



EXPEDITION REPORT

Expedition dates: 8 – 15 May 2017

Report published: April 2018

**Gentle giants:
Protecting leatherback sea turtles through direct
conservation action on the Caribbean coast of Costa Rica**



EXPEDITION REPORT

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

**Expedition dates:
8 – 15 May 2017**

**Report published:
April 2018**

**Authors:
Fabian Carrasco
Latin American Sea Turtles**

**Matthias Hammer (editor)
Biosphere Expeditions**

Abstract

From 27 February until 31 October 2017, nesting activities of leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*) and loggerhead turtle (*Caretta caretta*) were recorded on Pacuare beach, on the Caribbean coast of Limon province, Costa Rica. 279 leatherback nests, 72 green turtle nests, 10 hawksbill nests and 1 loggerhead nest were logged. 200 nests were relocated into a custom-built hatchery where they were guarded 24/7, 19 were incubated *ex situ* and 8 were relocated to a safe place on the beach. The emergence success of the nests of leatherback turtle was 58.77% (SD = 24.77, n = 162), green turtle 71.1% (SD = 23.92, n = 53), and hawksbill turtle 71.9% (SD = 23.74, n = 8). The single loggerhead nest had an emergence success of 61.53%. From all the saved nests, a total of 12,591 neonates were released (leatherback 7,349, green turtle 4,262, hawksbill 900, loggerhead 80).

10 green and 5 hawksbill adult turtles we recorded to have been killed by poachers; the true number is likely to be higher. Despite this, the number of turtles killed is the same or lower than in previous seasons.

An average of 75% of turtle nests across four species (leatherback 58%, green 76%, hawksbill 67%, loggerhead 100%) were saved as a result of the project's beach patrol and direct conservation actions. This percentage of saved nests is the highest since the project started in 2012 and should be celebrated as a major success in sea turtle conservation by LAST, the local community, Biosphere Expeditions and other partners involved in the project.

Data recorded since 2012 suggest that nesting activity for leatherback and hawksbill remains stable in Pacuare. However, this should be treated with caution since the life cycle of these animals is slow.

LAST and Biosphere Expeditions will continue to run this project and make various recommendations for improvements in this report. The high number of poachers, as well as the nest and adult poaching rates, remain a serious concern. This project continues to fight a successful battle with the poachers with a high this year of 75% of nests saved. If the national authorities tasked with nature protection and law enforcement were to join efforts in turtle conservation properly, and there are encouraging signs of this starting to happen, then in the opinion of the authors, combined actions by NGOs and state authorities will have a high chance of success of bringing poaching down to levels below 10%, which would turn this project from extinction prevention into population recovery.

Resumen

Desde el 27 de febrero hasta el 31 de octubre se contabilizaron las actividades de anidación de la tortuga baula (*Dermochelys coriacea*), tortuga verde (*Chelonia mydas*), tortuga carey (*Eretmochelys imbricata*) y tortuga cabezona (*Caretta caretta*) en Playa Pacuare en el Caribe de la Provincia de Limón, Costa Rica. Se registraron 279 nidos de tortuga baula, 72 nidos de tortuga verde, 10 nidos de tortuga carey y un nido de tortuga cabezona. 200 nidadas fueron trasladadas al vivero donde fueron incubadas y protegidas 24/7, 19 fueron incubadas *ex situ* en hieleras de estereofón (mientras el vivero estaba en construcción) y ocho fueron relocalizadas en zonas seguras de la playa (también cuando el vivero estaba en construcción). El porcentaje de emergencia para las nidadas exhumadas de tortuga baula fue de 58.77% (SD.= 24.77, n = 162), 71.1% (SD = 23.92, n = 53) para tortuga verde, 71.9% (SD = 23.74, n = 8) para tortuga carey y el único nido de tortuga cabezona presentó 61.53%. Del total de las nidadas salvadas se liberó un aproximado de 12,591 neonatos (7, 349 fueron de tortuga baula, 4,262 de tortuga verde, 900 de tortuga carey y 80 de tortuga cabezona).

Se registró la matanza de 10 hembras de tortuga verde y 5 hembras de tortuga carey a manos de los cazadores furtivos pero se calcula que el número real es aún mayor. Se estima que el número de tortugas asesinadas es igual o menor que en las temporadas pasadas.

El 75% de los nidos de las cuatro especies de tortugas marinas (baula 58%, tortuga verde 76%, tortuga carey 67%, tortuga cabezona 100%) fueron salvados como resultado del patrullaje de la playa por parte del proyecto y las acciones de conservación implementadas. El porcentaje de nidos salvados es el más alto obtenido desde inicios del proyecto en el año 2012 y debe ser celebrado como el mayor logro alcanzado con respecto a la conservación de las tortugas marinas por parte de LAST, la comunidad local, Biosphere Expedition y demás personas involucradas en el proyecto.

Los datos obtenidos desde el año 2012 nos demuestran que las actividades de anidación de la tortuga baula y la tortuga carey permanecen estables en Pacuare. En todo caso, debido a que el ciclo de vida de éstos animales es lento, se debe seguir con precaución con las estrategias para su protección.

LAST y Biosphere Expedition permanecerán realizando acciones para el correcto funcionamiento del proyecto. En éste informe se hicieron varias recomendaciones para mejorar los esfuerzos de conservación.

El alto número de cazadores furtivos así como la cacería de las hembras y el saqueo ilegal de huevos siguen siendo un serio problema. El proyecto mantiene una competencia la cual esta resultado exitosa en contra de los saqueadores ilegales con un 75% de nidos salvados en el año. Si las autoridades nacionales apoyaran con la protección y la implementación de las leyes adecuadas, en conjunto a los esfuerzos de conservación, colaboraciones que recientemente han comenzado a suscitarse, en la opinión de los autores, el esfuerzo combinado entre ONGs y autoridades estatales tendrán una mayor posibilidad de reducir el saqueo ilegal de huevos a porcentajes menores al 10%, que cambiaría el enfoque del proyecto de prevenir la extinción de las tortugas marinas a recuperar sus poblaciones.

Contents

Abstract	2
Resumen	3
Contents	4
1. Expedition review	5
1.1. Background	5
1.2. Research area	6
1.3. Dates	7
1.4. Local conditions & support	7
1.5. Scientist	8
1.6. Expedition leader	8
1.7. Expedition team	8
1.8. Partners	9
1.9. Acknowledgements	9
1.10. Further information & enquiries	9
1.11. Expedition budget	10
2. Annual report of the nesting activity of sea turtles in Pacuare beach, Costa Rica	11
2.1. Introduction and background	11
2.2. Methods	12
2.3. Results	21
2.4. Discussion and conclusions	30
2.5. Literature cited	36
Appendix 1: Expedition diary & reports	38

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 8 to 15 May 2017 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 crocodylians. 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 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. 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).

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 Tecnología) 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 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 8 – 15 May 2017 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 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 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):

Helen Bartholomew (UK), Frank Brett (UK), Eilidh Carrington (Switzerland), Sandip Chakraborti (USA), Neil Goodall (UK), Lindsay Hickman (UK), Catherine Maden (UK), Rosalyn Mayho (UK), Valeria Quesada Phillips (Costa Rica)*.

*placement kindly sponsored via a GlobalGiving fundraising campaign

1.8. Partners

Our partner on this project is Latin American Sea Turtles (LAST) who represent WIDECAS (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. WIDECAS 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, 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 at 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 £1,480 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	15,450
 Expenditure	
Staff includes local & international salaries, travel and expenses	3,238
Research includes equipment and other research expenses	401
Transport includes car hire, fuel, taxis and other local transport	650
Base includes board and lodging at the research station	1,752
Administration includes local sundries, fees and miscellaneous expenses	50
Team recruitment Costa Rica as estimated % of PR costs for Biosphere Expeditions	6,430
 Income – Expenditure	 2,929
 Total percentage spent directly on project	 81%

Please note: This report details the results of an entire nesting season from February to November 2017. 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 turtle nesting on Costa Rica's Caribbean coast has been described since the 1970s, mainly in Tortuguero (Troëng & Rankin 2005). Humans have been using sea turtle products and by-products, mainly as a food resource, but also to produce handicrafts (Chacón 2002). More recently, as a result of the demographic increase of Costa Rica's population, the pressure on sea turtle species has intensified, increasing black market demand throughout the country, and targeting sea turtle eggs and meat.

In an effort to reduce the threat to sea turtles and help to re-establish healthy sea turtle population levels, a large number of conservation projects have been implemented on the Caribbean coast of Costa Rica. This Pacuare beach project is one of them. LAST (Latin America Sea Turtles) in association with WIDECAST (Wider Caribbean Sea Turtle Network) and the Asociación para el Ambiente de Nuevo Pacuare established the project in 2012.

The project involves the community in conservation activities such as guarding the hatchery or working as research assistants on beach patrols. The community of Pacuare is located in a remote and rural area of the country. Community members do not have paid jobs and many of them are involved in the trafficking and consumption of drugs. During sea turtle season, vagrant community members come to Pacuare to poach eggs and turtles, further increasing the pressure on the turtle species.

Conservation activities of this project are highly important to protect and restore the population of the four species that nest in this area, which are hawksbill sea turtle (*Eretmochelys imbricata*), leatherback sea turtle (*Dermochelys coriacea*), green sea turtle (*Chelonia mydas*) and loggerhead sea turtle (*Caretta caretta*). The hawksbill is considered Critically Endangered, green turtle and loggerhead turtle are classified as Endangered on the IUCN red list. The leatherback turtle was catalogued as a Critically Endangered until 2013 when the convention of the IUCN Sea Turtles Specialist Group changed its status to Vulnerable.

The main objective of the Pacuare project is to improve the conservation status of sea turtle species in the area by working with the community and governmental agencies. Working closely with other institutions and standardising conservation activities will help with the protection of the females during the nesting season and their reproductive success. The success rate of the project is also strongly linked with the number of citizen scientist volunteers on the beach each year as they are a non-confrontational counterforce to the number of poachers present at the same time. National and international citizen scientists provide help in data recording, beach and hatchery maintenance.

2.2. Methods

From the month of February until November, 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 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 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

Pacuare Beach ($10^{\circ}18'48.66''\text{N}$, $83^{\circ}21'17.25''\text{W}$ – $10^{\circ}13'25.37''\text{N}$, $83^{\circ}16'47.12''\text{W}$) 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 is geographically divided into three sections known for the project as:

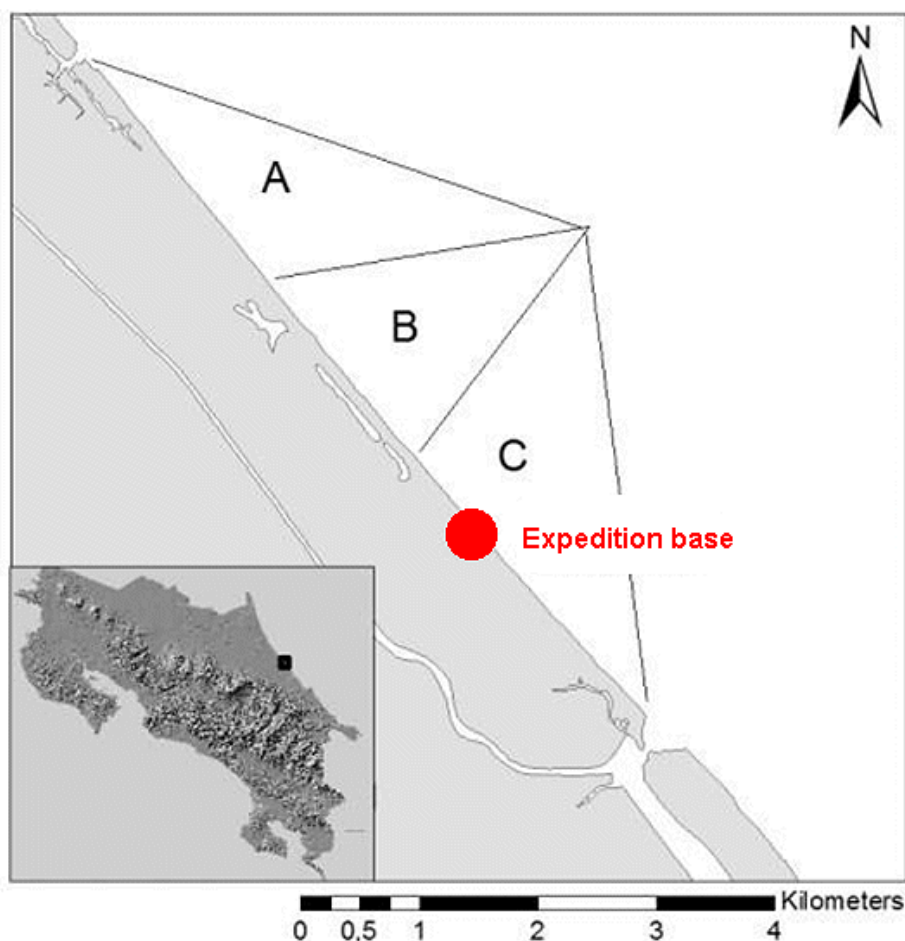


Figure 2.2a. Pacuare beach study site and sectors.

- 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 parallel line to the sea. In each site, 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).

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 professional.



Figure 2.2b. Training session for expedition citizen scientists.

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 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.



Figure 2.2c. Hatchery.

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 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 constant pressure from poaching in Pacuare, just eight nests were relocated to an alternate 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 nests ***in situ*** are those left in the original place selected by laying females at the time of oviposition. 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** are 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*** are 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** are those removed from their original locations and transferred into the hatchery.

Egg collection



Figure 2.2d. Egg collection.

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

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 2.2e. 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. When transporting the egg bag it was handled steadily 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 2.2g. 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 hatchling emergence.

Neonates were released at different parts around the beach so as to not create known feeding areas for predators. The hatchlings 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, hatchlings 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 hatchlings 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 2.2h. Measuring a hatchling.

Exhumations

Exhumations (Figure 2.2j) were performed on all hatched nests to evaluate the percentage of hatchlings emerged, the number of hatchlings live/dead remained 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 hatchlings 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 embryonic development (Figure. 2.2i).

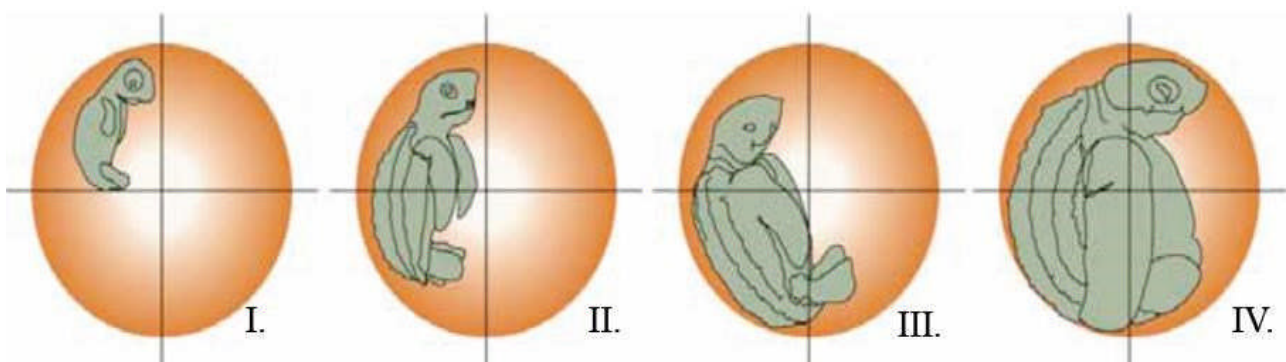


Figure 2.2i. Development stages of the embryos in non-hatched eggs (Chacón et al. 2007).

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 2.2j. Conducting an exhumation count.

Research permits

On 18 February 2017 the scientific permission to monitor the four species of sea turtles nesting in Pacuare was delivered under resolution SINAC-ACLAC-PIME-R-003-2017 and signed by Jorge Arturo Gonzáles Villalobos.

2.3. Results

2.3.1. Leatherback turtle

Nests and false crawl activity

From 26 February to 16 August 2017 a total of 487 nesting activities were recorded at Pacuare Beach. 279 of those activities were recorded as successful ovopositions. The remaining 208 were classified as false crawls, i.e. the females emerged from the sea, but the activity did not end in a successful nest.

In comparison to the five previous seasons when LAST has monitored the beach, the 2017 season was an average year (Figure 2.3.1), which is in line with the inter-annual fluctuations described by several authors (Troëng et al. 2004, Chacón-Chaverri and Eckert 2007).

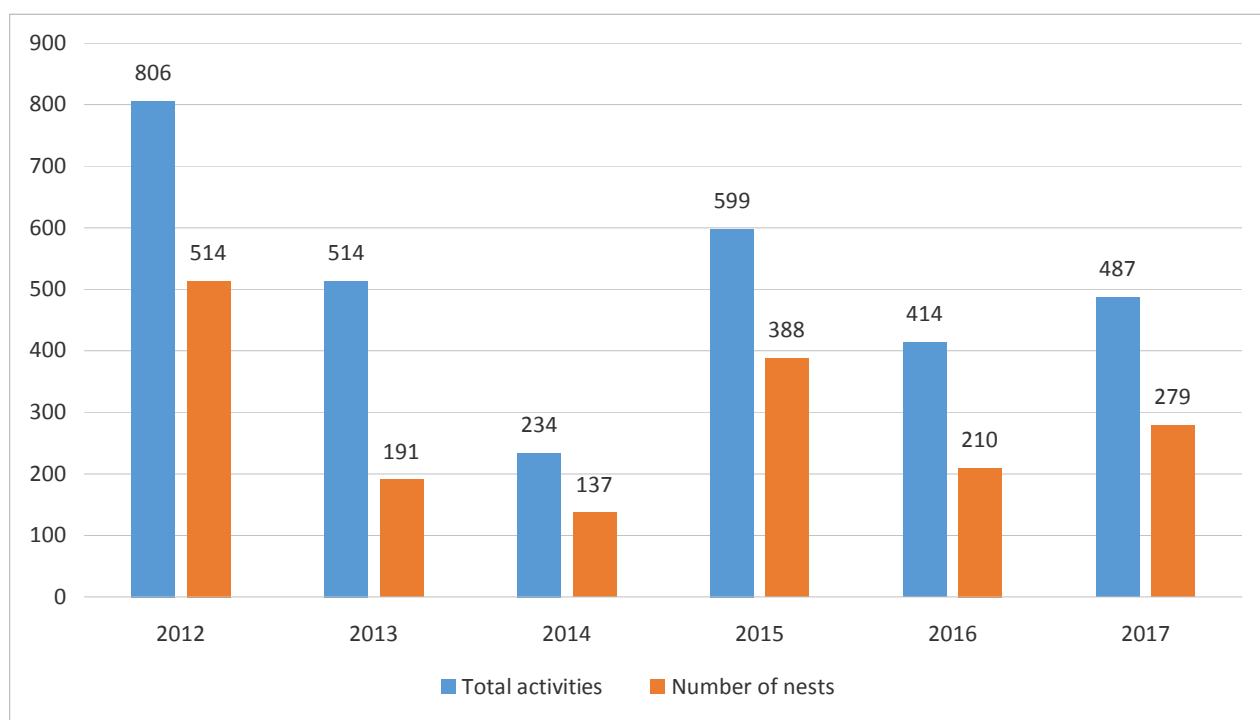


Figure 2.3.1a. Number of nests and nesting activities of *Dermochelys coriacea* recorded in Pacuare beach since 2012.

Seasonal distribution

April and May were the months with most nesting activity with 81 and 127 nests respectively. February and August corresponded to the beginning and the end of the season with one nest per month respectively. In March and June there were 22 and 41 successful ovopositions respectively. At the tail end of the season in July there were six. This pattern is similar to the one described for previous seasons (Chacón-Chaverri and Eckert 2007, Fonseca et al. 2012, Marion and Chacón 2013, Fonseca and Chacón 2014, Marion 2015).

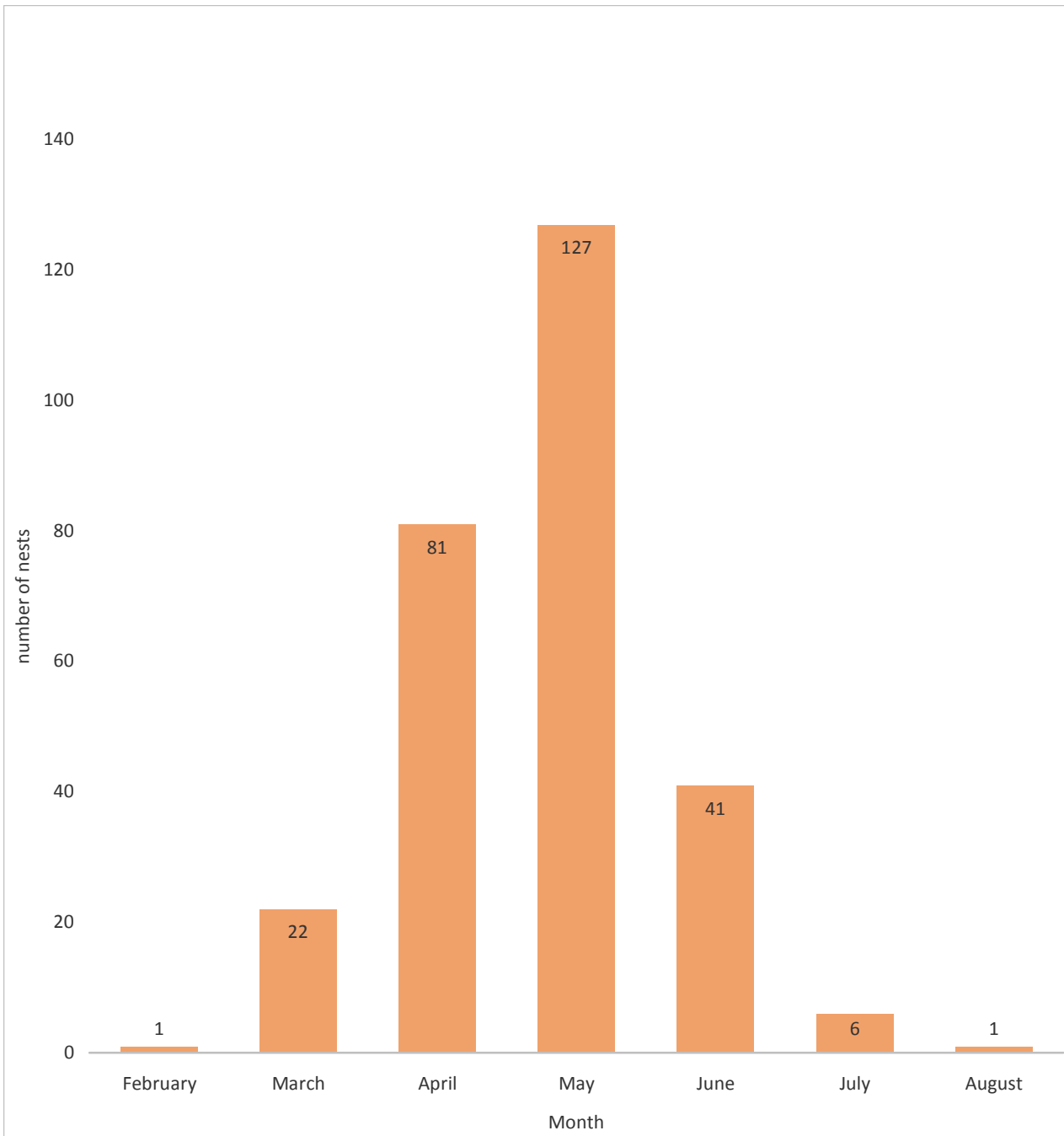


Figure 2.3.1b. Seasonal distribution of nesting activity for *Dermochelys coriacea* in Pacuare beach during the year 2017.

Spatial distribution

During the 2017 nesting season, nesting activities were recorded across all beach sectors. Most activities were recorded in sectors 11-20, 51-60 and 71-80. Due to the spatial distribution around the entire beach, the protection of the nests is a logistical challenge since it requires personnel present on seven kilometres of beach each day and night. For total coverage of the beach a minimum of eight patrols are required. The average number of patrols was six, which means that there were gaps in coverage (and thus openings for the poachers).

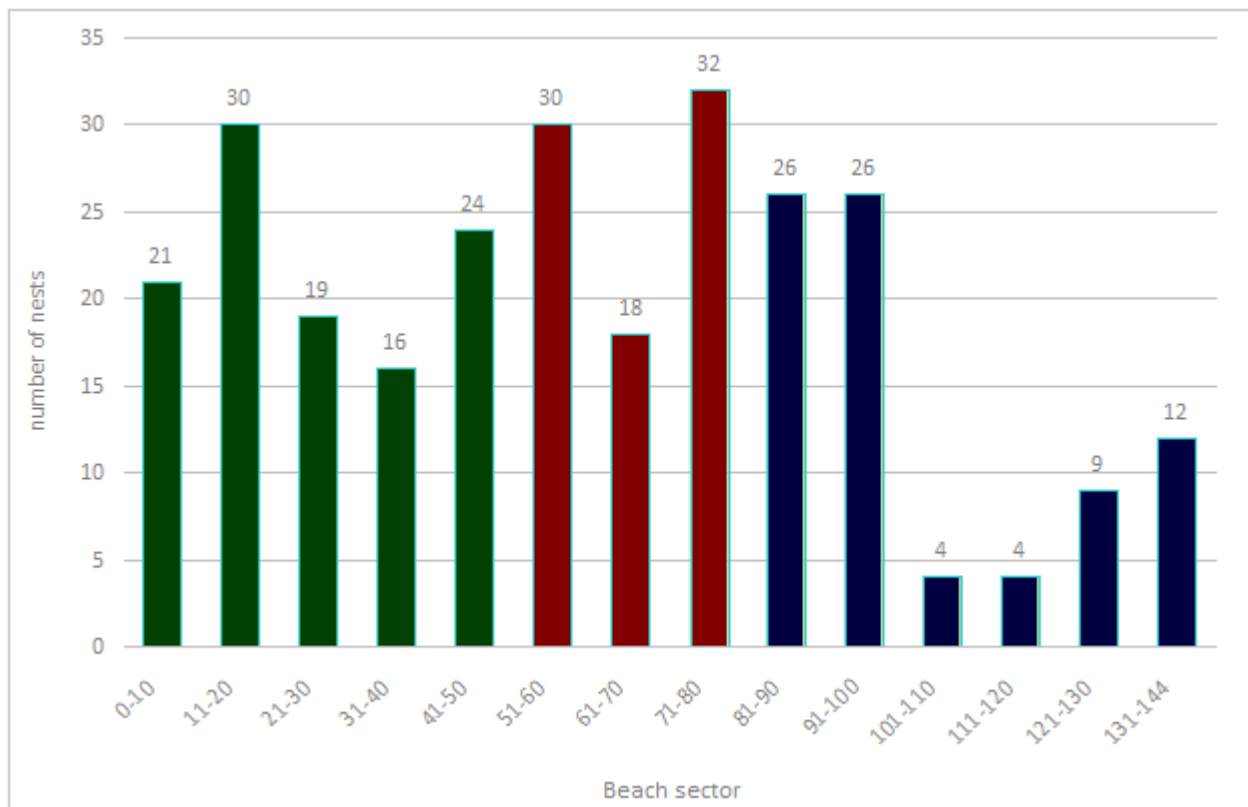


Figure 2.3.1c. Spatial distribution of nesting activity for *Dermochelys coriacea* in Pacuare beach during the year 2017. Green bars correspond to sector A, red bars to sector B and blue bars to sector C (see page 12).

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 in the same programme or at multiple programme locations.

During the 2017 season, a total of 158 nesting females were recorded. 23 were classified as neophytes, 124 were seen just once, 27 were observed nesting twice, four females were recorded three times and three females were registered four times.

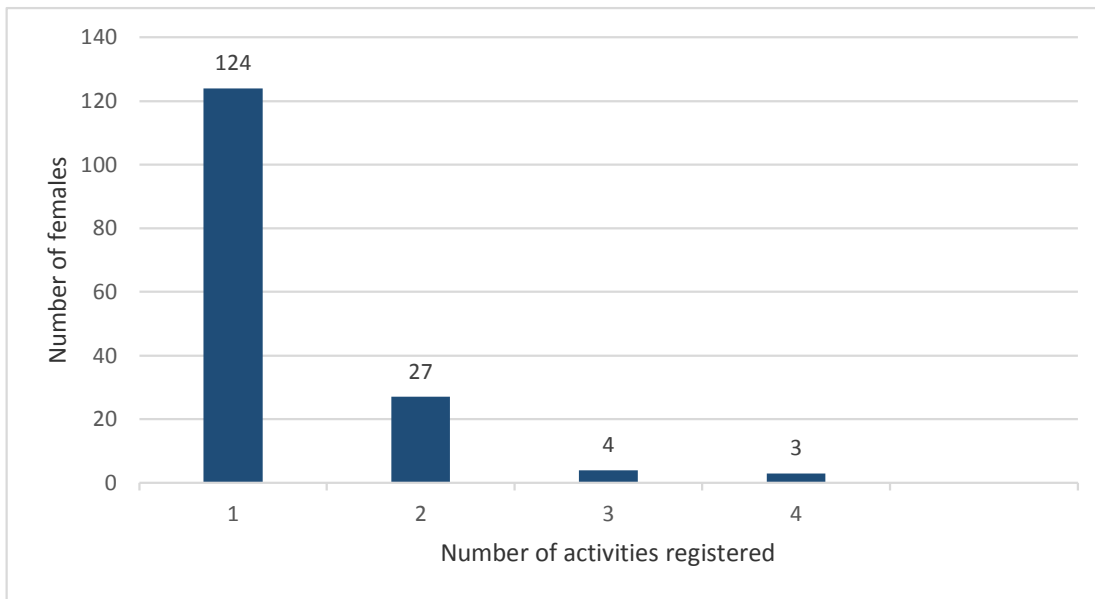


Figure 2.3.1d. Number of returning *Dermochelys coriacea* females registered in Pacuare beach during the year 2017.

Biometrics

The average curve carapace length (CCL) of the females measured in Pacuare was 150.79 cm (SD = 7.16, n = 150) and the curve carapace width (CCW) was 112 cm (SD = 7.06, n = 149). These measurements are similar to the ones recorded in Gandoca Beach between 1990 and 2010 (Chacón-Chaverri and Eckert, 2007, Fonseca and Chacón 2010) and Tortuguero (Harrison and Troëng 2003).

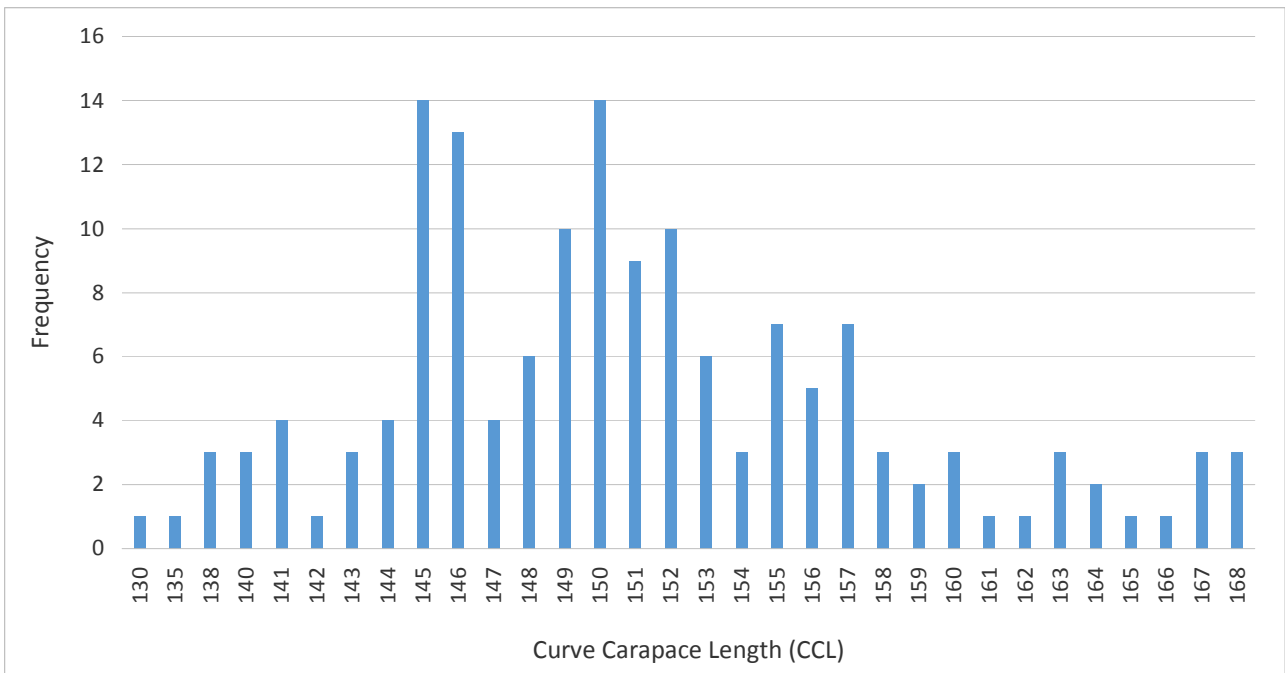


Figure 2.3.1e. Distribution of Curved Carapace Length (CCL) in cm, found in *Dermochelys coriacea*, Pacuare beach, 2017.

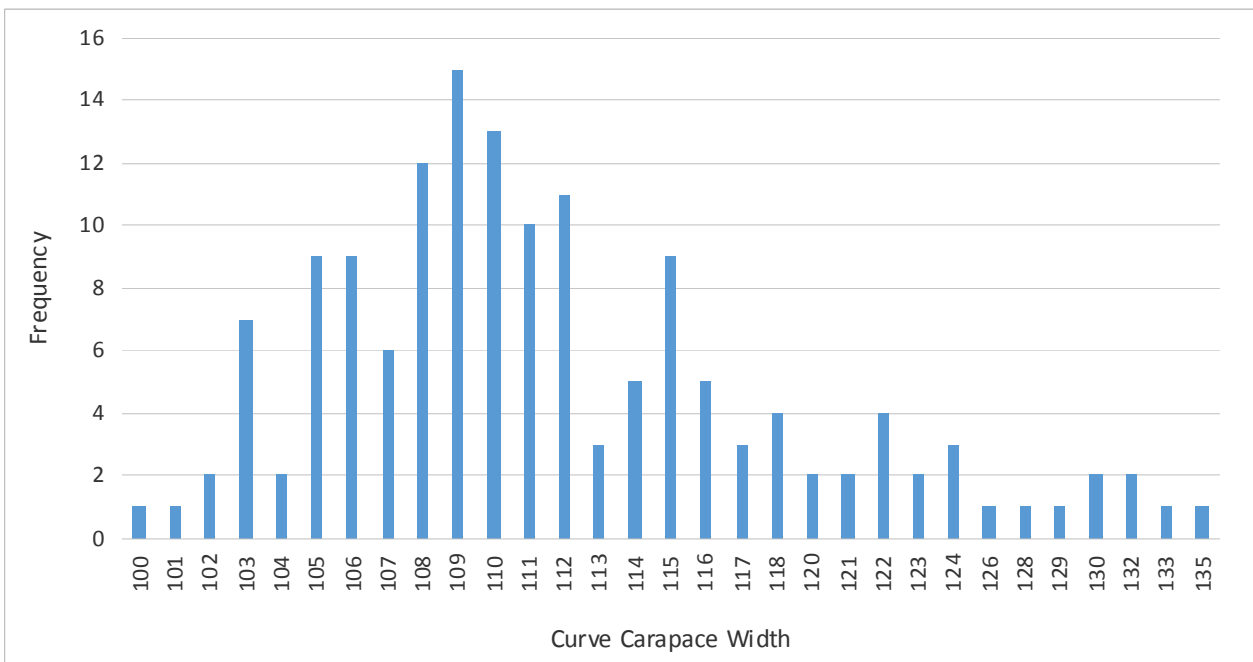


Figure 2.3.1f. Distribution of the Curve Carapace Width (CCW) in cm, found in *Dermochelys coriacea*, Pacuare beach, 2017.

Nest conservation

During the 2017 season, the percentage of nests that were poached was 42% (or the percentage of nests saved 58% (n = 162). This percentage of saved nests is the highest since the project started in 2012 (Figure 2.3.1g).

Of the saved nests, 83% were relocated to the hatchery, 12% were incubated *ex situ* and 5% were relocated to a safe place on the beach. It is vital that the majority of saved nests were relocated in the hatchery because Pacuare is highly frequented by poachers and

none of the nests can be left *in situ*. The nests incubated *ex situ* were the first nests of the season, when the hatchery was being built and the number of volunteers was not high enough to guard the nests at the hatchery.

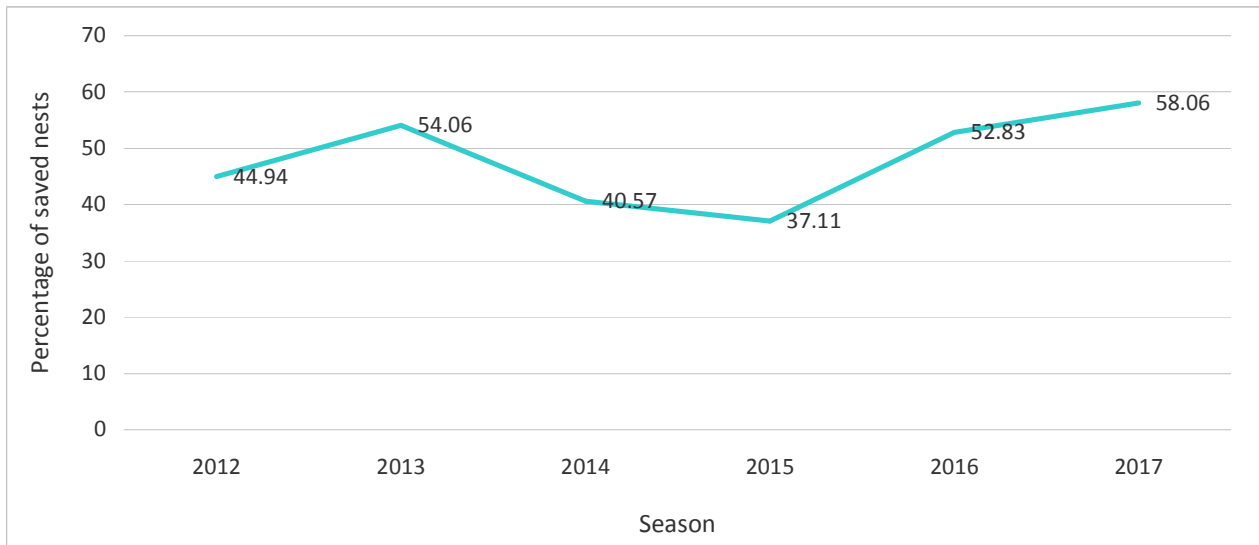


Figure 2.3.1g. Percentage of saved nests for *Dermochelys coriacea* in Pacuare beach since 2012.

Hatching and emergence success

An estimated 7,349 neonates, which emerged from the hatchery, relocated nests and the styrofoam boxes, were released at Pacuare beach during the 2017 season.

The emergence success of nests relocated to the hatchery was 64%. This percentage is the second highest percentage since the project started in 2012 (Figure 2.3.1h) and higher than the percentage registered in Gandoca, between 11 and 39% (Chacón & Eckert 2007) and Tortuguero: 42% (Troëng et al. 2007).

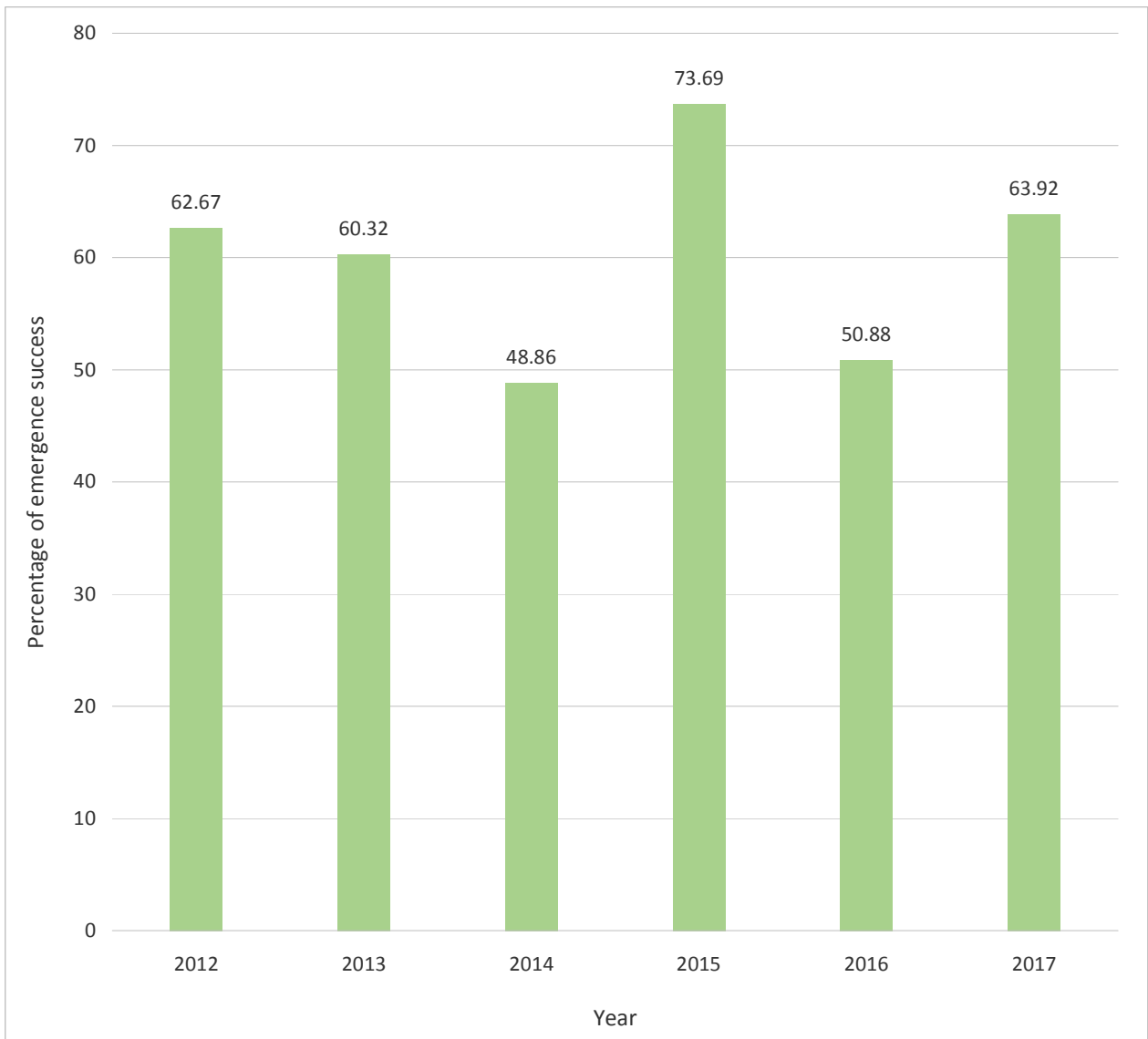


Figure 2.3.1h. Percentage of emergence success for *Dermochelys coriacea* in Pacuare beach since 2012.

2.3.2 Green turtle

Nests and false crawl activity

During the 2017 season, 175 nesting attempts were recorded for green turtle, of which only 72 resulted in a successful oviposition. This low number is due to the disturbance that turtles experience through poachers.

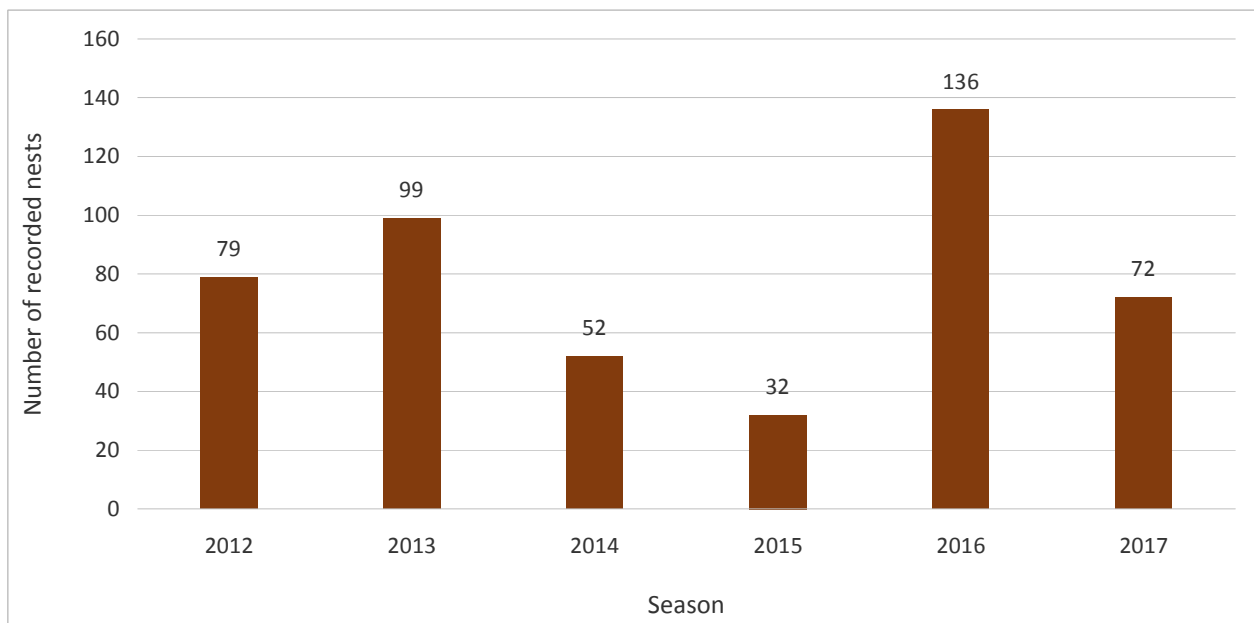


Figure 2.3.2a. Number of nests of *Chelonia mydas* recorded in Pacuare beach since 2012.

The majority of nests were registered in July and August with 27 and 35 respectively. In April there were two nests whilst in May and October there was no nesting activity. (Figure 2.3.2b). At Tortuguero most nests are found during September and October (González and Harrison 2012).

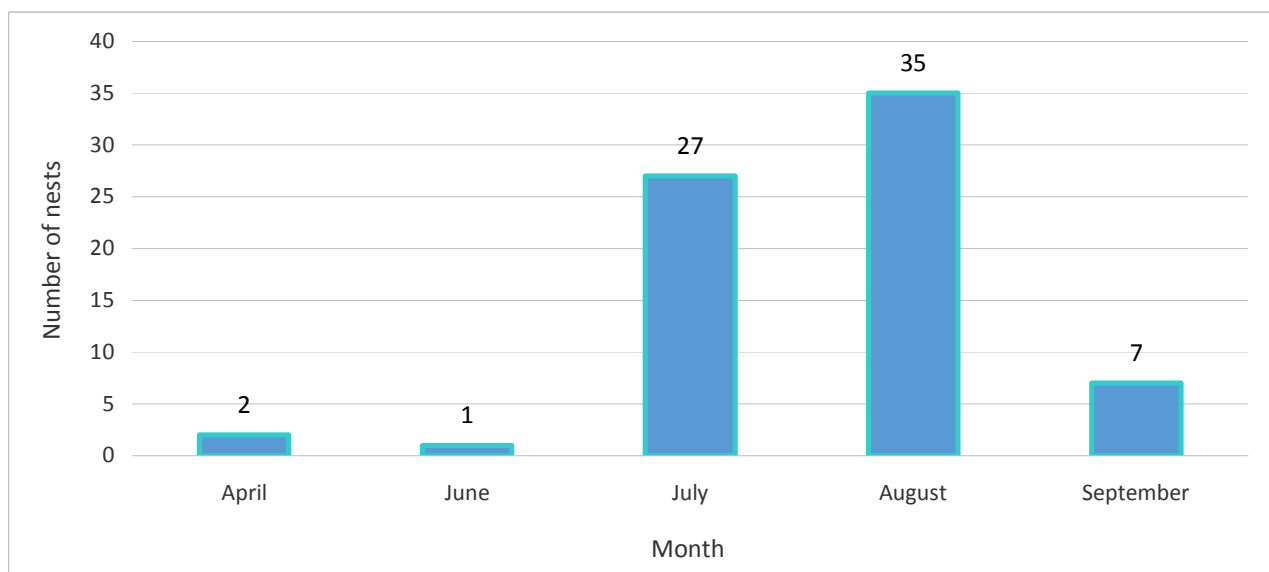


Figure 2.3.2b. Seasonal distribution of nesting activity of *Chelonia mydas* in Pacuare, Costa Rica in 2017.

Most of the nesting activity took place in sector 21-30 and 61-70 (Figure 2.3.2c). 56% of the nesting activity was in the north part of the beach (after wooden marker 50).

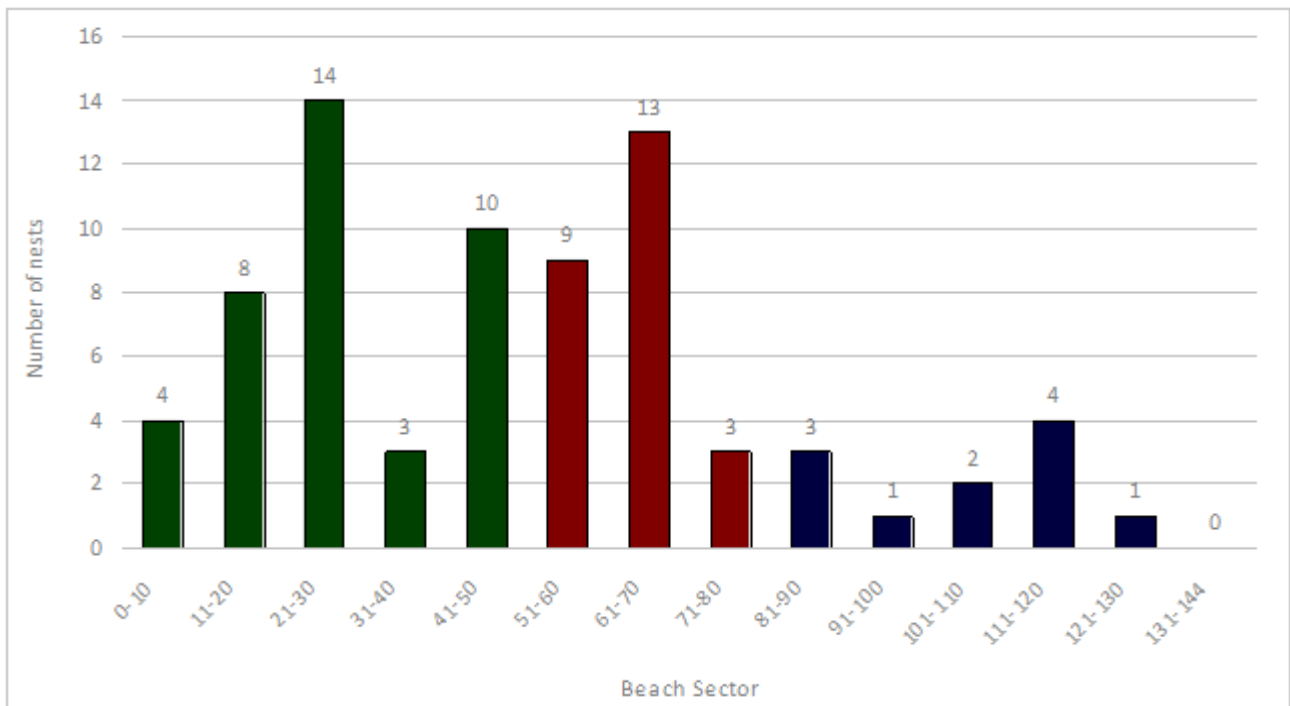


Figure 2.3.2c. Spatial distribution of the nesting activity of *Chelonia mydas* in Pacuare, Costa Rica in 2017. Green bars correspond to sector A, red bars to sector B and blue bars to sector C (see page 12).

Number of females registered

In 2017, 37 nesting females were recorded and 33 did not present any tags or evidence of previous tagging.

Number of killed females

Ten green turtle females were recorded as killed by poachers during the season, which is the lowest recorded since the project started in 2012 (Figure 2.3.2d).

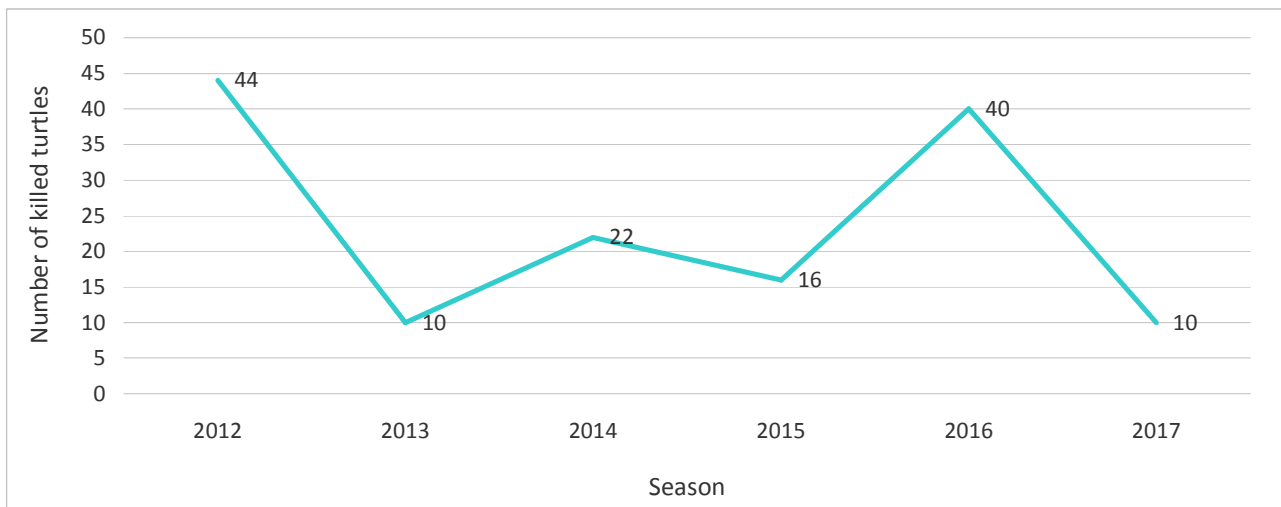


Figure 2.3.2d. Number of *Chelonia mydas* killed in Pacuare, Costa Rica.

Fate of nests

76% of nests were protected in 2017. Fifty-four nests were relocated to the hatchery and one was incubated in a Styrofoam box.

Hatching and emergence success

The percentage of emergence from the exhumed nests was 71% (SD = 23.92, n = 53) with 4,262 neonates released. The percentage of emergence is the lowest recorded since the project started in 2012 (Figure 2.3.2e).

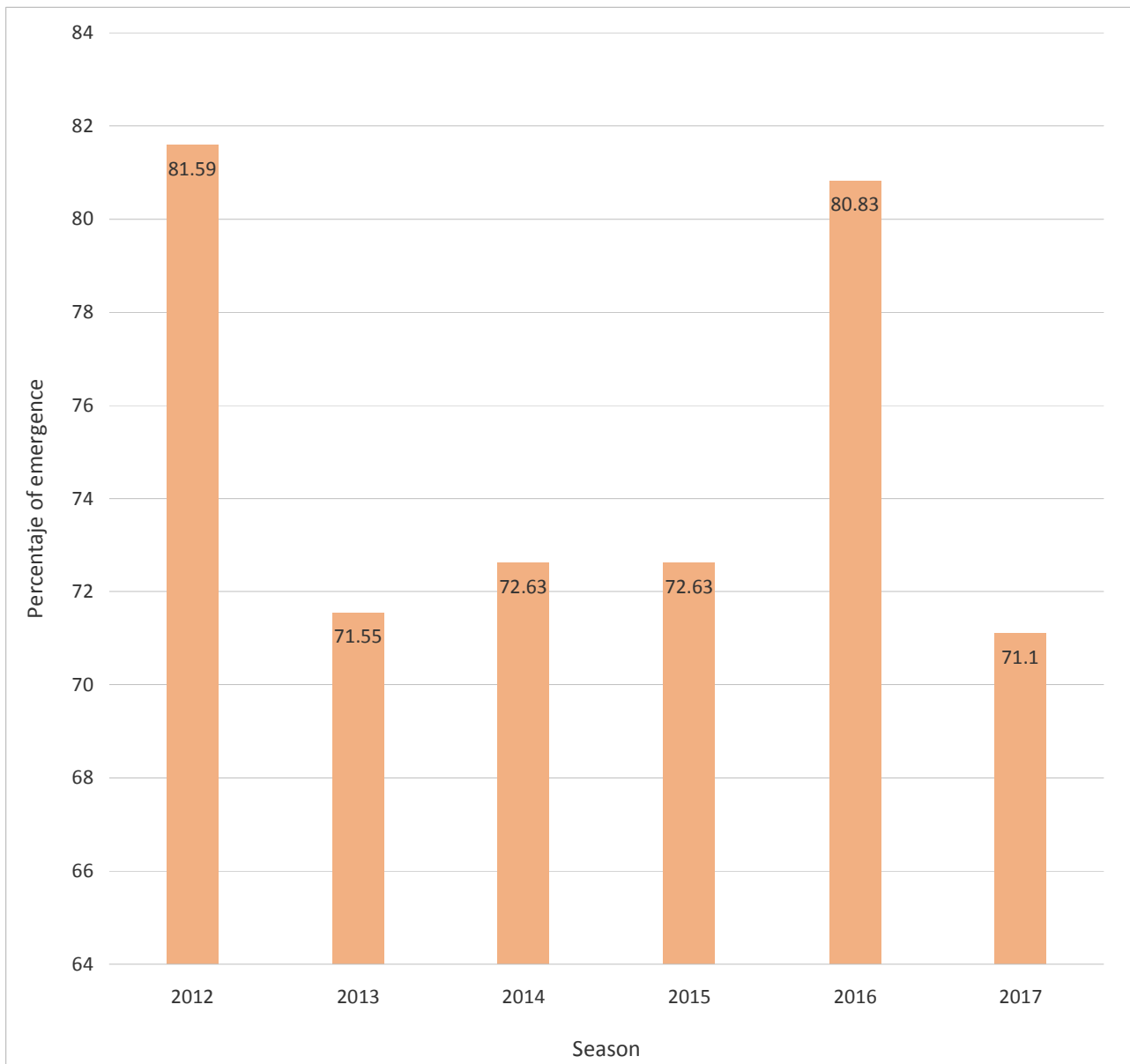


Figure 2.3.2e. Percentage of nest emergence for *Chelonia mydas* since 2012 in Pacuare, Costa Rica.

2.3.3. Hawksbill turtle

Nests and false crawl activity

21 nesting activities were recorded in 2017, of which 10 were successful. All 10 nests were relocated to the hatchery. The highest number of nesting activities were in July and August with seven and six respectively. Five turtles were recorded to have been killed (Figure. 2.3.3a).

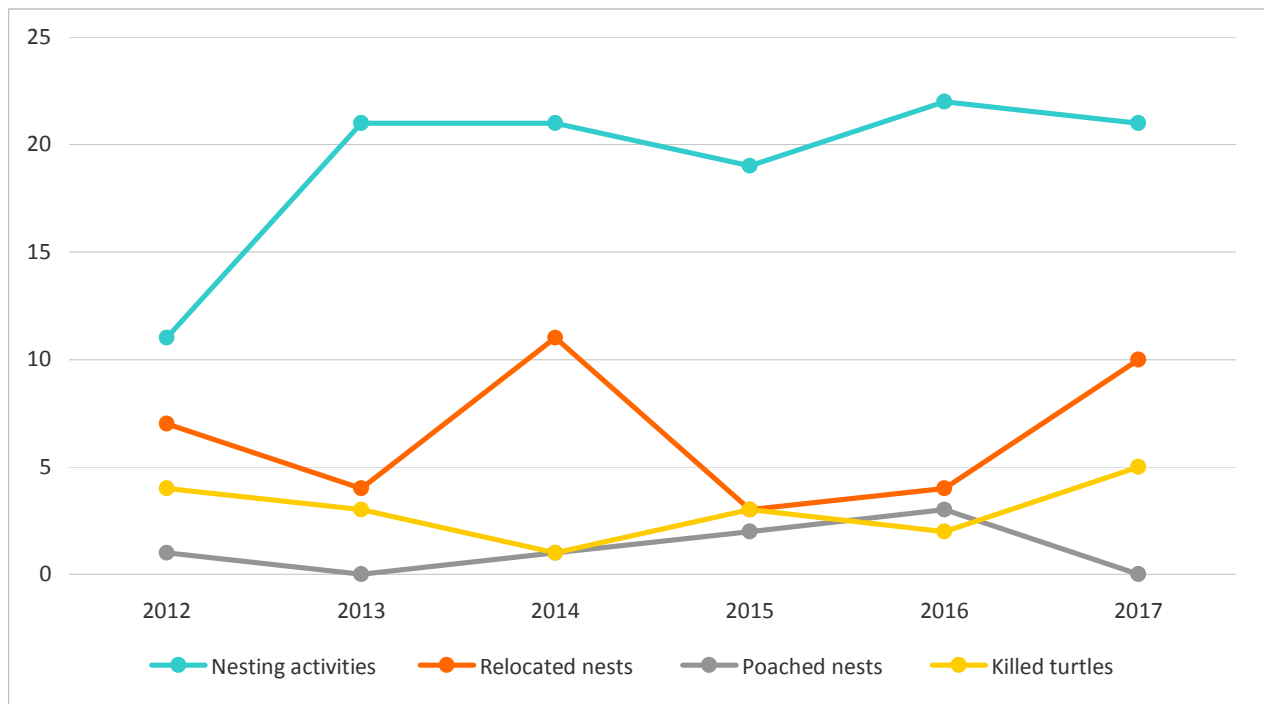


Figure 2.3.3a. Nesting activity, number of relocated and extracted nests and killed *Eretmochelys imbricata* since 2012, Pacuare, Costa Rica.

Hatching and emergence success

The average emergence success of exhumed nests was 72% (SD = 23.74%, n = 8) releasing an estimated 900 hatchlings. The highest emergence success percentage was from the nests relocated in July (95%), while the lowest percentage was from a clutch relocated in August (27%).

2.3.4. Loggerhead turtle

One loggerhead nest was found in July and relocated into the hatchery. After 55 incubation days, percentage of emergence was 61%, releasing approx. 80 neonates.

2.3.5. Environmental awareness

Expedition participants also took part in other activities such as weekly beach clean-ups. Mainly plastic waste was collected, then separated and later transported to a recycling centre in Bataan. The very high amount of plastic rubbish is easily observed, brought by both the sea and the river. There is no collection nor recycling coordination in place locally and awareness of (plastic) waste avoidance is low.

2.4. Discussion and conclusions

Leatherback turtle

487 nesting activities of leatherbacks were recorded during the 2017 season. From 162 clutches moved to the hatchery, 7,349 leatherback neonates emerged and were successfully released into the ocean. The emergence success was 59% (SD=24.77, n=162). The poaching rate for leatherback was 42%, which means that 58% of nests were saved by the project's direct conservation action. This percentage of saved nests is the highest since the project started in 2012 (Figure 2.3.1g).

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 et al. 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 et al. 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.

The phenomenon that there do not appear to be many remigrant leatherbacks at Pacuare could be explained by the fact that Pacuare is part of a beach complex where females nest. The genetic pool of the Western Caribbean (Dutton et al. 2013) runs from the south of Nicaragua to the north of Colombia. So females can return to nest in areas where LAST do not operate.

Green turtle

175 nesting activities of green turtle were recorded during the 2017 season. From 53 clutches moved to the hatchery, 4,262 green turtle neonates emerged and were successfully released into the ocean. The emergence success was 71% (SD=23.92, n=53). The poaching rate for green turtle was 24%, which means that 76% of nests were saved by the project's direct conservation action.

The nesting distribution pattern of this species in particular is a challenge for the project as it requires people across the beach at all times for good protection of nests. Also, it appears that green turtles especially get scared easily and return to the sea or are hunted before they finish laying eggs. If we compare the 2017 season with previous seasons, 2017 was an average year for laying. This shows the importance of continuous monitoring to determine long-term trends and accurate strategies to conserve and re-establish green turtle populations.

Ten green turtles were recorded to have been killed by poachers during the 2017 season. We estimate the real number to be even higher, because poachers in 2017 started using a new poaching strategy in which they tied a rope to the turtle and let the animal return a rope length into the ocean, only to retrieve and kill the animal later during the day, when no patrols (which work only at night when the turtles come to lay) are around. The strategy is applied so that patrols do not catch poachers in the act of killing and alert the coastguard.

It also allows poachers to capture more turtles as no time is spent at night, when the turtles are around, with killing and butchering, leaving more time for capturing. This is a worrying trend. Yet despite this, the number of turtles killed is the same or lower than in previous seasons (Figure 2.3.2d).

This fact shows that direct conservation action at Pacuare must continue in the face of poaching pressure and until a time that vagrant poacher presence is much reduced or eliminated from the beach. This can only be done with the cooperation of the resident community and the help of the coast guard. The latter was very helpful this year, but despite this only one green turtle was rescued.

The emergence percentage in 2017 was the lowest percentage recorded since the beginning of the project in 2012 (Figure 2.3.2e). This was probably because the nests were exposed to varying temperatures for a longer periods than usual due to the number of poachers on the beach. Because of this patrols had to wait until a turtle returned safely to the sea, meaning eggs were not reburied as quickly as they should have been under better conditions.

Hawksbill turtle

21 nesting activities of hawksbill turtle were recorded during the 2017 season. From 10 clutches moved to the hatchery, 900 hawksbill neonates emerged and were successfully released to the ocean. The emergence success was 72% (SD=23.74, n=8). The poaching rate for hawksbill was 33%, which means that 67% of nests were saved by the project's direct conservation action.

Five hawksbill turtles were killed by poachers. The nesting activity in 2017 was similar to the one recorded in 2014. Also, this year we had the highest number of killed turtles since LAST started the project in 2012. Two females were recorded trying to nest during the day, when no patrols were out, in a place 3 km away from the project base. Both were killed.

Loggerhead turtle

One nesting activity of loggerhead turtle were recorded during the 2017 season. From this one nest moved to the hatchery, 80 loggerhead neonates emerged and were successfully released to the ocean. The emergence success was 62%. Since there was only one loggerhead nest recorded during the season, which was relocated to the hatchery, 100% of nests were saved by the project's direct conservation action.

Loggerhead turtles are rarely observed along the Caribbean coast of Costa Rica, especially at Pacuare beach. Tortuguero National Park and Cahuita are the beaches that record the highest number of loggerhead nests throughout the year. The recording of a loggerhead nest by this project during the 2017 season is a good indicator of the recovery of the population. It may also be that loggerheads have discovered Pacuare beach as a relatively undisturbed place to lay their eggs, even despite the high number of poachers during the season, which are held in check by the efforts of this project.

Overall efforts

200 clutches of four different sea turtle species were relocated to the custom-built hatchery, nineteen were incubated *ex situ*, eight were relocated to a safe place on the beach and none were left *in situ* because of the high local poaching rate. However, overall 75% of all nests of the 2017 season across the sea turtle species were saved by the project's direct conservation action.

This is the highest number since the project started in 2017 and should be celebrated as a major success in sea turtle conservation by LAST, the local community, Biosphere Expeditions and other partners involved in the project.

Additional technology

During the 2017 expedition and in accordance with the 2016 recommendations, we trialled a handheld forward-looking infrared (FLIR) device that helped us to see a leatherback nesting from 30 metres away and a poacher walking by.

Discussion

The illegal extraction of eggs continues to be a challenge for the project. Since the start of the project in 2012, data recorded strongly indicates that Pacuare beach is one of the most important nesting sites, for the leatherback turtle in particular, but also for other sea turtles in Costa Rica (Marion and Hammer 2017). But every season, high levels of poaching are observed and whilst this project is battling successfully to keep poaching in check and save turtles, the overall problem should be dealt with some urgency by the local authorities, such as the Ministry of Environment and Energy (MINAE) and the police (Fuerza Pública), who are tasked with nature protection.

It is self-evident that the eradication of the poaching problem is not easy, since poaching provides a very significant income for otherwise very poor and disadvantaged resident and transient communities along Pacuare beach. 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 Acuicultura (INCOPECA) 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 trafficking and the illegal extraction of natural resources.
- Not all of the beach can be covered all the time by the project due to a combination of economical restrictions, logistical difficulties and lack of volunteers.

All of the above factors result in an ongoing, 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, 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 this 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%.

In 2017 there were encouraging signs of this beginning to happen. The local coast guard started to run sporadic patrols of the beach. Five poachers were arrested and taken to trial as a result, which did seem to have some effect on poachers, who appeared to spend fewer hours on the beach at night. We use cautious wording here, because we do not have any hard data to support this supposition. We did, however, come across more turtles in the process of laying than usual, with no poachers present, which suggests that fewer poachers were active.

Even a slight increase in authority involvement is to be welcomed. Ultimately, however, 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 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.

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 2018 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 tried with all species. If the device is able to recognise turtles inside the vegetation (where green and hawksbill turtles prefer to nest) or in the waves (when a poacher is attempting to capture a turtle), then the number of saved turtles and nests could increase considerably.
- 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.

2.5. Literature cited

Benson, S. R., T. Eguchi, D. G. Foley, K. A. Forney, H. Bailey, C. Hitipeuw, B. P. Samber, R. F. Tapilatu, V. Rei, P. Ramohia, J. Pita, and P. H. Dutton (2011) Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2(7), 1-27.

Chacón, D. (2002) Diagnóstico sobre el comercio de las tortugas marinas y sus derivados en el istmo centroamericano. Red Regional para la Conservación de las Tortugas Marinas en Centroamérica (RCA). San José, Costa Rica. 144 pages.

Chacón, D., J. Sánchez, J. J. Calvo and J. Ash (2007) Manual para el manejo y la conservación de las tortugas marinas en Costa Rica; con énfasis en la operación de proyectos en playa y viveros. Sistema Nacional de Áreas de Conservación, Ministerio de Ambiente y Energía. 103 pages.

Chacón-Chaverri, D., and K. L. Eckert (2007) Leatherback Sea Turtle Nesting to Gandoca Beach in Caribbean Costa Rica: Management Recommendations from Fifteen Years of Conservation. *Chelonian Conservation Biology* 6: 101-110.

Dutton, P.H., Roden, S.E., Stewart, K.R., LaCasella, E., Tiwari, M., Formia, A., Thomé, J.C., Livingstone, S.R., Eckert, S., Chacon-Chaverri, D. and Rivalan, P. (2013) Population stock structure of leatherback turtles (*Dermochelys coriacea*) in the Atlantic revealed using mtDNA and microsatellite markers. *Conservation Genetics* 14.3: 625-636.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard (2012) Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication BTP-R4015-2012, Washington, D.C.

Fonseca, L. G. and D. Chacón. (2010). Anidación de tortugas marinas en la Playa Gandoca, Caribe Sur, Costa Rica. Informe temporada 2010 WIDECAS. 24 pages.

Fonseca, L. G., H. Alguera, B. Vanegas and D. Chacón (2012) Reporte final de la anidación de tortugas marinas, Parque Nacional Cahuita, Costa Rica (Temporada 2012). Informe Técnico. WIDECAS. 21 pages.

Fonseca L. and D. Chacón (2014) Informe final de la anidación de tortugas marinas, playa Pacuare, Costa Rica. Asociación Last, 27 pages.

González, C. and E. Harrison (2012) Reporte del Programa de Tortuga Verde 2011, en Tortuguero, Costa Rica. Informe Técnico. STC. 56 pages.

Groombridge, B. and R. Luxmoore (1989). The green turtle and hawksbill (Reptilia: Cheloniidae): world status, exploitation and trade. Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. 144 – 152.

Harrison, E. and S. Troëng (2003) Report on the 2002 leatherback program at Tortuguero, Costa Rica. Caribbean Conservation Corporation. 32 pages.

Marion, M. and D. Chacón (2013) Reporte final de la anidación de tortugas marinas en Playa Pacuare, Costa Rica 2013. Asociación WIDECAS. Tibás, Costa Rica. 25 pages.

Marion, M. (2015) Reporte final de la anidación de tortugas marinas en Playa Pacuare, Costa Rica 2015. Asociación LAST. Tibás, Costa Rica. 28 pages.

Marion, M. and Hammer, M. (2017) Gentle giants: Protecting leatherback sea turtles through direct conservation action on the Caribbean coast of Costa Rica. Expedition report for expedition dates: 2 – 19 May 2016. Available via www.biosphere-expeditions.org/reports.

Troëng, S., D. Chacón and B. Dick (2004) Possible decline in leatherback turtle *Dermochelys coriacea* nesting along the coast of Caribbean Central America. *Oryx* 38: 395-403.

Troëng, S. and E. Rankin (2005) Long-term conservation efforts contribute to positive green turtle *Chelonia mydas* nesting trend at Tortuguero, Costa Rica. *Biological Conservation* 121: 111-116.

Troëng, S., E. Harrison, D. Evans, A. de Haro, and E. Vargas (2007) Leatherback turtle nesting trends and threats at Tortuguero, Costa Rica. *Chelonian Conservation and Biology* 6:117-122.

Appendix 1: Expedition diary & reports



A multimedia expedition diary is available on <https://biosphereexpeditions.wordpress.com/category/expedition-blogs/costa-rica-2017/>



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