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EXPEDITION REPORT

Expedition dates: 7 – 14 May 2018

Report published: April 2019

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Protecting leatherback sea turtles through direct conservation action on the Caribbean coast of Costa Rica

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Authors:
Fabian Carrasco
Latin American Sea Turtles

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Biosphere Expeditions

Abstract

From 24 February until 31 October 2018 nesting activities of leatherback turtles (*Dermochelys coriacea*), green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) were recorded on Pacuare beach, Costa Rica. A total of 191 sea turtle nests were protected (leatherback = 156, green = 29, hawksbill = 6). 173 nests were relocated to the hatchery and 18 nests were reburied in a safe place at the beach. The emergence percentage of the exhumed nests of leatherback turtle was 67% (SD = 21.52, n = 155), 74% (SD = 20.23, n = 24) for green turtle and 88% (SD = 20.78, n = 6) for hawksbill turtle.

A total of 10,960 neonates were released from all the protected nests (leatherback = 8,112, green = 2,038, hawksbill = 810). Ten green and five hawksbill turtles were killed by poachers, which is the same number of turtles killed as during the 2017 season, and evidence that poaching continues, but is not increasing.

65% of the total nests laid by the three species were saved as a result of the direct conservation actions taken by LAST, Biosphere Expeditions, the community and all the other partners involved in the project. This percentage of saved nests is the highest since the project started in 2012 and a credit to all involved.

The population of leatherback turtle remains stable, which is encouraging, albeit at a relatively low level due to lack of remigrant leatherbacks. Elsewhere, however, steep declines of up to 60% have been noted. 65% of leatherback nests were saved.

69% of green turtle nests were saved and 46% of hawksbill turtle. Challenges remain, especially those related to a lack of human resources available to patrol the beach to prevent poaching and the almost complete absence and lack of support from law enforcement, especially the coast guard. On the rare occasion that the coast guard is present, arrests are made, which anecdotal evidence suggests has a positive impact on reducing poaching activity at the beach overall. Given this, continued direct conservation actions such as nightly patrols and hatchery construction and guarding by the project, supported by citizen scientists and the community, are critical for sea turtle survival at Pacuare and elsewhere.

LAST and Biosphere Expeditions will continue the project in Pacuare beach to save nests and combat poaching, and to generate more scientific information in order to create management and conservation strategies to aid sea turtle population recovery. We encourage law enforcement to assist. If the police and coast guard were to help with beach patrolling, as well as the arrest and prosecution of poachers, the number of saved nests would increase considerably.

Resumen

Desde el 24 de febrero al 31 de octubre 2018 se registraron las actividades de anidación de tortuga baula (Dermochelys coriacea), tortuga verde (Chelonia mydas) y tortuga carey (Eretmochelys imbricata) en Playa Pacuare, Costa Rica. Durante la temporada se protegieron un total de 191 nidos de tortugas marinas de los cuales 156 correspondieron a tortuga baula, 29 a tortuga verde y seis de tortuga carey. 173 nidos fueron relocalizados en el vivero y 18 nidos fueron reubicados en sitios seguros en la playa. El porcentaje de emergencia para las nidadas exhumadas de tortuga baula fue de 67% (SD = 21.52, n = 155), 74% (SD = 20.23, n = 24) para tortuga verde y 88% (SD = 20.78, n = 6) para tortuga carey.

Del todas las nidadas protegidas se liberaron un total de 10,960 neonatos de los cuales 8,112 fueron de tortuga baula, 2,038 de tortuga verde y 810 de tortuga carey. Un total de 10 hembras de tortuga verde y cinco de tortuga carey fueron asesinadas durante la temporada; misma cantidad de tortugas asesinadas que la temporada 2017. Evidencia de que la matanza de tortugas continúa constante pero no está aumentando.

El 65% del total de nidos depositados por las tres especies fueron salvados como resultado de las acciones de conservación tomadas por LAST, la comunidad local y las personas involucradas en el proyecto. Éste porcentaje de nidadas protegidas es el más alto registrado desde el inicio del proyecto en 2012.

La población de tortuga baula permanece estable, lo cual es alentador, aunque a un nivel relativamente bajo debido a la falta de hembras remigrantes. Sin embargo, en otros lugares, se han observado fuertes caídas de hasta el 60%. El 65% de nidos de tortuga baula fueron salvados.

El 69% de nidos de tortuga verde y el 46% de tortuga carey fueron salvados. Los desafíos permanecen, especialmente los relacionados a la falta de personal disponible para patrullar la playa para prevenir la extracción ilegal de nidadas y la cacería de hembras anidantes, y la falta de apoyo por parte de las instituciones gubernamentales, como el servicio nacional de guardacosta. En las raras ocasiones que los guardacostas estuvieron presentes lograron hacer algunos arrestos, lo que que tuvo un impacto positivo reduciendo considerablemente las actividades ilegales de extracción de nidadas y cacería de tortugas. Bajo este escenario, la continuidad de las actividades directas de conservación, como patrullaje nocturno, construcción y cuidado de vivero por parte del proyecto apoyado por los ciudadanos científicos, la comunidad local son críticas para la supervivencia de las tortugas marinas en Pacuare y en otros lugares.

LAST y Biosphere Expeditions continuaran con el proyecto en Pacuare para salvar el mayor número de nidos posibles y combatir al saqueo de nidadas y la cacería de hembras anidantes, para generar más información científica y así crear estrategias para el manejo y conservación que ayuden a la recuperación de las poblaciones de tortugas marinas. Alentamos a las autoridades a apoyar en las actividades de conservación. Si las autoridades públicas ayudaran durante el patrullaje así como con el arresto y persecución de saqueadores, el número de nidadas y hembras protegidas incrementarían considerablemente.

Contents

Please note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this section, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

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 7 to 14 May 2018 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 be easily 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 polar 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. 2011). 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).

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 scientists 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 oceans 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 Columbus 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 7 – 14 May 2018 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 and 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 18 and 35° C with slightly lower temperatures at night and humidity around 85% (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 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 as there were no accidents or incidents.

1.5. Scientist

Fabian Carrasco was the head scientist for this expedition and is the on-site biologist at the Pacuare research site of LAST. He has dedicated much of his career to sea turtle research and conservation, and was previously a research assistant at Pacuare. Fabian has a Bachelor of Science degree in Biology from the Universidad Autónoma of Morelos, México. Fabian worked with three species of sea turtle in México before joining LAST in 2016. Fabian is a fully qualified first aider and speaks both English and Spanish.

1.6. Expedition leader

Ida Vincent grew up in Sweden and lived in Australia for ten years before moving to Seattle in the USA. Ida studied Marine Biology at the University of Queensland and Environmental Science at Murdoch University (both in Australia), finishing with BSc and Masters degrees respectively. Ida has worked as a marine scientist and aquatic ecologist in Madagascar, Papua New Guinea, the Philippines, Australia and the Pacific Northwest in the USA. She is also a qualified PADI divemaster, Reef Check trainer, as well as a climbing leader and instructor with the North Cascade Mountains as her backyard. Ida also enjoys photography, painting and writing. She has published both scientific and magazine articles about alpine climbing, as well as a murder mystery novel.

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):

Arhalous Attarian (USA), Georg Berg (Germany, press), Gary Hogben (UK), Sandra Hogben (UK), Skarlet Ilieva-Markova (UK), Anna Kantilaftas (Australia, press), Eva Kohl (Germany), Stefanie Parchmann (Germany), Nicole Stinn (Canada), Sherry Stinn (Canada).

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. 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 of LAST for being ever helpful and reliable in setting things up and keeping them running, and 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.

1.10. 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 www.biosphere-expeditions.org/reports. Enquires should be addressed to Biosphere Expeditions via www.biosphere-expeditions.org/offices.

1.11. Expedition budget

Each team member paid a contribution of €1,730 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	17,776
Expenditure	
Staff includes local & international salaries, travel and expenses	2,798
Research includes equipment and other research expenses	109
Transport includes car hire, fuel, taxis and other local transport	778
Base includes board and lodging at the research station	2,033
Administration includes local sundries, fees and miscellaneous expenses	524
Team recruitment Costa Rica as estimated % of PR costs for Biosphere Expeditions	8,676
Income – Expenditure	**2,848**
Total percentage spent directly on project	**84%**

Please note: This report details the results of an entire nesting season from February to October 2018. The bulk of the work during this period was conducted by LAST, with Biosphere Expeditions assisting during the leatherback nesting season in May.

Please also note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this section, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

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

2.1. Introduction and background

Sea turtles are ancestral reptiles that have been exposed to a multitude of threats over the last few decades, which have brought many species to the verge of extinction. Humans are a major culprit in reducing sea turtle populations through killing turtles and their eggs, utilisation of turtle parts and via other threats such as habitat loss, pollution, bycatch, boat strikes, etc. (Chacón 2002). With the human population pressure increasing in Costa Rica, the threats for sea turtle populations have also increased. For example, there is a well-established black market all around the country targeting sea turtle meat and eggs, with the Caribbean side one of the most important supply zones (Chacón 2002).

Sea turtle nesting studies in Costa Rica started in the 1970s mainly in Tortuguero National Park (Troëning & Rankin 2005). The Sea Turtle Conservation Project in Pacuare beach was initiated in 2012 by Latin American Sea Turtles (LAST) in association with WIDECAST and the Asociación para el Ambiente de Nuevo Pacuare. The project involves the community in conservation activities as research assistants or as staff managing the hatchery. The community in Pacuare is highly vulnerable, due to lack of jobs, low levels of education, as well as drug use and trafficking. During the sea turtle nesting season, individuals from nearby areas, by and large outside the local community, come to the beach to poach eggs and hunt sea turtles, which increases pressure.

Because of this, effective conservation activities are critically important for the protection and survival of the four species present in Pacuare beach: hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*) and loggerhead turtle (*Caretta caretta*) (Marion and Chacón 2013, Fonseca and Chacón 2014). Due to population decline around the world, the hawksbill turtle is catalogued as Critically Endangered; green turtle is classified as Vulnerable and loggerhead turtle as Endangered. Leatherback turtles of the Northwest Atlantic were classified as Vulnerable (from Endangered) in the 2014 assessment by the Convention of the Sea Turtles Specialist Group of IUCN, due to population recovery, mostly in Guyana, Trinidad and Tobago, Panama and Surinam. However, in the last assessment in 2018, leatherback turtles of the Northwest Atlantic were catalogued as Endangered by the IUCN Northwest Atlantic Leatherback Working Group, due to declines in nesting abundance caused by anthropogenic sources, habitat losses and changes in life history parameters (Northwest Atlantic Leatherback Working Group 2018).

The main objective of the project is to improve the conservation status of the sea turtles in Pacuare beach through citizen science and the support of government institutions, as well as the local community. Specific tasks are to increase the reproductive success of sea turtles by protecting nesting females and their eggs. Citizen scientists play an important role in this and the success rate of the project is directly linked to the number of volunteers on the beach each year. The presence of citizen scientists is the project's first line of defence against poaching. Other critical tasks performed by citizen scientists are data collection, as well as beach and hatchery maintenance.

2.2. Methods

From February until November 2018, daily nightly patrols were organised to monitor the 7.1 km of beach administrated by LAST / WIDECAST. National and international citizen scientists were involved in beach patrols, 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.

Citizen scientists were trained for a day or so upon arrival and then conducted most activities under the supervision of a trained staff member in order to reduce bias and errors in data recording. Evans and Birchenough et al. (2001) have demonstrated that, given training, volunteers can perform straightforward tasks as competently as more experienced scientists.

Study site

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 (Figure 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 was geographically divided into three sections known in 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 operate.
- Sector C (2.5 km): This sector is the most inhabited and also has the most driftwood, making nesting activities very challenging for turtles.

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

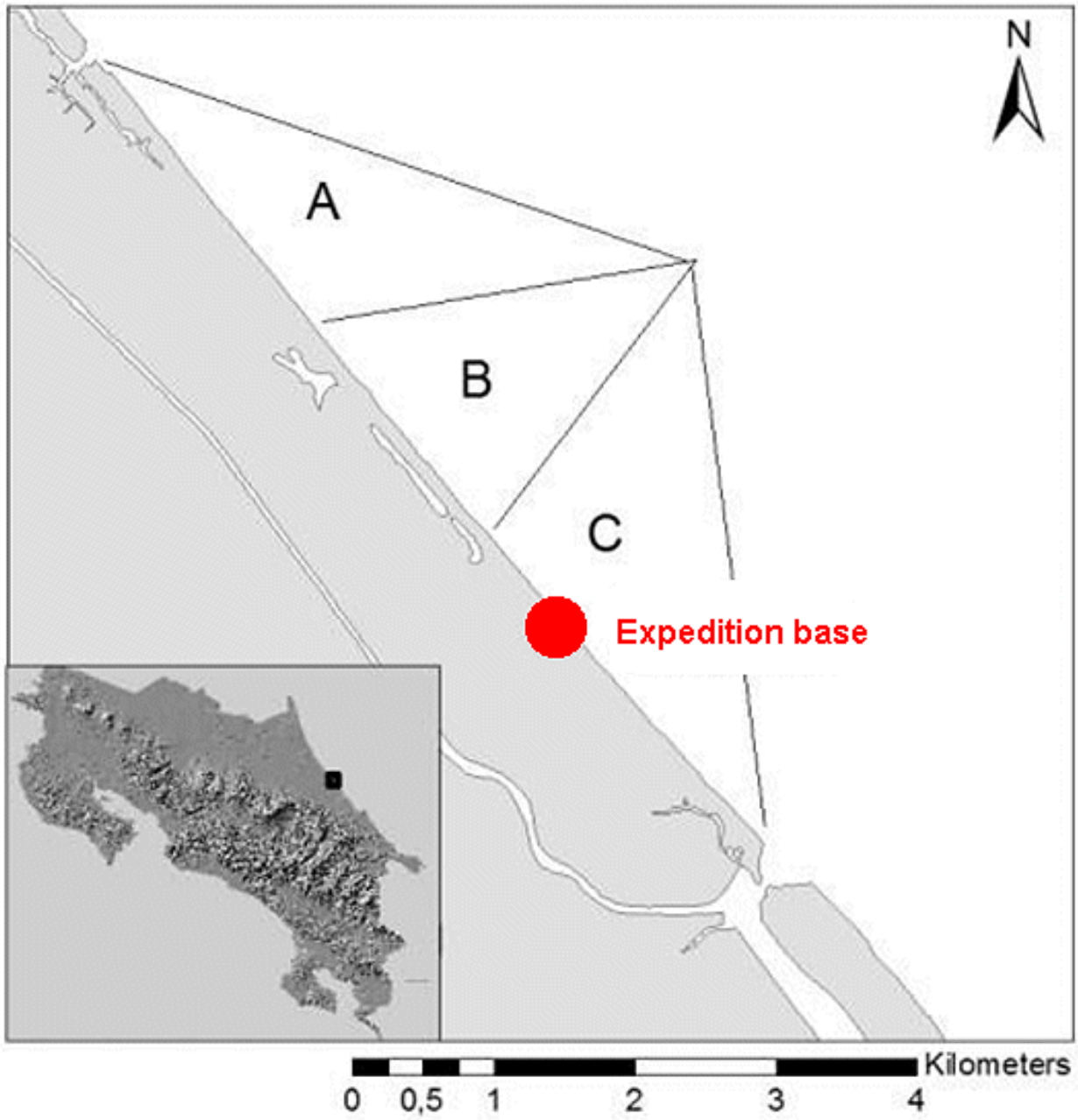

Figure 2.2a. Pacuare beach study site and sectors.

Training

Training of community and international research assistants took place during the first week of March. Research assistants participated in lectures on biology, ecology, threats, identification of the species, conservation strategies and monitoring protocols on nesting beaches, as well as practical training in tagging, data recording and relocation of nests. All training activities were coordinated at the LAST biological station.

During the season, national and international citizen scientists were trained by the resident biologist and the research assistants. On patrols, data collection and activities were supervised by a trained research assistant.

Figure 2.2b. Training session for expedition citizen scientists.

Hatchery

Figure 2.2c. Hatchery. Photo courtesy of Georg Berg.

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 210 squares of 50 x 50 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.

Nightly patrols

Staggered patrols of a maximum of eight 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 to not 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 constant pressure from poaching in Pacuare, just eight nests were relocated to an alternative safe place on the beach. Twenty nests were incubated *ex situ*. Both strategies were used because the hatchery was being built at the time. Two hundred nests were relocated to the hatchery for guarding and hatching. Nests were divided into four categories, *in situ* or natural, relocated at the beach, *ex situ* and relocated to the hatchery:

- The ***in situ*** nests were those left in the original place selected by laying females at the time of ovoposition. In Pacuare, *in situ* nests were those that were not found by project workers in time to collect eggs (i.e. when the turtle had already laid her eggs, covered the nest and left again). In that case, patrol members camouflaged the tracks to confuse poachers and to prevent them from locating eggs later on.
- Nests **relocated at the beach** were those that were collected and removed from the place that the laying turtle selected initially to a safer place on the beach (safe from erosion or poaching). In Pacuare, relocated nests were those found at the beginning of the season when the hatchery was not ready to receive eggs yet.
- Nests incubated ***ex situ*** were those removed from their original place and incubated in cooler boxes or Styrofoam boxes at the LAST biological station. This was done at the beginning of the season whilst the hatchery was being built.
- Nests **relocated to the hatchery** were those removed from their original locations and transferred into the hatchery.

Egg collection

Figure 2.2d. Egg collection. Photo courtesy of Georg Berg.

When patrols found a turtle without a poacher present, the patrol leader approached the turtle and decided the correct moment when the group could approach without interrupting the nesting process. When the turtle had finished digging the egg chamber, a sterile plastic bag was carefully put into the hole to collect the eggs the turtle was laying (Figure 2.2d). Measurements of the depth and width of the nest were also made. Once the turtle started to cover the nest, the egg bag was pulled out of the hole gently and located in a safe place. Biometric data was then collected.

Biometrics

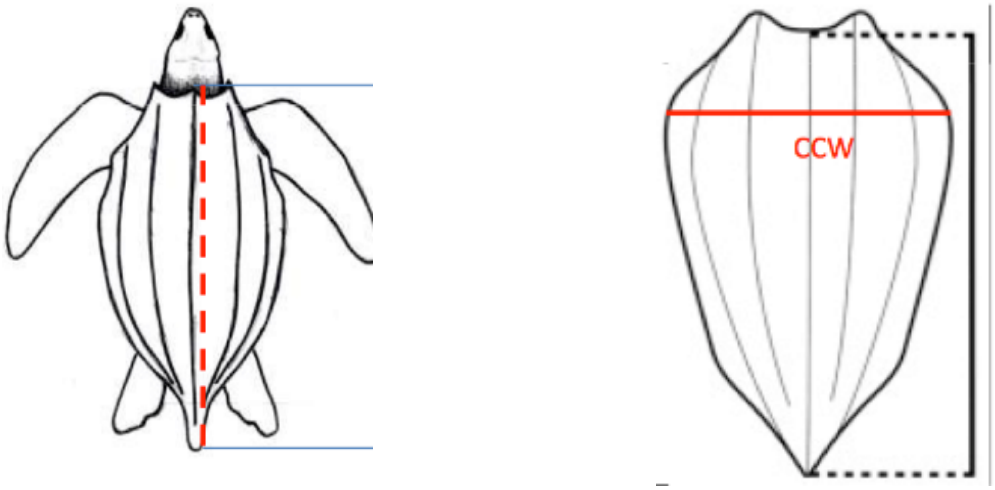

Figure 2.2e. Curve carapace length (left) and curve carapace width measurements (right).

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

Figure 2.2f. Measuring biometrics. Photo courtesy of Georg Berg.

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 Áreas de Conservación). Nesting females 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 2.2g. 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. When transporting the egg bag it was handled carefully in order to avoid movements that could damage the eggs and cause the abortion of the embryonal development. Once at the hatchery, one of the 210 squares was chosen, following a rule that each square that takes a nest must be followed by an empty square to avoid nests damaging each other (for example low / high temperature, excess of / lack of humidity, lack of oxygen or infection)

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 (Figure 2.2c).

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

Neonates

Hatchery shifts lasted for six hours maximum at night and two hours during daytime. Nests were checked every 15 minutes throughout the day and night to remove crabs, flies and ants but also to check for any neonate emergence.

Neonates were released at different parts around the beach so as to not create known feeding areas for predators. The neonates were released at a minimum distance of 10 metres from the high tide line so they could imprint on the beach.

During night time release, no light was used to avoid disorientating the neonates. During daytime, neonates were kept until 17:00 (when temperature was lowering), except on cloudy or rainy days when daytime releases were allowed if the temperature was low enough.

From every nest, 15 neonates were randomly chosen and both length and width of the carapace were measured with a caliper. Neonate weight was recorded with a 50 g PESOLA scale. Latex gloves were used and neonates were handled as gently as possible to avoid stressing or disorienting them.

Figure 2.2i. Measuring a hatchling.

Exhumations

Exhumations (Figure 2.2k) were performed on all hatched nests to evaluate the percentage of neonates emerged, the number of live/dead neonates remaining inside the nest and analyse the unhatched eggs. Each exhumation was made within 24 or 48 hours after the first emergence or 70 days after the nesting date if no neonates had emerged.

From every nest, the number of egg shells, live neonates and dead neonates were recorded. Eggs that had not hatched were opened to estimate embryonal development (Figure. 2.2j).

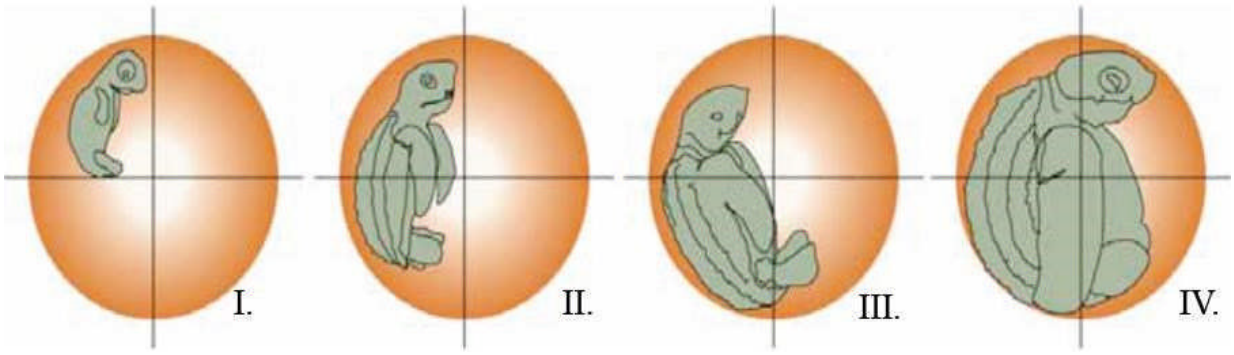

Figure 2.2j. Development stages of the embryos in non-hatched eggs (Chacón et al. 2007).
I) Embryo uses up to 25 % of the space inside the egg, II) up to 50%, III) up to 75%, IV) up to 100%.

The percentage of hatching and emergence was 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 = empty shells, N = total number of eggs and TM = number of dead hatchlings present in the nest or its surrounding area.

Figure 2.2k. Conducting an exhumation count.

Research permits

On 2 March 2018, LAST submitted an application for the research permits required by the Área de Conservación La Amistad Caribe (ACLAC) in order to monitor sea turtle species present in Pacuare. Permission was granted on 4 March 2018 under resolution **R-SINAC-PNI-ACLAC-010-2018** signed by Jorge Gonzáles Villalobos.

2.3. Results

2.3.1. Leatherback turtle (*Dermochelys coriacea*)

Number of nests

A total of 392 nesting activities were recorded during the 2018 season in Pacuare beach, of which 241 were successful and resulted in viable nests. Compared with the previous seasons, the 2018 season's data were slightly below average. The number of nesting activities in the season correspond to the inter-annual fluctuations described previously by several authors (Troëng et al.2004, Chacón-Chaverri and Eckert 2007) (Figure 2.3.1a).

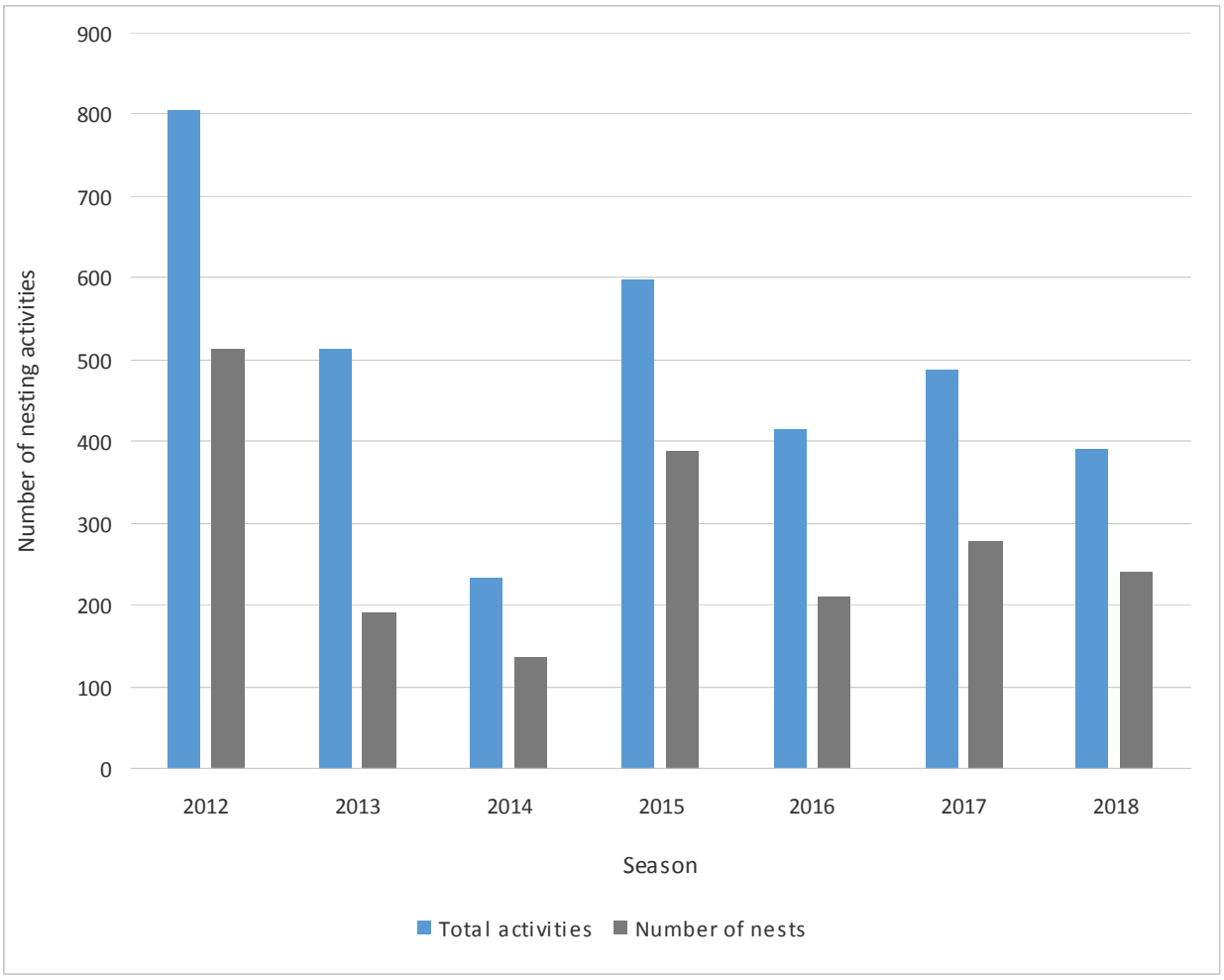

Figure 2.3.1a. Leatherback turtle nesting activities at Pacuare beach since 2012.

The months with highest amount of nests were April and May with 103 and 60 nests respectively (Figure 2.3.1b). No nests were recorded during the month of February, 49 nests were registered in March, 24 in June, four in July and one in August. As during the four previous seasons, the nesting pattern observed at Pacuare beach was similar to the one at Gandoca beach, where 71% of the nests were recorded in April and May (Chacón-Chaverri and Eckert 2007, Fonseca et al. 2012, Marion and Chacón 2013, Fonseca and Chacón 2014, Marion and Chacón 2016, Carrasco and Chacón 2017).

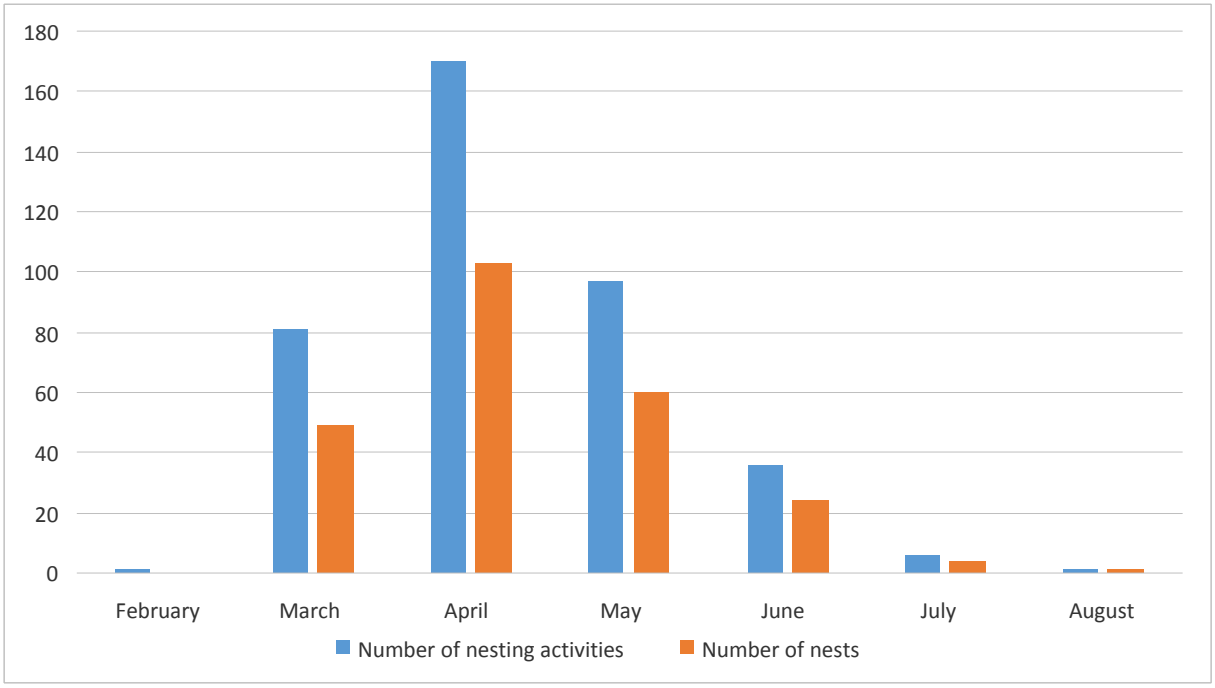

Figure 2.3.1b. Seasonal distribution of nesting activity for leatherback turtle at Pacuare beach during 2018.

During the 2018 season, nesting activities were recorded along all 144 wooden markers. The marked parts of the beach with the highest activity were 0-10, 51-60 and 81-90 (Figure 2.3.1c). The spatial distribution of the nesting activity continues to be a challenge for the project, because more staff and citizen scientists would be needed in order to successfully cover all the 7.1 km of beach throughout the whole night in order to thwart all poaching efforts.

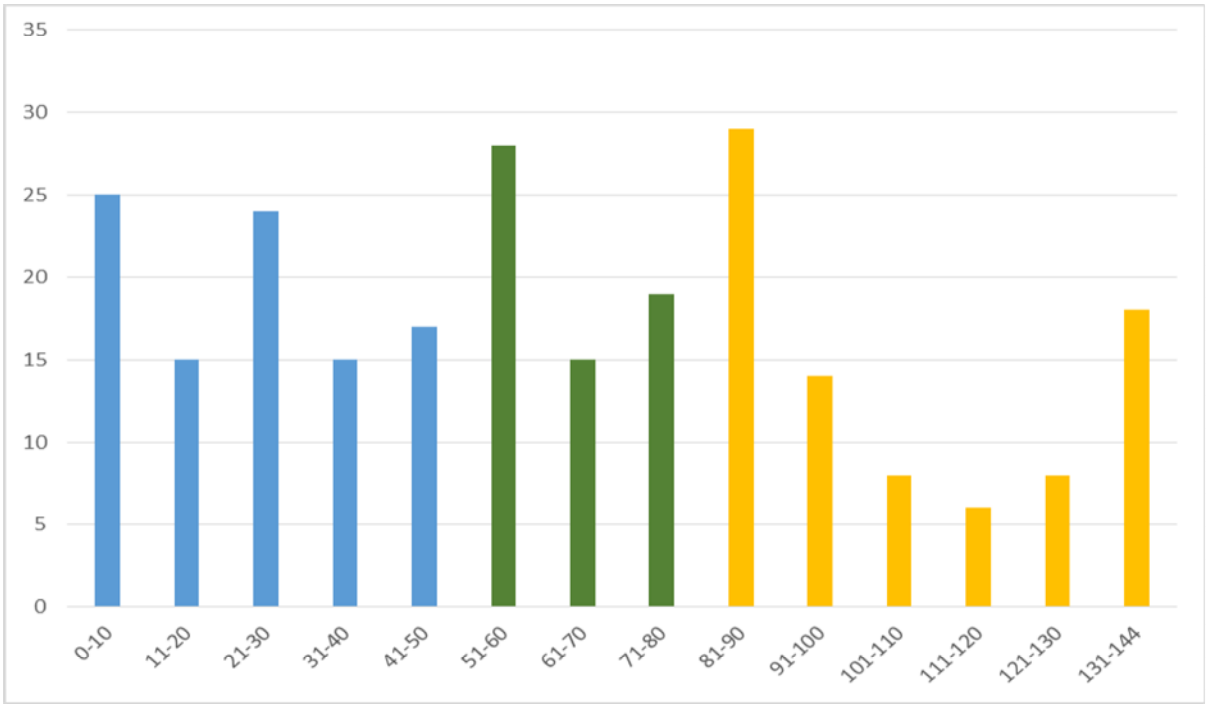

Figure 2.3.1c. Spatial distribution of nesting activity for leatherback turtle at Pacuare beach 2018 season. Blue bars correspond to sector A, green bars to sector B and yellow bars to sector C (see Figure 2.2a).

Number of nesting females

A total of 134 nesting females were recorded during the season, 29 of which did not show any tag or evidence of previous tags. These additional females are likely to be new females that have reached sexual maturity, replacing dead or poached individuals, which would be a good sign for the Caribbean population of leatherbacks in Costa Rica and Panama. Unfortunately, there are no studies that estimate sea turtle mortality in the area. Of the 134 nesting females recorded over the season, 97 laid only once, 23 twice and 12 three times. One turtle laid five times and another turtle six times (Figure 2.3.1d).

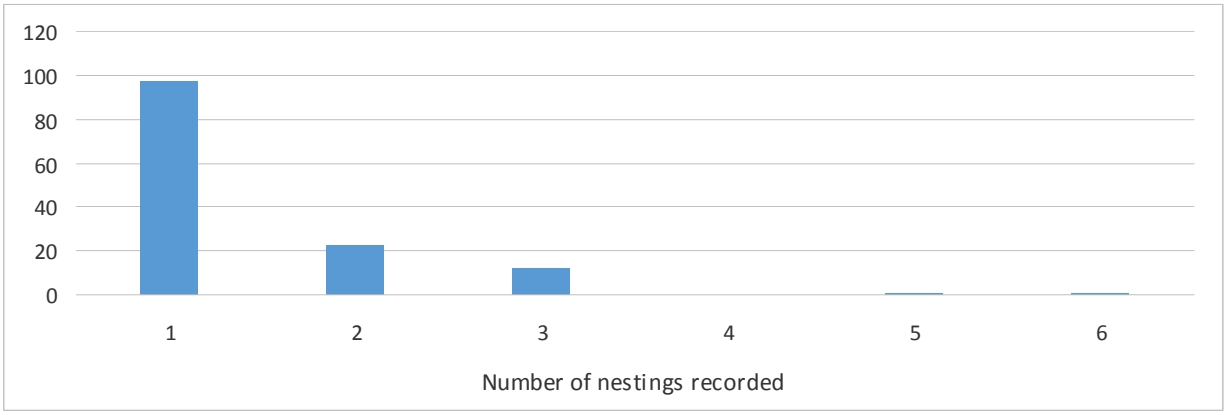

Figure 2.3.1d. Number of nestings recorded per female leatherback turtle at Pacuare beach in 2018.

Nest fate

The percentage of protected nests was 65% (n = 155) of the total amount of nests in the season. This percentage of saved nests is the highest since the project started in 2012 (Figure 2.3.1e). Of the saved nests, 89% (138 nests) were relocated to the hatchery and 11% (17 nests) were relocated to a safe place on the beach. The majority of nests were guarded at the hatchery, because the protection and control provided in the hatchery is better. Poachers hide in the vegetation at night to avoid detection. If a nest is relocated, this can be seen by poachers who can then poach the eggs once workers have finished with the beach relocation and left the site.

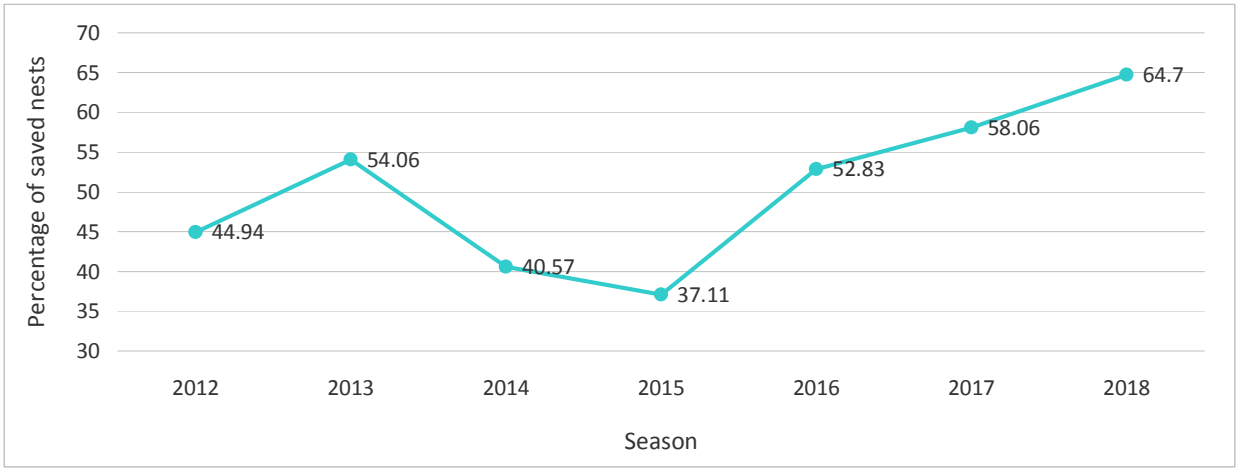

Figure 2.3.1e. Percentage of saved leatherback nests at Pacuare over time.

Nest hatching and emergence success

The emergence success of leatherback nests was 67% (SD = 21.52, n = 155), including hatchery and beach relocations. 8,112 neonates emerged from these nests.

The emergence success of the nests incubated in the hatchery was 69%. This percentage is the second highest percentage since 2012 (Figure 2.3.1f) and higher than the percentage recorded in Gandoca (Chacón and Eckert 2007) and Tortuguero (Troëng et al. 2007), where the emergence success was between 11 and 39% and 42.6 ± 35% respectively.

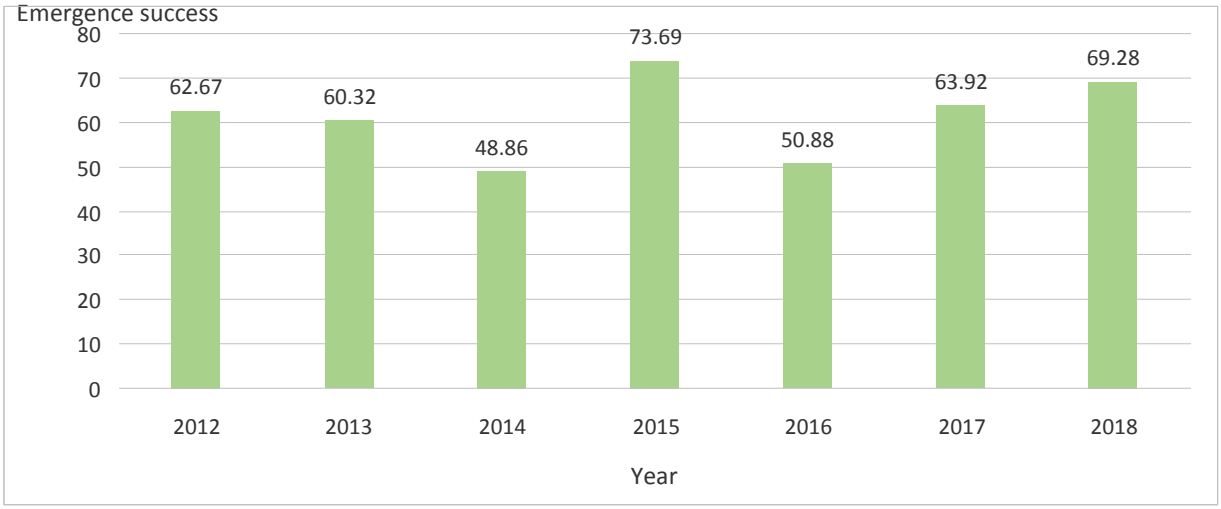

Figure 2.3.1f. Emergence success of saved leatherback nests at Pacuare over time.

2.3.2. Green turtle (*Chelonia mydas*)

Number of nests

126 nesting activities of green turtles (*Chelonia mydas*) were recorded, of which 42 ended up as successful nests. Disturbance by poachers for this species remains high as poachers arrive specifically for the green turtle nesting season, with turtles too scared to nest or killed before or while nesting.

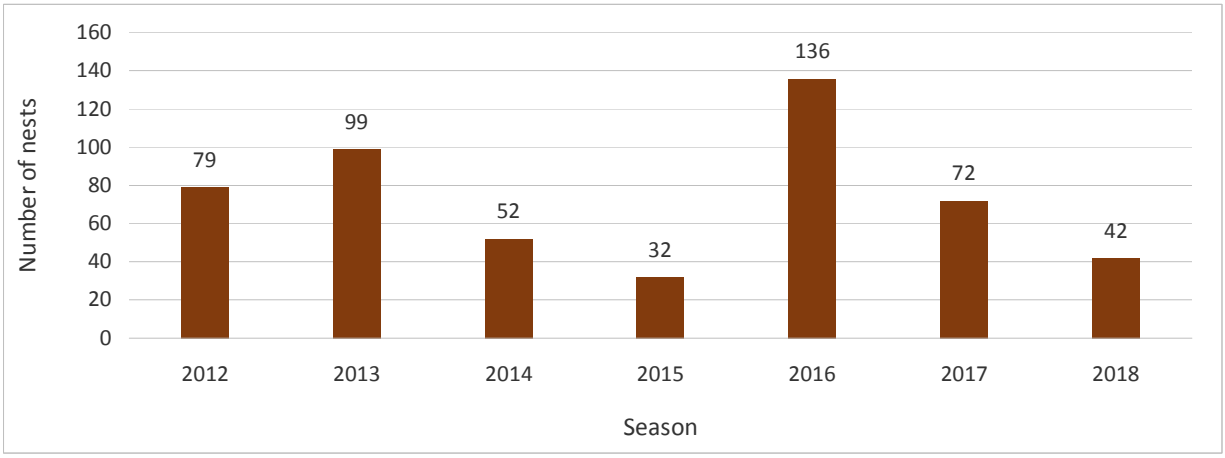

Figure 2.3.2a. Green turtle nesting activities at Pacuare beach since 2012.

Nesting activity is shown in Figure 2.3.2b. This is a similar pattern to the one observed in Tortuguero, where the nesting peaks in September and October (González and Harrison 2012).

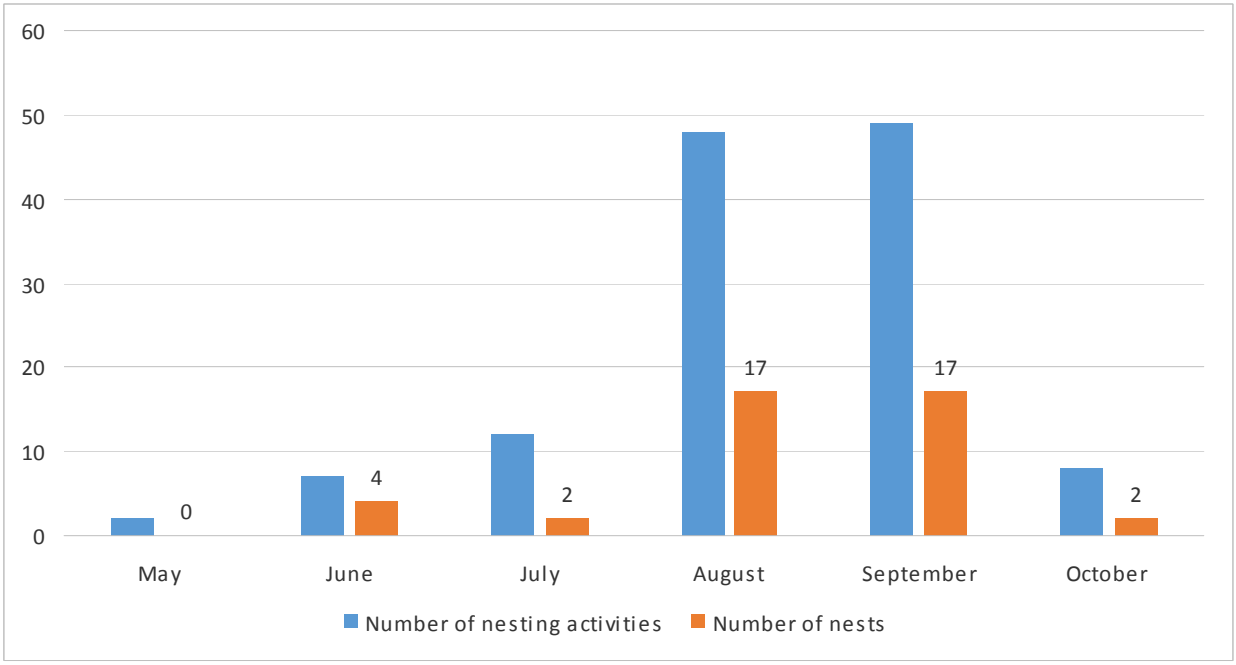

Figure 2.3.2b. Seasonal distribution of nesting activity for green turtle at Pacuare beach during 2018

Nesting activity was highest on sectors 11-20 and 21-30 (Figure 2.3.2c). 55% of nests were in the northern part of the beach (after the second lagoon). There were no nests in the sectors near Pacuare river mouth (121-130 and 131-144).

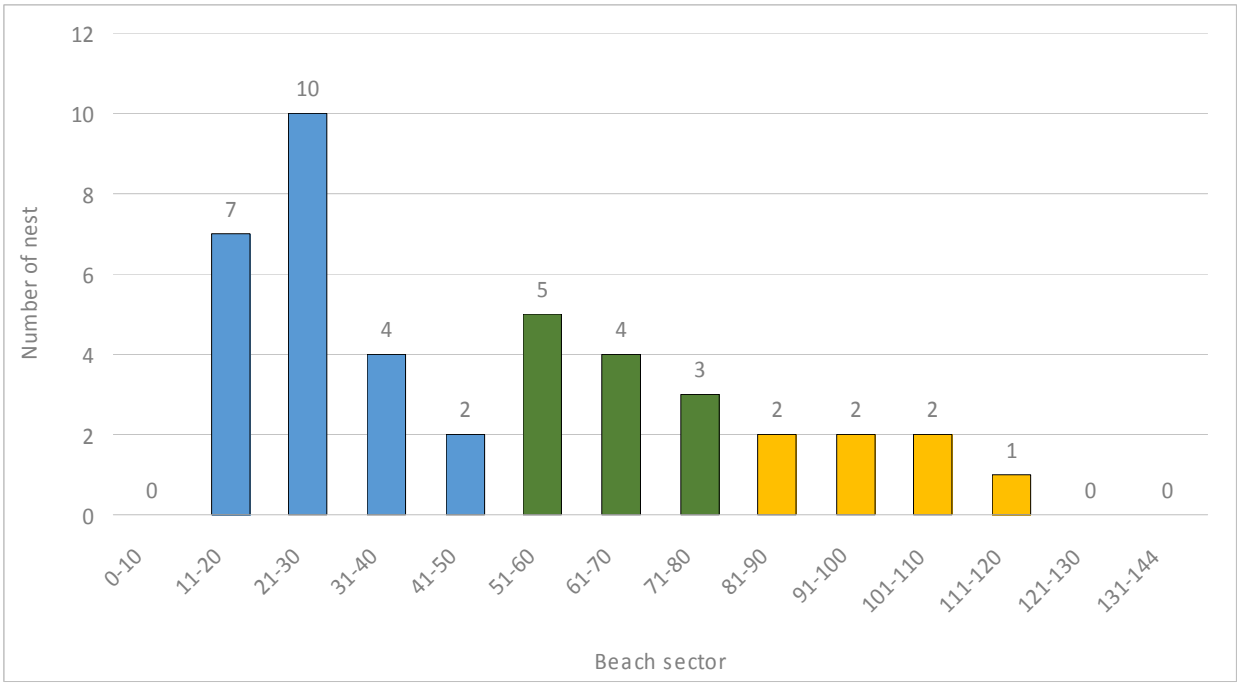

Figure 2.3.2c. Spatial distribution of nesting activity for green turtle at Pacuare beach 2018 season. Blue bars correspond to sector A, green bars to sector B and yellow bars to sector C (see Figure 2.2a).

Number of females

27 female turtles were recorded, of which 22 nesting turtles did not present any tag or evidence of previous tagging.

Number of turtles killed

Ten nesting females were killed by poachers, an overall low number (see Figure 2.3.2d), which becomes average when considered as a percentage of females killed compared with previous seasons (Figure 2.3.2e).

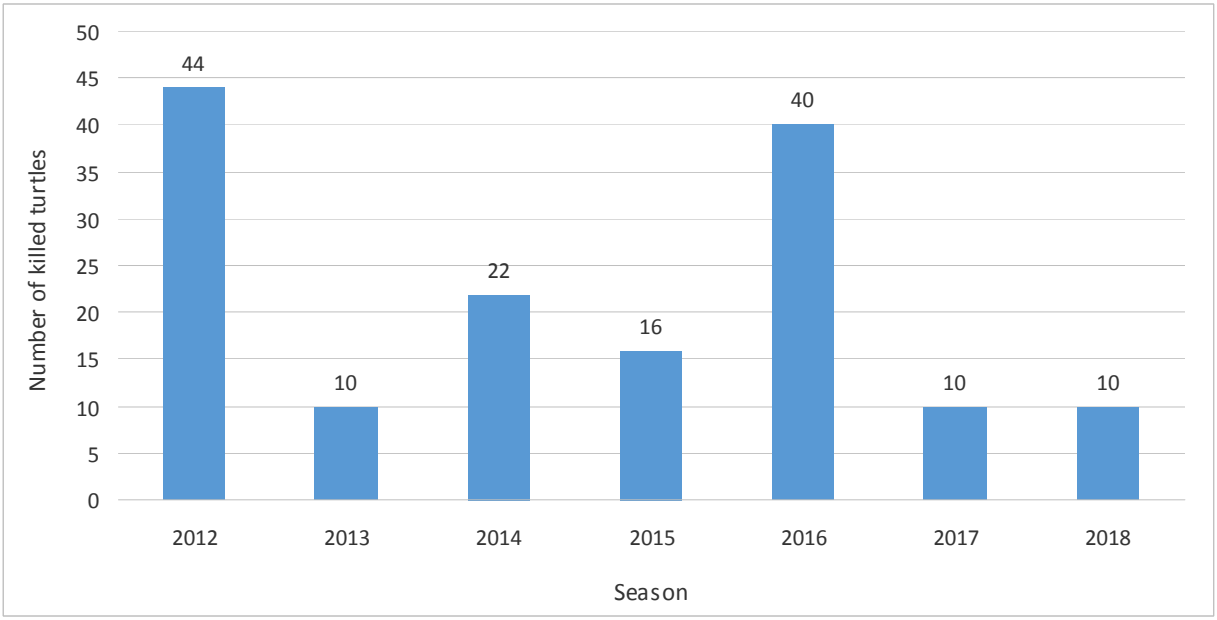

Figure 2.3.2d. Number of green turtles killed at Pacuare since 2012.

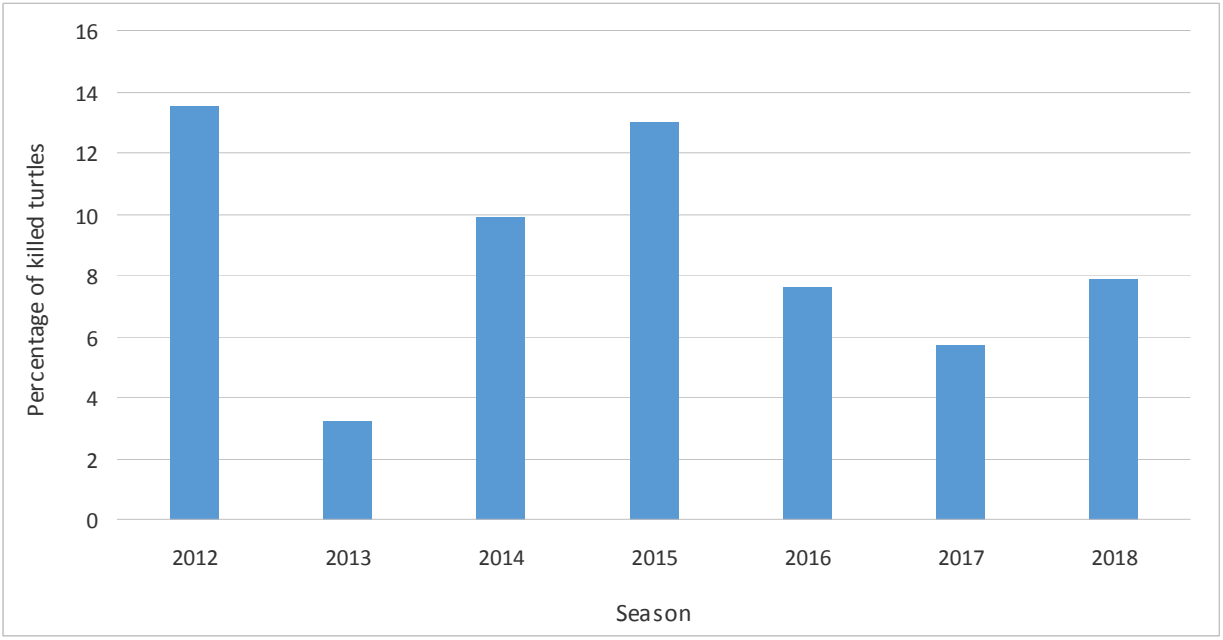

Figure 2.3.2e. Percentage of green turtles killed at Pacuare since 2012.

The coast guard, alerted by a community member, rescued a green turtle female and two green turtle nests, both nests were from turtles that had been killed by poachers only a few hours prior. Two persons were arrested and charged. We do not know whether the charges resulted in convictions, but the two persons arrested did not return to the beach for the rest of the season.

Two dead turtles were found on the beach in August. One of them was already too decomposed (Figure 2.3.2f) to determine cause of death. The second had a cracked carapace from the nuchal scute to the last vertebral scute (Figure 2.3.2g), possibly caused by a powerful impact against to a solid object, such as a boat strike.

Figure 2.3.2f. Decomposed green turtle.

Figure 2.3.2g. Green turtle with carapace broken**.**

Nest fate

69% of green turtle nests were protected in 2018. 29 nests were moved to the hatchery, out of which, 27 were collected during the night patrols and two were rescued by the coast guard. No nest were relocated on the beach.

Nest hatching and emergence success

The percentage of emergence from exhumed nests was 74% (SD = 20.23, n = 24), releasing approximately 2,038 neonates. Compared with the previous seasons this percentage is average (Figure 2.3.2h). 97% was the highest emergence percentage; this nest was collected in September. The lowest percentage (13%) was from a nest collected in August. The two nests saved by the coast guard had a low average percentage of emergence of 18%, because the eggs of the second nest did not develop, as they spent 14 hours in the open between being extracted and given to the project for nest transfer to the hatchery.

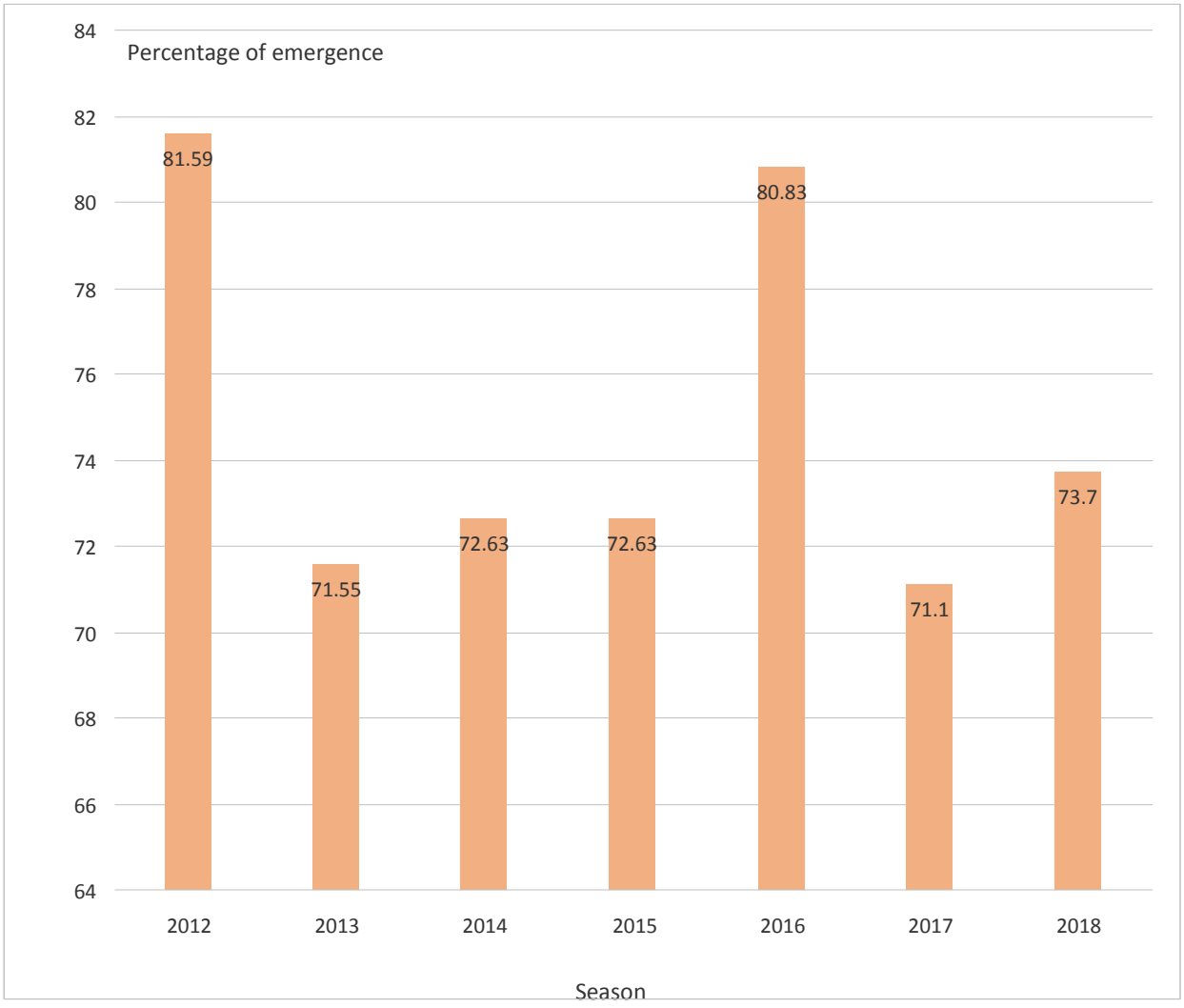

Figure 2.3.2h. Emergence success of saved green turtle nests at Pacuare over time.

2.3.3. Hawksbill turtle (*Eretmochelys imbricata*)

Number of nests

21 nesting activities were registered, out of which 13 were successful. Six nests were placed in the hatchery, two nests were poached and five nesting females were killed by poachers. This season was similar to the seasons 2014 and 2017 (Figure 2.3.3a).

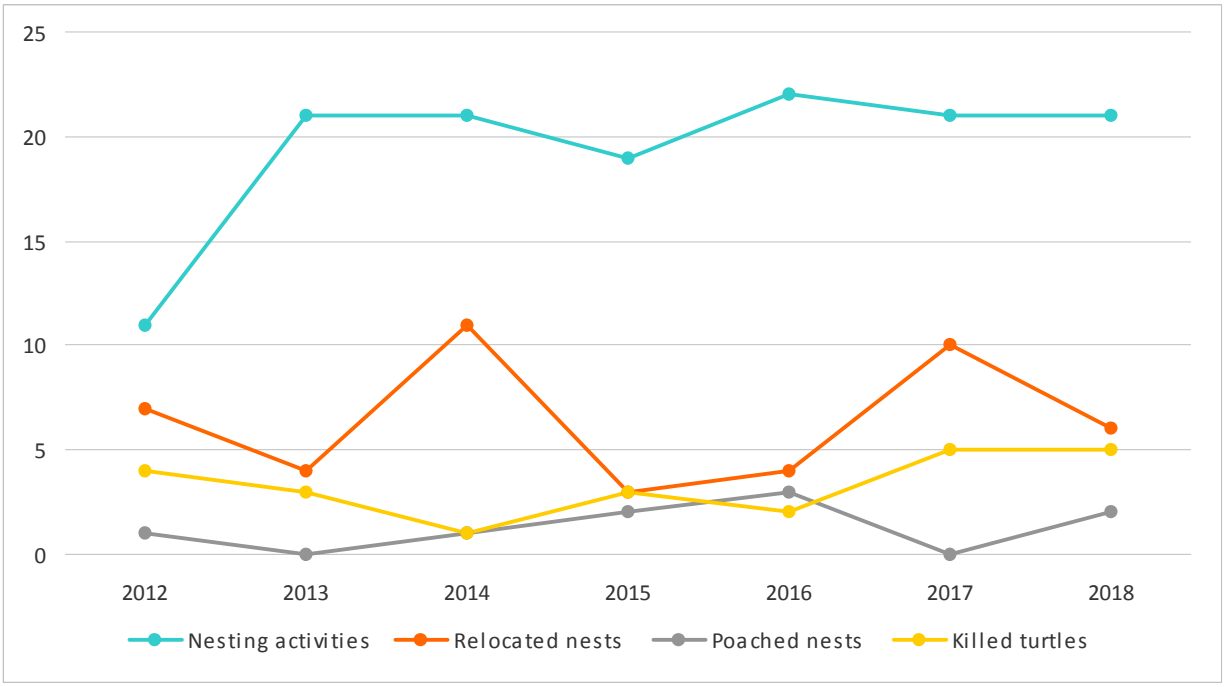

Figure 2.3.3a. Nesting activity, number of relocated nests, number of poached nests and number of killed hawksbill turtle at Pacuare over time.

Nest hatching and emergence success

The percentage of emergence of exhumed nests was 88% (SD = 20.78, n = 6), releasing an estimated 810 hatchlings. The nest with the highest emergence percentage (93%) was laid in May, as was the nest with lowest emergence percentage (75%) of the season. The latter was buried in a zone in the hatchery where shade was always present, which could explain the low emergence success.

2.4. Discussion and conclusions

Leatherback turtle

A total of 392 nesting activities of leatherback turtles were recorded throughout the season, out of which 138 nests were placed in the hatchery and 17 in a safe place at the beach. From all nests, 8,112 neonates were released into the ocean. The emergence success was 67% (SD = 21.52, n = 155), including the nests relocated at the beach and the nests placed in the hatchery.

Illegal harvesting of eggs was at 35%, which means that 65% of clutches were protected by the project's direct conservation actions. This percentage of saved nests is the highest since the project started in 2012 (Figure 2.3.1e).

The data recorded at Pacuare beach since 2012 indicates that the population of leatherback turtle remains stable, which is encouraging. However, the IUCN's Northwest Atlantic Leatherback Working Group has recently shown that the leatherback population in general is in steep decline with a 60% reduction in abundance over the last 20 years (Northwest Atlantic Leatherback Working Group 2018). This decline places the leatherback population of the northwest Atlantic into the Endangered category (IUCN 2014). Therefore, LAST and Biosphere Expeditions recommend continuation of monitoring to determine long-term effects and effectiveness of conservation action to keep the species from becoming extinct.

The low incidence of remigrant leatherback females at Pacuare is probably because females have a choice of nesting beaches anywhere on the Caribbean coast of Nicaragua, Costa Rica or Panama. Dutton et al. 2013 have shown that the genetic pool of the Western Caribbean runs from the south of Nicaragua to the north of Colombia. So females can return to nest in a plethora of areas where the project does not operate.

Green turtle

126 nesting activities of green turtle were recorded during the 2018 season. A total of 29 nests were placed in the hatchery, from those nests approximately 2,038 neonates emerged and were released into the ocean. The emergence success was 74% (SD = 20.23, n = 24). This percentage is average compared with the previous seasons (Figure 2.3.2h). The 2018 season had the second lowest green turtle numbers recorded at Pacuare beach since LAST started running the project in 2012, with only the 2015 season being lower (Figure 2.3.2a).

The poaching rate for green turtle was 31%, which means that 69% of nests were saved by the project's direct conservation actions. This is a very positive result given the resources and one that the project and its citizen scientists can be proud of. As with leatherbacks, challenges remain, especially those related to human resources to patrol the beach and prevent poaching. Because of the lack of resources, ten green turtles were killed by poachers this season. In addition two dead turtles appeared at the beach, probably killed by boat strikes. This shows that direct conservation action at Pacuare beach must continue in order to reduce illegal harvesting of eggs and slaughtering of nesting females. The project is working with the police and coast guard to reduce illegal activities in Pacuare beach and create a safe environment for all. In 2018 the coast guard rescued one nesting female captured the night before, when she was trying to lay her eggs, and two nests from turtles that had already been killed.

Hawskbill turtle

21 nesting activities of hawksbill turtle were recorded. From six clutches moved to the hatchery, 810 hawksbill neonates emerged and were successfully released into the ocean. The emergence percentage was 88% (SD = 20.78, n = 6).

The poaching rate for hawksbill turtle was 54% (including killed turtles and poached nests). This is of concern as only 46% of nests could be saved. One of the reasons for this is the coast guard and police absence throughout almost all of the season. More presence of these law enforcement bodies would mean better success in protecting turtles and their eggs from poaching (see the green turtle example above).

Five hawksbill turtles were killed by poachers to sell their carapaces on the black market. The nesting activity in 2018 was similar to the 2014 and 2017 seasons. This season was the second year in a row that five nesting females were killed (the highest number of hawksbill turtles killed in a season) and is a cause for concern.

Loggerhead turtle

No loggerhead turtle activity was recorded at Pacuare, which corroborates our hypothesis that the nest recorded in 2017 season was an isolated and sporadic event.

Overall efforts

173 clutches of three different sea turtle species were relocated to the custom-built hatchery, 17 were relocated to a safe place on the beach and none were left *in situ* because of the high poaching rate. Overall 60% of all nests of the 2018 season across the three sea turtle species were saved by the project's direct conservation action. This percentage is a good result given the resources available and one the project and its citizen scientists can be justifiably proud of.

However, with the support of the police and coast guard, this percentage could easily be higher, especially because the Costa Rican state is the only body that can take direct actions against poachers, such as arresting and prosecuting them (whereas this project has a non-confrontation policy). Sadly, the police and coast guard were almost completely absent from the beach throughout the nesting season. We encourage them to change this and be more proactive in turtle conservation, especially given their considerable resources and manpower.

Additional technology

During the 2018 season and in accordance with the 2017 recommendations, we trialled a handheld forward-looking infrared (FLIR) device to try to spot green and hawksbill turtles hidden by poachers in the vegetation or in the canals. Unfortunately the low number of green and hawksbill turtles and the extreme weather at Pacuare made using the device almost impossible.

Discussion

The number of protected nests and hatchlings released are a big achievement for LAST and its partners. The project has been active for seven years now and in this time was able to very significantly reduce the poaching of nests and nesting females in a place where those activities were very common; almost 100% of turtles arriving at the beach and their eggs were poached prior to 2012.

Having said that, poaching remains an issue. Data recorded since 2012 strongly indicate that Pacuare beach is one of the most important nesting turtle sites in Costa Rica, for the leatherback turtle in particular, but also for other sea turtles (Marion and Hammer 2016).

The continuation of poaching is explained by several factors, which are:

- The absence of authorities in charge of the protection of the natural resources in the zone including the National Service of Coast Guards (SNG), Instituto Costarricense de Pesca y Acuicultura (INCOPESCA) and the Ministry of Environment and Energy (MINAE).
- The lack of enforcement, most of all by police, in the law of wildlife protection (Law 7317) and the law of protection, conservation and sea turtles recovery (Law 8325).
- The project's limited resources, both in terms of finance and manpower, meaning that not all 7.1 km of beach can be patrolled all the time, leaving opportunities for poachers.
- The low number of job and other opportunities in the area, which makes criminal activities that generate income more likely and acceptable socially.
- The high value of turtle eggs and meat on the black market coupled with the virtual absence of law enforcement provides a strong incentive for poachers to continue to ply their lucrative trade in what are very poor and disadvantaged resident and transient communities along Pacuare beach. In this context it is important to note that most of the individuals involved in poaching appear to have a criminal record already (as ascertained through personal communication and observation), with a concomitant low threshold towards further illegal activities.

All of the above factors result in an ongoing, if successful, struggle of NGOs against what appear to be mainly transient and criminal poachers, many of whom appear to sustain an alcohol and drug addiction, through the depletion of the sea turtle population. As long as NGOs are by and large left to continue this struggle by themselves, poaching will remain a problem and nests will continue to be poached. 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 the project could be turned from extinction prevention into population recovery. In the opinion of the authors, combined action will have a high chance of success in bringing poaching down to levels below 10%.

Because of this, the project in 2018 worked closely with the coast guard. Every time turtle or egg poaching was noticed, project staff called the coast guard to try to save the turtles and arrest the poachers. As a result two poachers were arrested and charged with wildlife protection offences. However, limited coast guard resources, especially in manpower, prevented them from attending to many of the project's calls for help. Despite this, anecdotal evidence suggests that poachers are becoming more wary and are spending less time poaching.

Even a slight increase in authority involvement is to be welcomed and appears to be producing results. Ideally authorities should be proactive in the removal of transient, criminal poachers from the community. This can only be achieved with the cooperation of the community, which could lead, in an ideal world, to the establishment of safe, nature-based tourism in the area with significant economic benefits for the community. This social and economic development of the community of Pacuare is a crucial parameter to allow the project to meet its objectives and to protect the population of sea turtles.

We also recommend 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 reintroduce a successful programme of environmental education in the area. Its absence due to lack of financial resources and disinterest of partners such as banana plantations and commerce is already affecting the younger residents of the Limón area.

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 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 2019 season

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

- The use of Styrofoam boxes as a replacement artificial hatchery at times 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 a handheld forward-looking infrared (FLIR) device should be used mostly on green and hawksbill turtles along with the coast guard or police. If the device is used in conjunction with the national authorities, the success rate of saved turtles could increase considerably. Also, poachers are more likely to be caught and arrested with the use of FLIR technology.

- Continued nurturing of the existing relationship with the coast guard 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://blog.biosphere-expeditions.org/category/expedition-blogs/costa-rica-2018/

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