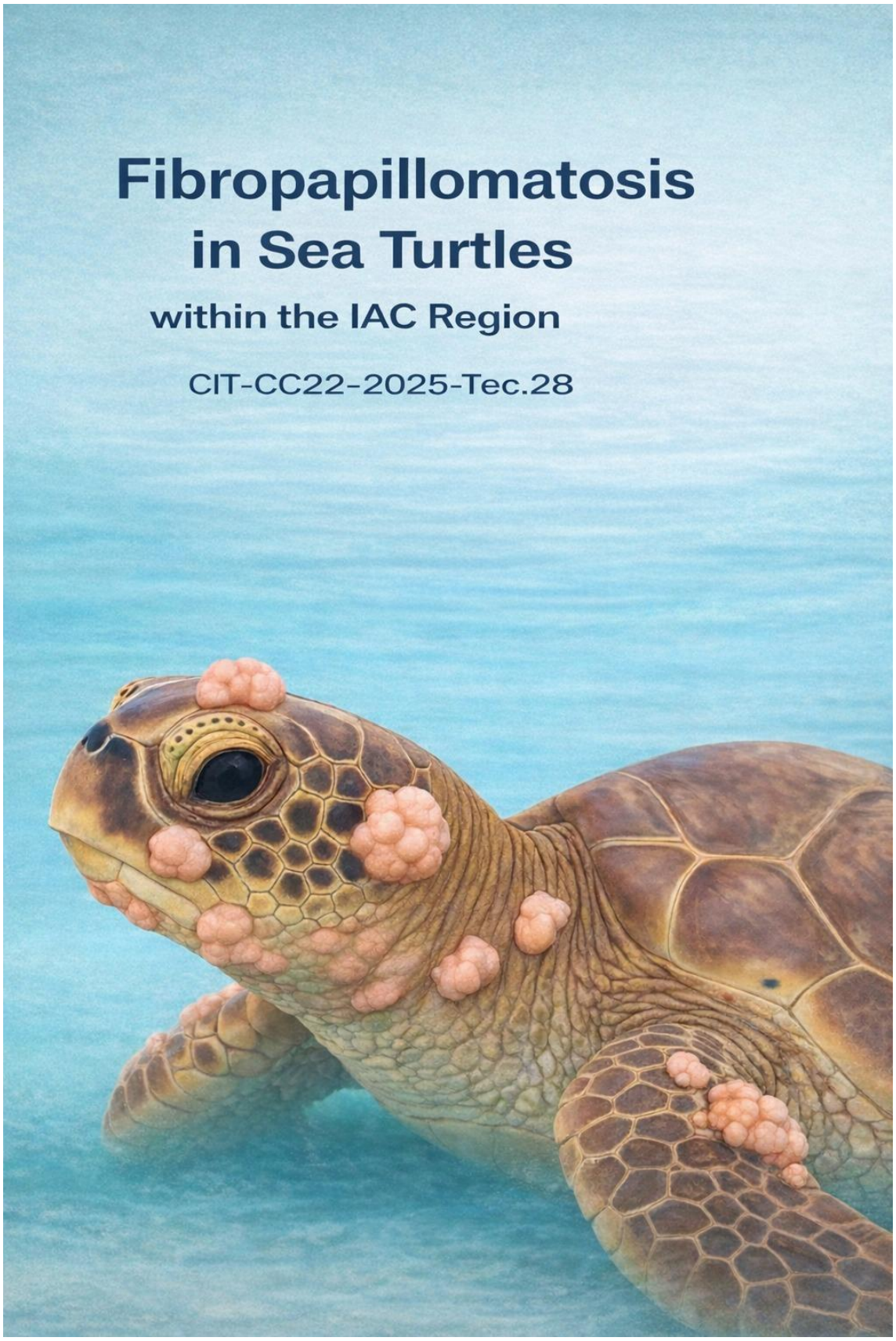
Fibropapillomatosis in Sea Turtles

within the IAC Region

CIT-CC22-2025-Tec.28



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1. Introduction

Fibropapillomatosis (FP) in sea turtles is a debilitating, infectious disease characterized by the formation of single or multiple benign cutaneous fibro-epithelial tumors, with involvement of visceral organs in some individuals (Herbst et al., 1999; Reséndiz et al. 2022). It is a widespread disease affecting sea turtles globally; typically affecting juveniles (Williams, et al. 1994; Ene et al., 2005) but has also been found in adults (Chaloupka et al., 2008; Dujon et al., 2021).

The disease has increased in recent years in some countries, e.g., Brazil (Celini, et al., 2002; Tagliolatto et al., 2016) and Puerto Rico (Kang, et al., 2008; Patrício, et al., 2011), and has appeared in countries where it had not been previously documented (Dos Santos, et al., 2010; Rodenbusch, et al., 2012; Duarte, et al., 2012; Reséndiz, et al., 2016; Balladares, et al., 2017; Álvarez-Varas, et al., 2019; Shaver, et al., 2019). It has also decreased in prevalence in some countries, e.g., Hawaii, USA (Chaloupka, et al., 2008, 2009; Hargrove et al., 2016; Work et al., 2020). The disease can result in significant debilitation and death, e.g., if tumors obstruct vision through growths on the eyelids and cornea and impair feeding, affect organ function, or predispose turtles to the development of comorbidities, such as anemia or infections. The consequences of FP for demographic parameters like growth, survival, and emigration are not well known (Lelong et al., 2025), but the disease is known to regress naturally in many animals.

Early studies of FP identified an association between the herpesvirus, Chelonian Herpesvirus (ChHV5), and tumor development, and demonstrated the transmissible nature of the disease. The interaction between immunological and environmental factors is thought to play a fundamental role in FP development (Work et al., 2019), with environmental cofactors including eutrophication, upland sources of pollution, and algal blooms, as well as physical oceanographic influences, contributing to the disease, although these relationships remain poorly understood (Herbst 1994; Hargrove et al., 2016; Lelong et al., 2025).

The prevalence of the disease varies significantly by region; in some areas, numerous cases have been reported in local populations, while in others it is only occasional (Herbst 1994), and prevalence can vary greatly even in adjacent bays (Lelong et al., 2025).

This overview highlights the importance of considering fibropapillomatosis not simply as a wildlife health issue, but also as an indicator of possible ecosystem alterations that impact sea turtles and the coastal environments they utilize.

The objective of this Technical Document is to update knowledge of this disease and assess its impact within the member countries of the Inter-American Convention on Sea Turtles (IAC). It also offers recommendations for monitoring, diagnosis and treatment.

2.Etiology

Fibropapillomatosis is associated with Chelonid herpesvirus 5 (ChHV5), a double-stranded, enveloped DNA virus composed of approximately 132 kilobase pairs, belonging to the Alphaherpesvirinae subfamily, genus Scutavirus (Ackerman et al., 2012). This association is based on several studies in which intranuclear viral inclusions morphologically consistent with herpesvirus were found in tumor cells by electron microscopy (Jacobson et al., 1989; Jacobson et al., 1991).

Transmissibility was confirmed by innoculating the skin of healthy young green turtles hatched and reared in captivity, with tumor lysates that were treated so as to preserve the viability of enveloped viruses. The innoculated turtles developed tumors typical of FP, and ChHV5 was demonstrated in these tumors using multiple methods (Herbst et al., 1995). Intranuclear inclusions were also observed in cell cultures of green turtle skin, later confirmed by conventional and nested PCR in fibropapillomas of all species (Ariel et al., 2017), with quantitative PCR showing a higher viral load in tumors than in intact skin. Associated HV antigens have also been detected through histopathology and immunohistochemistry. More recent molecular studies have identified different viral variants (Greenblatt et al., 2005), have characterized the ChHV5 genome (Ackermann et al., 2012), detected ChHV5 in sea turtles from various localities with and without tumors (e.g., Page-Karjian et al., 2015; Alfaro-Núñez et al., 2016), and have examined viral evolution in relation to disease occurrence (Ene et al., 2005; Patrício et al., 2012). Other pathogens have also been detected in the tissues of sea turtles with FP, including other viruses, e.g. Retroviridae (Casey et al., 1997), Papillomaviridae (Lu et al., 2000; Mashkour et al., 2021), Iridoviridae (Reséndiz et al., 2015), and Tornovirus 1 (Ng et al., 2009), but none of these appear causally linked with FP. Parasitism by turtle blood flukes (spirorchiid trematodes) was also proposed as a cause of FP in the early years, based on the presence of fluke eggs within tumors. However, this was mostly disregarded after the discovery of ChHV5 and the critical transmission study. No further evidence of a relationship between flukes and FP has been found (Dujon et al., 2021).

To establish the cause of an infectious disease, ideally one needs to fulfil Koch's four postulates or principles (also known as Henle-Koch postulates): the isolation of the infectious agent,

experimental infection of a host without the disease, observe subsequent development of the disease, and re-isolate the agent or provide another demonstration of its presence. Despite efforts by many researchers (e.g., Lu et al., 2000; Work et al., 2009), CHV5 has not been isolated and cultivated in a manner that allows further transmission studies or completion of disease postulates. For this reason, ChHV5 is considered "associated" with fibropapillomatosis in sea turtles rather than it being the confirmed, causative agent. Nonetheless, it can be argued that more scientific evidence exists that ChHV5 causes FP in sea turtles than for the association between human papillomaviruses and cervical cancer in women – a disease for which extensive vaccination programs exist.

Common features of herpesvirsuses in general are for infection to be relatively widespread within a host population, for disease to manifest in a small proportion of infected individuals, and for infection to be lifelong with the virus entering periods of latency (e.g., Sehrawat et al., 2018). As viral detection methods have improved, ChHV5 has not only been detected in the skin of healthy turtles but also in the environment, such as in the marine water column and in sand (Farrell et al., 2021). That a higher concentration of ChHV5 DNA glycoprotein B has even been observed in the skin of healthy animals compared to the tumor-free skin of turtles with fibropapillomatosis, demonstrates the persistent latency of the infection (Alfaro-Nuñez et al., 2016) and points to certain cofactors that must trigger the disease. These factors may include the presence of endo- or ecto-parasites, sudden temperature changes, biotoxins (Shaver et al., 2019), pollution (Vilca et al., 2018), and immune status. At the beginning of disease development, there is a high level of lymphocyte infiltration in the epidermal region of the tumor, i.e., there is an immune response to tumor cells and/or viral infection. Defenses then weaken, so immunosuppression may not be a prerequisite for the development of fibropapillomatosis, but rather a consequence of the advanced stage of the disease (Perrault et al., 2021).

Four phylogeographic groups of ChHV5 variants have been identified - Eastern Pacific (USA, Costa Rica, Chile and Ecuador), Midwest Pacific (Australia and Hawaii), Western Atlantic/Eastern Caribbean (Florida, Barbados, Brazil), and Atlantic (Gulf of Guinea, Brazil, Puerto Rico) (Patrício et al., 2012, Reséndiz et al., 2022). The variants are thought to at least partially reflect turtle movements (Patrício et al., 2012) and are shared among sympatric species occupying the same locations, indicating interspecies transmission within regions (Page-Karjian et al. 2021). This supports the importance of contact transmission as the most likely form of contagion (Patrício et al. 2012).

Two of the critical questions that remain to be elucidated about ChHV5 and FP are: 1) why the disease emerged to epizootic proportions in some populations in the late 1900s; and 2) what factors are driving differences in disease trends among populations (i.e., declining, increasing, or stable disease prevalence over time).

3. Epidemiology

Fibropapillomatosis has been found in all species of sea turtles. Since the first report in the green sea turtle in 1936 by Smith and Cohates (1938), it has appeared in the following marine turtle species: *Caretta caretta* in 1990 (Harshbarger 1991), *Natator depressus* in 1991 (Limpus et al., 1993), *Lepidochelis kempii* in 1993 (Barragan and Sarti, 1994), *Lepidochelis olivacea* in 1997 (Aguirre et al., 1999), *Eretmochelys imbricata* in 1996 (D'Amato and Moraes-Neto 2000), and finally, it was discovered in *Dermochelys coriacea* in 1997 (Huerta et al., 2002).

The most severely affected species is *Chelonia mydas* (Dujon et al., 2021), where FP has reached epizootic proportions in several populations (Adnyana et al., 1997; Work and Balazs 1999; Flint et al., 2010; Chaves et al., 2013). In places such as Florida, USA, it reached a prevalence of 69% (Foley et al., 2005), in Hawaii between 31 and 69% (Aguirre et al., 1994; Work et al., 2020), and in some states of Brazil, prevalences have reached 34.4% (Torezani et al., 2010).

The disease is mainly distributed in warm water areas of the tropics and their surroundings (Herbst et al., 1995; Adnyana et al., 1997), although it has been recorded in temperate zones. The southernmost cases to date were a turtle found in Quilmes, Argentina (34°43´00¨S 58°16´00¨N) (Origlia et al., 2023) and San Antonio, Chile (33°35’41’’S, 71°36’26.9’’W)(Álvarez-Varas et al, 2019). The distribution of the disease may be influenced by the effect of temperature on the virulence of herpesviruses. Haines and Kleese (1977) conducted a study with 3-week-old wild green turtles in a controlled environment where the only variable was temperature. They identified that gray spot disease, caused by Chelonid herpesvirus type 1, developed earlier compared to the control group when the temperature was either increased gradually or abruptly, and there was also a positive correlation between the increase in temperature and the severity of the lesion. Sea turtles with FP under care at rehabilitation facilities are known to exhibit higher rates of tumor growth during warmer months, suggesting a temperature effect on disease progression (Stacy et al., 2018; Page-Karjian et al., 2019).

Various environmental factors have been associated with FP, such as exposure to pollutants derived from industrial, agricultural, and domestic effluents, since the affected animals are

primarily found on the coast, and an increased FP prevalence has been observed in these areas, which have lower water renewal (Guimarães dos Santos et al., 2010). Significant associations have been found between nutrient availability, phytoplankton concentration, and the presence of fibropapillomatosis. The highest prevalence is found in areas with low silicate concentrations, high nitrite concentrations, and high levels of toxic phytoplankton. These algae flourish at high water temperatures (greater than 30°C) and can produce biotoxins and neurotoxins that can exert inflammatory effects and exacerbate oxidative responses, which are sources of cancer (Dujon et al., 2021).

Animals with tumors are not frequently found in the smaller oceanic phase size classes. The strong association between the increased frequency of the disease in areas with higher turtle densities, along with several phylogenetic studies support the hypothesis that the most important transmission route is through direct contact (Ene et al., 2005; Jones et al., 2020). The presence of more ChHV5 virus in tumors suggests that the shedding of tumor cells could be an important source of infection. Transmission through mechanical vectors such as leeches or trematodes has also been indicated. In a study conducted by Farrell et al. (2021) all leeches feeding on fibropapillomas were positive for ChHV5 DNA, while only half of leeches on healthy tissue were positive. However, a meta-analysis did not observe a clear relationship between the spatial distribution of leeches and cleaner fish and the prevalence of fibropapillomatosis (Dujon et al., 2021). Indirect transmission is thought to be associated with virus transmission in water, sand, and sediment (Farrell et al., 2021). Elimination of ChHV5 has been observed in ocular, oral, and cloacal swabs, and its presence has been reported in skin biopsies, body fluids, tissues, and organs of tumor-free turtles in populations where fibropapillomatosis is common (Page-Karjian et al., 2015; Page-Karjian et al., 2017; Monezi et al., 2016; Farrell et al., 2021).

This disease most commun attack juveniles (Wiliams et al. 1994, Ene et al. 2005), however cases also have been found in adult individuals (Chaloupka, et al. 2008, Dujan et al. 2021).

4. Symptoms

Fibropapillomatosis (FP) in sea turtles is clinically identified by the development of proliferative masses (tumors), which can be cutaneous (external) and visceral (internal) (Page-Karjian 2019). These may appear as flat plaques, verrucous nodules, lysed or polypodoid, lobulated, or cauliflower-like (Herbst 1994; Page-Karjian 2019; Reséndiz et al., 2022). The color, number, and size of FP masses can vary widely, depending on the location of the tumor and the severity

of the disease, ranging from grayish white to dark brown, and ranging in size from a few millimeters to more than 30 cm in diameter (Herbst 1994; Page-Karjian 2019; Reséndiz et al., 2022). These tumors can be affected by secondary invaders such as fungi and/or bacteria, causing infections in the ulcerated lesions (Aguirre et al. 1994; Herbst 1994; Page-Karjian 2019; Resendiz et al., 2022).

Both stranded and free-ranging sea turtles suffering from FP generally show signs of debilitation or cachexia. Severe FP has been associated with various abnormalities in clinical pathology findings, such as anemia, leukopenia, lymphopenia, eosinopenia, and heterophilia (Work et al., 1999; Aguirre et al., 1995; Page-Karjian 2019). Hypoproteinemia, hypocalcemia, hypoalbuminemia, and hyperglobulinemia can also be detected in green turtles affected by FP (Work et al., 1999; Page-Karjian 2019). These changes, which indicate anemia of chronic disease and antigenic stimulation, are consistent with the clinical manifestation of FP. Turtles with severe FP often have multiple comorbidities, including bacterial, fungal, algal or parasitic infections (Aguirre et al., 1994; Herbz 1994; Page-Karjian et al., 2014).

4.1 External Tumors

Cutaneous tumors are the most characteristic and commonly recorded clinical sign of FP. They can present as single or multiple lesions anywhere on the skin of the body, carapace, and plastron (Herbst 1994). The usual histological characterization of FP-type cutaneous tumors shows papillary epidermal hyperplasia supported by thick fibrovascular stalks, with a variable ratio of epidermal to dermal proliferation (Herbst 1994; Herbst et al. 1999; Page-Karjian 2019).

Lymphocytes and macrophages can be observed at the tumor edges, as well as infiltrating tumors in numbers ranging from moderate to significant. In certain tumors, histological evidence of clinical regression is present (Page-Karjian 2019).

Tumors are generally most frequently located in areas such as:

- The corners of the mouth (causing feeding problems).
- Anterior and posterior flippers (which can limit swimming and mobility).
- The neck and cloacal region.
- The eyelid and cornea
- The plastron and carapace, less frequently.

4.2 Internal Tumors

The internal tumors observed in sea turtles are not metastases from skin tumors. Metastasis is the spread of neoplastic cells to different tissues from the primary internal tumor. Histological

descriptions of these tumors include fibromas, myxofibromas, and fibrosarcomas (Page-Karjian 2019).

By contrast, examinations of oropharyngeal fibropapillomas performed by Aguirre et al. (2002) indicated that the internal tumors were comparable to the typical external fibropapillomas previously described in green turtles. The size, appearance, and anatomical location of the tumors confirmed that these turtles showed total or partial occlusion of the nasopharynx, glottis, larynx, and adjacent tissues (Aguirre et al., 2022). Thus, the oropharyngeal fibropapillomas were considered locally invasive and significantly affected the morphophysiology of breathing and feeding in these turtles (Aguirre et al., 2002).

4.3 General Signs

Depending on the number and location of the tumors, affected turtles may present general symptoms (Aguirre et al. 2002; Page-Karjian 2019), namely:

- Lethargy and reduced swimming activity.
- Abnormal buoyancy or loss of hydrodynamic control.
- Difficulty feeding and progressive weight loss.
- Respiratory problems.

In advanced stages, the combination of symptoms endangers the animal's life in its natural habitat, making it susceptible to predators, boat strikes, or incidental capture.

5. Diagnosis

The diagnosis of fibropapillomatosis is based on a combination of clinical observations, histopathological studies, and molecular techniques. Although it is easily recognized on macroscopic examination, a conclusive diagnosis requires histopathological findings compatible with FP, and diagnosis of ChHV5 DNA using molecular techniques is also recommended (Page-Karjian 2019; Reséndiz et al., 2022). If possible, all turtles undergoing rehabilitation with FP should undergo imaging studies to rule out visceral tumors (Page-Karjian 2019).

5.1 Clinical Examination and Severity Classification

External lesions are easily recognizable and can be multiple. As mentioned above, their morphology varies from smooth to warty or cauliflower-shaped nodules. They are found in soft tissues, including the eyelids, corners of the mouth, flippers, neck, and cloacal region.

When they affect ocular structures, they can cause blindness, while in flippers, they limit locomotion (Herbst 1994; Jacobson et al., 1989, Work and Balazs 1999).

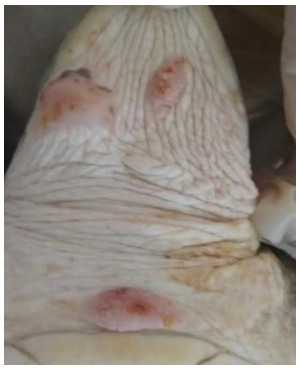
Depending on the size of the FPs, there is a classification to determine the degree of severity (Aguirre et al., 1999; Work and Balazs 1999, Reséndiz et al., 2022):

- 1 mm to 5 cm are considered grade 1 (mild)
- 5 cm and 10 cm are considered grade 2 (moderate)
- Greater than 10 cm are considered grade 3 (severe)

Score 1

(Image: Eduardo Reséndiz)

Score 2



(Image: Ong Karumbé-Uruguay)

Score 3

(Image: Eduardo Reséndiz)

5.2 Diagnostic Histopathology

A definitive diagnosis of cutaneous FP requires histopathological findings compatible with this disease, although it is easily recognized on macroscopic examination. Cutaneous tumors associated with fibropapillomatosis (FPs) present characteristics such as orthokeratotic hyperkeratosis, papillary epidermal hyperplasia with broad fibrovascular stalks, and a variable ratio of epidermal to dermal proliferation (Jacobson et al., 1989; Herbst et al., 1999; Reséndiz et al., 2022), balloon-shaped degeneration in epidermal cells, inclusion bodies, fibroblast proliferation in the dermis, and angiogenesis in the dermis. Inflammatory and immune cells, such as lymphocytes and macrophages, can be detected at tumor margins and infiltrating tumors (Herbst 1995; Reséndiz et al., 2022).

5.3 Molecular diagnosis (PCR, qPCR, serology, and complementary techniques)

The presence of ChHV5 can be deduced through the identification of its DNA using molecular diagnostic methods such as conventional PCR, Nested PCR or qPCR. To date, several detection methods have been validated, focusing on genes encoding ChHV5 DNA polymerase (UL30), capsid proteins (UL18), viral envelope proteins (glycoproteins B and H), as well as unusual genes (F-Sial) (Quackenbush et al, 2001; Alfaro-Núñez et al., 2016; Jones et al., 2020; Reséndiz et al. 2022).

Numerous studies have detected ChHV5 DNA in blood samples and in buccal and cloacal swabs from turtles with fibroblast proliferation lesions; however, these samples have lower sensitivity to ChHV5 DNA compared to tumor or skin biopsies (Reséndiz et al., 2022). It is recommended that, in cases of suspected fibroblast proliferation, ChHV5 confirmation be performed using a combination of methods. Diagnostics such as PCR, *in situ* hybridization, or immunohistochemistry are also useful. Furthermore, it is useful to directly observe the zones of herpesvirus morphogenesis through histopathology or transmission electron microscopy to confirm the relationship between the appearance of the virus and tumor lesions (Reséndiz et al., 2022).

For a more exhaustive diagnosis of ChHV5 infection, sequencing of PCR amplicons is necessary. For example, a serological immunoassay that uses recombinant antigens to detect antibodies against ChHV5 glycoprotein H has been established, although it is not yet commercially available (Herbst et al., 2008; Page-Karjian 2019; Reséndiz et al., 2022).

6. Treatment

6.1 General considerations and clinical management

The treatment of fibropapillomatosis presents significant challenges, as the etiology is multifactorial, there is no definitive cure, and the veterinary resources used in marine reptiles are limited. It is also important to note that medical testing, disease identification, care, therapeutic care, management, surgical procedures, and the use of medications are tasks that are undertaken only by veterinarians (Mader 2006; Reséndiz et al., 2022). For the care of turtles suffering from FP, adequate water quality and temperature, species-specific nutrition, hydration, pain control, and treatment of secondary infections should be considered (Norton 2005). Antiviral therapies such as L-lysine or acyclovir can be applied as support to improve care; however, to date, no controlled research has been conducted demonstrating the effectiveness of these treatments in relation to FP lesions (Page-Karjian 2019).

6.2 Surgery and Tumor Removal Procedures

Surgical removal is currently the most effective method for treating cutaneous FP lesions present on the skin, in the mouth, and in the eyes. Local or general anesthesia is used, depending on the size, number, and level of invasion of the tumors. Removal of multiple tumors often requires general anesthesia (Page-Karjian 2019).

The most commonly used technique for tumor removal is the carbon dioxide (CO_2) laser. Alternatives also available include rapid excision, extensive local excision, cryotherapy, radiosurgery, electrochemotherapy, and electrical cauterization (Mader 2006; Page-Karjian 2019).

The CO_2 laser reduces bleeding in the area of tumor expansion by cauterizing and sealing the cut site(s) while the tissue incision is made (Mader 2006; Page-Karjian 2019). Laser power, pulse rate, and handpiece size can vary depending on the surface area and depth of the tumor(s) (Page-Karjian 2019).

FP lesions with plaque-like characteristics or large, broad-based lesions can be removed using reduced power, while pedicled or narrow-based tumors require higher power. It is essential to proceed with caution when removing lesions from the eye, using low power and pulse rates, ensuring that corneal tissue is not damaged by ablating angled ocular tumors (Mader 2006).

Generally, sutures are not necessary, and the area where the tumor has been removed can be allowed to heal by secondary intention. However, if a deep tumor is removed, sutures may be essential. It is important to administer analgesics and antibiotics preoperatively. After tumor

removal, careful postoperative monitoring should be performed, including keeping patients dry in a tub for 24 hours after the procedure (Page-Karjian 2019).

6.3 Postoperative Care and Recovery Prognosis

Skin wounds can heal completely within 12 weeks. Multiple surgeries to remove tumors are acceptable and may be preferred for turtles with large numbers of tumors (Mader 2006; Page-Karjian 2019). A 4- to 6-week recovery interval should be allowed between surgeries. An important consideration is the potential for tumor regrowth. In one study, 38.5% of green turtles that underwent tumor surgery showed tumor regrowth an average of 36 days after the procedure (Page-Karjian et al., 2014; Page-Karjian 2019). If tumors do regrow and can be resected, it is preferable to avoid continuous cycles of resection and tumor regrowth. To help prevent tumor recurrence, it is essential to include a wide margin of healthy tissue in the resection whenever possible, as healthy skin around tumors can act as a source of ChHV-infected cells (Lackovich et al., 1999). Reducing tank water temperatures by 2–5°C after tumor removal surgery may also help decrease the likelihood of viral reactivation (Page-Karjian 2019).

Another possible treatment to prevent relapse is the use of homeopathy (Narita et al., 2021). Homeopathy could also be used in cases where tumors are inoperable or the animal is in critical condition and cannot undergo surgery. Further research is needed to evaluate its effectiveness in treating FP.

7. Prognostic Indicators and Considerations for Release

The number of tumors, their location on the body, morphological characteristics and disease progression, as well as the overall health status and severity of other health conditions, should serve as the basis for establishing classification criteria for sea turtles affected by FP (Mader 2006). In certain cases with an unfavorable prognosis, surgical intervention is not possible; this is the case with visceral or intraocular tumors, tumors that have afected deep bone structures (carapace, plastron), and aggressive recurrent tumors (Mader 2006; Page-Karjian et al., 2014). Turtles with these lesions may be considered clear candidates for euthanasia. Other types of tumors are more manageable and should be analyzed individually, taking into account comorbidities, available resources, treatment options, and the possibility of quarantine. Although one study found that green turtles with ocular tumors were significantly less likely to be successfully rehabilitated than those with non-ocular tumors, turtles with less severe ocular tumors may be eligible for treatment if materials and trained personnel are available. In the same analysis, turtles with only flat, plaque-like FP lesions were found to have a significantly more favorable prognosis, including spontaneous regression of the lesion in over 50% of cases,

compared with turtles with more warty FP lesions (Page-Karjian et al., 2014). Generally, FP is viewed as an incidental finding in loggerhead sea turtles (*Caretta caretta*), and rehabilitation initiatives targeting these turtles with FP may result in a more positive outcome than those focused on green turtles with the same condition (Page-Karjian 2019).

8. Reports from IAC Member Countries

8.1 Methodology

A survey was designed and sent to member countries of the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC). The form (Annex 2) was developed by the Fibropapillomatosis Working Group (WG-Fibropapilloma) and distributed to the members of the Scientific Committee and members of the Consultative Committee of Experts. The objective was to gather updated information on the presence and characteristics of the disease in each country.

For this analysis, six main variables were considered: species affected, type of diagnosis, anthropogenic impact, year of the first case, and total documented cases. In the latter case, only the absolute values reported by member countries were included, excluding those presented as percentages (Figure 1 and Table 1). The information came from government sources, academic institutions, and non-governmental organizations.

8.2 Results and Comparative Analysis

Eighteen responses were obtained from the IAC member countries: Belize, Dominican Republic, Venezuela, Brazil, Mexico, Costa Rica, United States, Peru, Chile, Uruguay, Argentina, Panama, Guatemala, Honduras, Netherlands – Caribbean Netherlands (Bonaire, and Sint Eustatius), Sint Maarten, as well as from collaborating countries such as Aruba, which provided valuable information at the request of the IAC Secretariat (Table 1). In the case of Ecuador, the information included comes from the record published by Cárdenas et al. (2019); however, since this data comes from a single publication and it is not official government information (national case data), it is only mentioned in this study as reference. We include a list of all collaborators that provides answers to the survey (Annex 3). Figure 1 shows the species of sea turtles that presented fibropapillomatosis in each region and IAC member country.

Species documented with FP include:

- *Chelonia mydas* (green sea turtle)
- *Caretta caretta* (loggerhead sea turtle)

• *Lepidochelys olivacea* (olive ridley sea turtle)

• *Lepidochelys kempii* (Kemp's ridley sea turtle)

• *Eretmochelys imbricata* (hawksbill sea turtle)

• *Dermochelys coriacea* (leatherback sea turtle)

FP primarily affects *Chelonia mydas*, a species recorded in most IAC member countries, including the Caribbean and the eastern Atlantic and Pacific regions. Other records focus on subtropical and tropical areas, where the disease has also been detected in *L. olivacea, E. imbricata*, and, to a lesser extent, *D. coriacea, C. caretta*, and *L. kempii*.

The oldest records are from the United States (1938) and Venezuela (prior to 1979), followed by Brazil (1986), Mexico, and Belize (1990). Subsequently, in the following decades, new cases were reported in countries such as Costa Rica and Uruguay (both with records in 2000). In the last 10 years, new records have been reported between 2015 and 2019 in countries such as Peru, the Dominican Republic, Aruba, and Chile. This shows that the detection and understanding of the disease have spread eastward and southward across the Pacific (Table 1, Figure 2).

Of the total records submitted by IAC members, and considering the information available for Ecuador, 15 positive records of at least one case of fibropapillomatosis in sea turtles were found. This indicates records in 14 of the 16 IAC member countries.

However, Sint Eustatius (Caribbean Netherlands), Guatemala, and Honduras have not reported any cases to date.

The United States is probably the country with the highest number of reported cases; followed by Brazil, Bonaire, Mexico, and Uruguay, and then Venezuela and Costa Rica. For the other countries, the reported cases were either single cases or close to ten (Figure 3).

Approximately 47% (7) of the 15 countries that reported cases of the disease and responded to the survey affirmatively reported the presence of internal tumors associated with fibropapillomatosis, while the rest have not observed this type of lesion or lack information on the matter. This is a very complex issue since, to evaluate the presence of internal tumors, a necropsy must be performed if the specimen is deceased, and imaging studies (expensive and impractical equipment) must be performed if the specimen is alive. Therefore, many animals may have internal tumors that we are unaware of.

Most cases of fibropapillomas have been observed in marine areas with anthropogenic impacts such as urban pollution, pesticide use, livestock farming, and hydrocarbons, among others. Therefore, a higher frequency of cases in areas with these types of impacts could be related. However, the United States mentioned in the survey that, according to studies, this correlation is not always true, as there are areas with high urban growth (e.g., San Diego Bay) and low prevalence of the disease, as well as pristine areas (e.g., Big Bend, Florida) with high prevalence.

It is worth noting that studies linking fibropapillomatosis to environmental pollutants have only been conducted in Brazil, Mexico, Chile, the United States, Bonaire, and Uruguay, demonstrating limited geographic coverage in the evaluation of potential etiological factors associated with the disease.

Regarding the developmental stage of affected individuals, the disease has been recorded in juvenile, subadult, and adult turtles, with available reports indicating no clear predominance of one age group over another. This trend could be related to methodological differences between studies, local variations in exposure to risk factors, or limitations in sample size, among other factors.

Table 1. Information provided by IAC Member Countries and other collaborators (*) in the region of Fibropapillomatosis in Sea Turtles.

Country	FP	Species	Diagnostic technique	Anthropogenic impact	First report	N°cases	Internal tumors
Argentina	Yes	*Chelonia mydas*	Histopathological analysis Molecular diagnosis		2019	1	
Aruba*	Yes	*Chelonia mydas*	Direct observation	Not mentioned	2005	5	No
Belice	Yes	*Chelonia mydas*	Direct observation	Contamination	1990	7	Yes
Bonaire-Caribbean Netherlands	Yes	*Chelonia mydas*	Direct observation	Landfill Tourism activity	2006	400	Yes

Brasil	Yes	*Chelonia mydas* *Lepidochelys olivacea* *Eretmochelys imbricata* *Caretta caretta*	Direct observation Histopathological analysis Other studies	Fishing Urban pollution Pesticide pollution Industrial pollution	1986	>7000	Yes
Chile	Yes	*Lepidochelys olivacea*	Direct observation Histopathological analysis Molecular analysis	Not specificed	2015	1	Yes
United States	Yes	*Chelonia mydas* *Caretta caretta* *Lepidochelys olivacea* *Lepidochelys kempii* *Eretmochelys imbricata*	Direct observation Histopathological analysis Molecular analysis	Yes, they exist, but it does not specify which ones.	1938	>1000	Yes
Guatemala	No					0	No
Honduras	No					0	
México	Yes	*Chelonia mydas* *Caretta caretta* *Lepidochelys olivacea* *Lepidochelys kempii* *Dermochelys coriacea*	Direct observation Histopathological analysis Molecular diagnosis Immunohistochemistry Electron microscopy	Fishing Tourism Pesticide Pollution Industrial Pollution Port Activity	1990	138	Yes
Sint Eustatius-Caribbean Netherlands	No	—	—	—		0	Yes

Sint Maarten-Netherlands	Yes	*Chelonia mydas*	Direct observation	Contaminación urbana	2010	7	No
Panamá	Yes	*Lepidochelys olivacea* *Eretmochelys imbricata*	Direct observation	It exists, but it is not specified which ones	2010	5	No
Perú	Yes	*Chelonia mydas agassizii*	Histopathological analysis	Fishing Livestock Aquaculture Urban pollution	2019	1	No
República Dominicana	Yes	*Chelonia mydas*	Direct observation Histopathological analysis	Urban pollution	2019	13	Yes
Uruguay	Yes	*Chelonia mydas*	Direct observation Histopathological analysis	Agriculture	2000	123	No
Venezuela	Yes	*Chelonia mydas* *Eretmochelys imbricata* *Lepidochelys olivácea*	Direct observation Histopathological analysis	Urban pollution Hydrocarbons	Reports prior to 1979	79	No

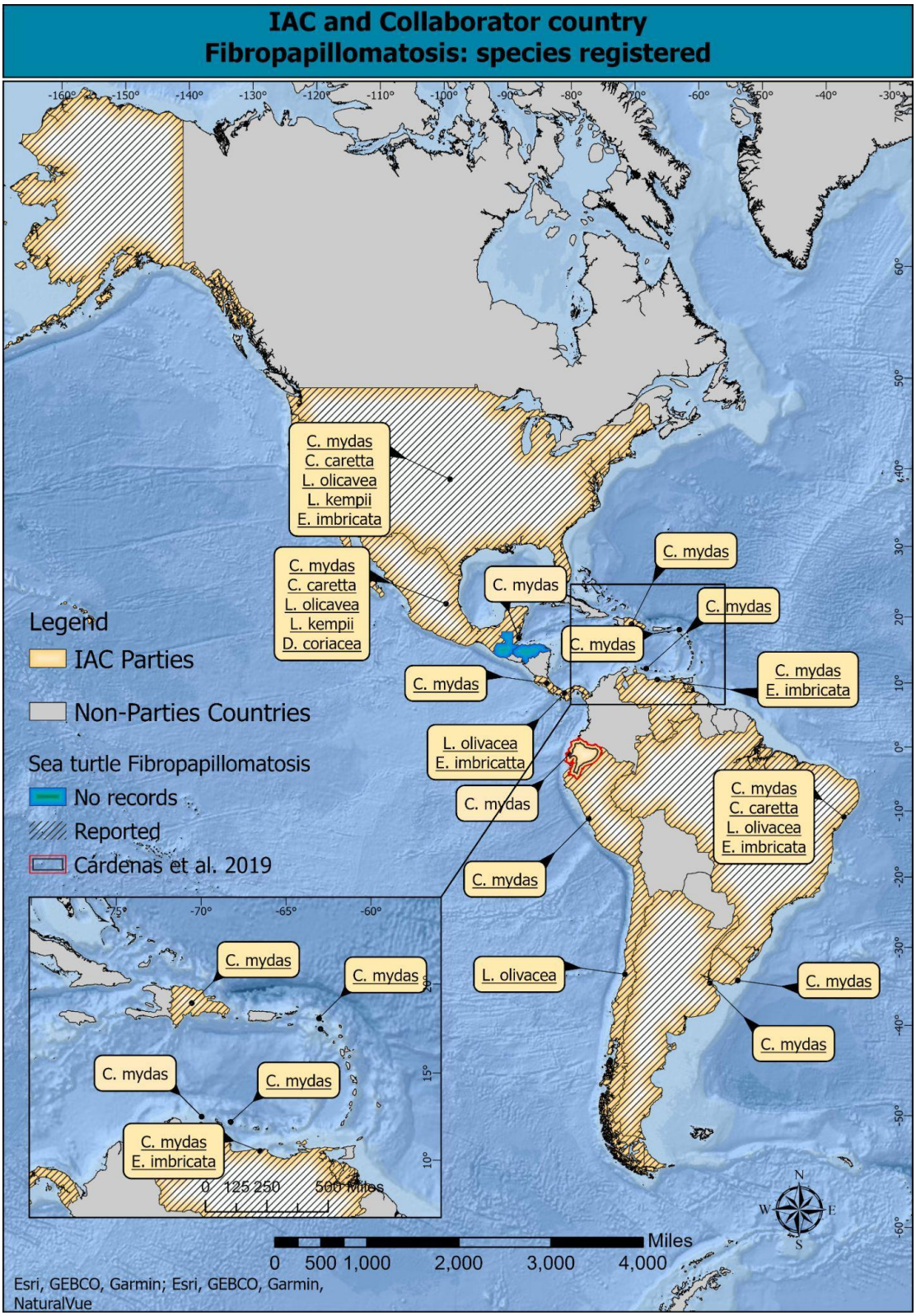


Figure 1. The map shows the geographic area of the IAC member countries (in yellow) and non-member countries (in gray), in the American continent and island regions of the Caribbean and the Pacific. For each country or region, the species of sea turtles in which fibropapillomatosis (FP) has been documented are indicated.

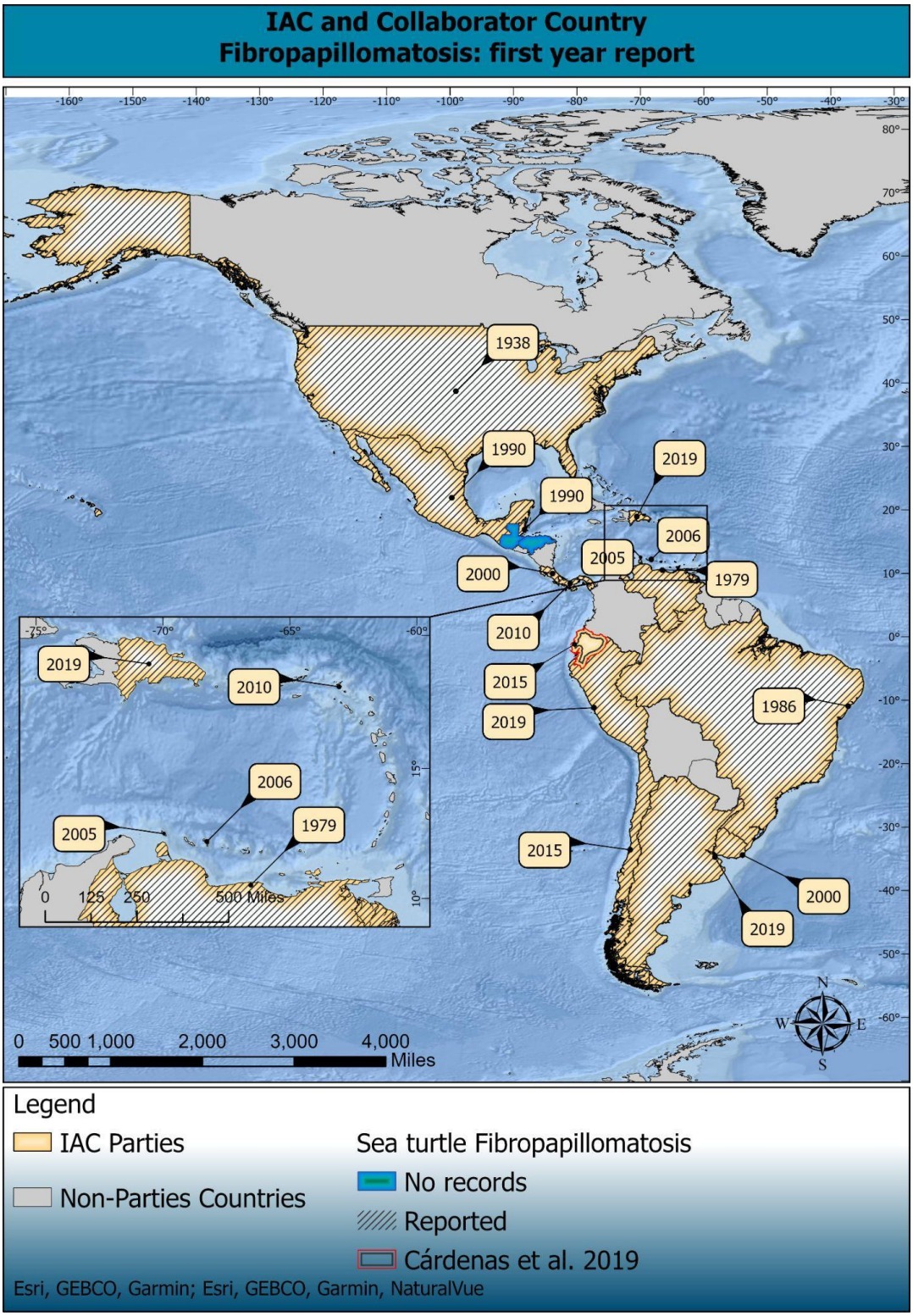


Figure 2. The map shows the geographic range of IAC member countries (in yellow) and non-member countries (in gray), encompassing the Americas and island regions of the Caribbean and the Pacific with confirmed FP cases and the year of the first reported case, while areas with no records are shown in light blue. Areas with information from specific scientific publications (such as Cárdenas et al. (2019)) are indicated with a red border.

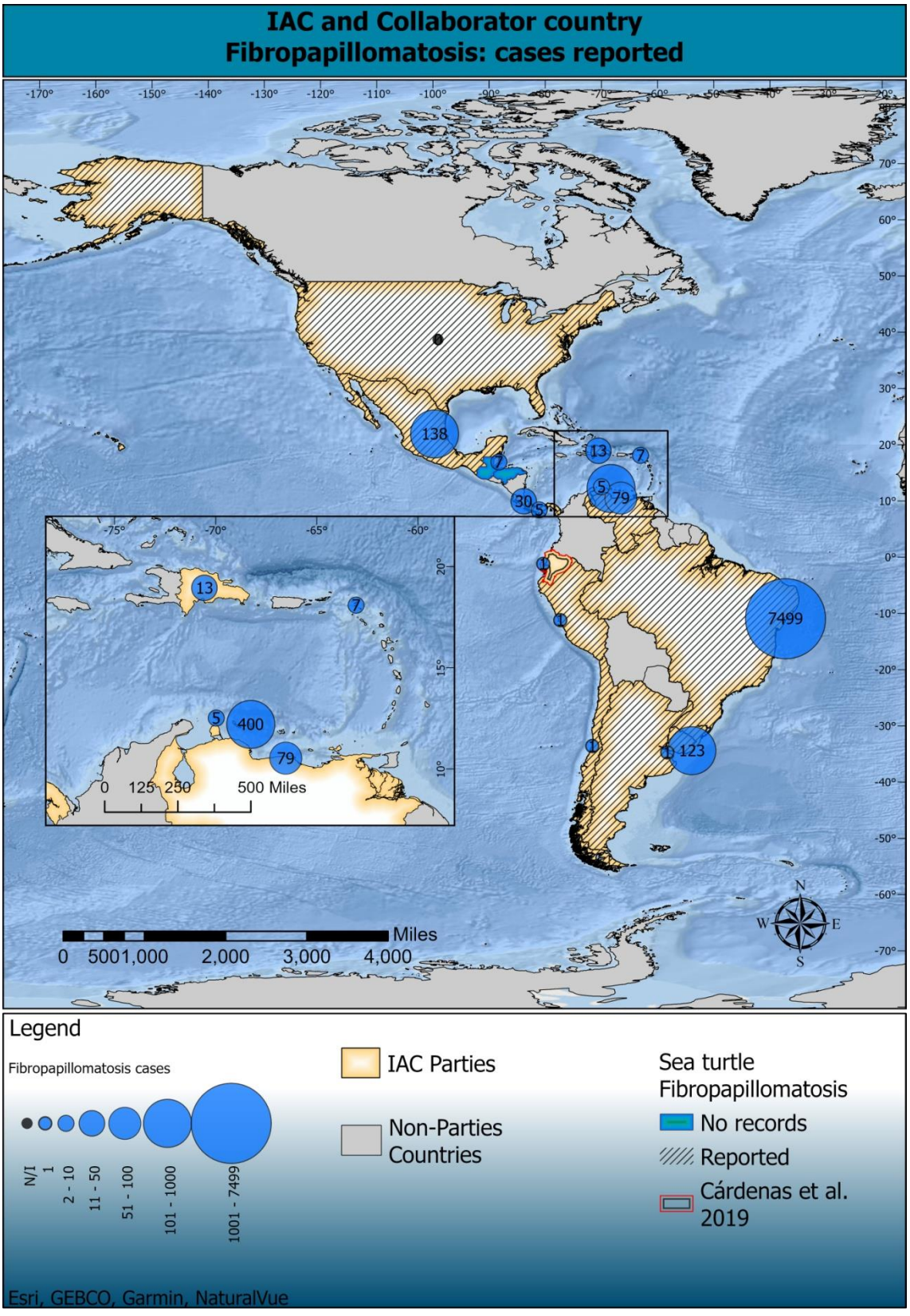


Figure 3. Distribution map of the number of reported cases in IAC member countries. It should be noted that this information was obtained through the forms provided to the IAC Fibropapilloma Working Group.

9. Impact on Conservation

Globally, fibropapillomatosis has a heterogeneous distribution, with a differentiated impact. It is endemic in the U.S., but in a large number of tropical, subtropical, and temperate countries, there are no or few reported cases. It is also necessary to consider the coverage of monitoring programs across countries, an aspect that can influence the ability to detect the disease.

In conclusion, it can be surmised that this disease does not currently have a major impact on the conservation of sea turtles, since despite being one of the most frequent causes of stranding in Hawaii (Chaloupka et al., 2008) and Florida (Foley et al., 2005), it is not a predominant cause of mortality. In the last decade, the North Atlantic green turtle population in Florida has increased considerably despite the continued presence of fibropapillomatosis (Hargrove et al., 2016). The *C. mydas* status by IUCN has recencly changed to Least Concern, a significant contribution to this is the high nest numbers in Florida (Wallace and Brodierick., 2025).

To date, there have been no cases of ChHV5 transmission to humans. Although ChHV5 virus is related to herpes simplex viruses HSV 1 and 2, which cause oral and genital herpes, and the green turtle papillomavirus could be phylogenetically related to the human cervical papillomavirus (Eduardo Resendiz, pers comm), both groups of viruses are host specific and therefore should pose no zoonotic risk to humans. However, it is good practice for safety and protection measures to be maximized both in the field and in the rehabilitation centres.

10. Recommendations

When handling turtles in the field, use disposable gloves whenever possible. Before handling the turtle, check for any tumors.

Measuring and marking equipment should be used exclusively for turtles with tumors and should always be disinfected (alcohol, benzalkonium chloride). The turtle's skin should also be disinfected with iodopovidone or chlorhexidine. If dedicated equipment is unavailable, perform measurements and marking after completing the work with turtles without tumors.

If possible, send the affected turtle to a rehabilitation center to evaluate the need for tumor removal surgery. If this is not possible, take samples and document the tumors photographically and morphologically.

In care or rehabilitation centers, it is recommended to maintain physical separation between turtles with tumors and clinically healthy ones, either through separate tanks or distinct areas e.g., keeping turtles with FP in different rooms with exclusive equipment for them; staff should even change their clothes when entering the room with turtles without FP (Stacy, et al. 2018).

Staff working in rehabilitation must always wear gloves, a mask, and appropriate work clothes to protect themselves from direct contact with affected turtles, ensuring adequate biosecurity during handling. In addition, separate cleaning utensils and materials should be available for each group of animals (with and without FP), avoiding their exchange. Differentiation can be done using a color code.

In the case of marine turtles admitted for rehabilitation with diseases other than FP, it is advised that once recovered, the specimen be released within three months of admission, in order to reduce the risk of developing tumorous lesions during captivity.

When the animal's condition permits, tumor removal can be considered, since these lesions can release a high viral load into the aquatic environment. Therefore, removing these tumors reduces the likelihood of spreading the virus. Tumor removal should only be performed under specialized veterinary supervision and following the ethical and health guidelines established by the competent authorities.

Therapeutic recommendations include surgical procedures, medical procedures, or a combination of both.

Surgical treatment:

- Excision with a scalpel

- Cryosurgery

- Radiosurgery

- Electrochemotherapy

- Electrical cauterization

Medication treatment:

- L-Lysine

- Acyclovir

- Homeopathy

11. Institutional Strengthening Proposals and Next Steps

In light of the progress made by the member countries of the IAC in identifying and monitoring fibropapillomatosis in sea turtles, it is a priority to strengthen the institutional mechanisms for registering and reporting the disease at the regional level. Here we include the FP Working Group proposals as well as those received from the IAC Scientific Committee members during the review of this document at the 22nd IAC Scientific Committee meeting. The proposed actions aim to strengthen early detection, safe management, and applied research on fibropapillomatosis, contributing to evidence-based decision-making.

Systematic information collection: It is essential that each country have a designated state entity—such as a national marine resources directorate, environmental authority, or sea turtle conservation program—to centralize the collection, verification, and systematization of FP cases diagnosed within its jurisdiction. The creation or consolidation of these entities will allow for the unification of registration criteria and prevent the underestimation or overestimation of the disease's incidence, ensuring that the data generated are comparable, verifiable, and useful for management decision-making at the regional level.

Capacity strengthening and outreach: It is proposed that a virtual workshop be held within the framework of the IAC with some of the regional experts in the treatment, surgery, and post-surgery care of fibropapillomatosis, so that the IAC Parties can implement the recommendations presented here as soon as possible. Urge the Parties to the IAC, with the support of national and regional experts (support from IAC countries), to implement technical training for field personnel and veterinarians, as well as community awareness campaigns on the importance of reducing pollutants and protecting coastal habitats.

Applied research: Strengthen research on the relationship between coastal pollutants and the prevalence of fibropapillomatosis, given that current studies are limited. Systematic imaging evaluation of healthy and sick turtles, using radiographs, ultrasounds, magnetic resonance imaging, computed tomography, or endoscopy, would be useful to assess the true impact of internal tumors. This presents a significant challenge due to the economic (study costs) and logistical effort involved (transportation to health centers equipped with imaging equipment).

Biosecurity Guidelines: It is recommended that the next revision of this document include official biosecurity protocols for handling in the field and in rehabilitation centers, either those currently applied in IAC countries or those found in the literature, considering: mandatory use

of gloves and exclusive materials for affected turtles, physical separation and differentiated utensils for individuals with and without fibropapillomatosis, and standardized disinfection procedures.

Periodic review and update: To achieve a more accurate assessment of the impact of fibropapillomatosis on marine turtle populations in the IAC region, it is recommended that the survey results in this Technical Document be updated every five years. This update should systematically include information on:

• The prevalence of the disease in each country or study site,

• The developmental stage of affected individuals (juveniles, subadults, or adults),

• The predominant score or degree of involvement, following standardized classification criteria.

This information will allow for the identification of geographic and temporal patterns, the assessment of the relative severity of outbreaks, and the establishment of evidence-based research and conservation priorities. Furthermore, the systematization and comparative analysis of this data will strengthen the IAC's capacity to issue regional guidelines for the early detection, control, and mitigation of the disease.

National and Regional Monitoring Networks: IAC member countries are urged to establish a national fibropapillomatosis (FP) monitoring network, linked to their respective government entities, to collect data on disease incidence. These national networks would, in turn, support the formation of a scientific cooperation network among IAC member countries. These national monitoring networks may feed into a standardized regional database, with homogeneous criteria for diagnosis, severity classification, and reporting. IAC Parties such as Mexico have offered their support by contributing expertise in molecular diagnosis, histopathology, and immunohistochemistry, and by sharing protocols with other IAC member countries.

In summary, the next steps should focus on institutionalizing data collection, standardizing health indicators, capacity building, research and strengthening regional coordination so that fibropapillomatosis can be addressed in an integrated manner as a health, ecological, and conservation challenge within the framework of the Inter-American Convention for the Protection and Conservation of Sea Turtles, under the One Health approach.

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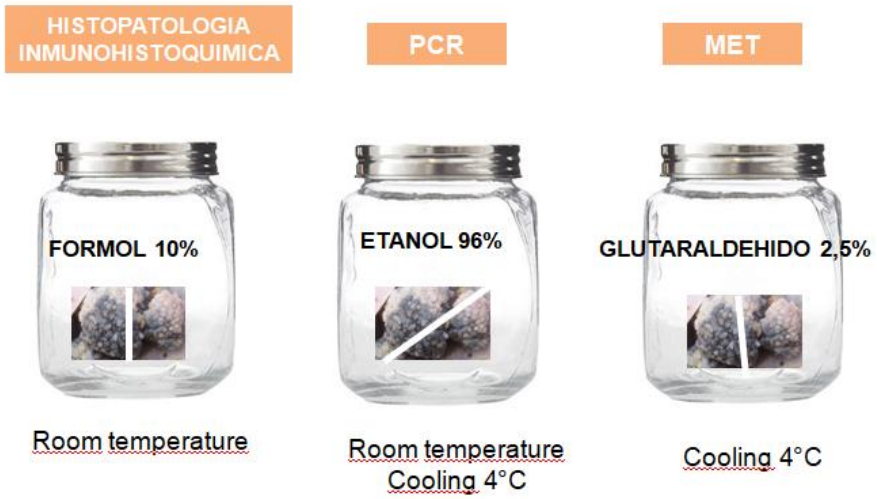
13. Annex 1: TUMOR SAMPLING ACCORDING TO DIAGNOSTIC TECHNIQUE TYPE

Types of solutions used to preserve samples depending on the study to be performed:



14. Annex 2: FORM FOR GATHERING INFORMATION ON FIBROPAPILLOMATOSIS FOR IAC COUNTRIES AND COUNTRY CONTRIBUTORS

1. CONTACT:

Name:

Affiliation:

Email

2. COUNTRY:

3. Have you recorded fibropapillomatosis cases in your country? Answer YES or NO

4. If the previous answer is YES, in which year was the first case reported?

5. Does your country compile data on the incidence of fibropapillomatosis in sea turtles?

5. Do you have information about fibropapillomatosis cases in the last ten years? YES/NO and describe – How is the prevalence of the disease?

6. How many cases do you have confirmed? Indicate the number.

7. Indicate how fibropapillomatosis was documented, was it by direct observation, or with anatomical/pathological studies?

8. In which sea turtle species(s) has fibropapillomatosis been reported?

9. In what areas have these cases been documented? List the areas and if possible provide the GPS coordinates of the areas

Indicate if any of the areas are characterized by the presence of anthropogenic impacts, for instance agricultural pesticides, run off from urban areas?

10. In what sea turtle life stages has fibropapillomatosis been found? Juvenile and/or Adult?

11. Have you encountered cases with the presence of internal tumors?

12. Has other work been done on the individuals with fibropapillomatosis in your country, such as contaminant studies?

13. What institutions/agencies/organizations undertake work with sea turtles with fibropapillomatosis in your country? Indicate whether there has been any collaborative work with other countries.

14. Please provide a bibliography to inform the WG of scientific research on fibropapillomatosis undertaken in your country, as well as contact information for researchers and/or NGOs dedicated to sea turtle treatment of fibropapillomatosis in your country.

15. Annex 3: TABLE OF COUNTRIES AND INSTITUTIONS THAT PARTICIPATED IN THE SURVEY

Country	Name	Association	Mail
República Dominicana	Jazmín León	Acuario Nacional	jazmin.leon@acuarionacional.gob.do
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Brasil	Adriana Jardim	NGI ICMBio Abrolhos	adriana.silva.bolsista@icmbio.gov.br
Brasil	Marta Jussara Cremer	Universidade da Região de Joinville - UNIVILLE	mjc2209@yahoo.com.br
Brasil	Silmara Rossi	Projeto Cetáceos da Costa Branca - Universidade do Estado do Rio Grande do Norte(PCCB-UERN).	smara.rossi@gmail.com
Brasil	Daphne Wrobel Goldberg	Instituto Albatroz	daphne@projetoalbatroz.org.br
Brasil	Projeto Aruanã – Tartarugas Marinhas da Guanabara	Instituto de Pesquisas Ambientais Littoralis	projetoaruanarj@gmail.com
Brasil	Igor Carvalho Santos	Instituto Tartarugas do Delta/ONG	igorphb_05@hotmail.com
Brasil	Gabriella Dutra Santos/ Rodrigo Malta Vanucci	Fundação Projeto Tamar	gabriella.dutra@tamar.org.br Rodrigo.vanucci@tamar.org.br
México	Fernando Gual Sill	Director General de Vida Silvestre	fernando.gual@semarnat.gob.mx

México	Eduardo Reséndiz	Universidad Autónoma de Baja California Sur (UABCS) Health assessments in sea turtles from Baja California Sur	jresendiz@uabcs.mx
Costa Rica	Didiher Chacón Chaverri	LAST, Coordinador América Latina WIDECAST	dchacon@widecast.org
Chile	Leslie Bustos	Subsecretaría de pesca y acuicultura	
Estados Unidos	Ann Marie Lauritsen	US Fish and Wildlife Service	Annmarie_lauritsen@fws.gov
Bonaire	Kaj Schut	Sea Turtle Conservation Bonaire	stcb@bonaireturtles.org
Sint Maarten	Leslie Hickerson	Nature Foundation Sint Maarten	director@naturefoundationsxm.org
Sint Eustatius	Eleanor Butler	STENAPA	eleanor.butler@statiapark.org
Perú	Jennifer Chauca	Instituto del Mar del Perú	jchauca@imarpe.gob.pe
Uruguay	Virginia Ferrando	Karumbe	bluevicone@yahoo.com
Guatemala	Airam Andrea López Roulet	Consejo Nacional de Áreas Protegidas	airam.lopez@conap.gob.gt
Panamá	Marino Abrego	Ministerio de Ambiente de Panamá	meabrego@miambiente.gob.pa

Belice	Linda Searle	Ecomar	linda@ecomarbelize.org
Sint Eustatius	Eleanor Butler	STENAPA	eleanor.butler@statiapark.org
Aruba	Richard van der Wal	Turtugaruba Foundation	turtugaruba@hotmail.com