Chelonia mydas fibropapillomatosis in Baie Blanche, Tintamarre Island Saint Martin (FWI), an environmental sciences and veterinary cross-analysis

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Research Article

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Abstract

Chelonia mydas's fibropapillomatosis is a panzootic neoplastic disease that has been affecting the species since 1930's, starting in Key West Florida USA. Most likely induced by the Chelonian HerpesVirus 5 (ChHV5), fibropapillomatosis has been recorded as affecting all species of marine turtles, provoking the growth of malignant external and internal round shaped tumors to marine turtles, that share numerous genomic similarities with human cancers. This research focuses on the two pristine bays of Tintamarre island in Saint Martin (French West Indies), Baie Blanche and Lagon, where the early stage of fibropapillomatosis has been observed affecting juvenile *Chelonia mydas* resident of Tintamarre. The results obtained when cross-analyzing the environmental monitoring and studies performed of Tintamarre island and a veterinary health assessment of *Chelonia mydas* juvenile and sub-adult marine turtles of Baie Blanche, bring a different perspective to the environmental pressures that may be responsible of the expression of the disease in *Chelonia mydas.* Macro-algae and Cadmium (Cd) contamination of marine turtles habitat and foraging grounds are environmental parameters that are found as possibly inducing fibropapillomatosis clinical expression in Tintamarre in this research, concurring with previous publications findings. Tintamarre island in Saint Martin (FWI) is a key site to study pertaining to marine turtle fibropapillomatosis.

Introduction

Saint Martin (18,0° N 63,0° W) is a French oversea territory located on the northern part of the Caribbean Arch (Fig. 1). Tintamarre (18,1° N 62,9° W) is an uninhabited island located on the north-eastern side of Saint Martin (Fig. 2). Juvenile, sub-adult and adult *Chelonia mydas* affected by fibropapillomatosis have been observed around the island of Saint Martin at all stages of the neoplastic disease (Duffy et al. (2018), Yetsko et al. (2021)). A rigorous monitoring of marine turtles "nesting season" has been implemented since 2009, parallel to the scrupulous monitoring of the health of marine turtles habitat and foraging grounds that are coral reefs and seagrass meadows since 2007. As fibropapillomatosis is suspected to be co-triggered by environmental co-factors (Jones et al. (2015), Duffy et al. (2018), Yetsko et al. (2021)), such a regular assessment of marine turtles' habitats health may have brought some answers to the origins of the disease on the island and to the actions that may be recommended to be strengthened or implemented to mitigate the panzootic neoplastic disease.

Materials And Methods

This research analyses the studies published of Baie Blanche (18,116°N 62,988°W) and Lagon (18,109°N 62,983°W) bays, the two bays constituting Tintamarre island in Saint Martin (FWI), since the inception of marine turtles habitat monitoring on the island in 2007, and correlates these datas with the veterinary health assessments of marine turtles of Baie Blanche performed in 2015 and in 2017 (personal observations). This research attempts to identify environmental parameters likely to co-trigger fibropapillomatosis and/or its horizontal spread within the resident population of juvenile marine turtles of Tintamarre island in Saint Martin (FWI) (Jones et al. (2020)).

Results

1. The marine turtles of Tintamarre island in Saint Martin (FWI)

The resident population of juvenile *Chelonia mydas* of Baie Blanche (18,116°N 62,988°W)

Chelonia mydas hatchlings when they emerge of their nests disperse into the open Ocean on sargassum mats to enter a neretic foraging phase that may be delimited by ocean temperature isotherms (Lopez-Castro et al. 2013). Recruitment and aggregation to foraging grounds is non-random: when reaching an appropriate size and after 3 to 5 years (Jones et al. (2015)) in the North Atlantic gyre, marine turtles will actively move out of the constraints of the Gulf Stream current and associated gyres and recruit to adjacent foraging locations. Homing to a foraging area located in the proximity of a natal beach may also be affecting the architecture of the juvenile foraging aggregations. Westward-moving eddies are of a complex structure and may change the distribution of early stages of *Chelonia mydas* in the Caribbean region (Bass et al. 2006). Two sub-adult green turtle residing in Baie Blanche Tintamarre, Sasha (74 cm CCL) and Joe (similar size, unknown CCL), were satellite tagged in 2015. Sasha satellite tag emitted for 157 days while Joe's emitted for 307 days, allowing to collect significant data about the foraging behaviour of the green turtle resident population of Tintamarre. The satellite tracks of the green turtles showed they were predominantly foraging around the island of Tintamarre and occasionally emitted from a few miles away, in Pinel island bays in particular (Fig. 3 and Fig. 4).[1] The environmental characteristics of Tintamarre's bays are therefore the most probable to influence juvenile and sub-adult *Chelonia mydas* health status of Baie Blanche and Lagon bays (Jones et al. (2020)).

The nesting marine turtles of Tintamarre island Baie Blanche ((18,116°N 62,987°W) and Lagon (18,115°N 62,985°W)

Baie Blanche is a *Chelonia mydas* and *Eretmochelys imbricata* nesting beach. Lagon is a *Chelonia mydas*, *Eretmochelys imbricata* and *Dermochelys coriacea* nesting beach (Eckert et al. (2019), Saladin C. (2020)). Lagon was reported as a major nesting beach for *Eretmochelys imbricata* in IUCN SSC MTSG report of the island of 2020 (Saladin C. (2020)). The circulation of fibropapillomatosis in the resident population of *Chelonia mydas* may impact the health of these three population of marine turtles at Tintamarre as the disease is contagious, possibly affects all species of marine turtles (Jones et al. (2015), Duffy et al. (2018), Jones et al. (2020)), and may disseminate abroad on their migratory path.

2. A Veterinary health assessment of *Chelonia mydas* juvenile and sub-adult marine turtles of Baie Blanche (18,116°N 62,987°W)

Observations and distance health assessments of resident juvenile and sub-adult *Chelonia mydas* foraging in Baie Blanche were performed in 2015 and 2017 (personal observations). These in-water surveys were of approximately 2 hours each and covered the areas described in Fig. 5.

During the survey of 2015, 8 juveniles and subadults *Chelonia mydas* were observed swimming and foraging on *Thalassia testudinum* seagrass meadow of Baie Blanche. One green turtle was presenting a tumor at the junction of her right shoulder and neck of an average of 5 cm of diameter.

In 2017, 9 *Chelonia mydas* were observed swimming and foraging on *Thalassia testudinum* seagrass meadow, one of them at a juvenile stage, was presenting a tumor of a few millimeters invading the inferior eyelid of her right eye, that may have originated from the conjunctiva. No parasites nor phoretic fishes (*Remora* spp.) were observed on the affected juvenile *Chelonia mydas*. *Remora* spp., which are phoretic fishes to marine turtles and are also able to attach to boats, are nonetheless frequently observed attached to *Chelonia mydas* in Baie Blanche.

3. Review of the studies of Baie Blanche seagrass meadows and Chicot coral reef station

Studies of Baie Blanche seagrass meadows

Baie Blanche seagrass meadows is mix, mainly composed of *Thalassia testudinum* (29%) and of *Syringodium filiforme* (70%). The invasive seagrass *Halophila stipulacea* was observed on one radial (1%) during a study performed in 2016 (Bousquet C. (2016)), with an estimated growth rate of 1,81 cm/j-1 (Moisan E. (2014)). The study of 10% of the seagrass meadow of Baie Blanche in 2016 showed a fragmentation of the native seagrass meadow due to scars created by boat anchors. A quarter of the boats frequenting Tintamarre Bay have been reported to anchor directly onto the seabed. Interruption of the seagrass meadow of less than 2 meters (“mitages”) were rare (1% of the study area), whereas larger interruptions of the seagrass meadows of more than 2 meters (“fragmentations”) represented 9% of the study area. 128 scars (0,012/m2) due to boat anchors were reported, some of them showing a dynamic of repairs by native seagrass species. The seagrass meadow dynamic appeared to be rapidly changing during the study, showing a change of the total density, of the distribution of the seagrass species, in particular of *Syringodium filiforme*, and signs of repairs of the boat anchors scars. Tintamarre seagrass meadow was scored 2 “good health status” as a mix seagrass meadow of *Thalassia testudiunum* and *Syringodium filiforme* with non to little presence of macro-algae. Although, inappropriate direct boat anchoring into the seagrass meadow of Tintamarre is a chronic stress affecting the seabed and can favor the invasion of the Bay by *Halophila stipulacea* (Bousquet C. (2016)).

Four stations of mix seagrass meadows of *Thalassia testudinum* and *Syringodium filiforme* on St Martin were selected and extensively studied in 2017 and 2018, with the aim to develop a seagrass meadow monitoring method: Grand Case, le Rocher Creole, Tintamarre and Galion. The potential anthropogenic pressures gradient was estimated based on the proximity and intensity of anthropogenic perturbations, four criterions were considered: turbidity, organic matter, nutrients and pollutants. Tintamarre was indexed as a site showing little anthropogenic pressures (Kerninon F. (2020)). Structural and morphological features of Tintamarre site were recorded, physiological parameters including ratios of stable isotope δ15N, proportion of nutriments N and P, and traces of metallic elements Mn, Fe, Zn, Pb, Cd, Cr, Cu, Ni and Hg concentrations in dry forage, were measured in leaves and rhizomes of *Thalassia testudinum* (Table 1, Table 2 and Table 3). Content in trace metallic element Mn Fe and Zn showed higher

concentrations linked to the gradient of anthropogenic pressures. Cu element values showed inter-annual variations and were not linked to the gradient of anthropogenic pressures. There were no significant differences linked to the gradient of anthropogenic pressures of content in Cr and Ni. Hg was not detectable. Mn Ni and Cd were more abundant in leaves than rhizomes of *Thalassia testudinum.* Foliar necrosis of *Thalassia testudinum* was not correlated to the gradient of anthropogenic pressures. 30 % of the seagrass meadows studied were showing signs of grazing from the indigenous herbivorous fauna (Kerninon F. (2020)).

Zn, Cd, Cr, Hg, and Cu were identified as posing a potential risk to marine turtle populations around the world and skin cells of marine turtles have been demonstrated to be the most sensitive organ to these cytotoxic compounds (Finlayson et al. (2019)). Concentrations of elements with long biogeological half-lives in *Chelonia mydas* tissues, such as Cd, are dose and age dependent, tending to dilute as the turtle grow, which can explain the sensitivity of juvenile green turtles to trace metallic pollutants' toxicity. For instance, neritic forage Cd concentrations of 0.10, 0.13, and 0.19 µg/g of dry forage would result in 10%, 20% and 50% kidney cell mortality (Dogruer et al. (2021)). However Tintamarre bay in Saint Martin (FWI) showed very low pollution in trace metallic elements tested both in 2017 and 2018 in *Thalassia testudinum* rhizomes and leaves. Thresholds were estimated for *Thalassia testudinum*, depending on the anthropogenic pressures gradient and pristine conditions were defined as: 0,8 < δ15N < 2,5‰; N < 1,8%; P < 0,2%; Mn < 50 µg/g; Pb < 0,75 µg/g; Fe < 100 µg/g; Zn < 20 µg/g. Tintamarre is listed as a bay showing pristine conditions regarding the *Thalassia testudinum* seagrass meadow characteristics (Kerninon F. (2020)). Nevertheless, when considering Cd concentrations in *Thallassia testudinum* (Kerninon F. (2020)), results showed a notable variation between the concentration in leaves and rhizomes of *Thalassia testudinum* (Table 1 and Table 2), a significant annual variation (Table 2), and in 2018, exceeded the threshold of 0,1 µg/g of dry forage, susceptible to induce, after a prolonged exposure above this level, adverse health effects on organs of *Chelonia mydas* (Dogruer et al. (2021)).

Chicot coral reef station (18,06512°N 62,58980°W)

Chicot is the coral reef station found at the top of a rocky spur at a 12 meters depth at the South-eastern side of Tintamarre island (Chalifour J. (2017), Fig. 2). The reef's position in the open sea may assure its pristine quality via the constant renewal of its waters. Chicot coral reef station has been monitored since 2007 by the Reserve Naturelle de Saint Martin and has been showing a strong proportion of non calcareous macro-algae of essentially *Dictyota* spp. genra since 2007, with a mean coverage of 32,5% of the reef between 2007 and 2016, associated with a yearly increase of the coverage by non-calcareous macro-algae of the reef since 2017, which can be correlated to an increase of nutrients N and P at the site from anthropogenic pollution sources (Chalifour J. (2017), Chalifour et al. (2021)). 65% of the coral reef was covered by non-calcareous macro-algae in the second half of 2020 (Chalifour J. (2021)). Eutrophic coastal ecosystems may promote herpesvirus infections among herbivores : disease and Nitrogen-foot-prints were reported as elevated where macroalgae is chronic and widespread (Van Houtan et al. (2010), Jones et al. (2015)). *Chelonia mydas* marine turtles forage on macroalgae that likely sequester environmental N as arginine. Arginine is known to regulate herpesviruses and contribute to tumor

formation, Arg is involved in cell inflammation, immune dysfunction and in promoting viral tumors. Arg may be specifically important for herpesviruses which are linked to fibropapillomatosis tumors. Experiments showed that herpes does not grow without Arg, as Arg is a key building block of the viral envelope that facilitates localization, fusion, and entrance to host cell nuclei (Van Houtan et al. (2010), Jones et al. (2015)). Anthropogenic pollution of Tintamarre coral reef is likely to co-trigger marine turtle fibropapillomatosis at the site. Cyanobacterias were nonetheless reported as absent at Chicot coral reef (Chalifour J. (2017), Jones et al. (2015)). It is also important to note that the presence of sea urchins *Diadema* spp. is rare at Saint Martin's coral reefs (< 0,2 individuals per m2) and is a sign of the overall mediocre health of the coral reefs around the island (Chalifour J. (2017)).

[1] See Sasha satellite tracks animated map at http://www.seaturtle.org/tracking/index.shtml?tag_id=139068a&biga=1 (Accessed 27th August 2021); and Joe satellite tracks animated map at http://www.seaturtle.org/tracking/index.shtml?tag_id=139067&anime=1 (Accessed 28th August 2021), courtesy of the Reseau Tortues Marines Guadeloupe.

Discussion

At the time of the 6th mass extinction, the anthropogenic pressures threatening all species of marine turtles are considerable and the threat of the contagious neoplastic fibropapillomatosis seem to increase, affecting northern areas of the globe where the disease had not been observed before (Duffy et al. (2018), Yetsko et al. (2021)).[2] The results of this research in Tintamarre island in the Caribbean concur with previous publications describing that macro-algae and Cd are probable environmental factors triggering the clinical expression of the disease in juvenile marine turtles (Van Houtan et al. (2010), Dogruer et al. (2021)). The observation of early stages of fibropapillomatosis in the resident population of juvenile and sub-adult *Chelonia mydas* is nonetheless contradicting the pristine conditions of Tintamarre bays (Jones et al. (2015), Duffy et al. (2018), Yetsko et al. (2021)). The study of Tintamarre bay's environmental pressures on marine turtles appears therefore essential to continue to be conducted so as to advance the knowledge and mitigation possibilities of the disease. The role of UV radiation and water temperature are suggested to be investigated in Tintamarre (Jones et al. (2015), Duffy et al. (2018)), as the prevalence of *Prorocentrum*, a dinoflagellee algae producing toxic okadaic acid that is a known tumor promotor (Jones et al. (2015)). Apart from Cd, whether the trace metallic elements concentrations measured in *Thalassia testudinum*'s leaves and rhizomes are toxic for marine turtles is unknown. The impact of organic pollutants on marine turtles of Baie Blanche is also unkwown. Measures of trace metallic elements and organic pollutants in *Syringodium filiforme* leaves and rhizomes may bring important data about the environmental contamination and the risks threatening the marine turtles inhabiting Tintamarre island. A precision veterinary research focused on marine turtles in Tintamarre is fundamental to be performed, and is recommended to include but is not limited to, the screening of the presence of the most likely etiologic agent of marine turtle fibropapillomatosis (Jones et al. (2015), Duffy et al. (2018), Yetsko et al. (2021)), the oncogenic Chelonian Herpesvirus 5 ChHV5, and chelonid fibropapilloma-associated

herpesvirus (CFPHV), in hatchlings, nesting and resident marine turtles, clinically healthy and affected animals. The biomonitoring of trace metallic element (Villa et al. (2019)) and organic pollutants emanating from boats exposure in the blood and scutes of marine turtles may also bring significant results so as to explain the presence of the disease in juvenile and sub-adult *Chelonia mydas* of Tintamarre island in Saint Martin (FWI), and shed light on the mitigation actions that may be implemented so as to tackle the panzootic neoplastic disease.

[2] See https://www.cabi.org/isc/datasheet/82638#tooverview (Accessed 29Th August 2021).

Conclusion

Baie Blanche and Lagon at Tintamarre island appear as crucial bays to study marine turtles' fibropapillomatosis. Tintamarre's conditions of anthropogenic pressures for *Thalassia testudinum* are considered pristine despite a high boat density, based on trace metallic elements (Mn, Pb, Fe and Zn) and δ15N, N and P elements concentrations. However resident juvenile and sub-adult marine turtles, mainly foraging at and occasionally in the close vicinity of Tintamarre island, are clinically affected by early stages of fibropapillomatosis. These results differ from previous publications where *Chelonia* mydas's fibropapillomatosis was strongly linked to the water quality of the foraging bays of the green turtles (Jones et al. (2015), Duffy et al. (2018), Yetsko et al. (2021)). The concentration of the trace metallic element Cd measured in 2018 in leaves of *Thalassia testudinum* seagrass meadows of Tintamarre nonetheless exceeded the recommended standard for *Chelonia mydas* of 0,1 µg/g of dry forage (Dogruer et al. (2021)) and its concentration may significantly vary throughout the year. Non calcareous macroalguae have been largely covering Tintamarre's reefs and affirm that they may be a significant co-trigger of fibropapillomatosis at the site (Van Houten et al, (2010), Jones et al (2015)). A precision veterinary research centered on marine turtles appears essential to be performed so as to continue to attempt to elucidate the origins of the disease in Tintamarre and suggest actions to implement to mitigate the impacts of marine turtle fibropapillomatosis.

Abbreviations

Arg
Arginine
CCL
Curved Caparace Length
Cd
Cadmium
ChHV5
Chelonian HerpesVirus 5
FP

fibropapillomatosis
FWI
French West Indies

Declarations

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Tables

Due to technical limitations, Tables 1-3 are only available as a download in the supplemental files section

Figures

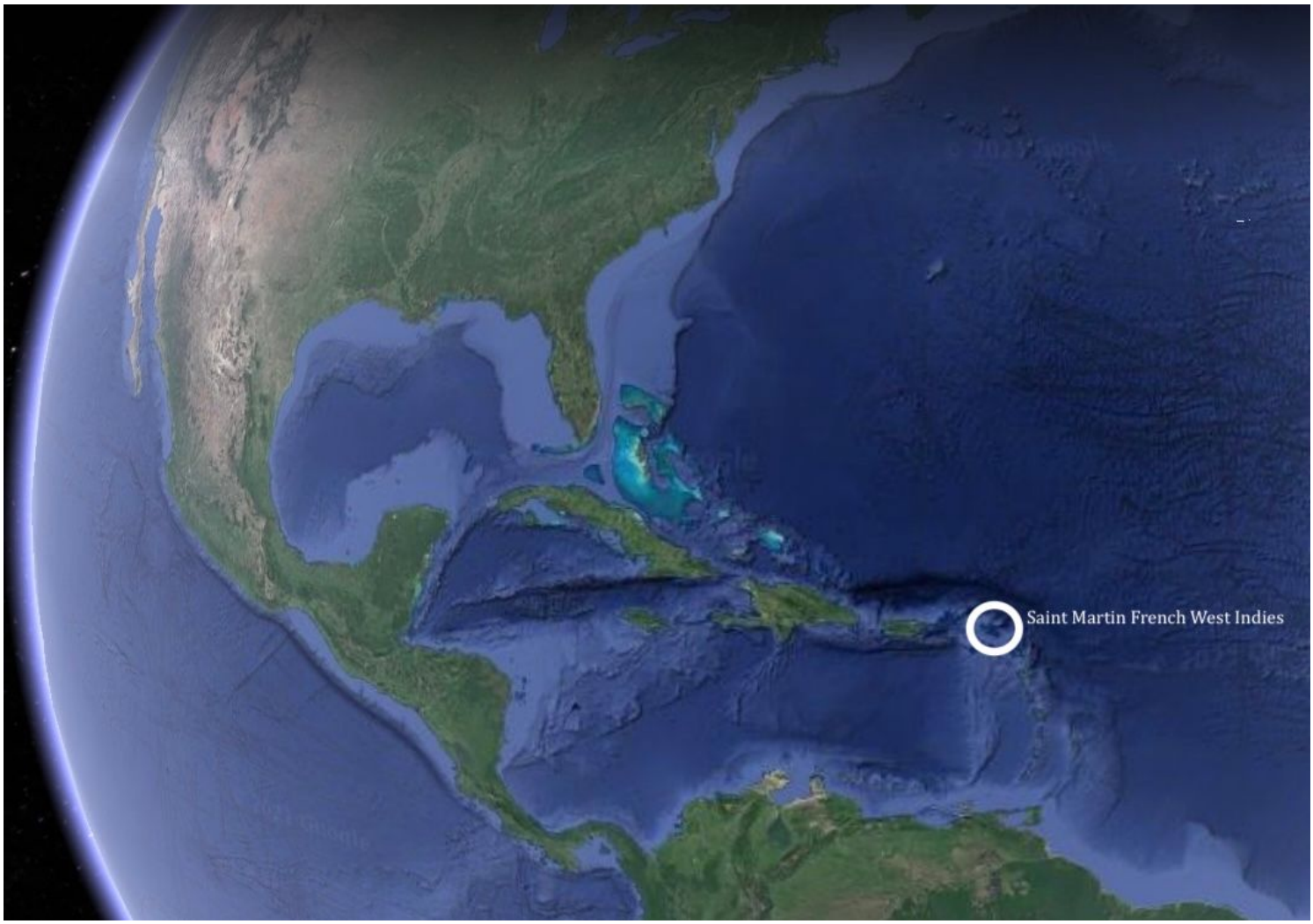

Figure 1

Localisation of the island of Saint Martin in the Caribbean Arch - source image Google Earth

Figure 2

Localisation of Tintamarre island at the north-eastern side of Saint Martin

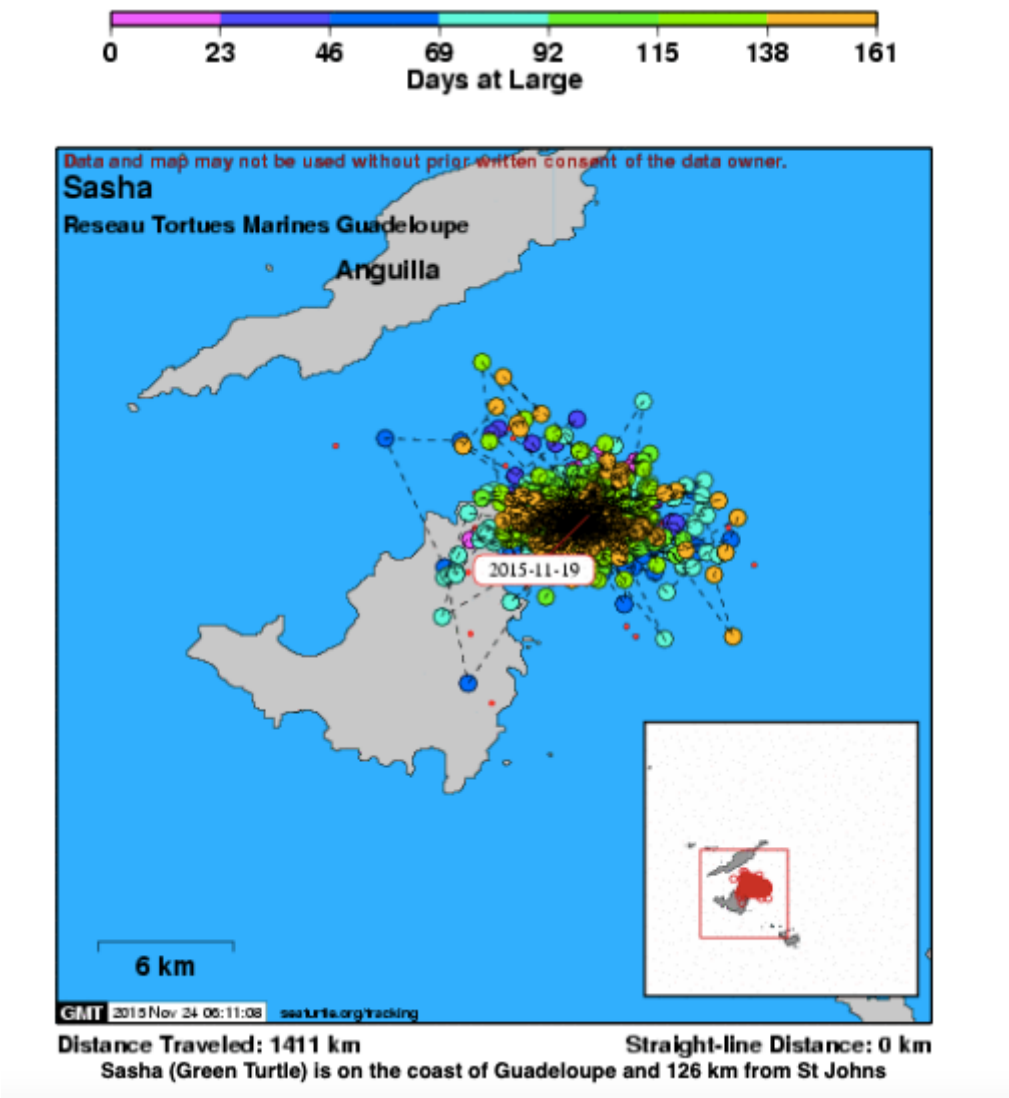

Figure 3

Satellite tracks emitted by Sasha the green turtle in 2015 in Tintamarre island - source SeaTurtle.org, courtesy of Reseau Tortues Marines Guadeloupe

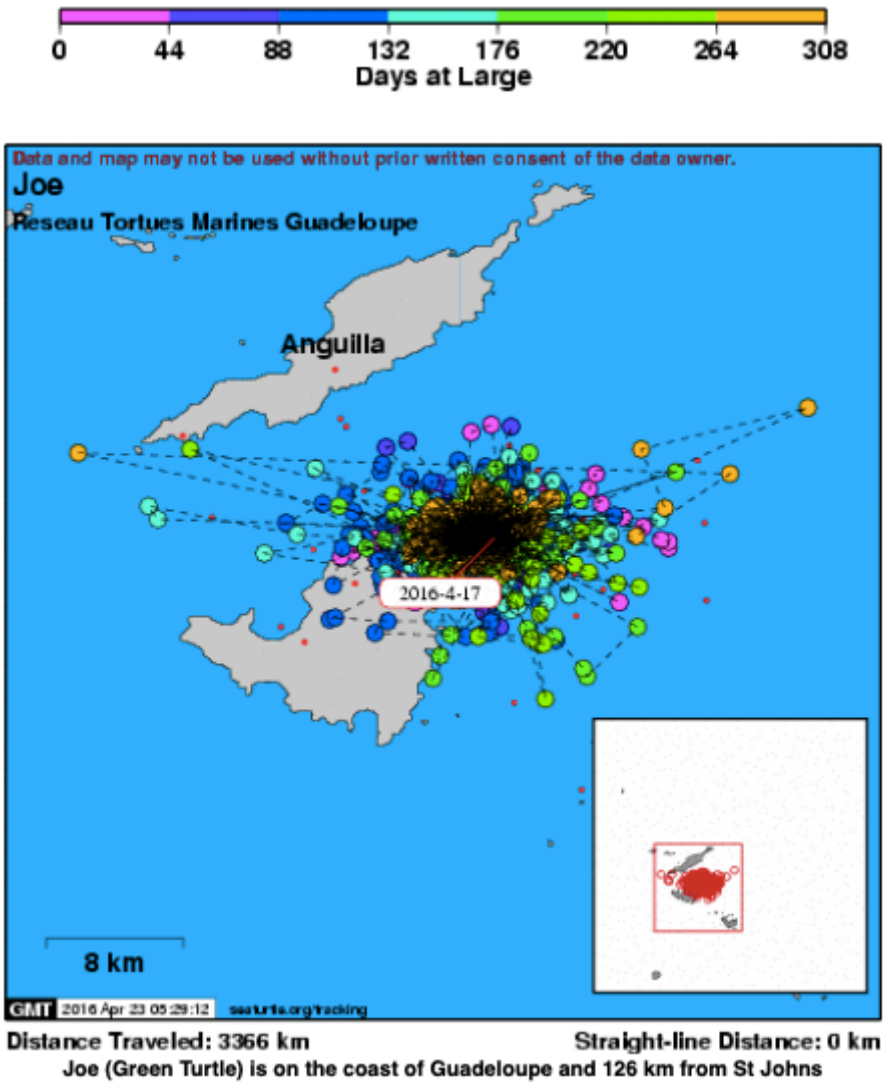

Figure 4

Satellite tracks emitted by Joe the green turtle in 2015 in Tintamarre island - source SeaTurtle.org, courtesy of Reseau Tortues Marines Guadeloupe

Figure 5

Areas covered by the veterinary in-waters surveys of 2015 and 2017 in Baie Blanche, Tintamarre island Saint Martin (FWI)

Supplementary Files

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