

# 15 YEARS OF GREEN SEA TURTLES NESTING SITES MONITORING

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TETIAROA ATOLL  
FRENCH POLYNESIA



TE MANA O TE MOANA

# IA ORA NA



**DR. CÉCILE GASPAR**  
CO-FOUNDER & DIRECTOR OF  
STRATEGY AND  
CONSERVATION PROGRAMS

" I remember how fascinated I was the first time I observed a green sea turtle's hatching on the atoll of Tetiaroa in 2006! It was that day that Tetiaroa's green sea turtle scientific monitoring program was born. To methodically observe, to better understand the stakes of conservation in a world that changes so quickly...  
A beautiful mission on an exceptional atoll that allowed us, with the help of many passionate volunteers and biologists whom I would like to thank here, to collect crucial data that you will find in this report. It was also an opportunity to live moments of incredible symbiosis with nature.  
The circle of life that could make us find one of the first babies born on the atoll in 2006 come back to lay again on the beach where it was born, in a few years... "

" Having participated in the monitoring of green sea turtles with the teams of *Te mana o te moana* for several years, and spent camping nights on several *motu* to observe green sea turtles laying and hatching, I know the energy that it requires. Congratulations on these 15 years of hard work! I am proud to be able to continue to occasionally participate in this study and have this "ocean's spirit" live on. "



**TUMI BRANDO**  
COLLABORATOR



**RICHARD BAILEY**  
CO-FOUNDER & PRESIDENT

" Since 2007, *Te Mana o Te Moana* has been following the nesting activity of green sea turtles on the atoll of Tetiaroa. In 15 years, the number of tracks on the beaches has increased considerably! Aside from the very important contribution to the scientific knowledge on this curious and amazing species, it is this great success in conservation that will forever remain one of *The Brando* resort's and *Tetiaroa Society's* greatest pride! "

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# TE MANA O TE MOANA

"Spirit of the ocean"



Founded in 2004, Te mana o te moana association acts for the protection of the Polynesian marine environment and more specifically sea turtles. In addition to setting up a dedicated Sea turtle care center on the island of Moorea and providing educational programs in particular for local schools, one of the association's major achievement is the long term monitoring of green sea turtle's nesting on Marlon Brando's atoll: Tetiaroa.

## OBJECTIVE OF THE ASSOCIATION

Te mana o te moana's objective is to implement concrete actions to understand, educate and protect the Polynesian marine environment

SEA TURTLES  
EDUCATION  
ENVIRONMENT  
in French Polynesia



Since 2004

Understand to better protect

*Ha'api' no te pāroru*





# TETIAROA: A "HOPE SPOT" FOR BIODIVERSITY

Located 53 km North of Tahiti (17° 00' S, 149° 56' W), Tetiaroa is a private atoll, located in French Polynesia within the Society's archipelago. The atoll includes 12 *motu* (islets) surrounding a sparkling lagoon, and covers a total area of nearly 30km<sup>2</sup>.

The different *motu*, mainly composed of sandy substrate, have a variable surface, morphology and vegetation. Only *Onetahi motu* (located in the Southwest of the atoll) is inhabited, hosting the luxury eco-resort *The Brando* since July 1st, 2014.



© Tim Mckenna



In 2019, Tetiaroa was labeled as a place of hope ("Hope Spot") by Sylvia Earle's international non-profit association: "Mission Blue".

Tetiaroa atoll is a rare, secluded place that serves as a refuge for a variety of seabird species, lagoon fish, terrestrial crabs, but also a nesting sea turtle, emblem of French Polynesia's ocean: **the green sea turtle**.

# TETIAROA TURTLE SANCTUARY



EVERY YEAR, TETIAROA ATOLL'S BEACHES ARE VISITED BY FEMALE GREEN SEA TURTLES (*CHELONIA MYDAS*) SEARCHING FOR THE RIGHT PLACE TO LAY THEIR EGGS.

DURING A SINGLE NESTING SEASON, FEMALES WILL LAY EGGS SEVERAL TIMES BEFORE RETURNING TO THE OPEN OCEAN TOWARDS THEIR FEEDING SITE, SOMETIMES SEVERAL THOUSAND KILOMETRES AWAY FROM THEIR NESTING AREA.



© Alexis Rosenfeld



© Alexis Rosenfeld

In 2007, thanks to the authorizations and the support of French Polynesia's Direction of the Environnement, *Te Mana O Te Moana* created the Tetiaroa Turtle Sanctuary, assisting with the conservation of this emblematic species, through 3 main domains of action:

-  **RESEARCH & CONSERVATION:** collecting complete data on the different elements characterizing green sea turtle nesting. This thorough monitoring allows us to expand our knowledge of the populations in the South Pacific and to favor the establishment of conservation plans, intended for local actors and conservation planners
-  **MITIGATING HUMAN IMPACTS:** managing in the best possible way the cohabitation between sea turtles and atoll residents
-  **PUBLIC AWARENESS:** raising awareness for the protection of sea turtles to both tourists and residents of the atoll through conferences and participation to field work carried out by our team





# MONITORING EFFORTS

SINCE 2007, THE ORGANIZATION HAS BEEN CARRYING OUT ANNUAL SCIENTIFIC MONITORINGS ON THE DIFFERENT *MOTU* OF TETIAROA'S ATOLL.

Monitoring efforts were not always the same from one season to the next. Indeed, from 2007 to 2013, the atoll was almost uninhabited; the logistics of monitoring did not allow to come regularly.

It was not until 2014, when *The Brando* eco-resort opened, that the association's field teams were able to stay on site for the entire nesting season. This constant monitoring allowed to collect data with great precision!



SINCE 2007, TEAMS FROM TE MANA O TE MOANA HAVE BEEN WALKING AROUND THE BEACHES OF *TETIAROA* ATOLL, BY DAY... AND BY NIGHT!



# MONITORING EFFORTS

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## KEY FIGURES

**2 300+** days of monitoring

**400+** camping nights on uninhabited motu (islets)

**20 000+** kilometers covered by our teams

**100+** volunteers involved under the supervision of marine biologists and the association's veterinarian

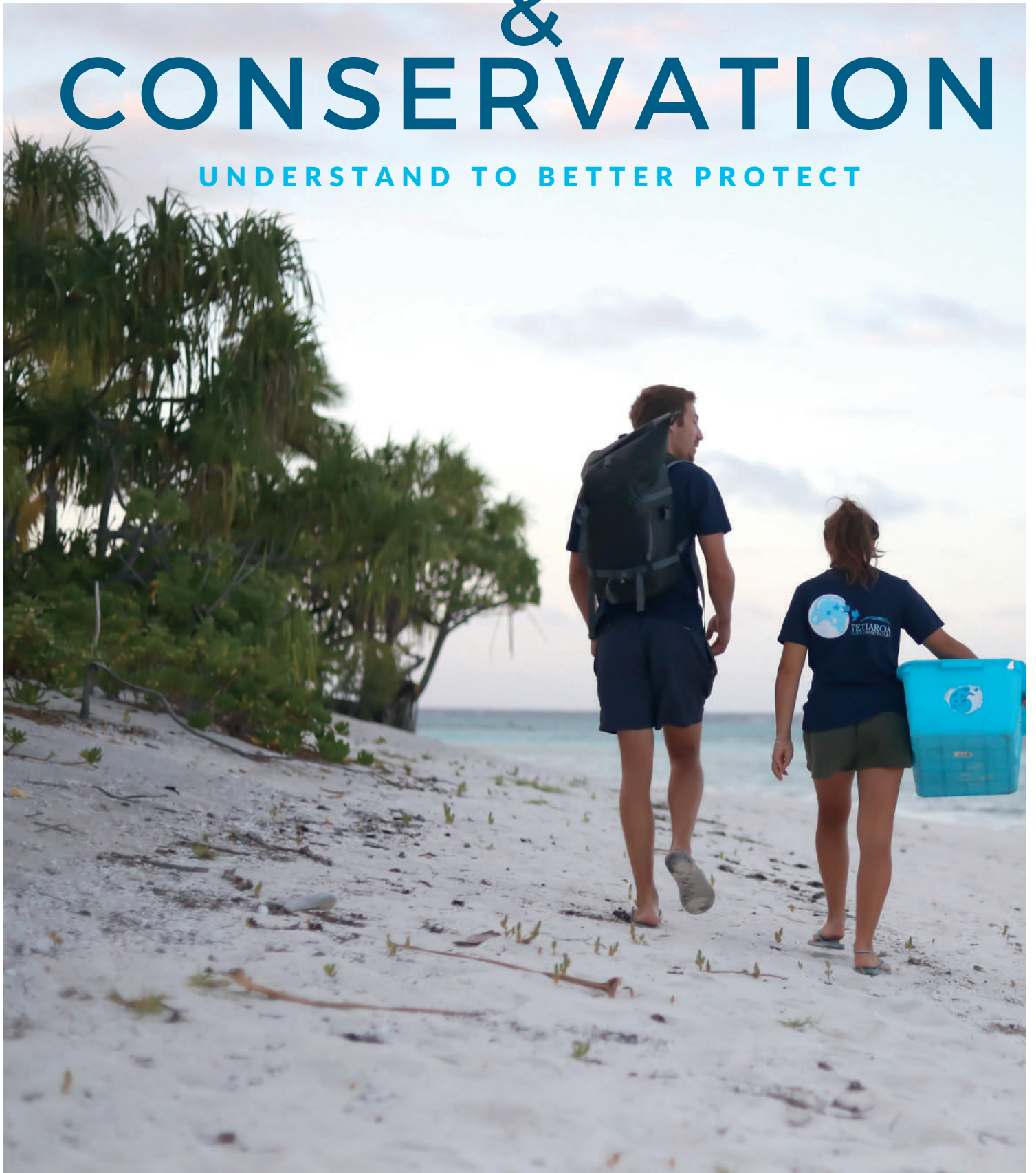






# RESEARCH & CONSERVATION

UNDERSTAND TO BETTER PROTECT



# NESTING FEMALES IDENTIFICATION

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## OBJECTIVE

THE SUCCESS OF A SPECIES' CONSERVATION STRATEGY RELIES ON RIGOROUS SCIENTIFIC FOUNDATIONS. THE FIRST STEP IN ASSESSING THE CONSERVATION STATUS OF A POPULATION IS TO **DETERMINE THE NUMBER OF INDIVIDUALS** WITHIN THAT POPULATION AND TO **ASSESS THE PAST, PRESENT AND PROBABLE EVOLUTION** OF THIS NUMBER. THE ACCURACY OF THESE ESTIMATES DEPENDS ON THE EFFORT INVESTED IN DATA COLLECTION.

To precisely evaluate the abundance and the evolution of a population of sea turtles through time, and to better understand their activity, the **mark-recapture** approach is a particularly robust method.

Due to the complex and long life cycle of sea turtles, it is strongly recommended to maintain the mark-recapture studies at nesting sites in the long term.

## METHOD

The identification of nesting females is done using 3 complementary methods:

- Genetic sampling
- Equipping the 2 front flippers with satellite ring tags
- Photo-identification of the 2 facial profiles





# IDENTIFICATION AND OBSERVATION

## FOCUS ON PHOTO-IDENTIFICATION

The scales on both sides of the sea turtles face are, like fingerprints, unique to each individual and do not change over time. It allows to learn more about individual movements depending on the number, location and frequency of photographs taken.

This method is called "photo-identification". It is a noninvasive method that does not require to manipulate nor to capture individuals.

This process has been developed by researchers from Ifremer and Kelonia, based on Reunion Island.

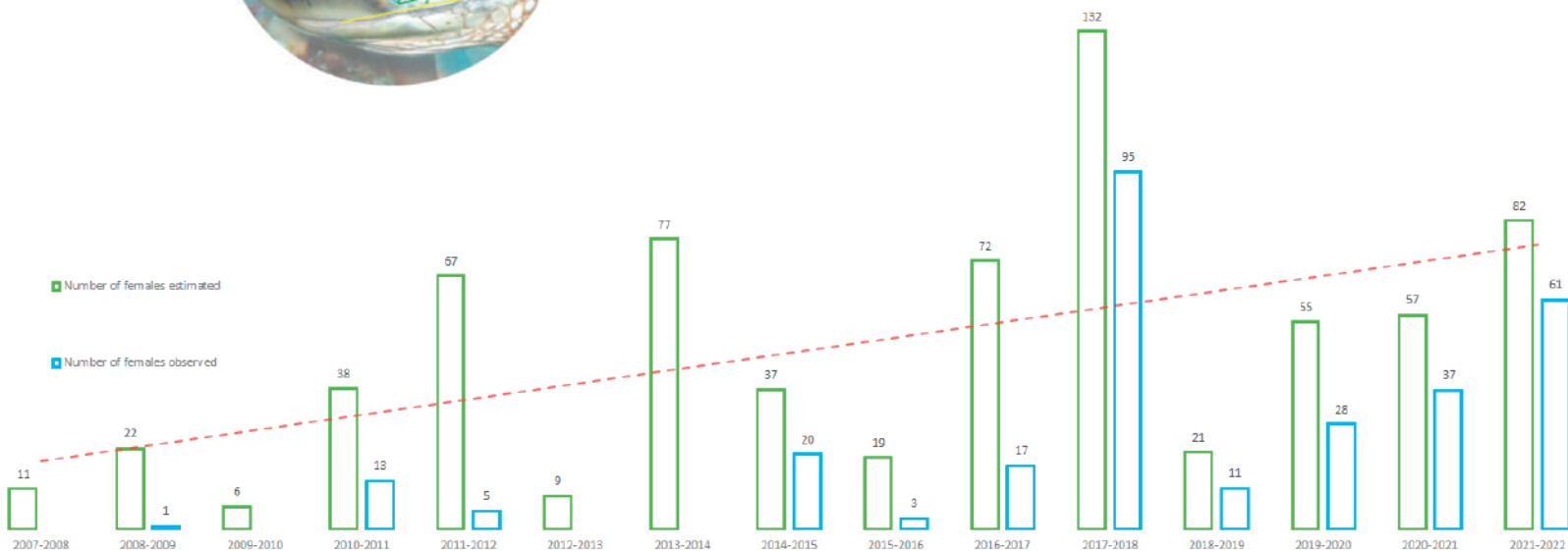
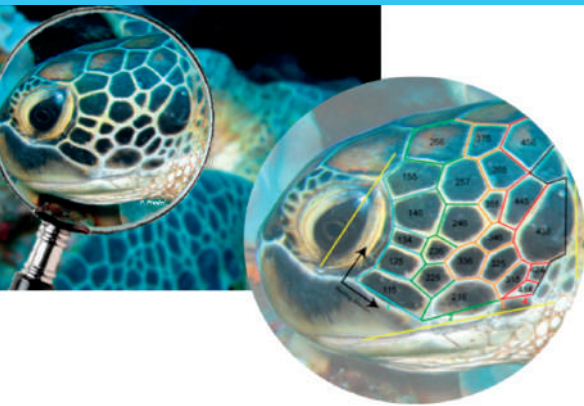
GREEN SEA TURTLES ARE CLASSIFIED UNDER B CATEGORY OF THE POLYNESIAN ENVIRONMENTAL CODE. HENCE, SINCE 2007, THE ASSOCIATION HAS OBTAINED FROM THE DIRECTION OF THE ENVIRONMENT OF FRENCH POLYNESIA ALL ADMINISTRATIVE AUTHORIZATIONS CONCERNING THE SCIENTIFIC MONITORING OF GREEN SEA TURTLES.

### KEY FIGURES

- + 950 nesting females observations
- + 420 egg-layings observed
- = 277 nesting females inventoried
- = 12 females observed during 2 different nesting seasons - 1 of them during 3 seasons
- > 3 to 8 years remigration interval
- > 30% of nesting females observed only once

Thanks to the rigor of the surveys carried out for 15 years, it is now possible to estimate the size of the population of nesting females each year. The number of individuals seems to increase significantly over the seasons.

*Below, the total number of females identified (in blue) and estimated (in green) for each nesting season. The estimation of seasonal abundance was modeled according to SWOT recommendations.*



# NESTING PARAMETERS

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DIRECT OBSERVATIONS OF NESTING FEMALES PROVIDE ACCESS TO VALUABLE DATA ON INDIVIDUALS AND ON SOME NESTING PARAMETERS.

6

**egg layings per female per season on average**  
Record of 11 nestings for the same individual

12

**days observed between 2 nestings for the same female**

3h30

**egg laying time on average**  
Including ascent, egg laying and descent

64

**days on average between the first and last observation of the same nesting female**  
Record of 135 days for the same individual

6 000 +

**meters can separate 2 nests of the same female**  
During the same season





# SATELLITE MONITORING

ARGOS SYSTEM IS ONE OF THE MAIN TECHNOLOGIES DEPLOYED BY SCIENTISTS AND CONSERVATIONISTS.

IT ALLOWS IDENTIFYING FEEDING AREAS, NESTING AREAS, AND FOLLOWING SEA TURTLES THROUGHOUT THEIR MIGRATION.

Since 2010, **Te mana o te moana has equipped 8 nesting green sea turtles** with satellite tags. This project allowed the collection of exclusive data concerning the migration of female nesting adults around the Pacific Ocean.

## RESULTS

Among 8 adult green sea turtles equipped, **6 females made a long migration of over 3,000 km towards the Western Pacific**, towards the Fiji Islands. On average, their monitoring have lasted 116 days and the females' average swimming speed was 44 km/h.

The 2 other equipped females stopped emitting after a few days, probably due to an emission problem from the ARGOS tags.

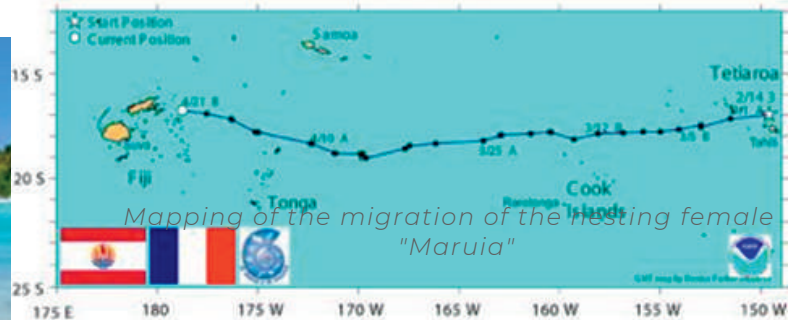
## NEXT STEP

The Direction of the Environment of French Polynesia plans to **equip breeding males around the atoll with satellite transmitters**.

Indeed, their feeding area as well as their movement during nesting season still remain a mystery!



Update as of 4/28/11:  
2011 post-nesting movement of adult female green turtle, Maruia, ID 53765  
released Feb 14, 2011 from Tetiaroa, French Polynesia  
CCL: 97.0 cm Weight: 100 kg Days transmitting: 73 days  
TAM-2639 6/24





# FOCUS ON THE NESTING FEMALE "PUPU"



Photograph of Pupu during its first contact

**Pupu, which means "shellfish" in Tahitian, is a female observed during 3 different nesting seasons by the association's teams!**



## 2011-2012 - FIRST CONTACT

Pupu was in the middle of the *motu Tiaraunu*, flipped on her back and exhausted, probably several days after the visit of poachers.



## 2017-2018 - OBSERVATION 2

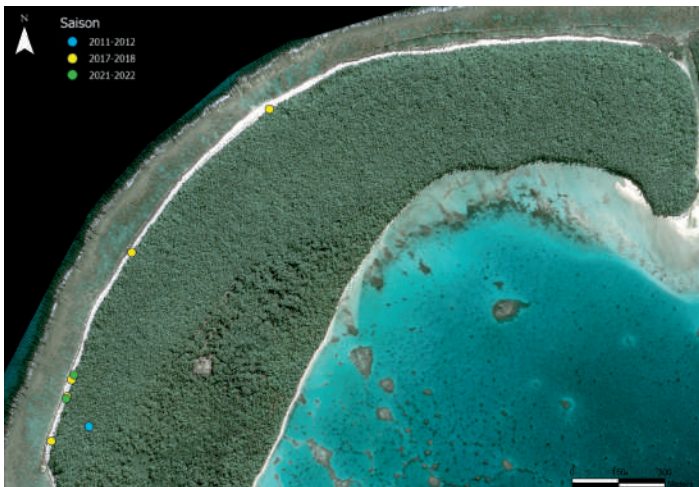
Pupu was seen 5 more times on the *motu Tiaraunu*. Our teams were able to follow its ascents for 95 days.



## 2021-2022 - OBSERVATION 3

10 years after the first contact, Pupu was seen 4 times, still on the *motu Tiaraunu*.

THANKS TO PHOTOS OF PUPU'S PROFILE, TEAMS WERE ABLE TO RECOGNIZE HER EACH TIME!



Mapping of Pupu's various egg layings

## PHOTOS OF PUPU'S RIGHT PROFILE ALLOWING ITS IDENTIFICATION

2011-2012



6 YEARS

2017-2018



4 YEARS

2021-2022



# TRACKS MONITORING



## OBJECTIVE

For logistical reasons, the field teams cannot carry out an accurate and complete count of females individually on all the *motu*. To make up for this shortage, turtle track monitoring is necessary and is one of the primary objectives of the association.

THIS MONITORING ALLOWS TO KNOW PRECISELY THE NUMBER OF CLIMBS OBSERVED EACH SEASON ON EACH *MOTU*, BUT ALSO TO IDENTIFY THE TYPE OF TRACKS MADE BY THE FEMALES (EGG LAYING, ATTEMPTED DIGGING OR SIMPLE CRAWL) AND TO STUDY THE DIFFERENT ENVIRONMENTAL CONDITIONS OF THE NESTING AREA (SAND GRAIN SIZE, DISTANCE SEPARATING THE NEST TO THE SEA, ETC.).

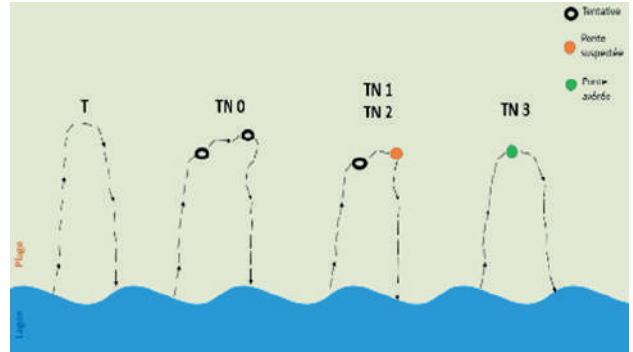




# METHOD

UPON THE DISCOVERY OF A TRACKS OR A DIGGING, DIFFERENTS CHARACTERISTICS MUST BE DETERMINED, PARTICULARLY THE **KIND OF ASCENT**.

- **Simple track (T)**: the turtle climbed the beach and then descended without digging
- **Attempt of egg laying (TN0)**: the track can be found alongside one or more diggings which didn't lead to any egg-laying
- **Egg laying**: could be incertainly suspected (**TN1**), almost certainly (**TN2**), or absolutely certain (**TN3**). The fact that eggs were laid can only be confirmed if it has been observed or if the nest has been dug up and the eggshells counted after the hatching phase.



Once the type of track has been identified, **the date** of the turtle climb is estimated, and **the number of attempts** is counted. Different environmental characteristics are taken, such as **the surface substrate quality**, the **light exposure**, the quality of the **coastline**, and the **distance from the nest to the sea**.

Each event is geolocated using precision GPS.

# DATA ENTRY APP

SINCE THE 2021-2022 NESTING SEASON, AN ENTRY APP AND ASSOCIATED DATABASE HAVE BEEN DEVELOPED WITH THE SPONSORSHIP OF ESRI.



This development was necessary to facilitate the data entry on the field, but also to standardize all the past and future data collection, from 2007 until now.

Thanks to this app, it is not necessary to use paper anymore! Indeed, it allows a direct entry of data from field surveys using a smartphone or tablet.



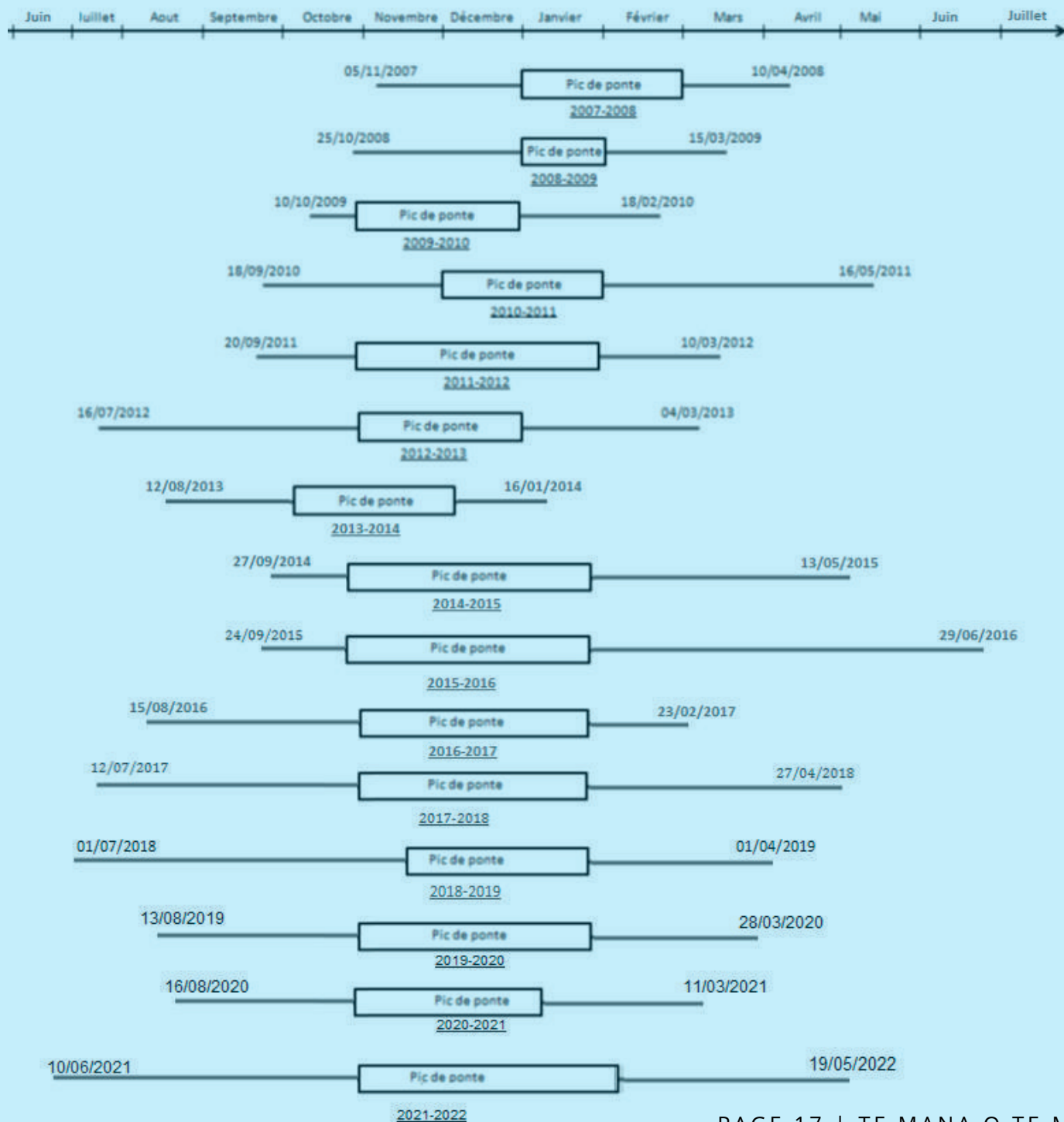




# NESTING PHENOLOGY

EACH YEAR, SIGNIFICANT VARIATIONS ARE TO BE NOTED IN THE NESTING SEASONALITY ON TETIAROA.

Seasons seem to start earlier each year, and to be longer in time. The nesting peak has been stable for several seasons, taking place in November, December and January.





# SPATIAL DISTRIBUTION

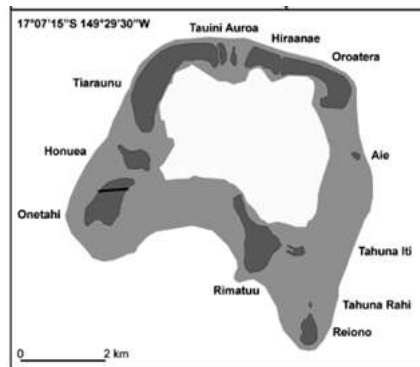
THE RELATIVE ATTENDANCE OF FEMALES ON THE ATOLL OF TETIAROA IS ALSO HIGHLY VARIABLE FROM ONE *MOTU* TO ANOTHER.

However, the major nesting areas are the same each season and are mainly located on the coasts facing the reef crest.

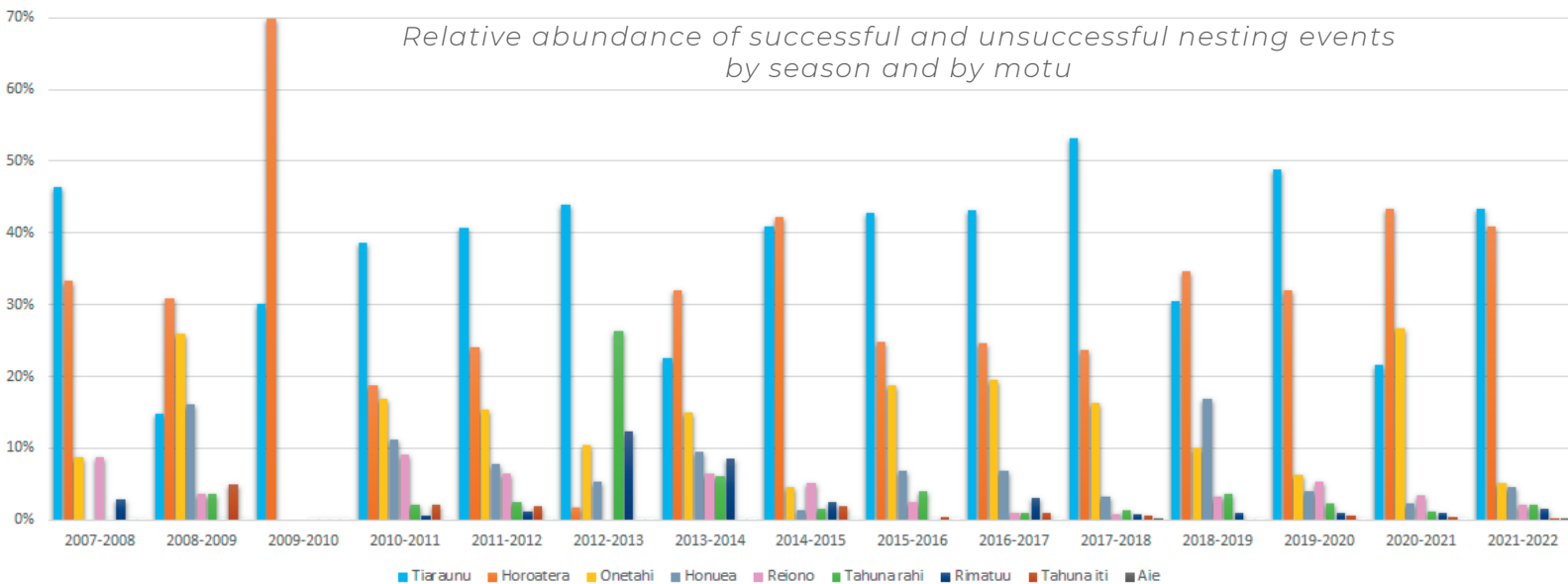
Since monitoring began in 2007, the two largest Northern *motu*, *Tiaraunu* and *Horoatera*, have gathered more than 70% of events each season. The *motu* in the Southwest, *Onetahi*, also stands out from other *motu*, welcoming on average nearly 15% of crawls all seasons combined.



Mapping of Tetiaroa atoll



Relative abundance of successful and unsuccessful nesting events by season and by motu





# NESTING EVENTS

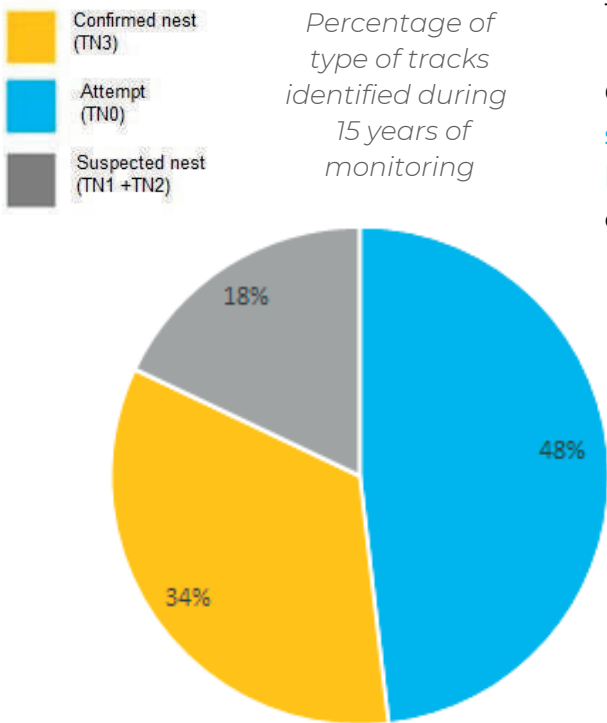
IN TOTAL, **5,852 TRACKS HAVE BEEN INVENTORIED** OVER 15 YEARS OF MONITORING

The number of nesting events is very heterogeneous depending on the nesting seasons, varying from 53 climbs during the 2009-2010 season, to 1,316 during the 2017-2018 season.

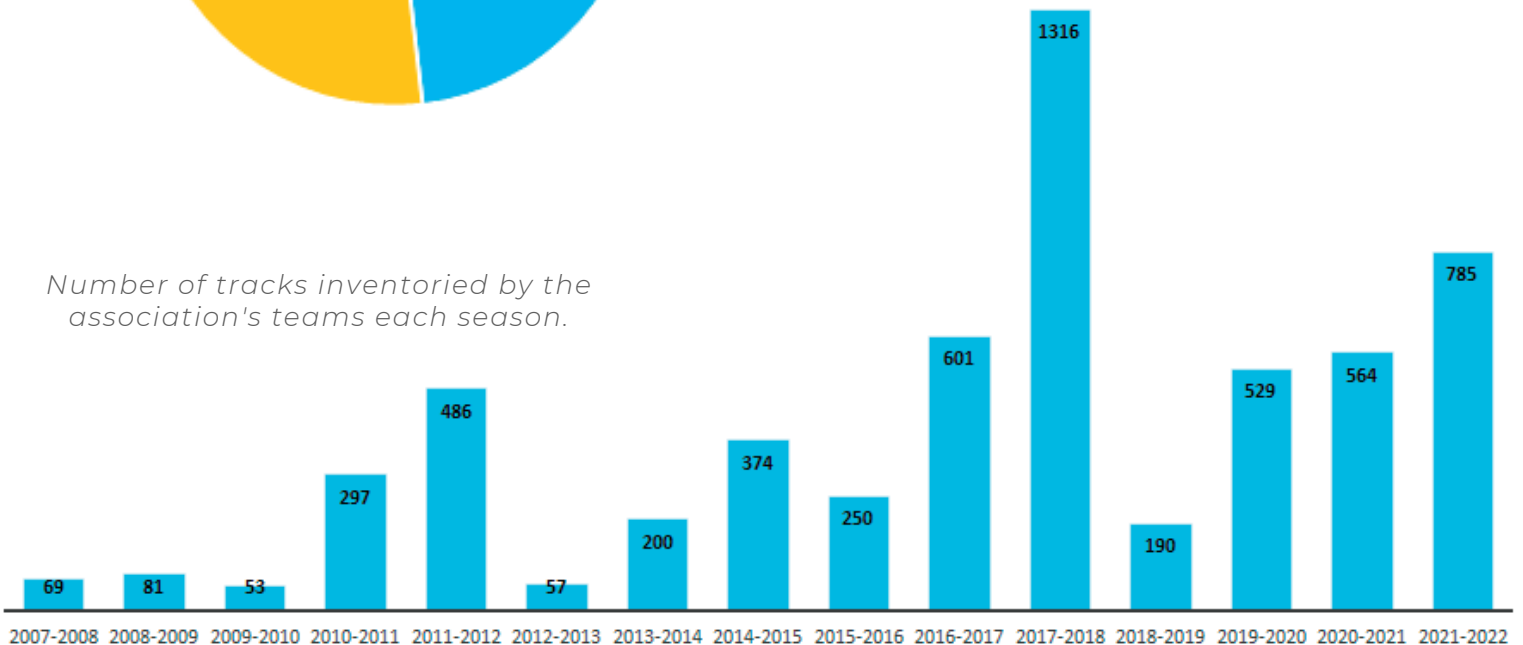
For females green sea turtles, **an ascent on the beach does not necessarily result in egg laying.** Indeed, on Tetiaroa atoll, digging attempts are not successful 48% of the time.

The type of substrate found on the surface seems to significantly influence the success of the digging attempt. Indeed, the more the substrate is coarse and made up of coral debris for example, the more the female tends to abandon her attempt.

On average, during their visits of beaches, **female green sea turtles make up to 2 digging attempts before laying.** But this can vary between 0 and 13 attempts, ending or not by the egg laying!



*Number of tracks inventoried by the association's teams each season.*



## METHOD

## OBJECTIVE

**Nest excavations provide valuable information on some nesting parameters:** number of eggs per nest, hatching success, nest depth or egg incubation time. They also allow helping hatchlings that are weakened, deformed or stuck in their nests.

After the main phase of hatching, a minimum safety period of 48 hours is respected before excavating the nest.

During the excavation, all the eggs are taken out of the nest, counted and then separated into two piles with hatched eggs on one side and unhatched on the other. It is important to look at the content of unhatched eggs, in order to differentiate an infertile egg, an unfertilized egg and an embryo which died during its development process. Data such as the number of dead or alive hatchlings stuck in the nest, as well as the maximum depth of the nest is collected.

In order to carry out genetic analyzes supported by the Direction of the Environment of French Polynesia, a skin sample is collected on dead individuals (embryos or hatchlings).



# NEST PARAMETERS

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NEARLY 2,000 NESTS DUG BY THE ASSOCIATION'S TEAMS OVER THE PAST 15 YEARS. THIS METHOD PROVIDES VALUABLE INFORMATION ON NESTING PARAMETERS

54

centimeters of maximum nest depth on average

64

incubation days on average

86

eggs laid per nest on average

78

hatched eggs per nest on average

91%

of hatching success per nest

98%

of embryonic development success

Proportion of hatched eggs out of the number of eggs with development potential (unfertilized and infertile eggs excluded)

300 000+

newborns on the atoll for the past 15 years

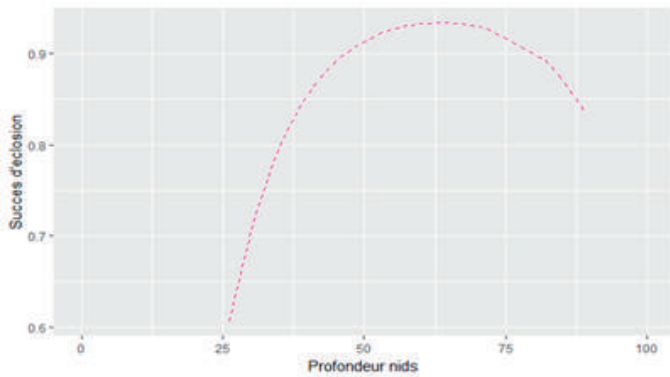




# EMBRYONIC DEVELOPMENT

DURING THEIR DEVELOPMENT, SEA TURTLE'S EMBRYOS REMAIN VERY VULNERABLE TO ENVIRONMENTAL CONDITIONS SUCH AS THE QUALITY OF THE SUBSTRATE, RAINFALL, OUTSIDE TEMPERATURES, THE GRAIN SIZE OF THE SAND, ETC.

The variability of these parameters conditions the development of embryos during incubation.



On Tetiaroa, it has been demonstrated that nest depth significantly influences the success of embryonic development and hatching success. If the nest is not deep enough, eggs will be more subject to the changes of their environment, with low development success. Conversely, eggs laid too deeply undergo less variation and their embryonic success tends to decrease.

Hatching success is at its maximum (greater than 90%) when the nest is between 50 and 75 cm deep.

The interruption of the embryo's development may also be due to genetic anomalies.

## GENETICS ANOMALIES ENCOUNTERED

The most common non-viable genetic abnormalities observed are:

- **malformations:** embryos with 2 heads, shell with inverted curvature, head deformations (absence of eye, nostrils, etc.)
- pigment deficiency (albino type)
- twin embryos

These represent less than 1% of the dead embryos found.



# RESCUED HATCHLINGS



## FOCUS ON THE HATCHLINGS OF THE FEMALE HOTUA HAU

During the 2017-2018 season, the excavations of the nests laid by the female named Hotua Hau, led to an incredible discovery!

Indeed, out of the 6 excavated nests, 9 alive hatchlings were found without back flippers by our teams.

One of them survived for several months at the Sea Turtle Care Center on Moorea.

While all eggs have hatched, **some alive hatchlings are stuck at the bottom of their nest**, due to a mechanical obstacle (root, coral, etc.), malformation, predation in the nests, or even a genetic anomaly, making it very unlikely for them to emerge of the nest.

During excavations, **more than 2,250 hatchlings stuck at the bottom of their nests were found and rescued by our teams**, and released into the lagoon as soon as possible.

When the hatchlings did not have enough energy to reach the lagoon, they were sent for advanced care to the Sea turtle care center, managed by the association, on Moorea.



TO THIS DAY, 93 HATCHLINGS HAVE BEEN TREATED, REHABILITATED AND THEN RELEASED INTO THE OCEAN BY TEAMS FROM THE SEA TURTLE CARE CENTER.



© Didier Brémont

# STUDYING PREDATION



## OBJECTIVE

SEA TURTLES' SURVIVAL RATE IS VERY LOW, ESPECIALLY DURING THE FIRST YEAR OF THEIR LIFE.

INDEED, AS SOON AS THEY LEAVE THEIR NEST, **THE HATCHLINGS MUST FACE INTENSE PREDATION PRESSURE**, BOTH ON LAND AND IN THE SEA.

Te mana o te moana carried out a study to better understand the **impact of predation** on Tetiaroa's green sea turtles hatchling success. First, by doing an inventory with photos and videos of the different natural predators found on the atoll, whether on land or in the lagoon.

Then, by carrying out a **research program** on the predation of two introduced predators, the black rat (*Rattus rattus*) and the Polynesian rat (*Rattus exulans*). This 3-year study was part of a global rat eradication project on the entire atoll led by Tetiaroa Society foundation.



© Didier Brémont



# NATURAL LAND PREDATORS

AMONG THE DIFFERENT TERRESTRIAL SPECIES PRESENT ON TETIAROA ATOLL, 4 SPECIES OF CRABS HAVE BEEN REGULARLY OBSERVED PREDATING GREEN SEA TURTLES HATCHLINGS .

Although present in large quantity, the various species of nesting seabirds on the atoll have almost never been a problem.

- *Ocypode quadrata*: They attack both incubating eggs and green sea turtles hatchlings in their nest. They are able to extract young turtles from their nest, even before they reach the surface!
- *Coenobita perlatus*: Detritivorous, they mostly attack dead individuals rather than hatchlings reaching the ocean.
- *Eriphia sebana* et *Grapsus tenuicrustatus*: Both observed on "beach rock" type coastlines, they attack the hatchlings just before they reach the lagoon.

*Ocypode quadrata*



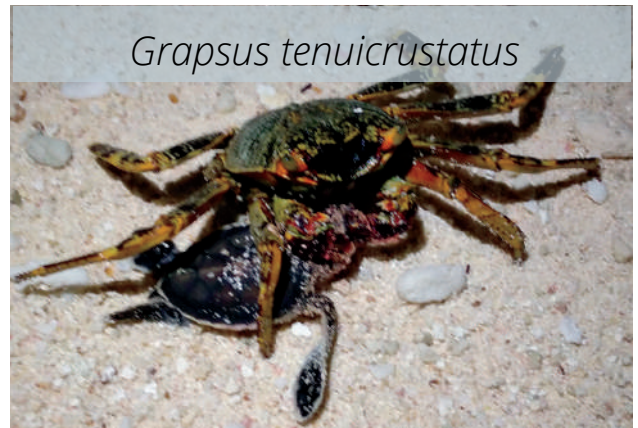
*Coenobita perlatus*



*Eriphia sebana*



*Grapsus tenuicrustatus*



# INTRODUCED LAND PREDATORS



FREE OF CATS, DOGS, PIGS AND OTHER INTRODUCED LAND SPECIES, TO THIS DAY, ONLY TWO SPECIES OF RATS (*RATTUS RATTUS* AND *RATTUS EXULANS*) STILL EXERT PREDATION PRESSURE ON TETIAROA'S POPULATION OF NESTING GREEN SEA TURTLES.

## PARTNERSHIP



In order to better understand the damages caused by these invasive species and to contribute to global eradication programs in tropical islands, the association, in partnership with the University of Hanover in Germany, has closely studied this theme.

## METHOD



Infrared cameras with motion detectors have been installed on different *motu*, allowing the observation of introduced predators without bias linked to human presence.

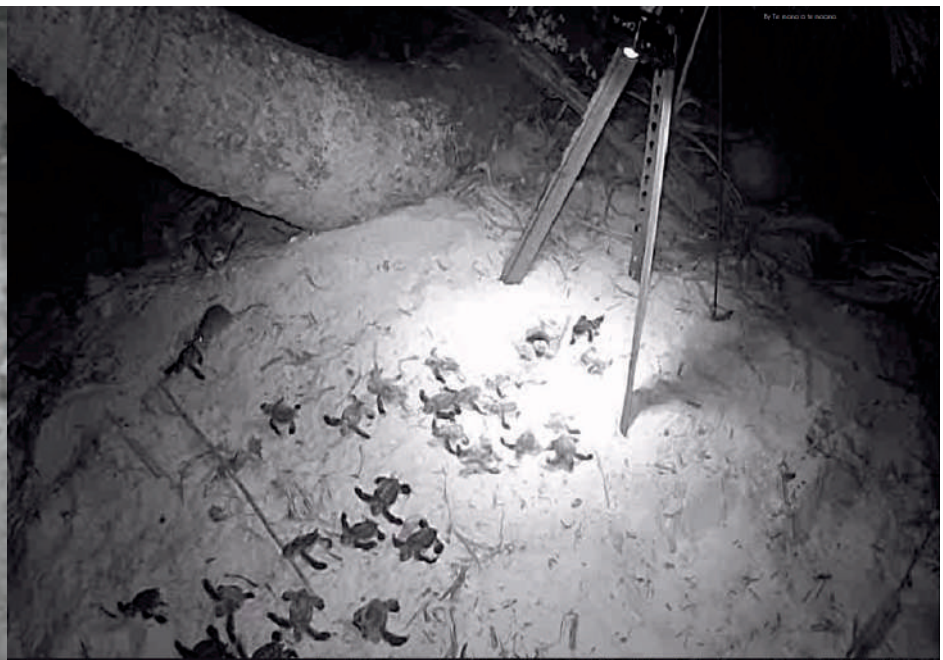
A total of 131 turtle nests and 94 control sites (sites without turtle nests) were recorded by our devices.

## RESULTS

Footages showed recurrent predation by rats on the hatchlings:

- Turtle nests were significantly more visited by rats than control areas
- The predation phases can take place before, during and after the main hatching
- Observed behaviors proved that sea turtles were a common and well-known food source for rats
- At least 64% of observed predation is attributed to black rats (*Rattus rattus*)

*The summary of this study is described in the scientific article by Gronwald M. et al., "Predation on green sea turtle hatchlings, Chelonia mydas (LINNAEUS 1758), by invasive rats" published in Pacific conservation Biology in 2019.*



# LAGOON PREDATORS



**13 nests on the motu Onetahi were monitored using a drone, in order to better understand the importance of predation in the lagoon, as well as the dispersal phenomenon following hatching.**

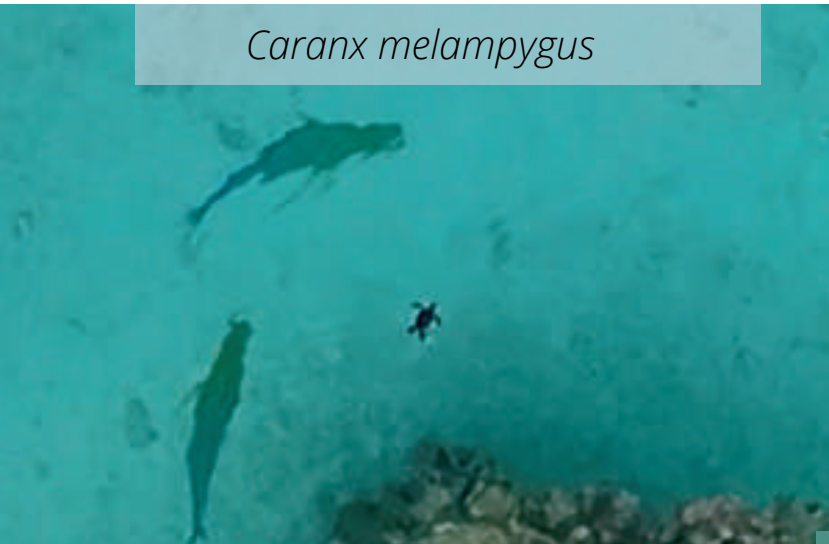
Monitoring was carried out from the moment the hatchlings left their nest, until they arrived outside of the lagoon, or until they disappeared from the image.

Even if hatchlings stay all together during their descent on the beach, in the lagoon, they are easily carried away by the current, and several hundred meters can quickly separate the individuals. Monitoring them was therefore not easy and we preferred focusing on certain individuals.

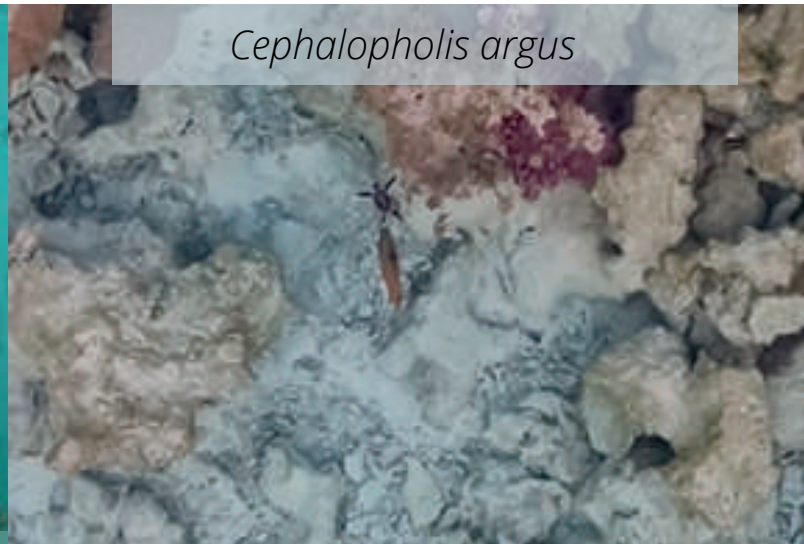
Exceptional footage of predation were obtained showing:

- 4 blacktip sharks predation (*Carcharhinus melanopterus*)
- 2 groupers predation (*Cephalopholis argus*)
- 5 octopuses predation (*Octopus cyanea*).
- Trevallies (*Caranx melampygus*) showed interest for hatchlings, but no predation was recorded

*Caranx melampygus*



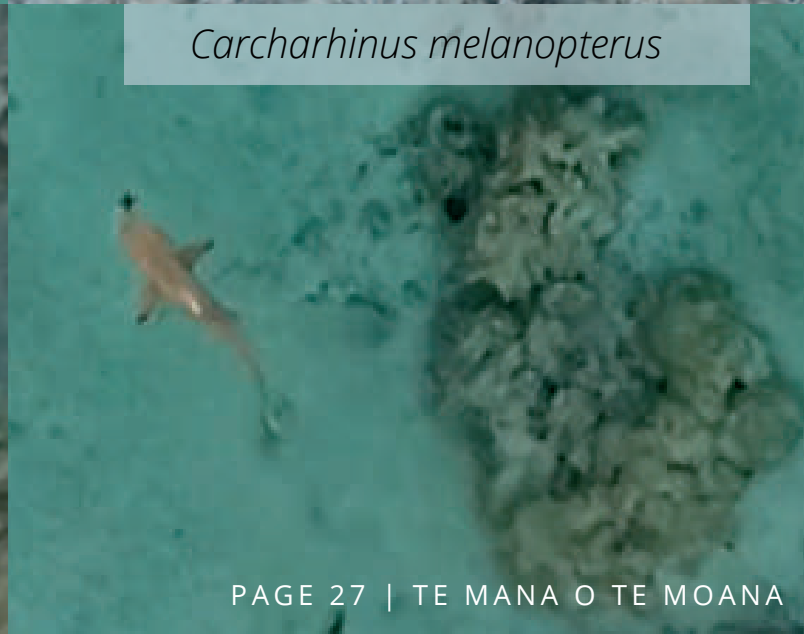
*Cephalopholis argus*



*Octopus cyanea*



*Carcharhinus melanopterus*



# STUDYING CLIMATE CHANGES IMPACTS



## OBJECTIVE



FOR 3 YEARS, WITH THE SUPPORT OF THE DUTCH MARITIME ENGINEERING COMPANY VAN OORD AND THE PRINCE ALBERT II OF MONACO FOUNDATION, THE ASSOCIATION HAS BEEN STUDYING THE EFFECTS OF GLOBAL CHANGES ON THE NESTING SITE OF TETIAROA ATOLL.

### IMPACTS RELATED TO:

- sea level rising
- temperatures increasing, especially the modification of male-female ratio
- decrease of hatching success
- loss of nesting areas
- changes in phenology and reproductive strategies

## CUTTING-EDGE MATERIAL

A tide gauge and immersible thermal loggers have been deployed in order to establish a reference state for the water level and surface temperatures of the lagoon and to monitor their evolution over time.

In addition, a fixed GNSS reference station was installed, in order to obtain a differential correction of an RTK radio signal. This GPS system allows a horizontal and vertical geolocation precision of about 20 centimeters.



# SEX RATIO STUDY

THE MODIFICATION OF THE MALE/FEMALE RATIO IS ONE OF THE MAIN EFFECTS OF GLOBAL CHANGE THREATENING SEA TURTLE POPULATIONS. THE SEX OF SEA TURTLES IS IRREVERSIBLY DETERMINED BY THE TEMPERATURES OF THE SAND DURING THE SECOND THIRD OF THE EMBRYONIC DEVELOPMENT. THE MORE WE WITNESS HIGH TEMPERATURES IN THE NEST, THE MORE WE OBTAIN A BIASED SEX RATIO IN FAVOR OF FEMALES, AND VICE VERSA.

Various studies in different parts of the world have already observed record rates of feminization of sea turtle populations.



## MATERIAL & METHOD

For several years, the association has been deploying thermal loggers in nests. The loggers were inserted in the middle of the eggs during laying and were recovered at nest excavation.

In total, 87 temperature loggers have been deployed within the incubation chambers, and 51 additional temperatures loggers have been installed in areas without nests to record the temperatures on the most prominent nesting beaches of the atoll.

### A-4 step process:

- Modeling the number of nests per day for each nesting season
- Reconstitution of nest temperatures using environmental proxies
- Description of the relationship between incubation temperature, hatching success and sex ratio
- Modeling of daily male and female hatchling output

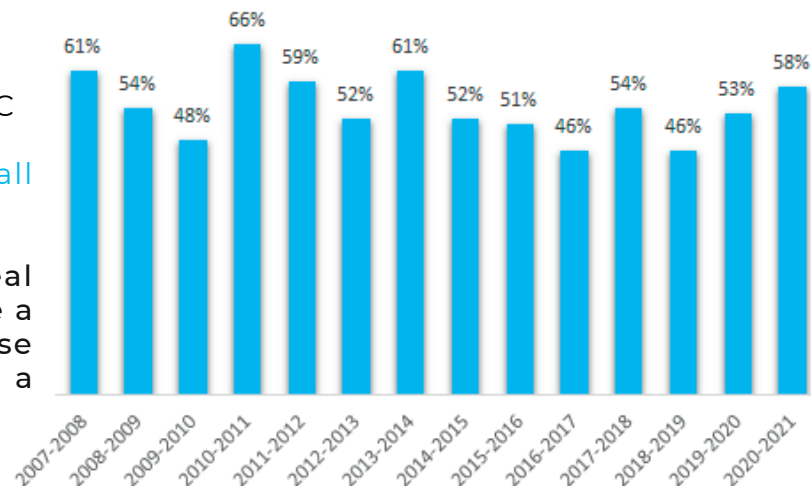
## RESULTS

Incubation temperatures relatively low:

-> mean = 28,5°C, standard deviation = 0,7°C

We estimated that currently 54% of all hatchlings are male.

The atoll of Tetiaroa seems to offer ideal incubation conditions and would seem to be a crucial site to preserve, in particular because of its production of hatchlings with a balanced sex ratio.



The details of this study are described in the scientific article by Laloë JO et al., "Production of male hatchlings at a remote South Pacific green sea turtle rookery: conservation implications in a female-dominated world" published in *Marine Biology* in 2020.



# EROSION STUDY

RISING SEA LEVELS MAY ACCELERATE EROSION AND ENGULF SOME COASTAL AREAS AS WELL AS MANY LOW ISLANDS AND ATOLLS. UNDERSTANDING THE SEDIMENTARY MOVEMENTS OF SANDY COASTLINES HAS BECOME A MAJOR CONCERN IN THE STUDY OF SEA TURTLES.



October 2019



December 2021

## METHOD

Morphological changes in beaches were followed by aerial topographic surveys using a professional DJI Phantom 4 drone.

In January 2021, detailed mapping expeditions have been carried out to monitor the amount of erosion and sedimentation on Tetiaroa's main turtle nesting beaches.

The results of this survey campaign were compared to the results extracted from the airborne LIDAR (Light Detection And Ranging) survey of May 2017.

This comparison allowed us to know the evolution of the of the atoll's coastline during 5 years.

## RESULTS

The total area of beaches seems to have increased in the last 5 years. However, **the newly created beaches are at low altitudes**, slightly above water level, and therefore could easily be flooded.

Furthermore, we observe **a considerable increase in steep slopes, considered impassable by females sea turtles**, especially on the *motu Honuea* and *Onetahi*, with respectively 28% and 13% of the beaches becoming unreachable by females.

*The details of this study are described in the report by TOURON M, et al., "Changements climatiques et tortues marines – L'observatoire de l'atoll de Tetiaroa (Polynésie Française)" published in 2021*



# FLOODED NESTS STUDY

WHEN THE BEACH SLOPE BECOMES TOO STEEP, FEMALES ARE FORCED TO EITHER GIVE UP THEIR EGG-LAYING, OR LAY THEIR EGGS IN A FLOODABLE ZONE. THE DISAPPEARANCE OF NESTING SITES COUPLED WITH THEIR RESTRICTED AVAILABILITY AND THEIR FLOODING CHARACTER DIRECTLY THREATENS NESTING AND HATCHING SUCCESS.



Nests laid in submersible areas have been:

- either relocated in a flooding-safe area
- or left as they are

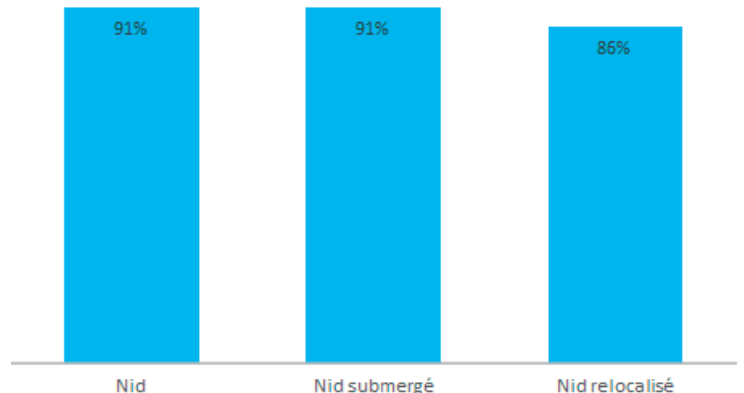
Excavations are always carried out after a minimum safety period of two days after hatching, allowing to quantify the hatching success and the impact of flooding and relocation events.

Results obtained show that both relocated and flooded nests have a high hatching and embryonic development success, similar to those observed naturally.

It seems that the flooding episodes do not yet represent a threat for the success of the eggs' development in Tetiaroa. Indeed, the installation of infra-red cameras on some nests allowed us to note that at the time of the events of strong swells, the beaches of the *Horoatera* motu were swept by large waves that come and go, the latter taking place only punctually. These short-lived episodes therefore have no impact on embryo development success.

Therefore, the decision to relocate nests should be made by predicting the duration and intensity of the flood, which seems difficult.

*The details of this study can be find in the report by TOURON M., VAN DER HELM M., POINTIS S., GASPARD C., Changements climatiques et tortues marines – L'observatoire de l'atoll de Tetiaroa (Polynésie Française) published in 2021*

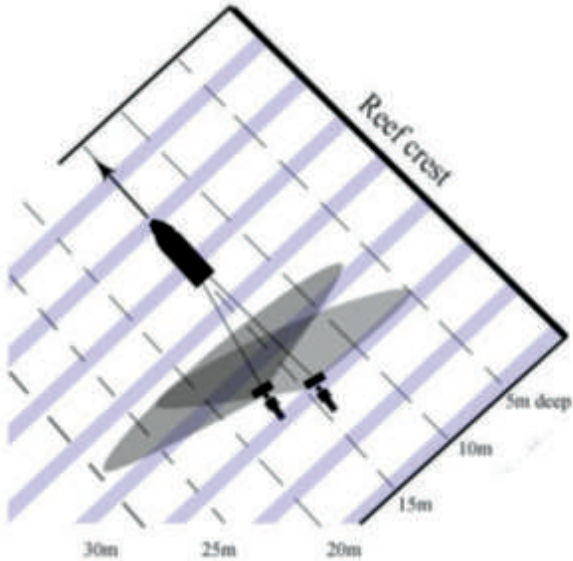


*Natural hatching success of nests "nid", nests flooded at least once during the incubation period "nid submergé", and relocated nests "nid relocalisé".*

# OFFSHORE INVENTORIES



## MANTA TOW



THE “MANTA TOW” TECHNIQUE CONSISTS OF TOWING ONE OR MORE OBSERVERS WITH A BOAT AT LOW SPEED ALONG THE OUTER SLOPE. THE OBSERVER STANDS ON A LARGE WOODEN PLATE CONNECTED TO THE BOAT BY A ROPE. THE OBSERVER USES A STATEMENT SHEET ON WHICH ALL THE NECESSARY INFORMATION IS NOTED.

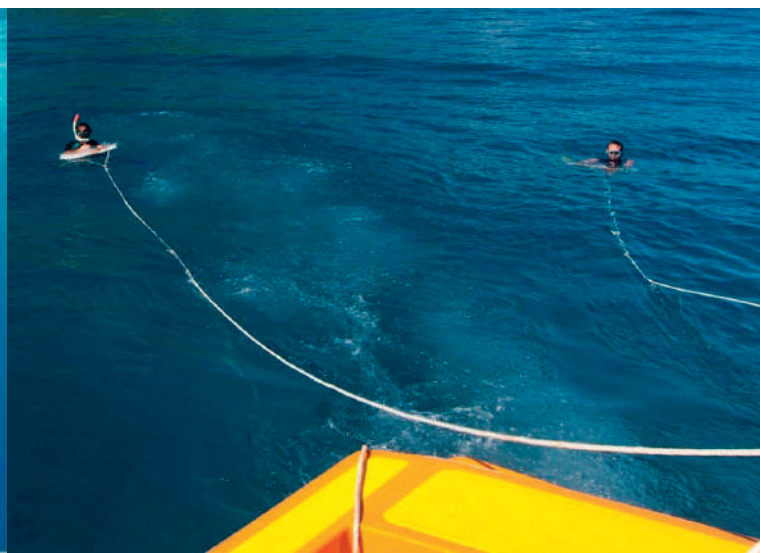
Regularly used during coral reef monitoring programs, the manta tow method had never been applied in the context of research on sea turtles before Te mana o te moana association first used it.

## RESULTS

On Tetiaroa, 3 offshore sampling missions were carried out between November 2010 and August 2011.

When conditions allowed it, observed sea turtles were captured, marked (ring tagging and photographing the two facial profiles), measured, sexed and then released.

In total, **28 sea turtles were identified**, with 20 hawksbill turtles (*Eretmochelys imbricata*) and 8 green sea turtles (*Chelonia mydas*). Observations showed only sub-adult individuals or adult females. No males were identified.





# PROTECTION

SITE PROTECTION AND MITIGATION  
OF HUMAN IMPACTS



# IMPLEMENTATION OF ADAPTED MEASURES

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Since 2014, the *motu Onetahi* in the Southeast of the atoll has been home to the luxury eco-resort, *The Brando*. The protection of the environment, and in particular that of the population of green sea turtles on the atoll are at its core.

TE MANA O TE MOANA ASSOCIATION HAS BEEN WORKING WITH THE RESORT SINCE ITS CONCEPTION, WITH THE AIM OF IMPLEMENTING CONCRETE ACTIONS TO MINIMIZE THE DISTURBANCE OF THIS EMBLEMATIC SPECIES.

- **Resort villas are hidden behind the beaches** but also elevated in order to preserve turtles nesting sites on the *motu*.
- **A special lighting policy** has been implemented, with the use of red lights on the main nesting beaches, which have a wavelength that is little perceived by sea turtles.
- **Staff is made aware** and encouraged to participate in the monitorings conducted by the association.



# AN ENHANCED MONITORING

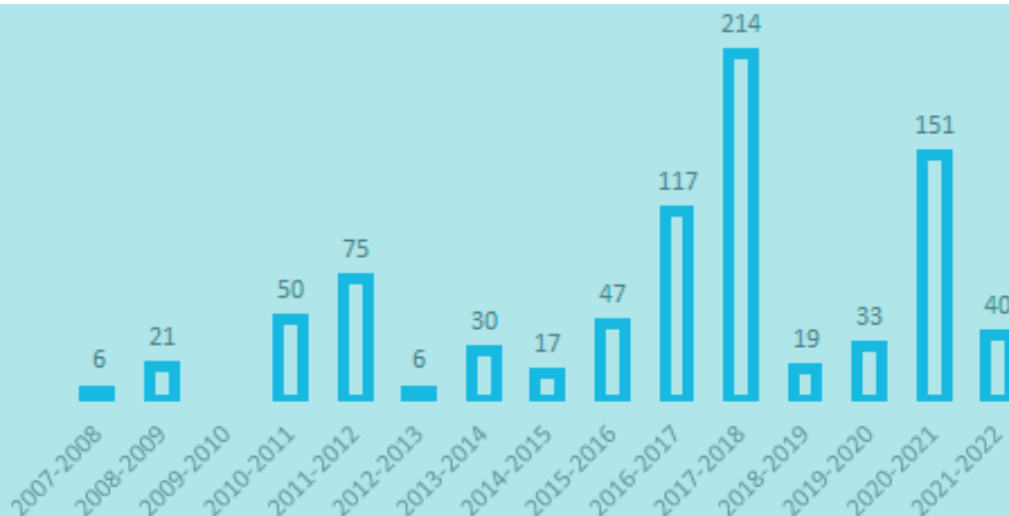


Special attention is paid to the *motu Onetahi* during the entire nesting season. Indeed, **every single night, up to 3 patrols are conducted** on the beaches in front of the villas by the association's field teams.

In addition, on this *motu*, a **circular fence is set up around the nests** throughout their incubation period. These protections allow a **careful observation of the hatchlings**, their state of health, their energy, and is a good way to fight against land predation. It also limits the negative effects of the resort's light pollution (such as desorientation), despite the efforts made by *The Brando*.



**Since the opening of the resort in 2014, the number of nesting events observed on the *motu* Onetahi seems to follow the positive evolution noted throughout the atoll, with a record in 2017-2018!**



Number of tracks recorded on the *motu* Onetahi each season



# PUBLIC AWARENESS

RAISING AWARENESS AND EDUCATING ON SEA  
TURTLE'S PROTECTION



# SHARING KNOWLEDGE



## IN THE FIELD...

The field teams of the association *Te mana o te moana* can be assisted in their mission by *The Brando* staff. Each person is made aware of the protection of sea turtles, but also the research and conservation projects set up.



Whenever possible, *The Brando* guests are also invited to participate in the nesting events taking place on the *motu Onetahi*.

These events are managed in partnership with *Tetiaraoa Society* foundation.

Conferences are regularly offered to hotel employees and guests throughout the nesting season.



## ...AND INTERNATIONALLY

The association regularly participates in conferences, seminars, symposia, etc. on sea turtles in French Polynesia, but also all over the world! This allows us to share our knowledge internationally as well as talk about the actions implemented in favor of a population of green sea turtles in the South Pacific.

# PROTECTING OUR ENVIRONMENT



## OCEAN WASTE



MOSTLY MADE UP OF PLASTIC FROM THE SEA, WASTE FOUND ON TETIAROA ATOLL BEACHES IS MAINLY MADE UP OF FISHING MATERIALS, PLASTIC BOTTLES, PLASTIC BAGS AND OTHER DAILY USE OBJECTS.

MICRO-PLASTICS ARE ALSO FOUND, MIXED WITH SAND AND SOIL, MAKING IT DIFFICULT TO COLLECT THEM.

**The presence of plastic pollution, coming from other islands of the *fenua* and elsewhere, is alarming for the health of our islands, both near and far!**



## BEACH CLEAN-UPS

The teams of *Te mana o te moana* take advantage of their numerous patrols on the beaches of Tetiaroa to collect as much waste as possible. Days dedicated to this mission are also sometimes organized.

For example, in 2006 and 2021, for Earth Day, many volunteers of the association came to survey and clean the beaches of the different *motu* for several days.

These kind of days are part of the global project to raise awareness and fight against plastic waste created by the association in 2019: [MANA HONU "Aita te pehu"](#).

Since its creation, *Te mana o te moana* has educated more than 120,000 children through its various educational programs!





# GOING FURTHER

MAINTAINING PROSPECTING EFFORTS AND  
MUCH MORE...



## MAINTAINING EFFORTS...

THE RESULTS OBTAINED DURING THESE LAST 15 YEARS CONFIRM THAT THE ATOLL OF TETIAROA IS A MAJOR NESTING SITE FOR THE GREEN SEA TURTLES POPULATION IN FRENCH POLYNESIA.



Responses to questions about the phenology of nesting events, the nesting cycle of females, nest characteristics, and hatchlings monitoring are just starting to emerge. It is essential to maintain this exhaustive monitoring so that Tetiaroa becomes the reference for other green sea turtle nesting sites in the South Pacific!

## ... AND START NEW PROJECTS

### STUDY REPRODUCTIVE MALES AND JUVENILES

The data obtained so far are focused on a part of the population, namely adult females and hatchlings. It would be necessary to expand our knowledge on all of the species age classes.

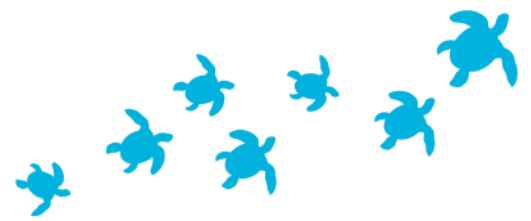
### STUDY MICRO-PLASTICS IMPACTS

Micro-plastics have different physical properties than natural sediments, high levels could change the conditions of nesting sites, especially in terms of incubation temperatures. Understanding the impacts of this pollution is becoming essential.

### FIND PARTNERS IN THE SOUTH PACIFIC

Colaborating with different structures protecting marine turtles in the Pacific by offering training, exchanges of data, etc.

### AND MUCH MORE...

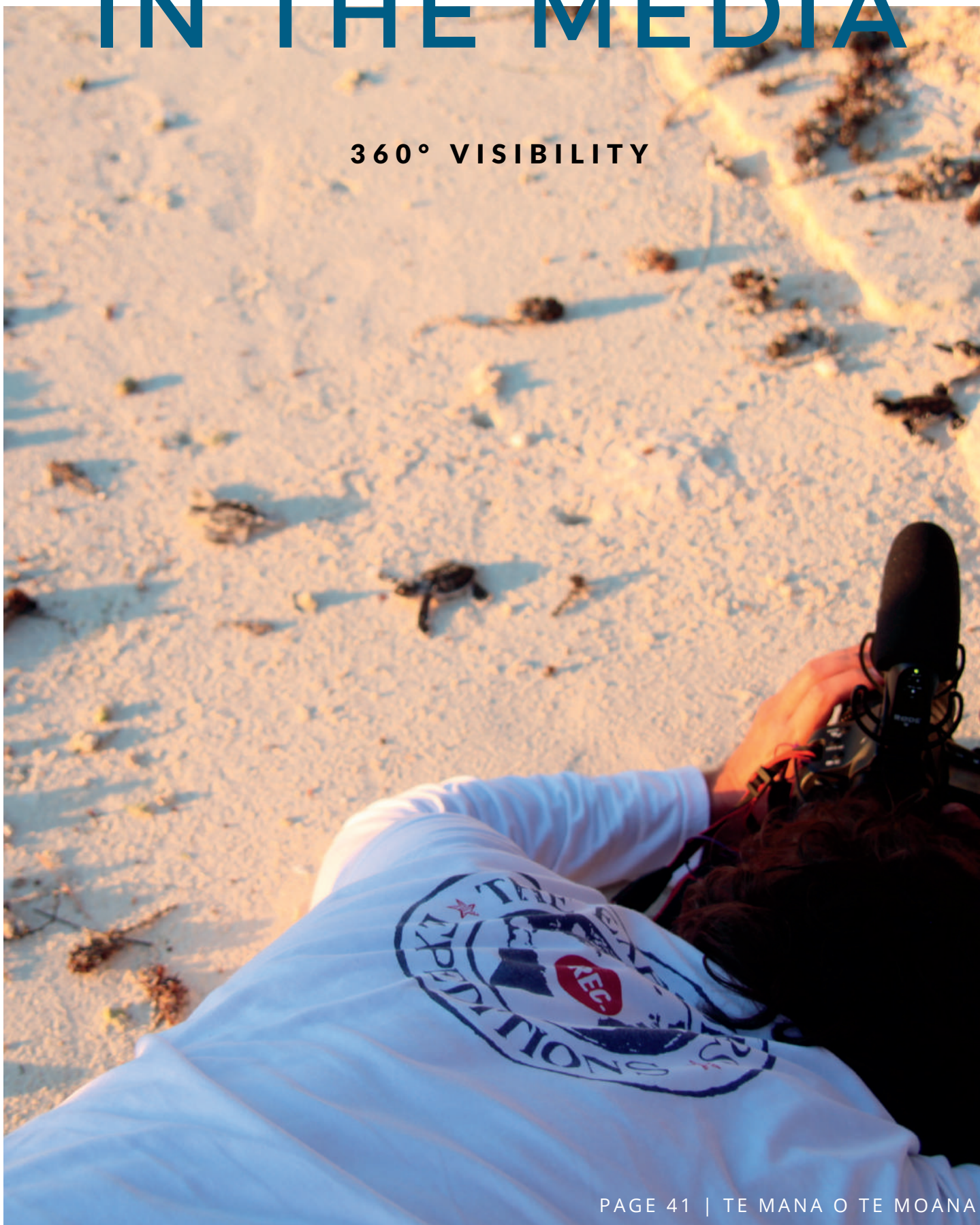




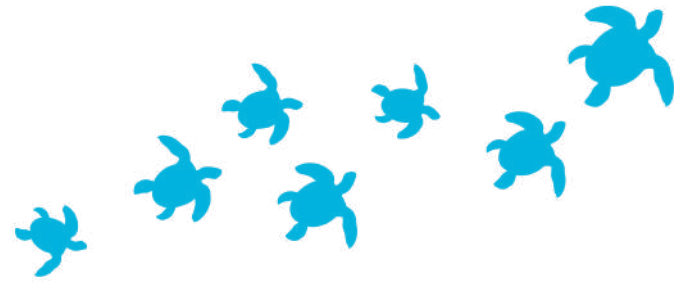


# IN THE MEDIA

360° VISIBILITY



# MEDIA COVERAGE



Since 2007, Te mana o te moana has been the subject of many press articles and reports:

- **In newspapers and local news magazines:** La Dépêche de Tahiti, Les Nouvelles de Tahiti, Tahiti Infos, Tahiti News, etc.
- **On the radio and local TV channels:** Polynésie 1ère, TNTV, Radio 1, Polynésie la 1ère radio, etc.
- **On national and international channels and TV shows:** Thalassa, le 20 heures de TF1, le 20 heures de France 2, Echappées belles, Une saison à Tahiti, 30 millions d'amis, 50 minutes Inside, ABC Ocean Mysteries, Tout s'explique, C'est pas sorcier, ADN, Ushuaia TV, Mission sauvage, Radio France, CBS, King 5, Disney channel, Animal Planet, The Explorer Network, etc.



# TV REPORTS



- **TNTV**
  - JOURNAL DU SOIR
  - ÉMISSION TATOU
  - WEBZONE
  - ÉMISSION MOANA
  - "L'Ô SUR TE MANA O TE MOANA"
- **POLYNÉSIE LA 1ERE**
  - JOURNAL DU SOIR
  - KID REPORTERS
  - VEVO, LE GRAND RENDEZ-VOUS
  - AHITEA
- **FRANCE 2**
  - JOURNAL DE 20H "LA CLINIQUE DES TORTUES"
  - TÉLÉMATIN
- **FRANCE 3**
  - "30 MILLIONS D'AMIS, LES RAIES DE MOOREA"
  - LES TEMOINS D'OUTRE-MER
- **FRANCE 4**
  - ÉCHAPPÉES BELLES "POLYNÉSIE, UN GOÛT DE PARADIS"
  - "UNE SAISON À TAHITI"
  - ÉCHAPPÉES BELLES "TE MANA O TE MOANA"
- **FRANCE 5**
  - LA QUOTIDIENNE "LA CLINIQUE DES TORTUES AU PARADIS POLYNÉSISIEN"
- **TF1**
  - LES MISS FRANCE AU CHEVET DES TORTUES MARINES
  - JOURNAL DE 20H "LES TORTUES DE TETIAROA"
  - JOURNAL DE 20H "LA CLINIQUE DE TORTUES"
  - 50 MINUTE INSIDE
- **THE EXPLORERS**
  - LA PROTECTION DES TORTUES VERTES À TETIAROA
- **GULLI**
  - "TAHITI QUEST"

ET PLUS ENCORE...



# MĀURUURU



# OUR PARTNERS



MAURUURU TO ALL OUR PARTNERS WHO HAVE SUPPORTED US FOR YEARS IN OUR MISSION TO PROTECT THE POPULATION OF NESTING GREEN SEA TURTLES ON THE ATOLL OF TETIAROA.

## MAIN PARTNERS

### → LA DIRECTION DE L'ENVIRONNEMENT

Authorizes and supports the association to carry out its research and conservation actions for sea turtles on the atoll of Tetiaroa.



### → FONDATION PRINCE ALBERT II DE MONACO



The foundation financially supported the project 'Climate change and sea turtles: Tetiaroa atoll observatory, monitoring and cartography'.

### → HINERAVA

Donates part of the profits of the "Tetiaroa Jewelry Collection" for the scientific monitoring carried out on the green turtles of Tetiaroa.



### → AIR TAHITI NUI



Allows the association to invite distinguished speakers and contributes to the team's travel to seminars and international conferences.

### → IFBD

Financial support for onshore monitoring carried out in Tetiaroa.



### → TETIAROA SOCIETY



Help in the logistics to carry out on the field monitoring on the atoll of Tetiaroa.

### → THE BRANDO

Supports and works closely with the association to protect the nesting population of sea turtles established on the atoll.



### → VILEBREQUIN



Support since 2016 on the monitoring carried out on the atoll of Tetiaroa by donating part of the profits from the sale of the swimsuit of the Te mana o te moana Collection.

### → PACIFIC BEACHCOMBER

Logistical support to the activities conducted on Tetiaroa atoll.



### → UNIVERSITY OF VETERINARY MEDICINE HANNOVER

Support since 2019 by donating equipment and providing interns to work on data.



# OUR PARTNERS



MAURUURU TO ALL OUR PARTNERS WHO HAVE SUPPORTED US FOR YEARS IN OUR MISSION TO PROTECT THE POPULATION OF NESTING GREEN SEA TURTLES ON THE ATOLL OF TETIAROA.

## MAIN PARTNERS

### ➔ ANDREW SABIN FOUNDATION



Financial support to the green sea turtle monitoring on Tetiaroa.

### ➔ JEAN-FRANCOIS CLERVOY & FRANK LEHOT

Financial support to the activities carried out on Tetiaroa atoll.

### ➔ KRISTIN HETTERMANN & SVEN LINDBLAD


Financial support and maintenance of the association's premises available on the atoll.

### ➔ VAN OORD



Donation of equipment and provision of a cartography expert to carry out erosion monitoring on the atoll of Tetiaroa.

### ➔ ESRI

Provision of the ArcGIS pack necessary to carry out monitoring on the atoll. 

### ➔ MIREILLE & RICHARD BAILEY

Financial support to the activities carried out on Tetiaroa atoll.

### ➔ CARL SWANES

Financial support to the green sea turtle nesting sites monitoring performed on Tetiaroa.



# OUR TEAM



A HUGE THANK YOU TO OUR TEAMS ON SITE: THE VOLUNTEERS, THE INTERNS, AS WELL AS ALL THE PEOPLE WHO HAVE DIRECTLY OR INDIRECTLY CONTRIBUTED TO MAKING THIS PROJECT POSSIBLE!



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