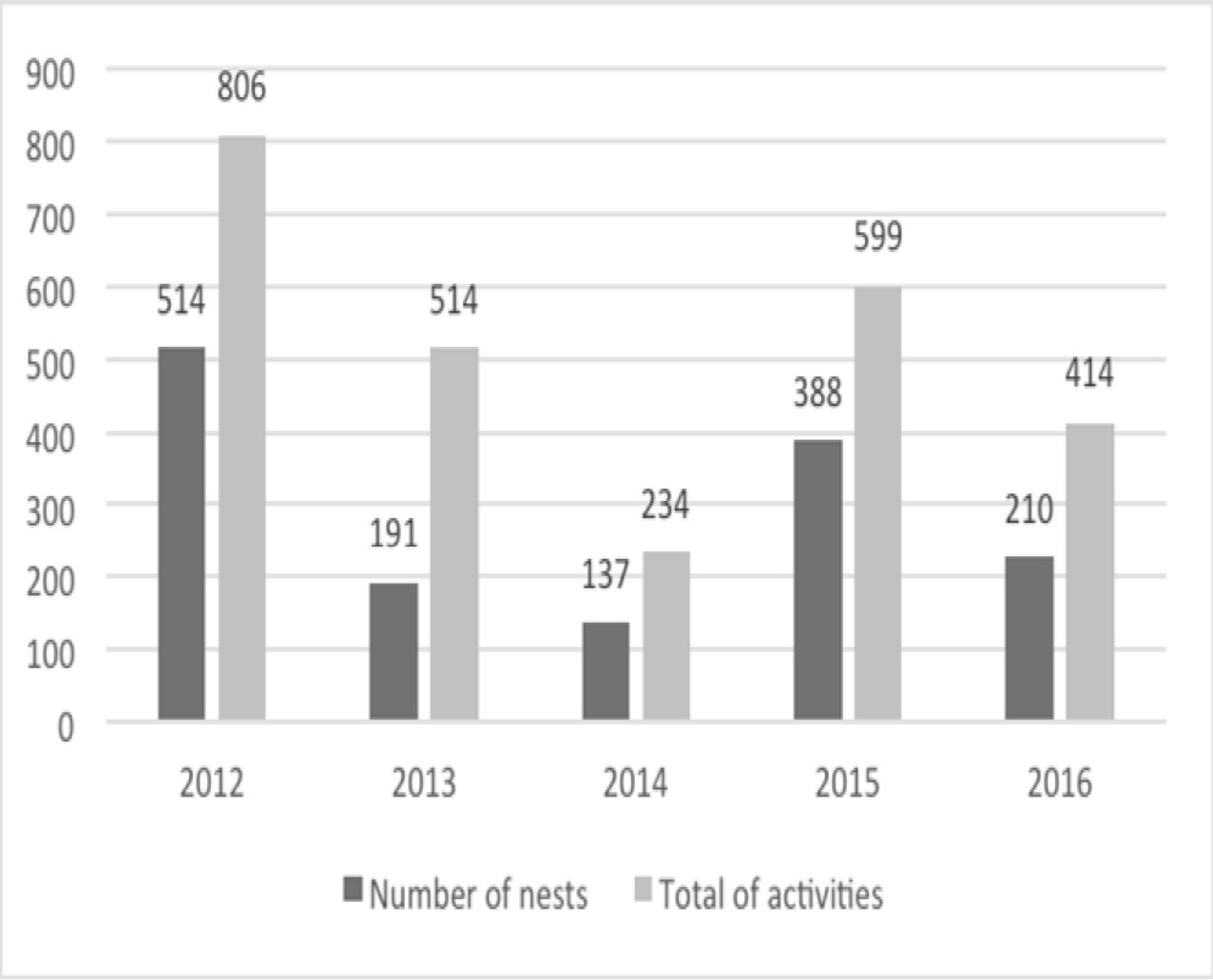

Figure 2.3.1a. Number of nests and nesting activities of *Dermochelys coriacea* recorded in Pacuare beach since 2012.

Seasonal distribution

The majority of nesting activities (71%) was recorded during the months of April and May with 98 and 60 nests respectively (Fig. 2.3.1b). Only two nesting activities were recorded in February and a unique and last activity was recorded during July. This pattern follows the one described during the previous seasons (Chacón-Chaverri and Eckert 2007, Fonseca and Chacón 2012, Marion and Chacón 2013, Fonseca and Chacón 2014, Marion 2015).

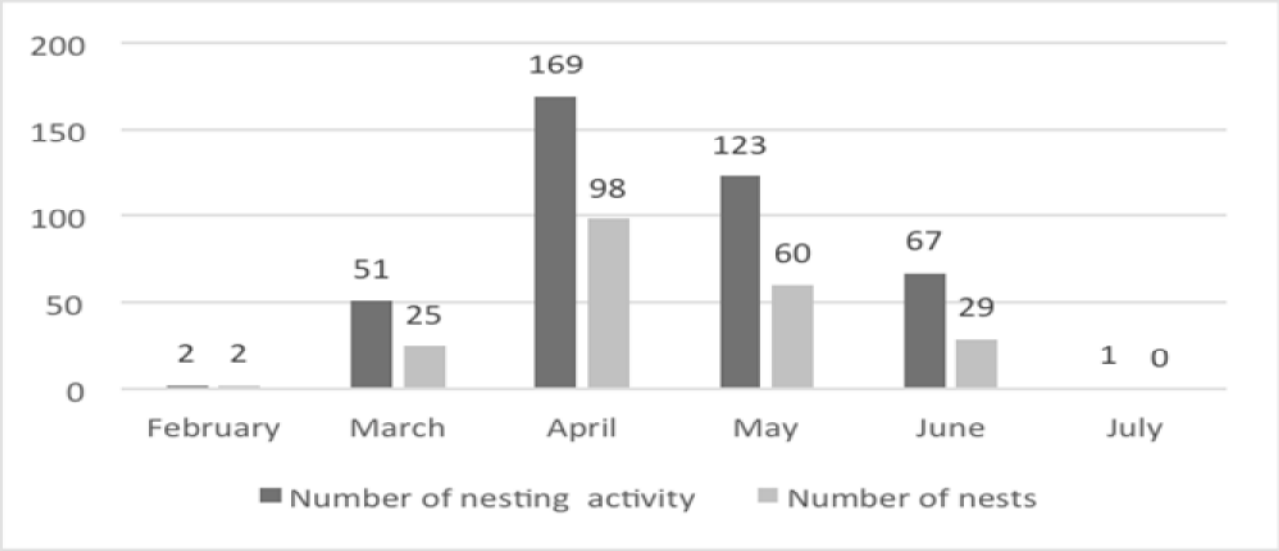

Figure 2.3.1b. Seasonal distribution of nesting activity for *Dermochelys coriacea* in Pacuare beach during the year 2016.

Spatial distribution

Nesting activity was recorded over the entire area of study. However, the majority of activities was observed between markers 21-30 (sector A), 41-60 (sectors A and B) and 71-80 (sector C). The spatial distribution of leatherback nesting activity presents logistical challenges, since it requires personnel to be present on all seven kilometres of beach. To ensure an efficient beach coverage a minimum of eight patrols were required each night, yet there were days that this number was not reached due to lack of volunteers.

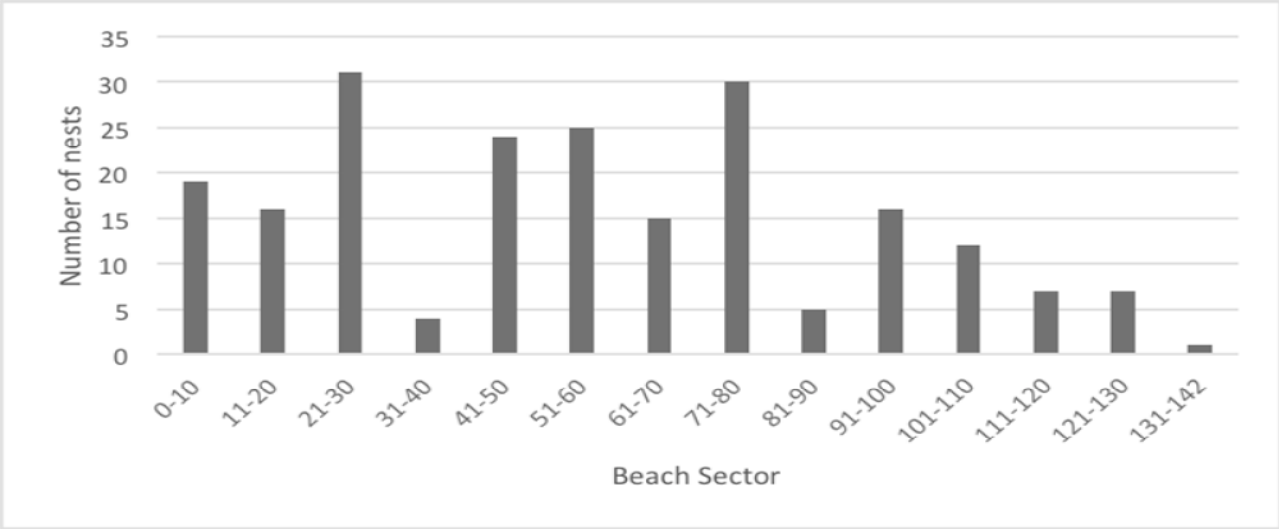

Figure 2.3.1c. Spatial distribution nesting activity for *Dermochelys coriacea* in Pacuare beach during the year 2016.

Number of females registered

Nesting turtles are generally classed as either neophytes or remigrants. A neophyte turtle is one which is in its first reproductive season. This is very difficult to distinguish without an internal laparoscopy to determine first-time breeding capabilities. For tag and release programmes, the term is often used for females with no tags or evidence of previous tags on flippers and that have not previously been recorded nesting at that location. Once tagged and seen repeatedly nesting within the same season, the turtle is then referred to as a renesting or interseasonal turtle.

Remigrant turtles are those which have a tagging history of two or more seasons recorded at the same programme or at multiple programme locations.

In Pacuare a total of 140 leatherback females were recorded during the 2016 season, of which 17 were classified as neophytes. 117 females were observed only once, 16 were registered twice and seven were recorded three times (Fig. 2.3.1d).

This phenomenon can be explained by the fact that Pacuare beach represents only a fraction of the beach complex where the females can nest. In fact, the genetic pool of the Western Caribbean (Dutton et al. 2013) runs from the south of Nicaragua to the north of Colombia (Chacón-Chaverri and Eckert 2007). As such, females will return to nest in areas where LAST does not operate.

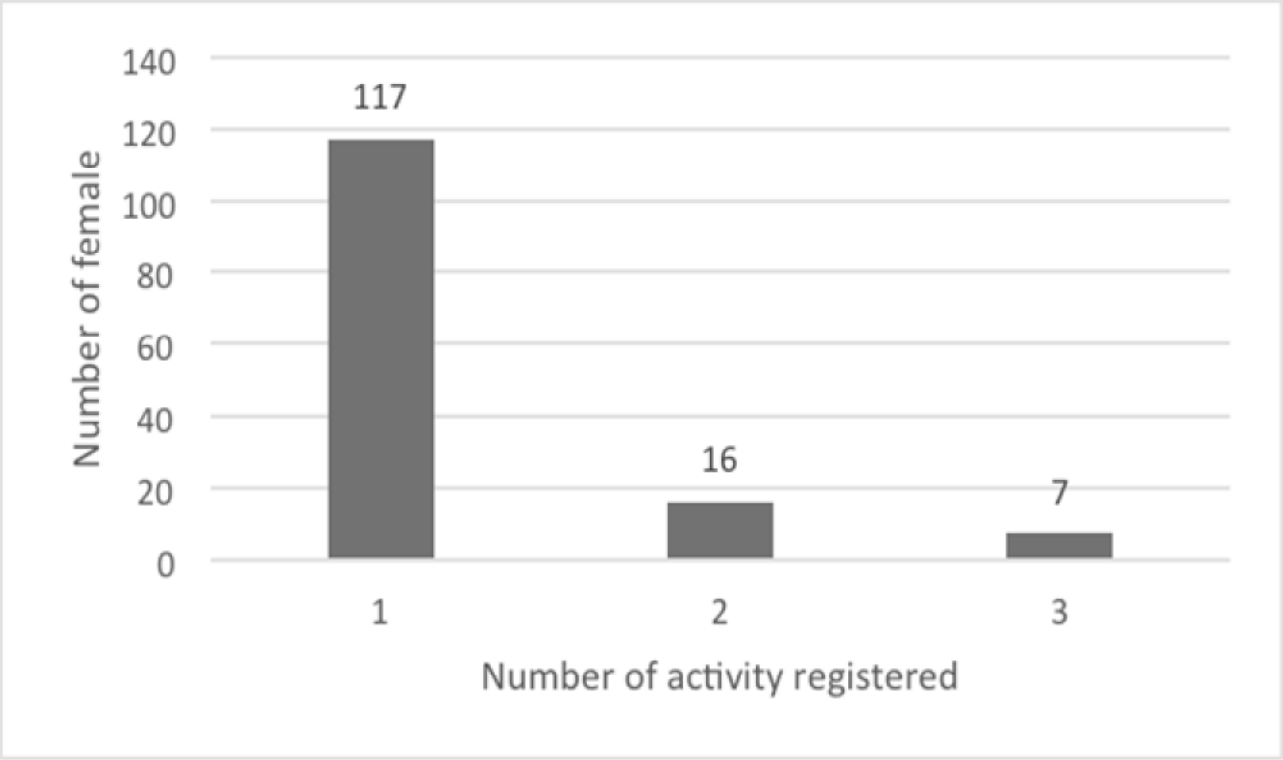

Figure 2.3.1d. Number of returning *Dermochelys coriacea* females registered in Pacuare beach during the year 2016.

Biometrics

The average curve carapace length (CCL) of the females measured in Pacuare was 153.60 cm (SD=39.9, n=140) and the curve carapace width (CCW) was 112.41 cm (SD=7.37, n=140). These measurements are similar to the ones described in Gandoca Beach between 1990 and 2010 (Chacón-Chaverri and Eckert 2007, Fonseca and Chacón 2010) and Tortuguero (Harrison and Troëng 2003).

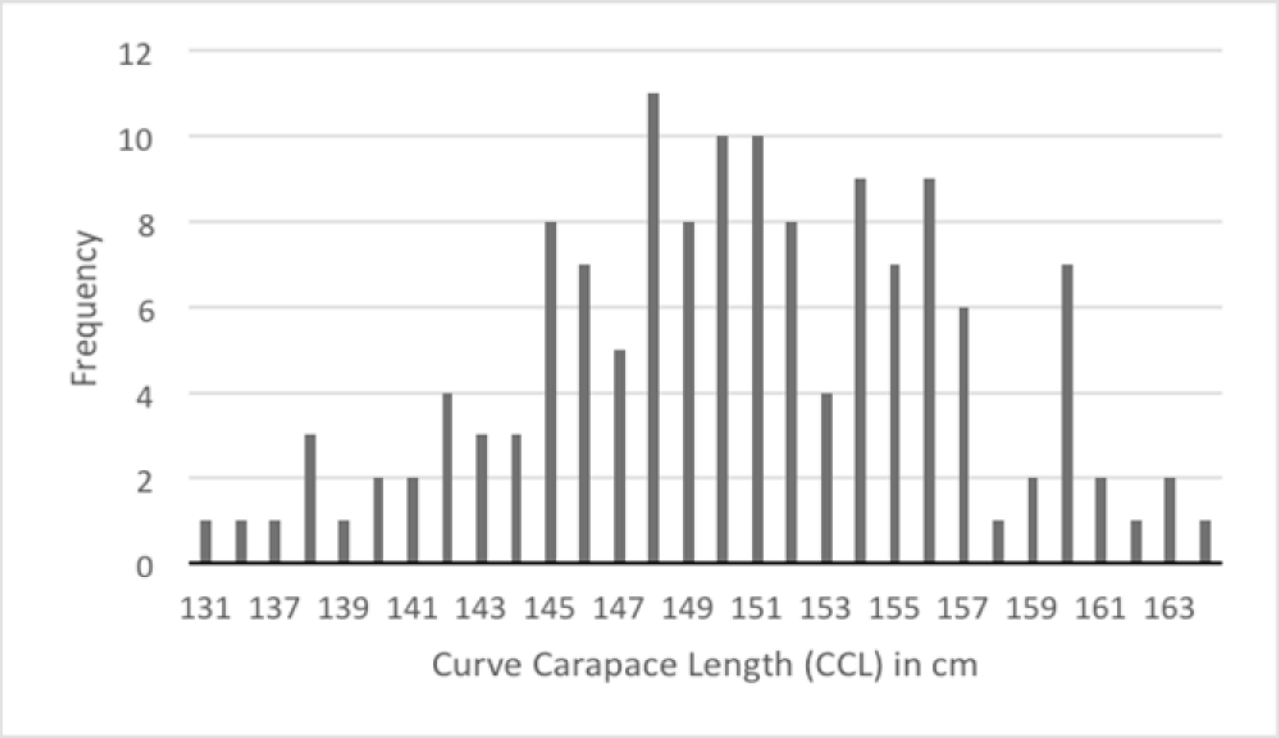

Figure 2.3.1e. Distribution of the Curve Carapace Length (CCL) found in *Dermochelys coriacea*, Pacuare beach, 2016.

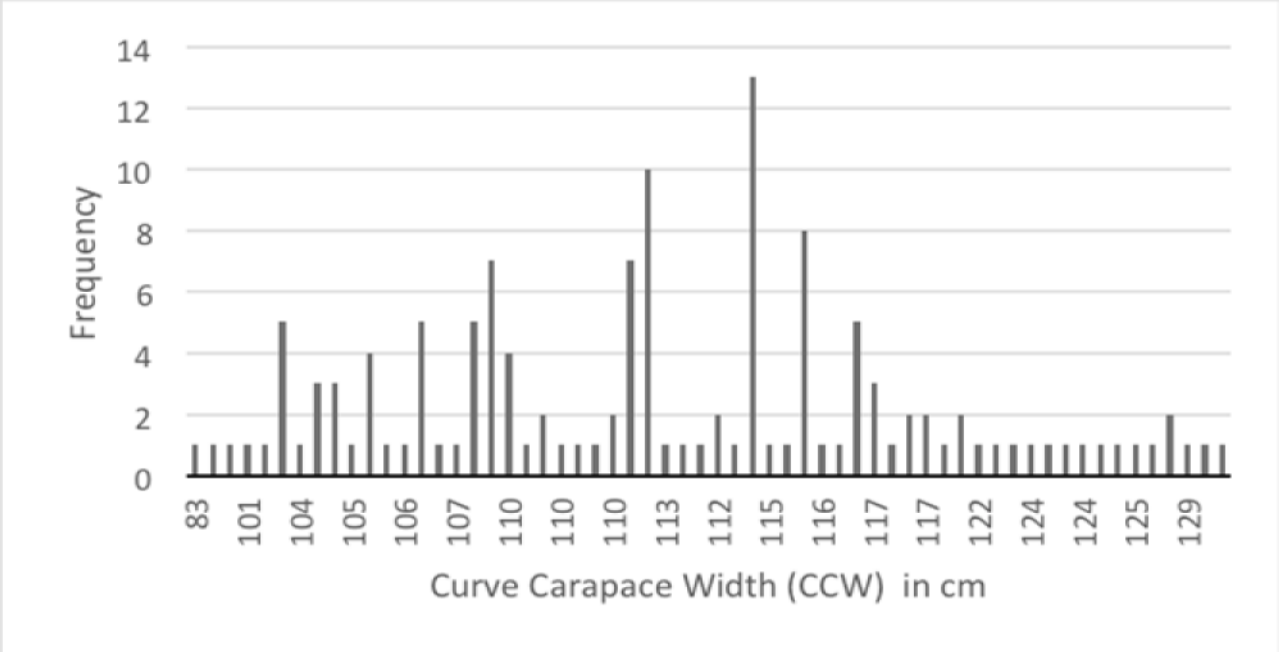

Figure 2.3.1f. Distribution of the Curve Carapace Width (CCW) found in *Dermochelys coriacea*, Pacuare beach, 2016.

Nest conservation

The percentage of nests that were illegally harvested reached 47% in 2016 (Fig. 2.3.1g), which is significantly lower than in 2015 when 63% were poached, and lower than the average percentage of nests poached over the five years of monitoring executed by LAST (54%). The higher number of volunteers participating in the program this year and the new participation of Biosphere Expeditions volunteers helped greatly in reducing the poaching rate through larger numbers of patrols every night.

All the nests that were collected by LAST were relocated into the hatchery owing to the high poaching activity. It was not unusual to record as many as fifteen poachers on the beach in one night and any attempt to relocate a nest on the beach, rather than to the hatchery, would have been defeated by a poacher passing by. There is also a correlation between the percentage of saved nests and the global nesting activity on a given night; a higher number of nesting activity means that the patrols are busy relocating nests or collecting clutches and cannot reach either of the limits of the study area. The parts of the beach left unpatrolled are therefore taken over by the poachers.

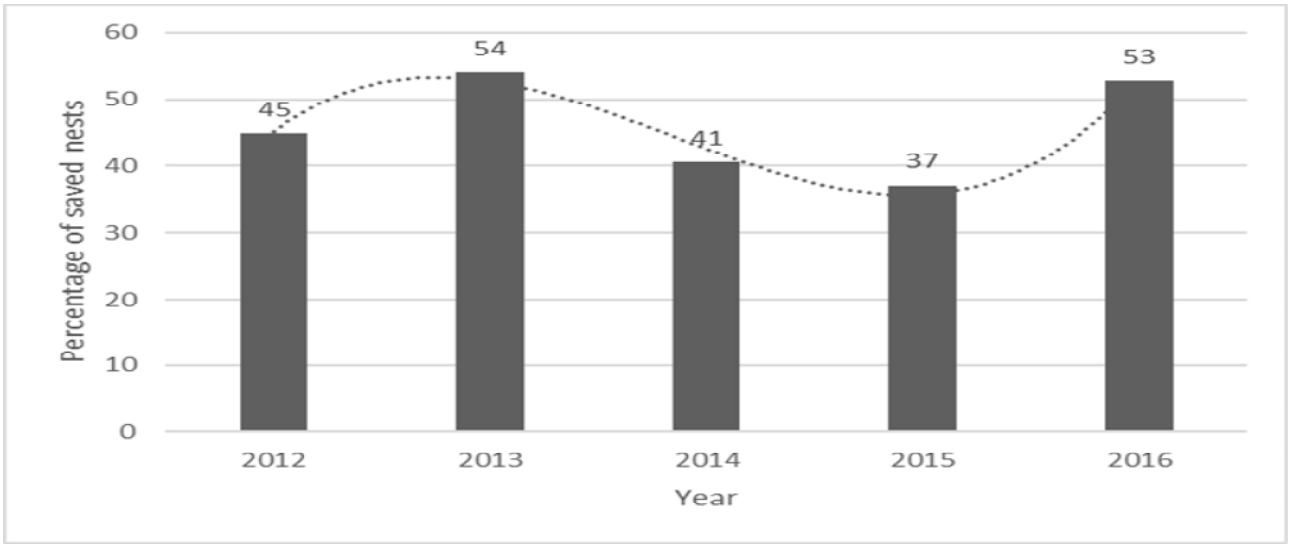

Figure 2.3.1g. Percentage of saved nests for *Dermochelys coriacea* in Pacuare beach since 2012.

Hatching and emergence success

A total amount of 4,147 leatherback neonates was released from Pacuare beach. Exhumations were completed on the 112 nests relocated in the hatchery. The emergence success (51%) remained above the results in Gandoca (11-40%) (Chacón and Eckert 2007) and Tortuguero (13-39%) (Troëng et al. 2007), but below average (59%) in comparison with the previous years (Fig. 2.3.1h). The majority of nests with low hatching success were those relocated during April, when very high temperatures and very little rainfall might have affected embryo development.

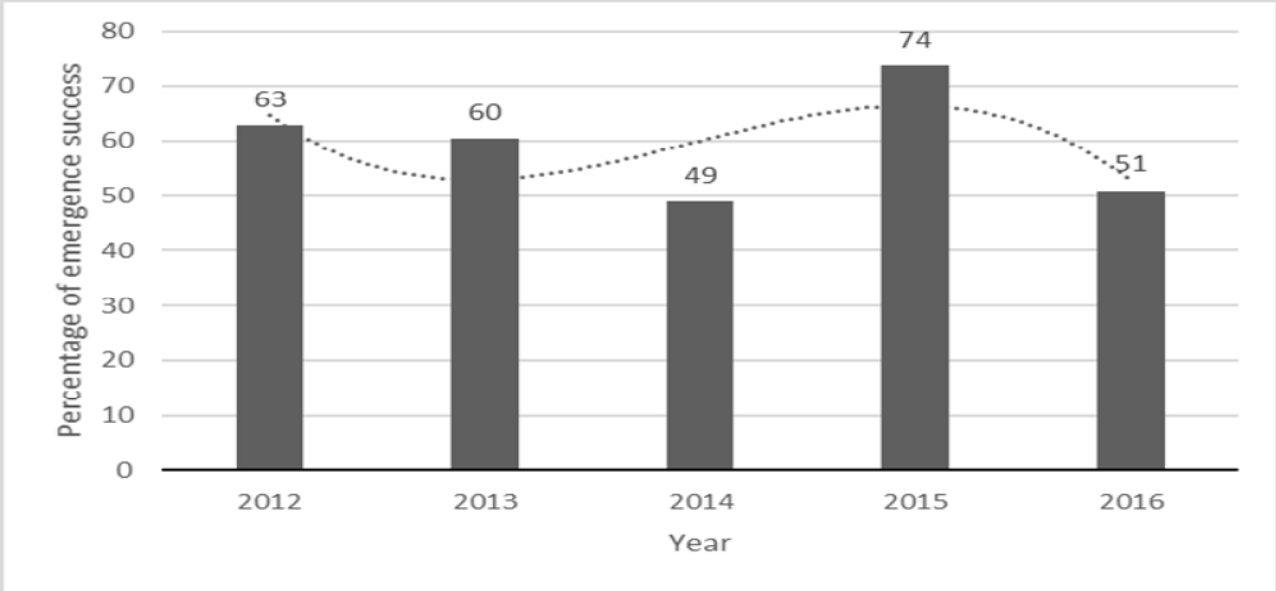

Figure 2.3.1h. Percentage of emergence success for *Dermochelys coriacea* in Pacuare beach since 2012.

2.3.2 Green turtle

Nests and false crawl activity

During the 2016 season, 525 green turtle nesting activities were registered, 136 of which were successful. Despite the disturbance caused by poachers, this has been the highest number of activities recorded since LAST started its surveys.

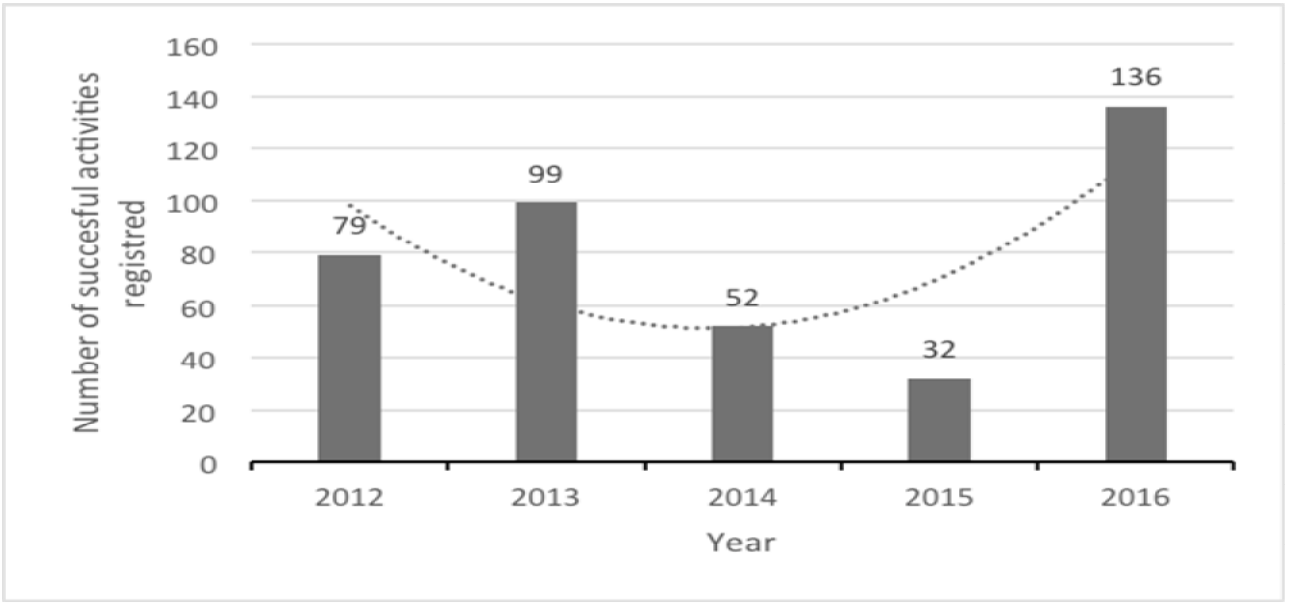

Figure 2.3.2a. Number of nests of *Chelonia mydas* recorded in Pacuare beach since 2012.

Most of the nesting activity was registered in the months of August and September, with 205 and 163 nests respectively (Fig. 2.3.2b). Only one nest was recorded during May and six in June. This pattern is close to the one observed in nearby Tortuguero, where peak activity is in September and October (González and Harrison 2012). Several activities were reported during the month of November but LAST was unable to confirm these activities due to a lack of personnel.

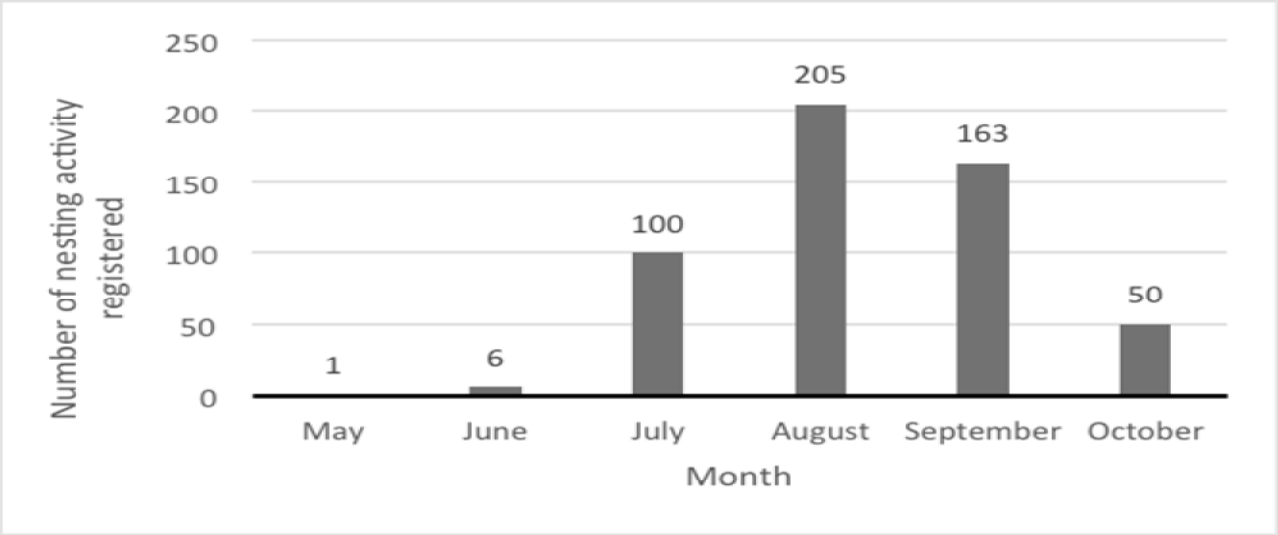

Figure 2.3.2b. Seasonal distribution of nesting activity of *Chelonia mydas* in Pacuare, Costa Rica.

Much of the activity was reported around markers 0-10 (sector A) and 21-30 (sector A) (fig.27). During this season 60% of the nesting activity was recorded in the northern part of the study area (before marker 50), but activities were also registered along other parts of the beach. This distribution pattern represents a challenge in terms of protection of the nests and the females since it requires a larger number of patrols along the 7.1 kilometres of beach.

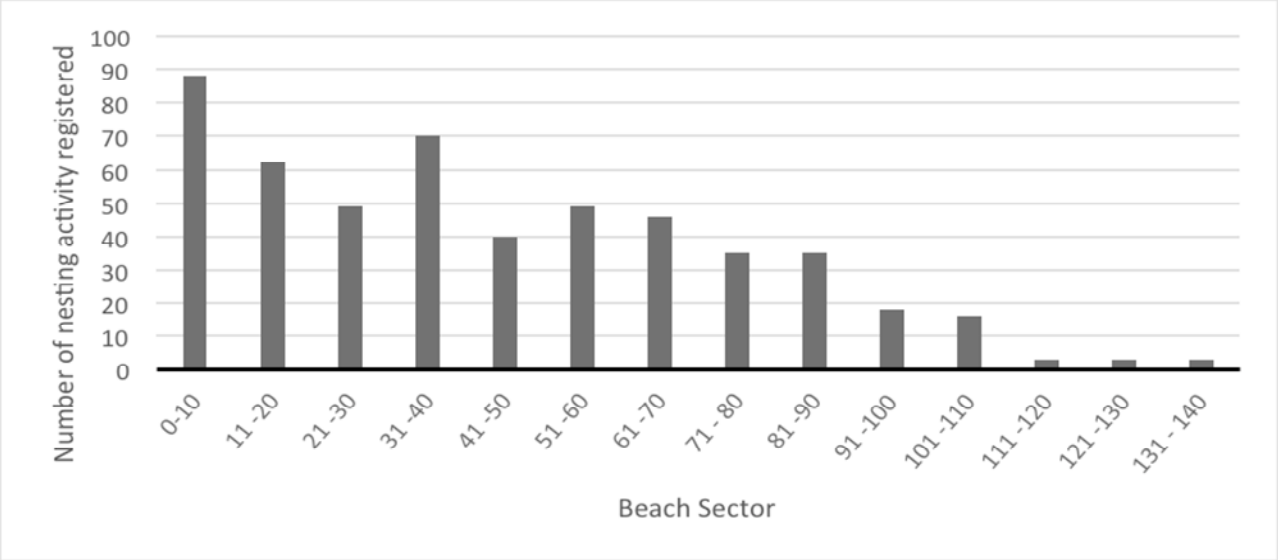

Figure 2.3.2c. Spatial distribution of the nesting activity of *Chelonia mydas* in Pacuare, Costa Rica.

Number of females registered

Sixty-eight females were recorded, of which 58 did not present any tags or evidence of previous tagging.

Number of killed females

An estimated number of forty females were killed illegally which is significantly higher than the numbers reported since 2013 (Fig. 2.3.2d).

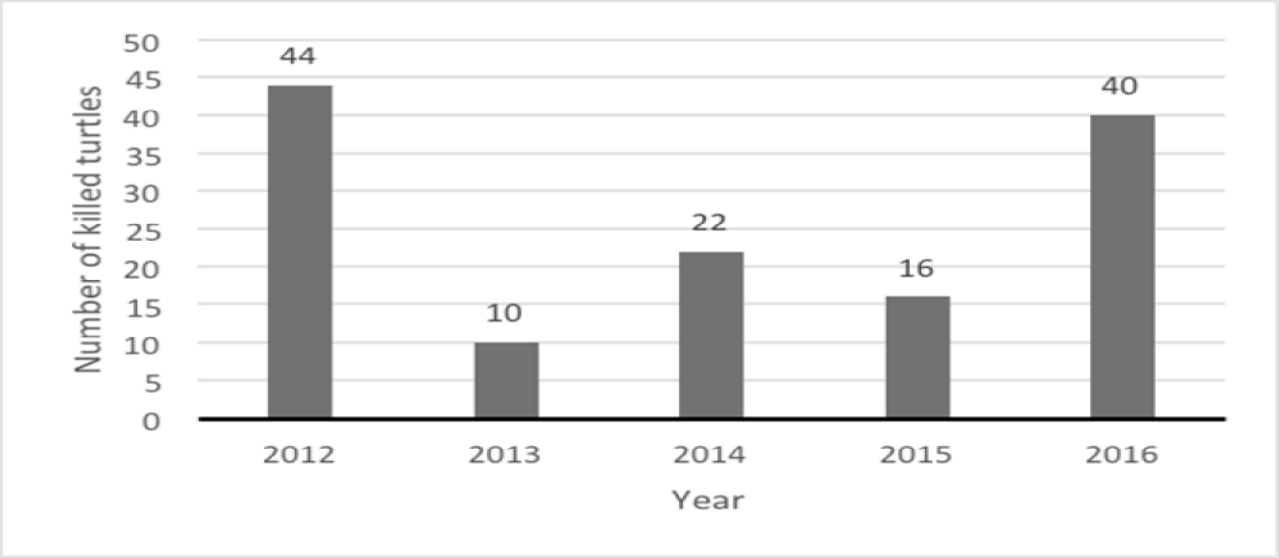

Figure 2.3.2d. Number of *Chelonia mydas* killed in Pacuare, Costa Rica.

However, the number of killed females (8%) out of the total number of females that came to nest in Pacuare is lower than the previous two years (Fig. 2.3.2e). In 2013, very few females were reported as killed but the monitoring ceased in September, therefore, it is likely that additional casualties were not reported.

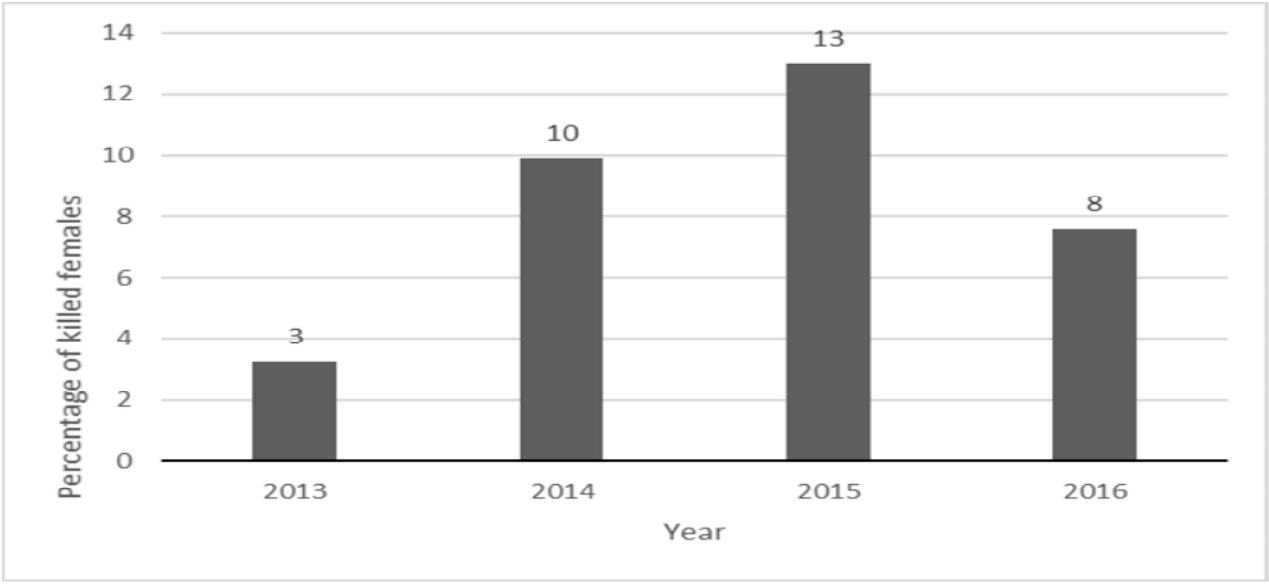

Figure 2.3.2e. Percentage of killed *Chelonia mydas* in Pacuare, Costa Rica.

It is important to mention that 15 turtles were rescued by the coast guard and three persons were arrested. However, they were released within 72 hours after their arrest and were observed by our staff engaged in illegal activities straight away.

Fate of nests

76% of nests were protected in 2016. One hundred and one were relocated in the hatchery and three were found in situ during a morning census. A large proportion of the nests were saved, but the problems of illegal killing must not be overlooked as it represents an obstacle to long-term conservation results.

Hatching and emergence success

The percentage of emergence from the nests exhumated was 80.83% (SD = 21.33, n = 95), releasing 8,266 hatchlings. The emergence success was higher for the nests left in situ with 92.04% (SD= 4.01, n= 3), whereas a percentage of 80.47% (SD=21.33, n=92) was recorded in the hatchery.

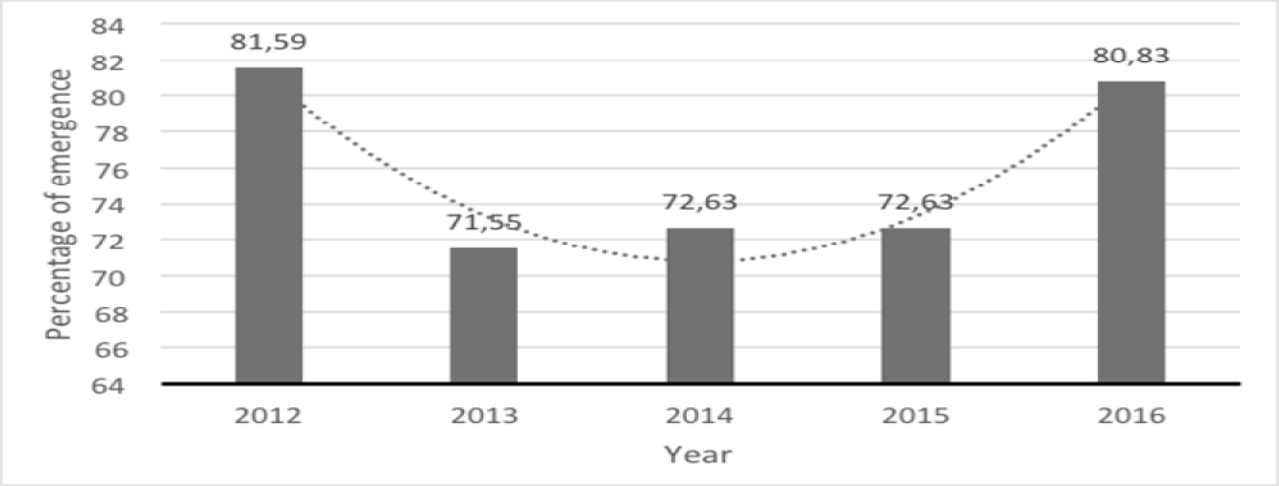

Figure 2.3.2f. Percentage of nest emergence for *Chelonia mydas* since 2012 in Pacuare, Costa Rica.

2.3.3. Hawksbill turtle

Nests and false crawl activity

During the 2016 season a total of 22 nesting events were recorded, out of which seven were successful. Three nests were illegally extracted and four were relocated to the hatchery. Most of the activity was recorded during the months of May, June and August with six, five and five activities respectively. These numbers coincide with the ones observed since 2012 (Fig. 2.3.3a).

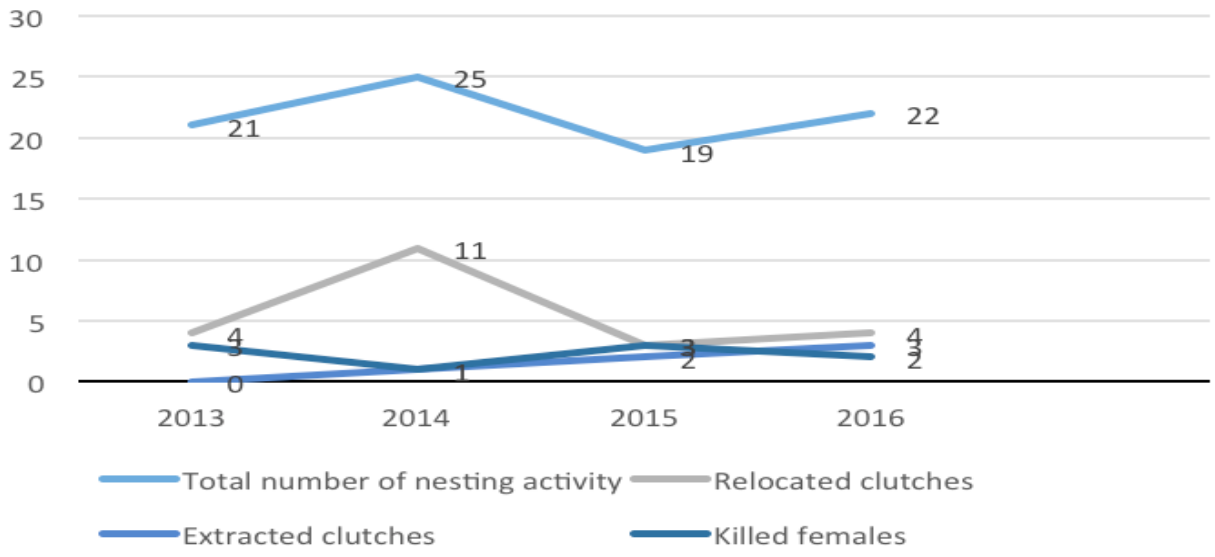

Figure 2.3.3a. Nesting activity, number of relocated and extracted nests and killed *Eretmochelys imbricata* since 2012, Pacuare, Costa Rica.

Hatching and emergence success

The average emergence success observed for the exhumed nests was 66% (SD = 37.82, n = 4), releasing 342 hatchlings. The highest percentage of emergence was recorded for the clutch relocated in July (93%), whereas the lowest was recorded for the clutch relocated in August with 0.59%. The latter was relocated at a depth of 71 centimetres, which might have affected the development of the embryo. In fact, the optimal depth observed for Hawksbill nests is around 45 to 50 cm; at a depth of 71 cm the temperature and humidity levels are no longer optimal.

2.3.4. Environmental awareness

In addition to the monitoring of the nesting females and neonates, Biosphere Expeditions volunteers also participated in other activities such as beach clean-ups, clearing of logs that prevent turtles to come ashore to lay their eggs, and recycling rubbish collected during beach clean-ups. Throughout the season, about 10 cubic metres of rubbish, mostly plastic, was collected and sent off to a recycling centre located in Bataan.

2.4. Discussion and conclusions

During the 2016 season at Pacuare, 414 nesting activities of leatherback turtle, 525 of green turtle and 22 of hawksbill turtle were recorded. 220 clutches were relocated to the custom-built hatchery, three were left in situ and none relocated on the beach, because of the very high local poaching rate.

From clutches moved to the hatchery, 12,755 neonates emerged (4,147 leatherback, 8,266 green, 342 hawksbill turtle) and were successfully released to the ocean. The percentages of emergence recorded were 51% (SD=30.31, n=112) for leatherback, 81% (SD = 21.33, n = 95) for green and 66% (SD = 37.82, n = 4) for the hawksbill turtle.

The average nest poaching rate recorded for each species was 40% for leatherback, 23% for green and 43% for hawksbill turtle. In addition, 40 green sea turtles and two hawksbill turtles were recorded to have been killed by poachers.

The number of saved nests and successfully hatched neonates is a significant achievement for LAST and its partners, such as Biosphere Expeditions, especially since the project was only established in 2012 and taking in account the challenging environment in which it operates, most significantly the intense egg and turtle poaching.

Leatherback turtle

The nesting activities registered since 2012 show that the population of leatherback turtles remains stable in Pacuare. However, this should be treated with caution since the life cycle of these animals is slow and previous observations have been made of the possible decline of the fourth biggest rookery in the world (Troëng 2004). Pacuare is one of the most important nesting sites in Costa Rica for leatherbacks, but still suffers a great deal of pressure from illegal poaching activities, as well as deaths recorded due to commercial fishing (Troëng 2004). LAST and Biosphere Expeditions therefore recommend that the programme continues its monitoring activities to determine the long-term effects of illegal extraction along with the conservation efforts that could prevent the very real possibility of the species becoming extinct.

Green turtle

The increase of green turtle activity seen in 2016 could be due to atmospheric oscillations related to global warming and the effect of these on the production of sea grass, a staple food for green turtles. A second hypothesis is a rise in population as a result of years of conservation work in both foraging and nesting areas in combination with the prohibition of the killing of sea turtles. This second hypothesis must, however, be treated with caution, since a study by Lagueux (2014) revealed that approximately 171,556 green turtles were killed between 1991 and 2011 in the Caribbean waters of Nicaragua. In fact the majority of the turtles nesting in Tortuguero and Pacuare use the Nicaraguan waters as a feeding ground (Troëng 2005). This shows the importance of pursuing the monitoring of these reptiles to define the long-term trend and to determine the conservation tools needed to recover the population. It also shows that global efforts spanning several countries are needed if sea turtle conservation is to succeed as sea turtles are a global species, roaming large distances across multiple countries and/or continents.

It is clear that the conservation work in Pacuare will need to run for several more years before illegal activities can be eradicated, especially with regard to green turtle killings and illegally extracted nests. Moreover, most of the people involved in such illegal activities do not live in Pacuare, which unfortunately diminishes the impact of local environmental awareness initiatives. Job creation for permanent residents of Pacuare is not a solution for this problem, unless the community make a concerted effort to remove transient poachers from the area.

Overall efforts

The data recorded since 2012 indicate that Pacuare beach is one of the most important nesting sites for the leatherback turtle in Cost Rica. Nevertheless, very high levels of poaching continue to be observed every year and should be dealt with with some urgency by the local authorities, such as the Ministry of Environment and Energy (MINAE) and the police (Fuerza Pública). The eradication of the poaching problem is not easy, since poaching provides a very significant income for otherwise very poor and disadvantaged communities along Pacuare, both sessile and transient. In addition, most of the individuals involved in poaching are already outlaws or delinquents with criminal records (as ascertained through personal communication and observation), with a concomitant low threshold towards further illegal activities.

The high percentage of illegal harvesting is explained by several factors, which are:

- The absence of effective action by the local authorities responsible for the protection of natural resources, including the National Service of Coastguards (SNG), Instituto Costarricense de Pesca y Acuacultura (INCOPESCA) and the Ministry of Environment and Energy (MINAE).

- The lack of job opportunities in the cantons of Siquirres and Matina, which encourages or forces a large portion of the population to turn to illicit activities such as drug traffic and the illegal extraction of natural resources.

- The reduced number of patrols deployed by LAST, due to economical restrictions, that are critical to cover efficiently the seven kilometres of beach and outnumber the poachers present on the beach.

All of the above factors result in an unequal, if successful, struggle of NGOs against transient and criminal poachers, many of whom sustain their alcohol and drug addiction through the depletion of the population of sea turtles on the Caribbean Coast. As long as NGOs are by and large left to continue this struggle by themselves, it will remain unequal. Despite this, and given enough future input from international volunteers and citizen scientists, many nests will continue to be saved and many hatchlings will be helped into the ocean, thereby preventing the local extinction of sea turtle populations. If, however, the national authorities tasked with nature protection and law enforcement were to join efforts in turtle conservation, then this could be turned from extinction prevention to population recovery. This, in conjunction with the removal of transient, criminal poachers from the community, which can only be achieved with the help of the community, could lead to the establishment of safe, nature-based tourism in the area with significant economic benefits for the community.

However, turtle-based tourism must be introduced with care. During 2016, LAST observed the presence of other organisations or persons willing to battle against the illegal extraction of eggs and the killing of the turtles. Even though their goals align with those of LAST, these organisations and/or individuals by and large lack the knowledge and/or indeed the permits to handle turtle eggs, as well as lacking the socio-economic understanding of the situation on the ground. On various occasions this interfered with the legitimate work of LAST. Thus LAST recommends a centrally organised control of organisations and people involved in turtle conservation in order to protect the stability of existing and authorised projects present in the area. The social and economic development of the community of Pacuare is a crucial parameter to allow LAST to meet its objectives and to protect the population of sea turtles.

LAST also recommends the creation of ecotourism activities, such as English classes for locals and the development of alliances with partners to promote sustainable exploitation of the natural resources of Pacuare. A police station should be set up to regulate, monitor and control such activities and to support both the locals and the tourists in case of emergency.

La Tortuga Feliz Foundation is a Dutch foundation established in Pacuare in 2004 which assists LAST in its mission by recruiting international volunteers; both organisations donate a percentage of the income provided by the international volunteers to the Asociación para el Ambiente de Nuevo Pacuare, which is in charge of employing the local research assistants. A high number of volunteers allows the recruitment of additional local guides but the month of April, which is the beginning of the peak nesting activity, is generally less frequented by volunteers. Therefore there were nights when the beach was understaffed and the opportunities for poachers were drastically increased. Therefore, LAST must continue to work with research partners, such as Biosphere Expeditions, so that more volunteers can be found to patrol the beach each night. This will not only help LAST to reach its objectives, but also bring a stable alternative livelihood to the community of Pacuare.

It is also crucial to raise environmental awareness amongst the local population of Limon province so that the consumption of turtle meat and eggs is reduced. Without consumers, there would not be any market, and poaching would cease.

Finally, the involvement of the municipality of Siquirres in the construction of properties in public areas is another important point to be considered. Most of the poachers live in slums or ranchos built illegally and without proper handling of human waste. If the municipality could remove these itinerant persons, they would be contributing to the reduction of the illegal extraction of eggs and killing of turtles.

The accumulation of (mainly plastic) rubbish on the beach could be prevented by setting up an effective collection system in the municipalities surrounding the area. There is in fact no rubbish collection or recycling coordination in place at all for the communities adjacent to the Pacuare River.

Recommendations for the 2017 season

LAST and Biosphere Expeditions recommend several measures to ensure population protection and recovery of all three turtle species present in Pacuare:

- An investigation into the use of Styrofoam boxes as a method of artificial hatchery deserves attention and should be considered when erosion patterns prevent the building of a beach hatchery and when the numbers of volunteers are not enough to conduct patrols as well as hatchery guarding activities at the same time.

- The use of long-range radios is crucial to coordinate the relocation of clutches and to ensure a more efficient coverage of the beach.

- The use of handheld forward-looking infrared (FLIR) devices by beach patrols should be investigated in order to find and protect nesting turtles more quickly and effectively.

- Continued nurturing of the existing relationship with the Coastguards is critical, so that the joint efforts of law reinforcement authorities and NGOs can continue to combat and eventually eradicate illegal turtle poaching and killing activities in Pacuare.

- The development of alternative livelihood opportunities for the local community is vital as a measure to reduce poaching activities and support the community in developing itself to attract eco-tourism and voluntourism.

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Appendix 1: Expedition diary & reports

A multimedia expedition diary is available on https://biosphereexpeditions.wordpress.com/category/expedition-blogs/costa-rica-2016/

All expedition reports, including this and previous expedition reports, are available on www.biosphere-expeditions.org/reports.