Human Ecology (2023) 51:1085–1111
https://doi.org/10.1007/s10745-023-00461-6

Living with the Sharks: A Multi-Methods Study Analyzing Human-Wildlife Conflicts as a Step Towards Coexistence (Réunion)

Romain Pinel[1] · Dorothée Denayer[2] · Tamatoa Bambridge[3]

Accepted: 26 November 2023 / Published online: 2 January 2024

Abstract
On the island of Réunion, a French overseas department located in the western Indian Ocean, a prefectorial decree taken by the authorities on July 26, 2013 has been reconducted for the past 10 years to forbid swimming and water-based activities, apart from the conditions set out in the injunction. This decision was the outcome of increased shark sightings and incidents causing, in particular, the deaths of 5 ocean users between 2011 and 2013. As a preliminary attempt to address the lack of empirical research on ocean users' social representations and their relationship to non-humans, this paper aims to primarily analyze thoroughly the issues of the acceptance of shark risk mitigation options. Data were gathered through a qualitative study that mobilized several ethnographic tools such as face-to-face semi-structured interviews, participant and non-participant observation as well as social media data survey. Results indicate that the many tensions generated by shark-human interactions (SHIs) on the island of Réunion are related to a lack of public consultation, thus calling the acceptance of the shark management strategy and the scientific recommendations into question. The findings may improve shark-human interactions management as we consider the management of risk as a process to develop a well-balanced way of living with the sharks where residual risk remains. This study contributes to the advancement of knowledge on the management of human-wildlife conflicts (HWCs) while the results tend to confirm the findings of many other studies showing that they are often rooted in human-human conflicts.

Keywords Human-Wildlife Conflicts (HWCs) · Shark risk mitigation strategies · Ocean-user's representations · Local knowledge · Interdisciplinary approach · Réunion

Introduction

In response to ecological evolutions, human-wildlife conflicts (HWCs) are becoming more frequent, mainly in the southern regions where human/non-human relationships evolve in a context marked by vulnerability to climate change.[1] Numerous animal species such as elephants in the central African forests (Barnes, 1996) crocodiles and hippos in Zimbabwe (Marowa et al., 2021) or jaguars, pumas and capybaras in Brazil (Marchini & Grawshaw, 2015) have disclosed ecological, economical and social issues and constitute case studies to analyze and discuss sustainable cohabitation between human beings and their environments. The close interfaces generating conflicts have also occurred in the north, as in France where HWCs have drastically increased since the beginning of the 2000s. Study cases on bears and wolves in Ariège, France, (Benhammou, 2003; Denayer & Collard, 2017) are currently raising some global issues. Another important factor is the proliferation of certain non-human species, or at least the transition from scarcity to abundance, as a result of conservation measures, climate change, and the displacement of exotic species (Tsing, 2022).

Global warming causing sea levels to rise has made small island regions all the more vulnerable (Duvat et al., 2017; Masson & Kelman, 2011) contributing to making some species and anthropic activities endangered because there are

[1] ND-GAIN measures overall vulnerability by considering six life-supporting sectors: food, water, health, ecosystem service, human habitat, and infrastructure - https://gain.nd.edu/our-work/country-index/

✉ Romain Pinel
romain.pinel@univ-reunion.fr

[1] University of La Réunion, Department of Physical and Sporting Activity Sciences and Techniques, Le Tampon, France

[2] University of Liege, Department of Environmental Sciences and Management, Arlon, Belgium

[3] PSL Paris University, EPHE-UPVD-CNRS, UAR 3278 CRIOBE Moorea, French Polynesia

more and more humans and non-humans on a shrinking territory. Considering social issues to further discuss HWCs is a scientifically proven dimension (Dickman, 2010). Consequently, an increasing number of studies in the humanities and social sciences field have focused on the management of conflicts between human beings and wildlife (Denayer & Collard, 2017) and mitigation options for public safety (Beek et al., 2014; Walker et al., 2016).

One of the animals we hear the most about in the media in connection with the HWC issue, is the shark. The shark question portrayed in the media and in the filmmaking as the movie Jaws released in 1975, has unequivocally participated in growing up the fear around the perception of shark encounters around the world (Neff, 2015). This is typically what happened in Réunion since 572 press articles on the shark question were published in the local newspaper Journal de l'Île de La Réunion (JIR) in 2014. Such a promotion following shark sightings and incidents occurring in island waters and elsewhere, undeniably have a profound influence. Subsequently, the overall public tend to consider that going for a swim outside surveillance zones would be a great risk to take. To that extent, the monitoring of the shark management strategy on the island of Réunion, as controversial it has been for the past 13 years, is part of a much larger global issue, that is to say, the cohabitation between humans and animals species (Micoud & Bobbé, 2006).

After examining available data about human-shark encounters on the island of Réunion, (Lagabrielle et al., 2018; Lemahieu et al., 2017; Taglioni & Guiltat, 2015; Thiann-Bo Morel & Duret, 2013; Thiann-Bo, 2019; Losen, 2023; Cillaureen & David, 2017) we decided to add further research in the humanities field. For that purpose, we started from the Grounded Theory (GT) which is defined as a qualitative analysis method developed by Glaser and Strauss in the late 1960s. Grounded Theory is, inductive, iterative and an interactive inquiry which necessitates entering the participants' world and gathering as complete accounts as possible (Charmaz, 2006). It uses observations, interviews, audio recordings and written materials to generate a comprehensive theory in order to understand social and psychological phenomena (Joannidès & Berland, 2008).

Since the cluster of shark bites in Réunion, a large amount of data on sharks in the ecological studies field was released (Blaison et al., 2015; Mourier et al., 2021; Pirog et al., 2015; Soria et al., 2019). However, studies focusing on the discourses of stakeholders have rarely been conducted directly. A new approach is therefore needed to illuminate this uncharted area. Our research aims at (1) determining individuals' social representations of shark-human encounters; (2) understanding ocean-users' social representations of French authorities shark management strategy and therefore (3) investigating the possible drivers influencing ocean-user's behaviors dealing with the risk of encountering sharks.

Study Area

Shark-Human Interactions (SHIs) Background in Réunion

Sharks have always inhabited the coastal sea waters of Réunion and occurrences between humans and sharks have never been so regular (Taglioni & Guiltat, 2015). Indeed, 47 SHIs have officially been reported since 1828. More than half of these interactions (27) were officially related since February 19, 2011 among which 11 have been fatal (International shark attack file). From that moment onwards, the ordinary risk of shark bite has been transformed into an absolute risk (Thiann-Bo Morel & Duret, 2013) leaving a majority of ocean users like board riders, beachgoers, tourists, surfers or local fishers dealing with the dual situation of pursuing their water-based activities at all costs, or stopping it all, conforming to the French authorities policy.[2]

Following the uptick in growth of shark incidents the term "shark crisis" was commonly adopted to describe the shark risk question in Réunion. It was firstly heard following the second deadly shark attack on the beach of Boucan Canot in 2011. However, each shark-human encounter mattered that year. To summarize the 2011 events, there were a total of four attacks. In February, the first one involved a tourist at the "Trois Roches" spot. In June, a young local bodyboarder at the "Petit Boucan" spot died in the second onslaught. A third shark bite was recorded in July at the "Roches Noires" spot. Finally, the fourth attack which occurred on September 19, 2011 has tipped the social climate in what is now called the "shark crisis" with the death in particularly violent conditions of a French bodyboarding champion, local to Boucan, who was killed on his homespot. From then on, SHIs have become a real risk because even local residents

[2] Prefectorial decree no. 321 of February 7, 2023 applicable in the département of Réunion, temporarily regulating bathing and some water-based activities in a 300-m strip of the western coastline, stipulates that:

"swimming, including with the aid of equipment such as flippers, mask and snorkel and water sports using wave power (surfing, bodyboarding, bodysurfing, longboarding, paddleboarding) are forbidden, except in lagoons and reef flats, in managed and supervised areas outside lagoons, and in operational experimentation zones (ZONEX), where activities may only be carried out under suitable environmental conditions and on condition that surveillance and warning measures are deployed, along with special shark risk reduction equipment, all of which must be formalized in a protocol appended to a municipal by-law.".

with expertise in their natural environment are likely to be killed in these encounters.

In response to the tragic events, French authorities nominated the Centre Sécurité Requin (CSR)[3] to manage the shark crisis. Their objective is to build a top-down approach in order to reduce the risk of SHIs. Various projects have been tested this past decade including, raising and lowering red flags on beaches or designing participative maps as the Dorsal Shark Report application.[4] However, target fishing of bull sharks (*Carcharhinus leucas*) and tiger sharks (*Galeocerdo cuvier*) remains one of the French authorities' preferred solutions. Authorities rather choose to manage by reducing SHIs rather than transforming relationships between human and wildlife. The trial of the SMART drumline technology aims to determine if this system is effective as a shark hazard mitigation tool. It consists of a big baited hook, anchored to the ocean's bottom. The shark bites the hook and gets stuck. Staff of the CAPREQUINS[5] projects are kept on call, 24/7, 365 days per year to monitor the system. This collaborative work between scientists and fishermen is particularly highlighted in the media. Besides, it must be recalled the bull shark is a difficult specie to catch as it takes an average of 2768 h to catch one.[6] Public opinion on a local basis is splitting up in the media and online social platforms. Is it fair to catch animals in this manner? Is it really efficient?

The implementation of such a shark management strategy has been triggering a lively controversy and has instilled fear in human-shark encounters, rising human-human tensions.

To this date the clash between shark fishing advocates and their opponents has built up the shark risk question. Back in 2004, we could already read the headline "Sharks fed by scuba divers" (October, 7th 2004) in local newspaper JRI. A few years later, in 2011, following the Prefectorial Order 1456 of September 26, 2011, conflicts between the Sea Shepherd Conservation Society and the Océan prévention Réunion association[7] over procedures for securing water-based activities sites, created a form of social instability. There were some other controversial events, as when a scientist who works on sharks had dressed up as an injured surfer for a party, causing a popular emotional uprising when the photographs went online. Another example was when Brigitte Bardot commented about shark fishing and consumption of its meat in the media back in March 2019. These various events have had the effect of stirring up tensions, particularly ethnic ones, calling into question the Reunionese "living together nicely".

Human-Human Tensions Arising from the History of the Island

The island of Réunion is a French overseas département located in the southwestern Indian Ocean basin. Nowadays social context and cultural framework of the island arise from its colonial background[8] (Vergès, 2008). Réunion's population is mainly made up of African, Asian, Indian, European origins, thus meaning there were no inhabitants before the colonial area. Consequently, we will consider socio-anthropological variables (Ostrom, 2009) in this study, as we believe it may help us to better understand the construction of social climates regarding the shark crisis.

The twenty-first century Reunionese society uncovered the emergence of conflicts such as those linked to the shark crisis or the claims of associations for the liberation of the coastline in the west. These disagreements have sometimes been associated with identity-based protests. Furthermore, this (post)colonial society is evidenced by high rates of illiteracy (Folgoat, 2016), unemployment (L'Horty, 2014), alcoholism (Géralin, 1953), and diabetes (Fianu et al., 2017) among Creole communities, which may extend the disparate colonial society.

The identity issue refers to a dominant culture and a dominated one. We believe that these conflicts of use, linked to the use of territory and resources, reflect the meeting of two cultural models, vectors of customary systems, norms and different representations. On one side is the Creole cultural system. On the other is the Western European system, conveyed by expatriates, mostly French, also called "zoreys[9]". After formalizing its French département status, land occupation on the island of Réunion

[3] A resource management support center for the shark issue, namely Centre de Ressources et d'Appui (CRA) was created in 2016. In 2020, the center changed its name to Centre de Sécurité Requin (CSR) that could be translated as shark safety center, and became a public interest group. The CSR is governed by the French state, Regional and departmental Councils of Réunion, municipalities of the western coast, University of Réunion and public establishments for cooperation between local authorities.

[4] The Dorsal Shark Report application is a free community-based shark alert app that allows beachgoers and authorities to immediately alert others about shark sightings or attacks in their area.

[5] The CAPREQUIN projects are designed to better understand the catchability of sharks on different fishing gears, with the aim of reducing the risk of SHIs.

[6] 2018-2022 report of the Centre de Sécurité Requin (CSR).

[7] Association under the law of 1901 whose purpose is to prevent the risk of shark attacks in France and more specifically in Réunion.

[8] Meaning the current literal equalism of the new civil society against the past which conveys intrinsic inequalities between humans (Ottino & Condominas, 1972).

[9] In Réunion, the creole-speaking term "zorey" refers to people from hexagonal France. Any pejorative or racist intention is absent when we use any of the commonly used terms "zorey" or "creole".

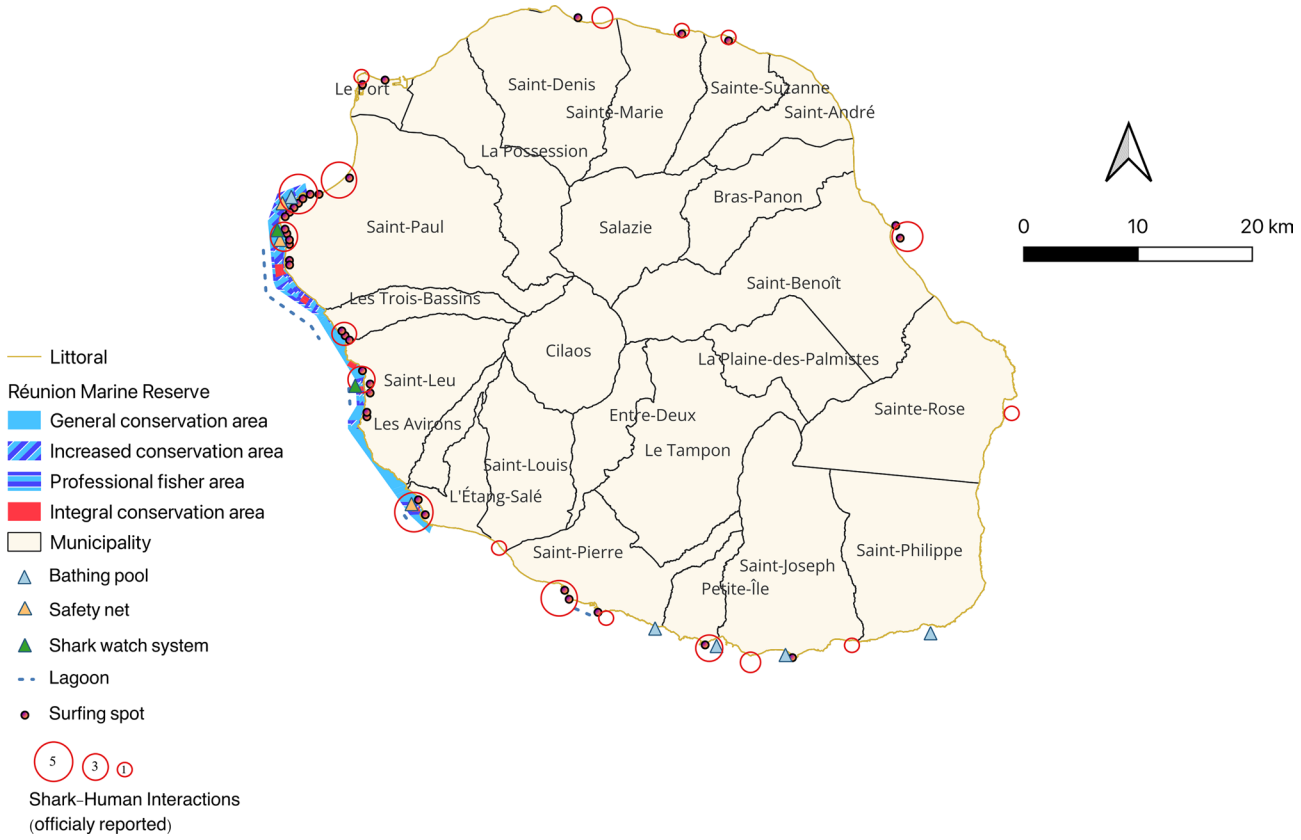

Fig. 1 Map of study área

underwent major transformations. Namely, there was a surge of coastline urbanization especially on the western coast. Moreover, along this same shoreline, there was a development of water-based activities such as surfing, thanks to all year long ideal conditions with a diversity of surf spots (e.g. Fig. 1). Hosting the ASP World Tour in Saint-Leu bay in 1994 associated with the development of sponsoring in the sector, the island of Réunion became very quickly one of the surfing hotspots internationally. However, the cultural framework of surfing is still very recently established in the social representations of the Reunionese population. This outdoor activity coming from overseas is sometimes questioned by some of the Reunionese since it was originally not a practice associated with their homeland. Furthermore, water-based contemporary activities such as surfing (Machado et al., 2021) or scuba diving (Pinel et al., 2021) may call into question the cohabitation between recreational and traditional activities. Indeed, some categories of ocean users like traditional fishers are directly dependent on natural resources and ecosystem stability. For instance, on the western coast of Réunion, there have been long-standing conflicts[10] between economic users of the seashore (restaurant owners, bars) and the collective for the defense of the Public Maritime Domain. As French law is applied in the département of Réunion, structures within the Public Maritime Domain had to vacate the premises in the interest of collective use and wildlife. The attempt to resolve this human-wildlife conflict thus generates a human-human conflict.

Some environmental issues, as in deadly shark-human interactions may be forced into prominence when led by a recurrence of incidents. Dramatic events like these are important on the public scene because they assist political identification of the nature of an issue, the situations out of which it arises, the causes and effects, the identity of the activities and the groups in the community which are involved with the issue (Solesbury, 1976). For example, in 2011, there was a gathering following a shark-human incident in an atmosphere of social tensions. Huguette Bello, a

[10] The authorizations to occupy the maritime public domain expired on June 30, 2018.

French politician from Réunion, replied to the water-based practitioners that day: "*The area of the bay of Boucan, Roches Noires… The elderly would forbid their children to set foot there…! I have lived here for 60 years… This is my country, sir*."

Evolution of the Natural Environment

The island of Réunion presents an extremely dense hydrographic network with no fewer than 750 gullies. As for weather conditions[11], trade winds play a critical role on this high volcanic island, hence heavy rainfall conditions accelerating water runoffs (Réchou et al., 2019). Storm drains washing away sediments down to streams' mouths make estuaries ideal places for species like bull sharks and tiger sharks, which have the reputation of being adaptive breeds. The co-occurrence of overcast weather, murky water and the quality of water supplies [12]are factors that may trigger SHIs since research has found these conditions were repeatedly met during unwanted interactions, including with bull sharks, a breed fond of low-salt turbid waters (Taglioni & Guiltat, 2015).

Additional factors like the rising quantities of sewage effluent on the island coast and the use of agriculture pesticide[13] may play a role in the perturbation of the watershed disturbance and de facto in the vulnerability of the coastal ecosystems. However, no study has been carried out to date on the impact that these substances could have on the behavior of the fauna. Other studies focused on demonstrating the change in marine mammal behavior in order to better understand shark senses and behavior, to change the way people see these animals and gauge their risk when entering the ocean (Clua & Linnell, 2018). This issue was also highlighted in a study conducted on the island of Réunion (Rard, 1999). Several studies were published on the CHARC Program[14] since its implementation in 2013 (Blaison et al., 2015; Mourier et al., 2021; Pirog et al., 2015; Soria et al., 2015, 2019). However, even if these studies have led to a better understanding of bull sharks and tiger sharks species, they may have also encouraged human-human conflicts between water stakeholders and the scientific community. Finally, we also believe that the industrial fisheries carried out by European seine vessels in the waters of the Indian Ocean since 1984[15] may play a role in the depletion of prey for sharks.

Issues Related to the Development of Tourism and Economy

From the 1980s onwards water-based activities have emerged with the development of the leisure industry in France. Simultaneously, the arrival of start-up airlines led to the end of the monopoly of long-standing airline Air France, resulting in growing the island tourism industry (Fontaine, 2004). Surfing has developed and democratized in the waters of Réunion with an estimated 40,000 practitioners in 2010 whereas there were just a few 700 in 1992 (Guiltat, 2011). A parallel can be drawn with the increasing number of sharks near the coasts, and the booming of this tourism activity. We can assume surfing and bodyboarding are water-based activities particularly affected by SHIs since they are 50% attacks on water-based activities (Taglioni & Guiltat, 2015). One possible explanation could be that this activity is relatively affordable, or at least does not require much equipment compared to other practices such as kite surfing or scuba diving. Nevertheless, with the uptick in growth of SHIs, surfers in Réunion must buy a compulsory life- saving equipment for surfing, such as the shark shield,[16] making this sport less affordable for all.

> *"French from the mainland have also developed new leisure activities, tennis, golf, board sports, various water-based activities such as scuba diving behind the barrier reef, deep-sea fishing, sailing, windsurfing, bodyboarding, longboarding."*(Bertile, 2006, p.597).

For the past 40 years, the development of tourist attractions on the island of Réunion shifted from the coastlines to the interior. Indeed, most of the hotels are located on western coast where shark sightings and incidents are the most recorded. Consequently, promoting a diversity of tourist attractions in order to keep visitors coming to the island was a primary concern for the economy. A study published in 2014 estimates that the loss of revenue over a year due to the shark crisis is around 20 million euros (Fabing, 2014). The impact on the economy of water-based activities is significant too. For example in 2014, 14 surf schools out of 16 were closed (same author). There were repercussions in scuba diving as well. With approximately 160,000 annual dives before the shark crisis and

[11] Réunion holds several world records for rainfall (World Meteorological Organization)

[12] The water transfer project of Réunion aims at capturing water from 4 rivers located in the cirques of Mafate (rivière des Galets, bras Sainte-Suzanne) and Salazie (rivière du Mât, rivière des Fleurs Jaunes). It is then piped underground over a distance of 18.6 miles or 30 kilometers to the west coast.

[13] Réunion is the second French département applying the most glyphosate onto croplands, especially on sugarcane crops (Ferdinand & Molinié, 2021).

[14] Knowledge of the Ecology and Habitat of two species of Coastal Sharks on the west coast of Réunion. Scientific Program financed by Europe (FEDER), the Réunion Region and the French state (DEAL) from January 2012 to April 2015.

[15] Tuna fishing agreement with the European Union.

[16] This personal protective gear costs around 600 euros.

110,000 in 2014, the overall volume is down about 31% (same author). Wouldn't the economic impact of SHIs in Réunion be too great for the authorities to deal with the whole issue on their own?

The RNMR in the Midst of the Controversy

Since the Réunion Marine Reserve (RNMR) was created in 2007 there have been no less than 11 shark attacks, 4 of which were fatal. Because a majority of SHIs have taken place within its perimeter, the RNMR has been central to conflictual interactions between its stakeholders. The RNMR is being incriminated by surfers, among others, of being "a food reserve for sharks" since fishing is prohibited in designated sanctuary zones. As an illustration of rising tensions between ocean stakeholders on the island of Réunion, it can be illustrated by the attacks on Molotov cocktails that happened at the RNRM in 2017. They occurred two days after the death of a local bodyboarder to Rivière-du-Mât who was killed in a SHI. The various stakeholders position themselves as new "publics" (in Dewey's sense: they investigate and publicly bring into existence the debate) of a controversy around coexistence devices. The pro-shark fishing stakeholders who are convinced by the large predator prevention fisheries programs assume that the RNMR is the main factor of SHIs whereas the anti-shark fishing stakeholders advocate that the SMART drumline technology generates all the more attacks. Everytime there is an additional SHI, actors most involved in the query strongly intervene in the public arena. For instance, the relations between ocean users and institutions in charge of the shark management strategy are transforming the social climate of the island. Therefore, this conflicting societal question is building up as manifest and permanent. However, the marine reserve alone hosts about 80% of the users of the Réunion coastline and coastal sports enthusiasts (Rard & Menou, 2011). Nevertheless, we can legitimately ponder on the issuance of the 800 fishing permits that are delivered annually allowing fishing practices in the marine reserve.

Materials and Methods

Data Collection

We conducted a multimethod field study to uncover Reunionese communities, water stakeholders' social representation of SHIs, their perception of the shark management strategy and of the authorities' decision-making process. We collected data using various research methods that included participant observation, social media data surveys and face-to-face semi-structured interviews. By cross-checking and comparing these three sources, we have identified convergence and divergence, and sought to have an enlightened opinion of the groups' representativeness. We decided to conduct an ethnographic survey since it provides insights into interactions between individuals and the major social forces shaping their lives (e.g. Table 1). We started from individuals' life stories or subjective experiences in order to then understand key organizational patterns stemming from their discourses. We focused on interactions between individuals, their perceptions of themselves and others, but also the roles they play according to their social situations. We chose to triangulate three methods in this project to neutralize some of the biases of stakeholders' discourses. The implementation of this connective process between data types helped us conceptualize social value models that take into consideration the complexity of socio-ecological systems. Grounded Theory has proven to be an essential tool in the development of this project since it is based on the principle of simultaneous data collection and analysis, thus leading to a constant comparison between data collected, their processing and theoretical research (Corbin & Strauss, 1990).

Table 1 Qualitative interview guide

Main questions	Follow-up questions
Can you tell me about the history of your ancestors?	How long have you been living here? How did you settle on the island?
What is your personal background?	What jobs did your parents do?
How did you start working with the ocean? Were there any people in your family who made out their living from the sea? What is your relationship with the ocean?	How would you describe Réunion islanders' relationship with the ocean?
Have you noticed any changes in the marine environment?	Have human uses also evolved? What about the number of users? Have fishing techniques changed?
Have you observed any conflicts between marine users?	
What is your take on environmental management tools?	
How do you feel about the risk of sharks in Réunion's waters?	
What is your take on shark mitigation strategy?	

Table 2 Research participants sample

Government or public sector (8)	Civil society (12)	Private sector (17)	General public (18)
CSR staff (1)	Local co	Fishers (7)	Water-based practitioners (surfers,
Marine observatory staff (2)	mmunity-based organizations	Tourism operators (5)	bodyboarders) (7)
Museum staff (1)	managers (7)	Other marine professionals (5)	Citizens (11)
RNMR staff (4)	Research community (5)		

Face-to-Face Semi-Structured Interviews

Prior to conducting the interviews, we determined a stratification[17] of 4 main categories of stakeholders who use and depend on marine waters of the island Réunion, whose activities affect it or who have interest in it (e.g. Table 2). (1) Government or public sector: regional and municipal level institutions, RNMR staff, CSR staff. (2) Civil society (not for profit): research community, local community-based organizations. (3) Private sector (for profit): fishers, tourism operators (scuba divers), other marine professionals. (4) General public: water-based practitioners (surfers, bodyboarders) and citizens who do not have a specific use of the marine environment.

We recorded a total of 55 face-to-face semi-structured interviews[18] including 49 in Réunion, 5 on Mauritius island and 1 in France on the mainland.[19] Prior to conducting the interviews, we obtained consent from potential research participants and we told them it would be anonymized. Afterward, we noticed the 4 categories were not exclusive as an ocean user can be both a water-based practitioner and a local community-based organization manager.

Participant and Non-participant Observation

Over 18 months, we observed and participated in the daily activities of Reunionese communities and water stakeholders in order to record their exchanges, their formal and informal conversations but also their behaviors. Through this ethnographic tool, we tried to fulfill three missions. (1) Immerse ourselves in local culture, (2) measure the various uses of the marine and coastal environments and (3) observe interactions between the stakeholders and the emerging conflicts. It allowed us to study changes in behaviors and discourses of social actors when they are behind the scenes. Indeed, when research participants are being interviewed, they might be performing and adopting attitudes constructed by the expectations of society (Wolfson, 1976). We sought to get in the world of the participants in order to gather accounts as thoroughly as possible. It gave us the opportunity to collect honest and intimate information about people. However, we are aware the data collected during these observations is filtered through our presence which from time to time might have altered the behavior of the groups under study.

Social Media Data Survey

Between October 2017 and December 2021, we collected data on Facebook pages such as those of local media, the CSR or associations involved in shark risk management in Réunion. We opted for this data collection method to represent the structure of interactions between the different stakeholders. We conducted a passive analysis approach, as we exclusively observed participants. Data obtained from Facebook users offers substantial opportunities for qualitative research. For the purpose of this paper, we focused on user-generated iconographic and textual data related to the shark question. What initially drove us to investigate on those platforms was the increase of influence of organizations, environmental groups or associations, in favor or against shark regulation programs (SRP) since 2011, revealing a polarization of opinions (Lagabrielle et al., 2018).

Data Analysis

We puzzled up the different stakeholders' representations to give a perspective of the most common themes in discourses we've heard and seen in behaviors during our fieldwork. Next, we fully transcribed, coded and analyzed the interviews. During the open coding phase, coding is carried out abductively, by successive iterations and progressive groupings, while including emotional coding such as tone of voice or laughter. This first coding phase shows the general situations encountered by the stakeholders, and turns them into concepts. The second phase, axial coding, aims at selecting the main indicators that emerge from the open coding phase. It will "lead to reason in paradigm terms, looking at causes, consequences and processes" (Joannidès & Berland, 2008). The last phase, called selective coding, consists in connecting all the categories together around one core category. We

[17] We suggest the classification of the "Stakeholder Participation Toolkit for Identification, Designation and Management of Marine Protected Areas" (RAC/SPA and IUCN-Me).

[18] The interviews were conducted by R.P. between February 2018 and March 2019. The sample is made of 9 females and 46 males. The average age of the population is 47. Informed consent was gathered from participants prior to the individual interviews.

[19] Interview of a Reunionese mother of a young professional surfer who decided to move to France because of the risk of SHIs.

used Atlas.ti, which is a software designed to optimize the qualitative data analysis process. We have listed over 708 citations associated with 45 indicators (open coding). In this paper we focus on 23 codes (axial coding) (e.g. Fig. 2).

Coding transcripts is one of the most important operations in Grounded Theory. It involves going through the data, comparing ideas, interactions, events, to find similarities and differences and assigning conceptual labels (Corbin & Strauss, 1990). By immersing ourselves in the universe of the research participants, we focused on various situations regarding human uses of the ocean such as fishing, surfing or scuba diving. Upon finishing our participant observations, we immediately recorded and transcribed our comments. We also studied the digital public space through data generated on social networks. In particular, we combined a semantic analysis, a thematic codification and ethnographic observations, to bring to light topics of discussions, tone and sentiment, influence and clout which are the most prevailing on the Facebook platform. Through our study we want to give a clear picture after ten years of restrictions on how risk culture has been developing in Réunion, and has interfered in interactions and behaviors among ocean stakeholders in the private or public arena. We want to provide a panoramic view of the tensions and problems encountered by Reunionese ocean stakeholders. As Grounded theory predicts, we have given a central place to research participants in the study. We will therefore be quoting extensively from the stakeholders' discourses in our results. As the interviews were conducted in French and Creole, we decided to turn to a professional translator, so as to be more consistent with the messages conveyed by the interviewees. We are aware it involves a degree of subjectivity and that it is hardly possible to measure unbiased since there are political and social-related issues.

Results

Managing the Coexistence Between Human and Wildlife is Controversial and a Source of Tensions

In times of dramatic events the question of the risk is emphasized, meaning there is a sharp focus on the matter. When SHIs dramatically increased in the coastal waters of Réunion, people started talking to a greater extent about it, and soon a whole range of volunteer initiatives and organizations sprung up. During our fieldwork, we observed a shared will among the various stakeholders to minimize future risks of

Fig. 2 Schematic representation of the Grounded Theory model

unwanted shark encounters. And yet, we noticed they were driven by the desire to find who should take the blame for such a situation all along the face-to-face interviews.

Interviews with Civil Society Stakeholders

The general feeling admits that the shark risk question stems from multifactorial causes. When interviewing members of local community-based organizations, we learned they all agree on the fact that scientific knowledge has not yet shed any light on the shark question since the results of research, to date, have only confirmed facts the locals already knew. And yet, a member of the research community we interviewed made clear their function guarantees them to have *"a broader knowledge of environmental issues"* (Mick, research community). These observations illustrate the rising tensions between empirical knowledge and the development of theoretical knowledge. As mentioned by a manager of a local community-based organization, this plurality of knowledge reduces the perception of risk in the general public *"even where there is the highest rate risk in the world, the probability remains very low"* (Tib, local community-based organization manager). The research programs are even questioned by the scientists themselves. *"I don't see how we can say that at some point we have fished enough, and now we can get back into the water and say there is no more risk.*" (Bernard, research community).

Interviews with the General Public

This plurality of knowledge is also shared by some water-based practitioners who have adapted to the risk by endorsing new attitudes to cohabit with sharks, by developing strategies to reduce shark-risk encounters. It can be proven by counting increasing numbers of water-based activities practitioners on surfing spots when there is swell coming in, then refusing to conform to the ban. That return to water flow could also be linked with the absence of SHIs since May, 2019, thus conditioning an acceptance of the risk of encounter. This risk-taking is not well accepted by the citizens and the water-based activities practitioners who made the choice to comply with the rules, not returning to water. *"I acknowledge that the underwater lookouts and the no-sharks devices work, but I wouldn't go in the water and be used as bait. I have a little girl and we're expecting another one, so I choose not to be selfish. You can't really talk about it with people who are still surfing. I can not be friends with those people anymore. I think that's selfish of them." (*Tao*,* citizen*).* Parenthood

Fig. 3 About fifteen surfers defying the ban on the Trois Bassins spot (Sept. 25, 2018)

therefore appears to be a factor that influences the perception of risk. Indeed, for other research participants, the risk proved too high so they made the decision to expatriate to the mainland.*"When my kids would go to their father's, I would go to the beaches just to make sure they didn't go in the water. It was unbearable."* (Juna, former water-based activity practitioner).

For those who remained (e.g. Fig. 3), the (ineffective) ban was experienced as an environmental injustice. *"It's now becoming a power struggle with the authorities, which shouldn't be happening because we are not doing anything wrong. We put our lives in danger, it's our business, we are aware of the risk, we know the environment better than they do… We are the victims, we play hide-and-seek with the police, we play hide-and-seek with the sharks, we are caught in a vice! That's why so many of us have left."(*Thomas, surfer). Additionally, the general public have regularly blamed the behaviors of shark attack victims. *"After all, if you look closely at who gets eaten by sharks, it's always the people who don't know much about the ocean and who defy the bans. Surfers or tourists who don't know the sea like we do. It is instinctive, we were taught."*(Max, citizen). The surfer community is often targeted by the various stakeholders. "It is only surfers who are attacked." (Denis, citizen). *"If one goes surfing there after floods like the ones we had, one shouldn't be surprised that people think you're crazy."* (Rodolphe, fisher).

Interviews with Public Sector Stakeholders

The shark-human interaction risk is more casually described by staff of the public benefit corporations. It seems they tolerate more the risk of encounters, but we should bear in mind that because of their professional activities, they have to conform to the prohibitions referred to in the prefectorial decree of July 26, 2013. *"When we went to Boucan, we were not afraid at all, maybe it was just unconsciousness, we would swim to the buoys. Now, I wouldn't go as far as the buoys (laughs), no, I wouldn't."* (Mina, RNMR manager). The combination of both a questioning of a past use of the

ocean and the emotional marker that is laughter, may underline the participant's distancing from the risk. Besides, two RNMR staff who grew up in families of fishers believe their perception of risk stems from their deep knowledge of the marine environment. *"In any case, sharks have always been fished, they have always been seen, and we will see them again.*" (Carl, RNMR manager).

Interviews with Private Sector Stakeholders

As we have mentioned previously, the shark risk question is very familiar within the communities of fishers as it has been transmitted through parenting education. *"Sharks have always been around, it is their place, they are important. I'm not going to go into that because it's media hype, it's controversy. It's a money spinner, the shark crisis."* (Joe, professional fisher). However, according to professional fishers, this transmission of knowledge tends to evaporate in contemporary Réunionese society. Additionally, tourism providers and other marine professionals explained the impact of the risk has often overtaken their economic activities. For instance, two owners of surfing schools we interviewed have moved out to Mauritius so as to keep their constituent livelihoods. Only a few tourism providers in the scuba diving industry have continued their activity in Réunion, but we must recall that scuba diving is one of the exceptions set out in the injunction of July 26, 2013. This differentiation between water-based activities is experienced as an injustice by the practitioners, thus building up tensions between the stakeholders. *"We forbid surfers to go in the water but they make a maximum of money with scuba diving*." (David, water-based activity practitioners).

Participant Observations

In the wild south and in the east, participant observation and informal conversations with fishers allowed us to better understand the construction of risk representations. It follows that the notion of the risk is first associated with the harshness of the ocean, the swell and the inhospitable coastline rather than as a consequence of the presence of sharks. Fishermen have sometimes mentioned that it is normal, ordinary for shark bites to happen on surfers in the west and that "*sharks only eat zorey*". We observed the practice of spear fishing on several occasions by practitioners who are well aware of the risks undertaken and who put in place strategies to reduce them. Ocean users taking risks is very different depending on the time of the day and the season, but also on the practice carried out. In this context where the experts do not fully manage the risk of encounters with sharks, ocean users are faced with a quandary and everyone tries to set their limits.

Social Media Survey

In response to an increase of SHIs in Réunion, social tensions emerged online between the various stakeholders (e.g. Table 3). Firstly, we witnessed tensions between water-based activity practitioners, as when surfers publicly blamed scuba divers for shark feeding. Secondly, tensions emerged between water-based activity practitioners and environmental managers, especially when an attack on Molotov cocktails happened at the RNRM. Thirdly, other social tensions came up between water-based activity practitioners and scientists. In reference to that event involving a scientist gawkily dressed up at a party, an episode that kept coming up into the interviewees' discourses: *"He goes to a party dressed up as an amputee guy in a surf suit and he laughs, takes a photo of himself and posts it on Facebook. And that's one of the guys running sharks programs in La Réunion?! How do you not want to generate hatred? Why did 18-year-olds start throwing tear gas canisters at the marine reserve facilities? What do you think, when they lose their friends and feel misunderstood? Even worse than that, when they see adults with responsibilities who don't care about the situation…"* (Thomas, surfer Étang Salé).

The Risk Management Strategy Revealed a Lack of Negotiation and Inclusiveness in the Decision-Making Process

Interviews with Civil Society Stakeholders

On the island of Réunion, the research community and local community-based organizations managers agree that the shark crisis is rooted in scientific miscommunication. *"Basically, people thought that because we were going to study these two shark species, we were going to provide a key solution to the crisis"* (Mick, research community). Community-based organizations managers who defend the free practice of water-based activities have often taken advantage of this lack of vulgarization, meaning there is little sharing of scientific knowledge. In that way, they take over the media by conveying a negative image of scientific research. *"In any case, they (the scientists) have not served any purpose other than to demonstrate what granmoun fishermen have already acknowledged"* (Tib, local community-based organization manager). These two stakeholders also agree on the fact that conflicts of interests have contaminated the shark risk management in Réunion.*"There is a narrow circle of specialists. They have a seat at the RNMR council. They decide both which projects are allocated fundings and it's their own projects that receive the money. It's all about scheming and so on. Afterwards, I understand people's reactions… Clearly, it's hard to get new insights"* (Mick, research community). Here, the research participant's

Table 3 Examples of posts relayed on Facebook pages dedicated to SHI in Réunion

Dates / Facebook group / Aim of the group	Topics of discussion	Stakeholders concerned	Arguments and debate issues	Fragment of the post
October 12, 2017 - Sharks Media Facebook page - Media coverage of the shark issue	Ban on marketing shark meat	Shark fishing advocates and shark fishing opponents	The two leading protagonists of the Reunionese shark issue clash on social networks over the traditional dimension of shark fishing. For some, the aim is to legitimize shark fishing and commercialization of its meat, and for others, to make it illegitimate. On the one hand, shark fishing advocates argue that shark fishing and the consumption of the meat have been carried on for generations in fishing districts. The size of the shark meant that it was shared or bartered between residents. On the other hand, shark fishing opponents are challenging this model, citing the risk of ciguatera. The latter are mobilizing a wide network of wildlife protection associations. Scientific and political stakeholders are particularly targeted by the negative comments from all the protagonists (pro and anti shark fishing).	Post) Commercialization of bulldog and tiger shark meat remains banned. Extract from "Le 19h00", Réunion 1ère. C1) We need to fire all these scientists…they're all thinking about their wallets that's all! C2) Yet I've read that people have been selling sharks in missouk for as long as I can remember. C3) I'm still convinced that the commercialization will be authorized, it's the prefect who decides, not the CRA and not the scientists. We'll have to hit him if it doesn't happen. C4) She's made a fool of us. A real policy with pretty words to put us to sleep. C5) A: Why the fuck kill the sharks, you bastards? B: To eat them, because they're big fish. And bastard yourself! C: You're right to take advantage of being behind your screen to call us bastards…you wouldn't have the opportunity otherwise.

Table 3 (continued)

Dates / Facebook group / Aim of the group	Topics of discussion	Stakeholders concerned	Arguments and debate issues	Fragment of the post
December 17, 2020 - Shark Safety Center (CSR) Facebook page - Public interest group in charge of the shark risk reduction	Shark fishing programs	Shark fishing advocates and shark fishing opponents	When the CSR informs its community that a shark targeted by the program has been caught, pro-shark fishing and anti-shark fishing stakeholders clash in the comment section of the publication. On the one hand, anti-fishing stakeholders denounce anthropogenic fishing and boating activities, while sharks occupy a legitimate place in the ocean. On the other hand, pro-fishing stakeholders point to the sanctimonious tone of their opponents in a context where fishing vessels on the mainland are much more involved in shark fishing overall. While these interactions between pro- and anti-fishing are almost a daily occurrence, the arguments put forward are often the same.	Post) SHARK RISK SURVEILLANCE - BULLDOG AND TIGER SHARKS CAPTURED. A 9-foot bull shark was caught late yesterday in Saint-Gilles. A 10.5-foot tiger shark was also caught early this morning in Saint-Pierre. These catches follow a period of 10 days without preventive fishing due to poor weather conditions. An exceptional deployment of fishing boats has therefore been scheduled until Saturday in Saint-Gilles, Saint-Pierre, Étang-Salé, … C1) A: A shark in the sea is like birds in the sky: the ocean is their element, not ours. It's up to us to adapt and respect it, instead of exterminating them because their presence disturbs us. Going into water, an element that isn't ours represents a risk, and we must accept it, we shouldn't adapt it to our selfish need to control everything. B: Your garden is overrun with weeds. Do you leave them in or remove them for the comfort of having a pretty garden? C: Not to mention that people have died. C2) Metropolitan France kills 220 large sharks a day and 11,000 dolphins a year. Yes, come and lecture us…. I'm talking about industrial fishing and canned tuna for which you plunder our ocean? Damn! Think before you spew your bullshit.

Table 3 (continued)

Dates / Facebook group / Aim of the group	Topics of discussion	Stakeholders concerned	Arguments and debate issues	Fragment of the post
April 17, 2021 - Océan Prévention Réunion Facebook page - Association under the law of 1901 whose purpose is to prevent the risk of shark attacks in France and more specifically in Réunion	Bulldog shark caught by fishermen in Saint André (east coast)	Animal rights activists and supporters of shark fishing	The OPR association encourages fishing for bulldog and tiger sharks by various means, such as vouchers in fishing stores for fishermen who send their photos to the association, and publication of the photos on their Facebook page. From then on, the posting of photos led to conflicting interactions between stakeholders. Once again, it's the advocates of shark fishing and their opponents who interact. Furthermore, we observe that shark fishing opponents interact very frequently with pro-shark fishers' pages.	Post) Many thanks to the fishermen. Live in Saint-André. A large-scale distribution of fresh fish is currently underway in the area. C1) So proud to be killers, that the instigators are blurred… A barbarity that continues, adding to the toll of 477 sharks already slaughtered since 2013. C2) What a shame to pose proudly next to this poor animal… Really! When will we have understood that sharks live and hunt in the sea… They're at the top of the food chain, so we're bound to get in there sometimes. But let's leave them alone! They're at home. If all the species we piss off on Earth started killing us too… there wouldn't be any men left on Earth for a long time. C3) Humans are at the top of the food chain. Like sharks, we hunt and most of the time we win. That's how we feed ourselves whether it's tuna, swordfish, or shark. Stop acting offended when you also eat tuna.

comment raises the question of the RNMR scientific committee composition. Should there be only researchers comprising this working group? This ambiguity is revealed by the lack of understanding of the preventive fishing programs from members of the civil society themselves, as well as the general public. *"Preventive fishing leads to what we do not even know anymore. They fish for bull sharks and tiger sharks but tiger sharks have never really been incriminated in the attacks"* (Tib, local community-based organization manager). We found out that among the different local community-based organizations aiming at guaranteeing access in Réunion, their managers have differing views on the current shark control program.

Interviews with Public Sector Stakeholders

Conflicts of interests are also incriminated by the RNMR staff we interviewed. *"Since it's the same president for the CSR and the same elected officials who serve on the board of directors, it was confusing."* (Mina, RNMR staff). As the RNMR has been central to conflictual interactions between its stakeholders (e.g. Fig. 4), it reveals once again a lack of communication in the approach of environmental management programs. *"I understand small fishermen who have always fished in the same area, from one day to another, people coming from the outside telling them « Sir, you can no longer come and fish here because it is forbidden.» Fishermen would reply they've been fishing here for years, their grandparents fished here, their great-grandparents too, they've always had fish, they still have fish today and that someone coming from the outside telling them that they're not allowed to fish anymore? Mind your own business!"* (Fredo, RNMR staff).

These interviews also provided information on poaching. They highlighted that the number of poachers is an indicator of a non-concerted environmental management tool. *"There were 90 tickets issued in 2017. The RNMR is among the French natural reserves where the most fines are given… We do a lot of sorting, otherwise it would be around 300 or 400 tickets a year. It has always been, it is anchored, it is like that"* (Fredo, RNMR staff). As far as SHIs risk reduction is concerned, relations between the two public benefit

Fig. 4 Deterioration at the entrance to the RNMR premises (December 4, 2018)

corporations, namely the CSR and the RNMR, are strained due to the divergent opinions regarding management tools. Since 2016, the CSR has been in charge of the shark control program which is in favor of removing and euthanizing target shark species caught in nets, whereas the RNMR prones conservation of fauna and flora. *"What the CRA (now CSR) is currently doing, I find difficult to conceive from a scientific point of view… I was told «We don't give a damn about your science, science has had its time. It didn't work, there were deaths. Let's stop with science, let's stop putting money into it, let's fish»."* (Mina, RNMR staff). According to the CSR, the program aims at trialing new technologies. *"We are still in the hypothetical phase and we need to find innovative solutions that would enable the user to feel safe at all times."* (Jano, CSR staff). The issues related to the acceptance of the targeted fishing program is viewed as a major constraint to the development of the Reunionese shark management plan. *"The Creole community, I think there's a large majority against. There are many detractors who criticize us for the lack of actions. There are either pro-environment or pro-fisheries. We are in the middle, whatever we do, we are criticized from both sides."* (Jano, CSR staff). This observation is shared by other managers of public institutions who are consulted to validate the scientific nature of the programs. *"Some people are upset because we are decimating populations that are already fragile, others are very happy because we are going to take all the sharks out of the water and we will be protected. I'm not sure that these people are right either."* (Fabienne, Marine observatory staff).

Interviews with the General Public

During face-to-face interviews we learned that participants believe the foundations of the Reunionese shark crisis were built on the premises of scientific protocol. Indeed, the first study regarding population ecology of coastal sharks, the CHARC program, was launched in 2012 while fatal shark bites across Réunion had already happened. It is precisely this slow scientific action that summoned up new and old bitterness. *"Since the beginning I have been saying that we need a scientific council but not composed by people only from here, an international scientific council, with identified specialists. It's up to the CSR to carry this."* (Erwan, citizen). Water-based activities practitioners are among the most critical stakeholders we interviewed on the shark management strategy in Réunion. They inquire about both the research community and the existing programs for environmental management and preservation. *"Scientists don't know shit, nothing, it's purely theoretical." (Henry, water-based practitioner).* Moreover, public money spent in order to secure western beaches of the island of Réunion is another element that shows the lack of public consultation and is, de facto, a matter of social tensions. *"Those studies*

for me were totally useless. A waste of money, energy, which created a lot of problems." (David, water-based activities practitioner). Additionally, we noticed the general public participants often put forward the feeling of autochthony as a strategy to legitimize their position in relation to that of the scientists, as well as to assert their Reunionese maritime culture. *"We didn't need the RNMR's scientists to tell us how we should manage our environment. There has been a culture of the sea for a long time here." (*Pedro, water-based activities practitioner*).* That lack of hearing is sometimes experienced as unfair. *"There is an injustice there, they did things without consulting us, without really taking our opinion into account. They did what they wanted to do. It comes from Europe, from far away."* (Pedro, water-based activities practitioner). We noted that the implemented environmental management tools in Réunion often come up against elderly generations' lifestyles. *"Every morning, a Creole would go downstairs and catch 2 or 3 fish so that they would have their curry for the day. Even if they catch a fish, they get their pack of cigarettes. But nowadays it's not the same, everything has changed because of the regulation."* (Damian, citizen). This alteration noticed by the general public could be explained by the recent introduction of these new normative rules. Another explanation could be that the people who brained this injunction are not autochtones.

This questioning of environmental management models is found in shark risk management. *"All these devices, these nets, for me it's a waste of money, it will not bring solutions. The nets can not hold yet, then imagine under several tons of pressure. That arrangement is only for two beaches… (laughs)"* (Manuel, citizen).

Interviews with Private Sector Stakeholders

Professional fishers also developed critical views of risk management strategy and more especially on scientific research protocol. Many of them shared their lack of understanding regarding the ban on marketing shark meat which started in 1999. *"I've eaten shark meat since I was a kid. It's just that these people are behind a desk and they make decisions."* (Joe, fisherman). Moreover, the fishers we interviewed expressed the same views on the possible link between Ciguatera intoxication and the consumption of shark flesh. They agree that no scientific study carried out on the island of Réunion has made the link between the consumption of shark meat and the contraction of this toxin. *"I've always fished for sharks, I've always eaten sharks. I've never heard of this Ciguatera. A scientist had to come along and say, well, we're going to stop fishing sharks because there's Ciguatera. How come? How many people went to the emergency room? How many people died from Ciguatera intoxication on the island of Réunion? None."* (Jean, fisherman). Both water-based activities practitioners, fishers and tourism providers therefore question the acceptability of such environmental management tools based on science. Shark management strategy in Réunion is also criticized for its cost and lack of results. *"There have been studies that have cost a fortune and we still don't know a thing. The management is not very efficient and it is expensive for the people of the island. It's mainly for the western coast but it costs everyone."* (Benoît, other marine professional).

Participant Observations

During our field work, we had the opportunity to interact with several residents who hold knowledge about sharks. As a consequence of their use of the marine environment, some have had direct interactions with sharks, notably shark bites - some of which were not even recorded in the archives (e.g. Fig. 5).

Additionally, there is already a research project in humanities and social science aimed at consulting stakeholders and users of the marine environment (Jaccoud, 2014), which was financed by the French authorities. Finally, the security measures put in place on the western beaches and the associated economic costs may seem excessive in relation to the number of beneficiaries (e.g. Table 4: observation of the "shark watch" system).

Social Media Survey

Table 5 shows several fragments of local newspaper's articles which were relayed on social networks and had the effect of stirring up conflictual relations. The almost daily interactions/altercations between pro-shark fishing and anti-shark fishing stakeholders on the Facebook pages of the CSR and some associations, show the extent to which the emergence of conflictual situations result from the occupation of the media place. The shark fishing matter is also a rather political issue insofar as people use words and arguments that go beyond local issues to challenge political risk management choices. What's more, the majority of participants who mentioned the shark risk management

Fig. 5 A fisher bitten by a shark on the calf in Ste Suzanne (March 12, 2019)

Table 4 Participant and non-participant observation

Places	Dates of observation	Observations	Details	Lessons learned
Étang Salé beach	Between December 2017 and March 2019	Use of ocean by the general public	People respecting or not the prefectorial decree.	The authorized bathing zone is framed by a permanently fixed protective net. This zone is open most of the time, except when there is strong swell. When there is swell, about a dozen surfers are regularly in the water before the opening of the beach lifeguard station. Soon, the dawn patrol is being evacuated by law enforcement authorities which had been notified by on-duty lifeguards. Other citizens do not respect the prefectorial decree either. We regularly observe participants getting on with their water-based activities (bodyboarding, skimboarding, swimming) outside the authorized bathing area. These practices are particularly observed after the beach lifeguard station is closed.
St Pierre beach and La jetée (pier) surfing spot	Between January 2018 and December 2018	Use of ocean by the general public	People respecting or not the prefectorial decree and other uses	The surfing spot by the pier is frequented all year long by approximately ten surfers. And yet, we have not observed any surfers sentenced to a fine by the police. In the lagoon there are a diversity of ocean users practicing water-based activities provided in the injunction (swimming, paddle, snorkeling). These activities are subject to change without notice when there is a shark around. It should be noted that kitesurfing is becoming increasingly popular with more and more regular users.
Terre Sainte neighborhood		Professional fishers' way of life	Evolution of uses in a fisher's neighborhood	A fisher's district underwent changes. It may be because of the evolution of the population living there. We observe gatherings of fishermen and/or locals by the roadside and along the coast.
Trois Bassins beach St Leu beach	September 2018	Use of ocean by water-based activities practitioners	People not respecting the prefectorial decree	There are the most frequented surfing spots during this period of prohibition. In Trois Bassins, we sometimes observed 20 + surfers and bodyboarders in the water, parents accompanying their children and beginners catching waves as this spot is suitable for learning water-based activities. The surfing spot of St Leu is one of the most internationally known. Only experienced surfers may ride this reef spot. Additionally, we heard about tensions between surfers and scuba divers during informal conversations.
St Louis coastline	November 2018	Wastewater management, agricultural practices and water runoff	Citizens' and fishers' specific uses of the coastline and near the mouth of the river	The beaches of St. Louis are mostly frequented by fishermen. The sewage treatment plant has considerably impacted the ecosystem, with discharges of treated water observed in several places. The mouth of the river is a known place for shark fishing.

Table 4 (continued)

Places	Dates of observation	Observations	Details	Lessons learned
La Saline Les Bains	Between December 2018 and March 2019	Use of the lagoon and the ocean by the general public	Citizens' uses of the coastline and specific interactions regarding the RNMR.	The beach of La Saline is the most frequented of the island because of its protective lagoon. Many families meet in the shade of the filaos but not all of them make the most of the lagoon. It is also a place that crystallizes tensions. Indeed, the premises of the RNMR have been degraded (graffiti) and there is an illegal occupation of the DPM by straw huts.
St Gilles Boucan Canot beach		Use of ocean by the general public and tourism economy	Monitoring of the shark watch system at the beach of the Brisants and citizens respecting the prefectorial decree.	The prefectorial decree is generally respected in the west with few violations observed during our fieldwork. We identified two bathing areas at Boucan beach, one of which is a pool by the ocean (often unfit for use) and the other is an area where lifeguards install a net daily depending on the conditions. At St. Gilles, swimming is allowed within a zone protected by a net. However, it was only open a few days a week during our fieldwork. At the beach of Les Brisants, the shark watch system allows licensed swimmers to sign a moral contract that stipulates not to surf outside the system. During our observations, there are about ten surfers per time slot while 15 watch persons are necessary to secure the spot.
Patate à Durand neighborhood (St Denis)		Professional fishers' way of life	Evolution of the uses in a fishermen's district	One of the first fishing districts in Réunion. Nowadays, fishing nets and buoys are placed on the sidewalks and in the stairwells. Informal discussions with the inhabitants allow us to conceive the evolution of the settlement and the uses within the district with professional fishermen who can now be counted on the fingers of one hand.
South coast (St Pierre to Sainte Rose)		Use of ocean by the general public	General public's uses of the coastline and specific uses from the fishers	Between deserted beaches, waterfalls and lava flows, the wild coast extends from Saint-Pierre to Sainte-Rose. Less favorable to ocean uses, there are nevertheless several fishing ports. Pools like those of Manapany or Grand Anse allow "safe" swimming for new generations.
East coast (Sainte Rose to Sainte Marie)		Use of ocean by the general public		Historically the land of the Indian indentured servicemen, the windward coast is populated with Tamil temples. With a wild coastline and no lagoon, the density of ocean users is much lower than on the west coast even if we regularly observe fishermen.

question seemed not to have a detached view of the issue, as their representations were often altered by the emotional impact of the human wildlife crisis. Among other things, they generally interacted about the following topics online: the place of surfing on the island of Réunion as a symbol of neo-colonialism, the illegitimate place of its practitioners in the ocean, the violence of the SHIs and the hypocrisy of animal rights activists. As a result, some people seem to have become hypervigilant, which is a cognitive process that influences the way people process information and can, in some cases, lead to ruminations and beliefs in a plot hatched that go beyond their reach. Stakeholders therefore attach greater importance to information that confirms whatever this means (Kramer, 1998).

Knowledge and Skills Acquired by Ocean Users Could Enrich Shark Management Strategies

As we have identified above, the current research programs do not seem to have taken into account Reunionese ocean-users' knowledge and skills. During our fieldwork we decided to give voice to the various stakeholders, so as to understand why it is pretty frequent to hear throughout the island "Reunioneses turn their back to the sea."

Interviews with Civil Society Stakeholders

Discourses among the research community are ambivalent regarding the matter of maritime culture in Réunion. On the one hand, there are scientists who convey the idea that communities have been turning their back to the sea since their early settlement. *"Reunioneses were really rather turned towards the land. They had never appropriated the sea, they did not have an experiential approach that allowed them to build an understanding of risk."* (Nash, research community).

On the other hand, other scholars recognize that part of the population has always been linked to the sea, particularly for food fishing. *"The inhabitants are not historically turned towards the sea, they are rather landlubbers or farmers, but afterwards there was still a fringe of the population who lived on the coast, who were fishermen."* (Mick, research community). This latter viewpoint appears to be generally shared by local community-based organization managers. *"Now that people fish, they have developed knowledge of fishing and therefore they know the sea well. There is still quite a community of fishermen. In every village that has become a town on the coast, there are very good fishermen."* (Tib, local community-based organization manager). Although fishermen have built up knowledge through their daily use of the Reunionese marine environments, their expertise does not seem to have been taken into account in the research programs for shark risk reduction. *"Years went by, there were still attacks… Finally, apart from saying that sharks are all around the island and that there are many more in winter than in summer, that sharks eat fish and turtles,* etc. *We have only shown things that are intuitive, things that seem logical. We didn't really revolutionize science. We've just gathered a certain amount of information. In essence it is more about fantasies or beliefs."* (Mick, research community). Owing to the fact that scientists in charge of shark management scientific programs in Réunion tend to consider fishermen's knowledge as beliefs, this contributes to revealing a lack of consideration of local professional fishers' expertise. We should bear in mind that scientists implementing these programs belong exclusively to the branch of natural sciences. By contrast, scientists in social sciences have already collected material on this Reunionese local fishers culture - even though environmental awareness tends to dissipate. *"It is a type of fishery on the rotation of the moon or following the tides. It is a gentle fishery that does not have a great impact on the area since the idea is to catch only what will be eaten. It follows a lunar cycle. There is still the idea of renewal, we respect a natural rhythm… It is a return to considering natural space and natural rhythms, which we perhaps knew better before than today."* (Manuel, research community). Additionally, knowledge on SHIs being mobilized by local community-based organization managers seem not to rely on scientific programs but rather on ground observations. *"It was necessary to be supportive and vigilant. These are the two conditions which when they are fulfilled, there is no attack. While advocating the return to water, I wanted to convince people to do it consciously."*(Tib, community-based organization manager).

Interviews with Public Sector Stakeholders

Note also that the RNMR staff opinions are divided regarding the saying heard on the island: "Reunioneses turn their back to the sea." Some personnel agree: *"It is an island that has turned its back on the ocean until very recently, even before water sports developed, the ocean was dangerous. It is strong and the coast is not very hospitable outside the lagoons.* (Gege, museum staff). However, other members of the staff are rather skeptical: *"Yes, some believe Creole have never turned their back to the sea. It was a way to feed a polemic that many people know to this day. Afterwards, there was the Creole turned towards the sea and the one who was indeed more in the background, which is still the case."* (Carl, RNMR staff). The fishing community too have a basic understanding of the Reunionese marine environment, acknowledging their common heritage which is associated with oral tradition. *"Fishermen and the elders have incredible knowledge. Everything that exists today*

is thanks to our elders… They tell you about such a place or phenomenon that you have to be careful. They tell you where not to go in the water because it is dangerous. If you listen, you could not do it better, but if you don't listen, there are consequences that can follow". (Carl, RNMR staff). Correspondingly, the question of resource management is another matter that conveys heterogeneous representations between stakeholders. We found in several speeches a common and generally accepted description of the Creole fishers' mentality shaping their attitudes towards marine resources: *"If he doesn't fish it, his friend will take it. Environmental education when we were children was a zero score (laughter)."* (Fredo, RNMR staff). Environmental managers rather consider awareness of the issues related to the preservation of the marine environment as a recent process. *"We used the sea but we were not aware of the ecology, that we had to protect it, be careful, not to take anything from it. There was no such notion."* (Mina, RNMR staff). Eventually, other speeches from research participants reminded us that the people of the island of Réunion have always cohabited with sharks, notably by limiting access to areas considered dangerous. *"We all know very well that we are not going to go swimming in Sainte Marie. It has long been a habit not to go there, neither in the bay of St. Paul. When I grew up, I was always told that I should not go to the bay of St. Paul, because it is dangerous and there are sharks. It's dangerous, there are sharks. It has always been the stories of my grandparents."* (Jano, CSR staff). In addition, a decrease of certain species of reef sharks was noticed. *"These small reef sharks were used to regulate everything around them. Gramoons have always seen sharks. My grandfather always told me that when he would go fishing, sometimes there were sharks that could get next to the boat. They were even bigger than the boat. It was never an obstacle for them."* (Carl, RNMR staff). Finally, another issue involved with Reunionese maritime culture is the consumption of shark meat. For instance, in the stakeholders' interviews, we repeatedly noted that the consumption of shark meat was associated with a common regional practice. As we have discussed earlier, the issue engendered questioning following its prohibition back in 1999. *"Of course there are Reunioneses saying they have never eaten bull sharks or tiger sharks, that they have never eaten the meat of the hammerhead sharks. But I can tell you that in all the fishing villages, in the seaside communities, some guy will tell you "I ate everything". I myself have already eaten shark meat… Reunioneses tell you they will buy sharks again, but that's not true. They won't buy shark meat in the stalls of fishmongers anymore. Because for them, in their minds, this animal can eat people. So I choose not to eat it."* (Carl, RNMR staff).

Interviews with the General Public

A recurrent element describing the relationship between Reunioneses and their marine environment showed up in the research participants' discourses. Some citizens believe the saying "Reunioneses turn their back to the sea." finds its foundations in colonial history of the island of Réunion. A few research participants expressed their views on colonial societies' settlements that may have determined this double talk between stakeholders. *"On the island there were two societies, a plantation society around the factories and a rural society of people in the highlands. We call them "ti blancs", people who were governors, petty masters, whose purpose was to supervise the slaves. But when slavery was over, they had nothing left, so they found themselves with small plots of land in the highlands. The indentured servants and slaves remained on the coast and around the factories."* (Dimitri, citizen). Others commented that relationships of domination in a post-colonial society are directly visible and measurable in Reunionese marine environments. In the 1980s, the French government employees arriving in Réunion, and settling in the west of the island, were the main recreational users of the marine environment. *"When one arrived here, who would make profits from the coastline? The Zoreys. When you would get in the water in 1988 there was barely 5% Creole. Now, it must be around 15%."* (Gef, citizen). Since then, the communities living on the seashore have developed knowledge, particularly about the risks associated with the fauna and flora. *"The coasts were wild. People knew that the ocean could be dangerous. Dangerous because of the creatures and because of the swell… When we would get near the water our parents would let us be free. But, they had told us the sea is dangerous, to be careful, to pay attention at such places. We know there are days when we should not go to the sea, days when it's more dangerous."* (Jo, local surfer). Nevertheless, traditional knowledge was only scarcely mentioned in research participants' from the general public discourses. This could be explained by a transition that has been operating in the use of marine environments. Nowadays, Reunioneses rather tend to use their marine environments to practice water-based activities. From a temporal perspective, the decline of traditional knowledge would coincide with the advent of leisure activities. *"People surf more, they go swimming more, whereas Reunioneses used to live from it."* (Max, citizen). This quote exemplifies that professional fishers are once again identified as the stakeholders who show the most aptitude for cohabiting with sharks. *"For my grandfather, it was never a problem. He wouldn't go for a swim, he's not a guy who would stay on the beach. He would pass on knowledge when we were little. He would warn us that there are sharks when we would see bugs swimming underneath. Sharks have never been a hurdle nor a fear for him."* (Manuel, citizen). Finally, we uncovered that the knowledge generated by a regular use of the ocean may contribute to reducing the risk of SHIs. For example, Reunionese

marine users have identified factors that increase the chances of encountering sharks. These include heavy rainfall, which results in highly turbid waters, particularly conducive for bull and tiger sharks to hunt. *"Every time it rains, it is the same. Yesterday it rained, and we know that today we shouldn't go in the water. We acknowledged that."* (Max, citizen).

Interviews with Private Sector Stakeholders

Reunionese stakeholders running local fishing companies, local travel agencies and other ocean-oriented businesses agree in identifying professional fishers as guardians of maritime knowledge. Focusing on traditional knowledge, we understood that this cultural transmission sheds light on the construction of the relationship between people of the island and their environment, in particular by labeling the places where risks of human-sharks encounters are the highest. *"There are areas that were more infested than others. When I was a kid, I never saw anyone going for a swim at Devil's Point (la pointe du diable). Then, there were the snorkeling and spearfishing guys, there were several of them in the water. They had a good command of the area."* (Joe, fisher). As a result, risks of shark-human encounters seem to be ordinarily and customarily accepted. *"When the weather was bad, and boats were caught outside the lagoon and insisted on passing through the channel, they would capsize. The crew bodies that were lost, would later be found half eaten because a shark had passed by."* (Dan, fisher). Professional fishers appear to have therefore developed different strategies to limit the risks they take. Some research participants also mentioned shark fishing was formerly a common practice in the area. *"People used to fish for sharks. They sold, they traded, they made a living. They didn't destroy natural resources. There were no beacons, no millions of euros of subsidies. They took a steel wire, a cable, a tuna head, and the next day they'd catch a shark."* (Henry, fisher). Scientific knowledge on ecology and environmental protection was rarely mentioned by the research participants from the private sector. One of the reasons an interviewee came up with is that sometimes studies belie natural processes. *"Today it is too instrumentalized, documented or regulated. People must take up this torch and say that it is up to us. Réunion is not only for the Creole, it is for us, the people. What I do well is for us. What you do will be for him. What they will do will be for the Reunioneses as a whole."* (Denis, fisher).

Participant Observations

The observations we carried out allowed us to list a certain number of traditional uses of Réunion seashores' inhabitants. We found out that the inhabitants of the East rather use the ocean by the necessity to fish for themselves whereas in the West, a recreational use of the ocean seems to have taken precedence, despite the fishing community still being present. We also observed a greater privatization of the coastline in the West, revealing this dichotomy between West and East. These different observations are markers of a stronger westernization of the Reunionese way of life in the West than in the East. This westernization is sometimes a source of conflicts that are ethnicized by the protagonists themselves, such as those we observed for the private use of the public maritime domain in La Saline. Besides, the data we gathered do not allow us to provide a one-sided answer on the traditional nature of shark fishing and consumption of its meat in Réunion. While shark meat has always been eaten in Reunionese fishing districts (Reunionese fishers used to catch between 20 and 25 tonnes of shark a year before the ban), some members of the population are much more reluctant to eat shark meat.

To address the growing risk of SHIs, some water-based practitioners have adapted to the risk by endorsing new attitudes to cohabit with sharks, by developing strategies to reduce shark-risk encounters. This is particularly true for spearfishers and some surfers. Among the strategies adopted by the latter: limiting your practice to specific times, looking underwater when you're waiting for the waves to peak, and above all keeping the water column busy by looking out for each other. This latter approach has been developed into an innovative system worldwide: the Vigies Requins Renforcées (VRR). This protocol is set up by the Réunion Surfing League and financed by the French government and some of the municipalities in the west of the island. It enables licensed surfers[20] to practice their sport under the watchful eye of a dozen of professionals, as well as technological tools such as drones and underwater cameras (e.g. Table 4). Meanwhile, water-based activities practitioners have returned in droves to the water, and shark watch systems are already saturated.

Social Media Survey

By monitoring the Facebook pages identified as areas of interaction between the various stakeholders, we were able to identify two main protagonists who clash daily over the activities of shark fishing and the consumption of its meat (e.g. Table 5). We observed a form of instrumentalization of environmental protection on social networks. The lobbying activities of environmental protection associations tend to

[20] Members of surfing clubs formally agree and sign a document to refrain from surfing outside the VRR system. However, informal conversations with surfers and professionals working within the VRR system, have shown that the riders still surf outside the VRR system.

polarize public attention on the Réunion context, whereas other countries such as hexagonal France are more involved in the large-scale incidental fishing of sharks (bycatch) by fishing boats.

Discussion

Responses to HWCs with Sharks Reveals Social and Environmental Injustice

For the past ten years, policies regarding SHIs have affected Reunionese livelihoods through the regulation of ocean uses. The ban is experienced as an environmental injustice, since the ultimate aim of such shark risk management policy is to ensure that there are no more victims. To put it differently, the French authorities do not take responsibility anymore for what is likely to happen in the water, when prohibiting water-based activities the most inclined to SHIs. Therefore, there are no more victims but rather people who trespass the prefectorial decree. Moreover, the discrimination between water-based activities is experienced as a social injustice by practitioners, thus building up tensions between the stakeholders.

Additionally, the shark issue in Réunion is rooted in scientific miscommunication. It started in 1999, when the first study supporting that eating shark meat could lead to being infected by the ciguatera, led to the ban of shark meat commercialisation. The general public misunderstood that sudden ban, thus triggering a loss of trust in natural sciences. However, the role of science is to act as an interface between reality and public opinion. In this latter case, science acted as a mediation of reality: it described as well as it transformed the reality insisting on risk disease (Kohler & Brondizio, 2017). In this past decade, even if many ecological studies have been published in Réunion (Blaison et al., 2015; Mourier et al., 2021; Pirog et al., 2015; Soria et al., 2019), it seems that the general public's role in risk regulation was

Table 5 Conflicts regarding fragments of local newspaper's articles which were relayed on social networks

Dates / Facebook group / Aim of the group	Topics of discussion	Stakeholders concerned	Arguments and debate issues	Fragment of the post
December 28, 2021 - Clicanoo Facebook page - Local media	Prefectorial decree for directed shark fishery in the RNMR.	Shark fishing advocates and shark fishing opponents	The RNMR is at the center of debates between shark-fishing advocates and their opponents. The advocates of shark fishing programs regularly mobilize the identity argument, since their opponents who interact on Facebook pages are often from the mainland, in France. Outsiders are therefore considered illegitimate when it comes to risk management, since they don't live on the island of Réunion. We can also link these interactions and the non-legitimacy of the opponents to the fishing program with the discourse of water-based activities practitioners when it comes to the origins of scientists who work or have worked on the question of shark risk reduction, who are most often from the mainland. These discourses are considered racist by the opponents of the fishing programs and moralistic by the defenders of these programs.	C1) A: Boy, shut up! And stay in France, over there in the Auvergne. I don't need your opinion! You from Réunion? No! So stop! B: Stop it! You're making me sick with your racist rhetoric. C2) We've had enough of metropolitans and others pretending to know best and giving lessons when they don't know any better than their own navels. At some point you've got to stop messing around! If you like it, so much the better! If you don't, it's all the same!

Table 5 (continued)

Dates / Facebook group / Aim of the group	Topics of discussion	Stakeholders concerned	Arguments and debate issues	Fragment of the post
March 19, 2019 - LINFO.re Facebook page - Local media	Reactions to Brigitte Bardot's comments on the relationship between islanders of Réunion and animals.	Animal rights activists from mainland France and from the island of Réunion	Following the publication made by Brigitte Bardot, animal rights activists and citizens of Réunion interacted on local media Facebook pages. On the one hand, animal rights activists pointed the finger at certain Reunionese practices, such as shark fishing using live dogs as bait. On the other, Reunionese responded to these comments by referring to the hypocrisy of "zoreil" who eat local goat dishes but take offense at certain local practices towards animals. The comment even went so far as to wish the "zoreil" dead. The media interventions of public figures have had the effect of heightening tensions between the Zoreil and Creole communities.	Bardot's quotes: - "I'm overwhelmed, swamped by letters denouncing the barbarity the people of Réunion inflict on animals." - "This island they call 'Devil's Island' is the only one among all the French overseas departments and territories that continues to behave so savagely towards animals." - "The natives have kept their savage genes, but French laws are meant to be respected and it's your job to enforce them." C1) A: What is using puppies or dogs as bait to catch sharks? Spilling blood into the ocean from a slaughterhouse is that normal? And then they cry when a shark attacks. B: No doubt the customs of the island's inhabitants. C: Since earlier I've been reading your comments, which are at the limit of what I can bear. No, she's not telling the truth, animal abuse is not a fact of people of color but of the entire planetary population. In France, many so-called "white" people mistreat their pets. D: There's nothing racist about what she said. It's just a statement about what happens to animals on Reunion Island. C2) You see the zoreils who come to eat cabris massalé at Tamil commemorations and who don't like sacrifices. I wish for them to choke and die 5 times in the same day. Brigitte Bardot you see.

completely put aside. We have also noticed a hierarchization of knowledge that has led to the invisibilization of some of the stakeholders who are the holders of shark-related traditional knowledge. Building bridges between scientific and Indigenous knowledge is an issue that has been the focus of relevant studies (Rivers et al., 2023). Henceforth, environmental controversies need to be approached from the lenses of sociological and anthropological studies as well as interdisciplinary approaches in order to better grasp the multitude of issues associated with HWCs.

Nevertheless, we have identified two categories of stakeholders which were invisibilized in that shark program's decision-making process. None of the inhabitants of the eastern coast nor those from the cirques in the interior of

Réunion island were consulted. If it were intentional or not, this bias suggests only inhabitants of the west coast are directly concerned by the management of the marine environment, especially within the RNMR. Anyhow, there is no question that the Reunionese natural heritage belongs to all the inhabitants of the island.

Consulting the Reunionese population, as was the case more recently with a public consultation on the release and tagging of captured juvenile tiger sharks,[21] seems to be an appropriate tool for sustainable and peaceful management of uses and resources (Giovos et al., 2021; Sheridan et al., 2021).

Living with the Sharks in Réunion

People of the island of Réunion have always cohabited with sharks and risks of shark-human encounters seem to be ordinarily and customarily accepted. Moreover, the harshness of the ocean, the swell and the inhospitable coastline are all elements that have shaped a risk culture, particularly for families living by the sea. However, since 2012 and the beginning of the so-called “shark crisis”, some of the ocean users have been placed in a position of constant vulnerability. In other words, they must quickly become tolerant to the risk, or put an end to their use. Risk is a notion socially constructed which varies from a social class to another and between cultures. In this case, from a western cultural point of view, it seems unacceptable to be the victim of a SHIs, whereas from the point of view of Réunion's Creole culture, this risk seems more acceptable.

To sum up, our findings reveal that the concept of risk has to be understood as an intention to develop a well-balanced way of living with the sharks where residual risk remains. To put it another way, people currently managing shark-related projects may be more inclined to attempt at managing animal populations rather than redefining the position of humans in their relations to animals (Barnett et al., 2022). Societal response to risk is multidetermined and thus needs to be studied in a multidisciplinary way.

SHIs Management Perspectives

It is now obvious that SHIs are considered a high profile issue on the island of Réunion involving a diversity of stakeholders. This plurality of individuals could explain the emergence of ethnic tensions in a post-colonial society. These tensions have been crystallized during events such as the deterioration of the RNMR premises and the management of the Public Maritime Domain on the west coast. Our field surveys enabled us to measure the difficult cohabitation between recreational activities and environmental policies conducted by the authorities, revealing contrasting and even ethnicized representations of natural resources. Thus, the shark risk management in Réunion should be approached not as a "crisis", but as an environmental controversy, and all stakeholders need to be consulted on the tools and means carried out to reduce human-shark encounters risks. This question reveals the transformative potential of the shark issue, in particular the fact of setting up measures to learn from that no-win situation, rather than adopting a "return to normal" perspective. In order to bridge the gap between expert views of risk and public perceptions, we have listed the tools that have been proposed worldwide and that could be implemented in the Reunionese context (e.g. Table 6).

As social problems analysts, we were urged to focus on how the SHIs issue in Réunion is generated and sustained by the activities of complaining groups and institutional responses to them. Here we question the contemporary modalities of sharing a common space, with all the antagonisms, struggles, negotiations, compromises and alliances that this implies. We analyzed the representations, discourses and local uses of the ocean, since they appear to reveal the ethnic plurality of a fragmented territory (Schirrer, 2008). The present findings confirm that managing the coexistence between human and wildlife is controversial and a source of tensions where there were none before. These tensions are the result of the unpredictable situation where expert knowledge (scientific and environmental managers) is no longer sufficiently precise or reliable to respond to the concerns of the stakeholders. Tensions have also been induced by the existence of the Reserve that contributed to reterritorialyze (Deleuze & Guattari, 1980) the space through new regulations and space control. In addition, it is worth discussing the risk management strategy proposed by the French authorities, as results revealed a lack of negotiation and inclusiveness in the decision-making process. This conclusion follows from the fact that occidental management methods are partly inherited from the colonial context which is outdated by the situation. Knowledge and skills acquired by ocean users could enrich shark management strategies by highlighting the diversity of SHIs risks. This confirms the need for a multidisciplinary approach which takes into account the specificities of local situations. Future studies could fruitfully explore this issue further by building a contingent that could fairly manage the shark controversy in Réunion. This is very much the key component in future attempts to investigate the implementation of western environmental management tools in a (post)colonial context. It might prove important since it is an issue that has

[21] The CSR has decided to set up a scientific research program (April, 2023) involving the release and tagging of juvenile tiger sharks caught as part of Réunion's targeted fishing program. The aim is to understand whether the sharks captured and released will remain close to the coast, or whether they will migrate overseas. In this context, a local survey carried out revealed that 60% of respondents were opposed to tiger shark captures, regardless of size.

Table 6 Summary of participatory tools to monitor HWCs

Context	Method	References
South Africa Indigenous and local knowledge holders continue to be largely neglected in ocean governance	Marine spatial planning (MSP) The process is co-developed to be contextual, equitable, and transparent. Enabling factors include thinking out of the box, taking the time to engage, listen and collaborate, and strengthening stakeholder capacity for co-development. Co-management approaches and specific cultural activity zones should be implemented to increase access to coastal areas for Indigenous and local knowledge holders	Rivers, N., Strand, M., Snow, B., Metuge, D., Lemahieu, A., & Benkenstein, A. (2023). Integrating Indigenous and Local Knowledge in Marine Spatial Planning
New South Wales Shark sightings and incidents that occurred on the NSW North Coast in 2015/16	Participatory workshops The NSW Government protocol for addressing beachgoer behaviour and risk management: - Assisting community members to responsibly self-assess risk in relation to encountering sharks, and improve trust in information and advice available to beachgoers; - Considerate the beachgoer behaviour, including behaviour changes and local responses to shark encounters and a variety of management measures, within the ongoing implementation of the Shark Management Strategy; - Working with groups that are considered to have a high risk tolerance to support responsible actions in relation to the risk of shark encounters	McClean, N., van Putten, I., Sbrocchi, C., Chin, A. Pillans, S. (2020) Reducing risk in human-shark interactions in NSW: Trialling a participatory approach to understanding beachgoer behaviour - Summary report. Faculty of Arts and Social Sciences, UTS, Sydney
Western Australian Government Shark encounters in WA are rare. However, every West Australian can bring something to the beach, to help stay safe	Protocole The WA government suggests a diverse range of tools, including: SharkSmart WA application; aerial surveillance (Helicopter and beach patrols); Personal shark deterrents for surfers and divers (Government is offering a rebate of $200 to Western Australian residents); Beach enclosures; Shark sightings, detections & responses (provides near 'real-time' information on shark sightings and detections to response agencies and the public, to assist people in making informed decisions about their water use); Shark Warning Systems	https://www.sharksmart.com.au/strategy/state-government
Mediterranean sea Degradation affects this large marine ecosystem, including its coastal habitats and biodiversity	Participatory toolkit Adopting a participatory approach, that is ensure the participation of key stakeholders, when planning, identifying, creating and managing MPAs	Stakeholder Participation Toolkit for Identification, Designation and Management of Marine Protected Areas. RAC/SPA and IUCN-Med Ed. RAC/SPA, Tunis. 30 pp

Table 6 (continued)

Context	Method	References
Réunion island Sharks' removal is at the heart of social debate in Reunion Islands (3860 shark fishing operations in 5 years) and data gaps provide a fertile ground for alternative discourses and social conflicts about shark risk	Marine spatial planning (MSP) Guidelines for spatially mitigating human-shark conflict in MSP: - Zoning shark risk management: Setting management targets. Each zone should address specific target or risk. Management type and intensity should differ from one zone to another according to zone's targets - Coupling recreation activities and shark risk management: development of zones for recreational activities should include consideration and perhaps allocation of shark risk management - Minimizing impact on ecosystem: uncertainty regarding impact on ecosystem should prevent or at least restrict and minimize allocation of shark risk management in proximity to vulnerable habitats	Shabtay, A. Lagabrielle, E., Plot, V., Potin, G., Guyomard, D. (2020). Marine spatial planning provides a comprehensive framework for building evidence-based shark risk management policies with sea-users. Environ. Sci. Pol

not yet been discussed in Réunion. Other questions arise from this acknowledgement, notably related to the theme of "living together" on a shared shrinking land.

Conclusion

In summary, we argue that HWCs can trigger human-human tensions. On the one hand, there is the science-based risk governance, and on the other, there is traditional knowledge and experience of ocean users in relation to sharks. The present findings confirm that two approaches run into conflicts in different ways: (1) the cognitive track with the discrepancies between the way they interpret the situation on the basis of very different experiences and knowledges, (2) the strategic track of how their expectations are dissonant, (3) the methodological track of a missed opportunity to involve ocean users in a participatory design of risk policy. In that case, local knowledge and participatory tools are elements that, when taken into account in the management of natural environments, make it possible to reduce the risks of conflict between the different stakeholders and between humans and wildlife. We recognize that traditional knowledge does not cover all contemporary and future uses, which is why a long-term, inclusive and participatory approach is essential.

Finally, we question the position and responsibility of the researchers working increasingly closer to the science/policy interface in a context of instrumentalization of environmental protection. We are aware of the necessity to produce scientific knowledge to respond to societal needs. Transdisciplinary approaches appear as a serious methodology to be explored in order to manage anthropic uses of the natural environment in an integrated way. Thus, it seems appropriate to explore the issues of undone science, power and interest that have often hindered the governance and transformation of marine environments towards greater sustainability.

Acknowledgements The authors would like to thank the interview participants for their openness and contribution to the research. We are also grateful to our English reviewer, Ms. Lucie Beaufreton, and editors of this paper for generous insights.

Authors' Contributions RP. collected, analysed the data, prepared figures and wrote the main manuscript. DD. and TB. supervised the manuscript. All authors reviewed the manuscript.

Funding This research did not receive any specific funding.

Availability of Data and Materials To guarantee the anonymity of the interviewees, audio recordings were destroyed after been transcribed. The anonymized interviews are numerically stored for use in any further approaches to the research subject. The profiles of people captured on social networks have been blurred.

Declarations

Ethics Approval Informed consent was gathered from participants prior to the individual interviews. Comply with Ethical Standards.

Competing Interests The authors, therefore, declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Barnes, R. F. W. (1996). The conflict between humans elephants in the central African forests. *Mammal Review, 26*(2–3), 67–80. https://doi.org/10.1111/j.1365-2907.1996.tb00147.x

Barnett, A., Fitzpatrick, R., Bradley, M., Miller, I., Sheaves, M., Chin, A., Smith, B., Diedrich, A., Yick, J. L., Lubitz, N., Crook, K., Mattone, C., Bennett, M. B., Wojtach, L., & Abrantes, K. (2022). Scientific response to a cluster of shark bites. *People and Nature, 4*, 963–982. https://doi.org/10.1002/pan3.10337

Beek, I. J. M. van, Debrot, A. O., Walker, P. A., & Kingma, I. (2014). *Shark Protection Plan for the Dutch Caribbean Eez*. 104. BO-11–011.05–030.

Benhammou, F. (2003). Stratégie et géopolitique de l'opposition à la conservation de la nature: Le cas de l'ours des Pyrénées. *Nature Sciences Sociétés, 11*(4), 381–393. https://doi.org/10.1016/j.natsci.2003.09.001

Bertile, W. (2006). La Réunion: Les problèmes réunionnais: la thérapeutique de la responsabilité. Océan Éditions, 908 pages.

Blaison, A., Jaquemet, S., Guyomard, D., Vangrevelynghe, G., Gazzo, T., Cliff, G., Cotel, P., & Soria, M. (2015). Seasonal variability of bull and tiger shark presence on the west coast of Reunion Island, western Indian Ocean. *African Journal of Marine Science, 37*(2), 199–208. https://doi.org/10.2989/1814232X.2015.1050453

Charmaz, K. (2006). *Constructing grounded theory*. Thousand Oaks, CA: Sage Publications. http://www.sxf.uevora.pt/wp-content/uploads/2013/03/Charmaz_2006.pdf

Cillaurren, E., & David, G. (2017). Quand les représentations s'invitent dans la conservation de la biodiversité, la réserve naturelle marine de La Réunion face à la crise Requin. *Vertigo, 17,* numéro 3 | http://journals.openedition.org/vertigo/18956

Clua, E. & Linnell, D. (2018). Individual shark profiling: an innovative and environmentally responsible approach for selectively managing human fatalities. *Conservation Letters*. https://doi.org/10.13140/RG.2.2.29453.38886

Corbin, J., & Strauss, L. A. (1990). Grounded theory research: Procesures, canons and evaluative criteria. *Zeitschrift Fuer Soziologie, 19*(6), 418–427. https://doi.org/10.1007/BF00988593

Deleuze, G., & Guattari, F. (1980). Mille plateaux. (Suite et fin de) Capitalisme et schizophrénie. Paris, Minuit « Critique ».

Denayer, D., & Collard, D. (2017). Travail et subjectivité: La conservation de l'ours brun pour métier. *Travailler, 38*(2), 119. https://doi.org/10.3917/trav.038.0119

Dickman, A. J. (2010). Complexities of conflict: The importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation, 13*(5), 458–466. https://doi.org/10.1111/j.1469-1795.2010.00368.x

Duvat, V., Salmon, C., Magnan, A., Duvat, V., Salmon, C., Magnan, A., & De, T. (2017). *Trajectoires de vulnérabilité des littoraux de l 'île de la Réunion aux risques liés à la mer (1950-actuel)*. ISSN 2258–7535.

Fabing, P. (2014). Impact économique de la crise requin à la Réunion. Saint-Denis de La Réunion, SAGIS/DEAL, 50 p. sur l'impact sur le tourisme, l'impact micro-économique sur les comportements et les activités sportives, et l'impact sur la dépense publique. http://www.info-requin.re/IMG/pdf/Impact_economique_crise_requin_a_la_Reunion_-_Sagis_-_Rapport_final_novembre_2014.pdf

Ferdinand, M., & Molinié, E. (2021). Des pesticides dans les Outre-mer français: État des lieux et perspectives. *Écologie & Politique, 63*, 81–94. https://www.cairn.info/revue--2021-2-page-81.htm

Fianu, A., Villeval, M., Naty, N., Favier, F., & Lang, T. (2017). Analyser la transférabilité d'une intervention: Application du modèle fonctions clés/implémentation/contexte à un programme de prévention du diabète. *Santé Publique, 29*, 525–534. https://doi.org/10.3917/spub.174.0525

Folgoat, A. (2016). La dynamique linguistique des relations spatiales en créole réunionnais et sa contribution à la question de l'illettrisme.

Fontaine, G. (2004). Le Tourisme à La Réunion. Travaux & documents, Éléments pour la connaissance de l'histoire et de la géographie de La Réunion. Vol. 2: Géographie, 22, pp.101–116. https://hal.univ-reunion.fr/hal-02181294

Géralin, H. (1953). Le problème de l'alcoolisme dans les territoires d'outre-mer. *Population, 8*, 291–310. https://www.cairn.info/revue--1953-2-page-291.htm

Giovos, I., Barash, A., Barone, M., Barría, C., Borme, D., Brigaudeau, C., Charitou, A., Brito, C., Currie, J., Dornhege, M., Endrizzi, L., Forsberg, K., Jung, A., Kleitou, P., MacDiarmid, A., Moutopoulos, D. K., Nakagun, S., Neves, J., Nunes, F. L. D., … Mazzoldi, C. (2021). Understanding the public attitude towards sharks for improving their conservation. *Marine Policy*. https://doi.org/10.1016/j.marpol.2021.104811

Guiltat, S. (2011). Le rôle des sports côtiers dans le développement territorial de l'ouest de La Réunion: entre nouvelle maritimité et jeux d'acteurs.

Jaccoud. (2014). *Mieux comprendre pour mieux agir. Approche sociale de la crise requin*. Saint-Denis de La Réunion, DEAL. https://www.info-requin.re/IMG/pdf/Etude_socio_-RAPPORT_DEAL_-_Approche_sociale_de_la_crise_requin_-.pdf

Joannidès, V., & Berland, N. (2008). Grounded theory: Quels usages dans les recherches en contrôle de gestion? *Comptabilité Contrôle Audit, 14*, 141–162. https://doi.org/10.3917/cca.143.0141

Kohler, F., & Brondizio, E. S. (2017). Considering the needs of indigenous and local populations in conservation programs. *Conservation Biology, 31*(2), 245–251. https://doi.org/10.1111/cobi.12843

Kramer, R. M. (1998). Paranoid Cognition in Social Systems: Thinking and Acting in the Shadow of Doubt. *Personality and Social Psychology Review, 2*(4), 251–275. https://doi.org/10.1207/s15327957pspr0204_3

L'Horty, Y. (2014). La persistance du chômage ultramarin: un problème aux causes multiples. *Revue française des affaires sociales*, 114–135. https://doi.org/10.3917/rfas.144.0115

Lagabrielle, E., Allibert, A., Kiszka, J. J., Loiseau, N., Kilfoil, J. P., & Lemahieu, A. (2018). Environmental and anthropogenic factors affecting the increasing occurrence of shark-human interactions

around a fast-developing Indian Ocean island. *Scientific Reports, 8*(1), 1–13. https://doi.org/10.1038/s41598-018-21553-0

Lemahieu, A., Blaison, A., Crochelet, E., Bertrand, G., Pennober, G., & Soria, M. (2017). Human-shark interactions: The case study of Reunion island in the south-west Indian Ocean. *Ocean and Coastal Management, 136*, 73–82. https://doi.org/10.1016/j.ocecoaman.2016.11.020

Losen, B. (2023). Shark attack risk on Reunion Island: Emphasis on local media construction. Marine Policy. https://doi.org/10.1016/j.marpol.2023.105851

Machado, V., Contreiras, J. P., & Duarte, A. P. (2021). Planning Tourism in Protected Natural Areas: Safety, Soft Law and Conflict Management between Beach Users. The Case of Surf in Aljezur, Portugal. *Sustainability*, *13*, 10739. https://doi.org/10.3390/su131910739

Marchini, S., & Grawshaw, P. (2015). Human-Wildlife conflicts in Brazil: A fast-growing issue. *Human dimensions of wildlife*, 323–328. https://doi.org/10.1080/10871209.2015.1004145

Marowa, I., Matanzima, J., & Nhiwatiwa, T. (2021). Interactions between humans, crocodiles, and hippos at Lake Kariba, Zimbabwe. *Human–Wildlife Interactions, 15*(1), 212–227. https://doi.org/10.26077/765a-76f4

Masson, V. L., & Kelman, I. (2011). Entendre les préoccupations des populations des petits États insulaires en développement dans l'adaptation au changement climatique. *Vertigo, 10*, Numéro 3. https://doi.org/10.4000/vertigo.10572

McClean, N., van Putten, I., Sbrocchi, C., Chin, A., & Pillans, S. (2020). *Reducing risk in human-shark interactions in NSW: Trialling a participatory approach to understanding beachgoer behaviour - Summary report*. Faculty of Arts and Social Sciences, UTS, Sydney.

Micoud, A., & Bobbé, S. (2006). Natures, sciences, sociétés. In *Natures Sciences Societes*. Retrieved from https://www.cairn.info/revue-natures-sciences-societes-2006-Supp.1-page-32.htm

Mourier, J., Soria, M., Blaison, A., Simier, M., Certain, G., Demichelis, A., & Hattab, T. (2021). Dynamic use of coastal areas by bull sharks and the conciliation of conservation and management of negative human–wildlife interactions. *Aquatic Conservation-Marine and Freshwater Ecosystems, 31*(10), 2926–2937. https://doi.org/10.1002/aqc.3674

Neff, C. (2015). The Jaws Effect: How movie narratives are used to influence policy responses to shark bites in Western Australia. *Australian Journal of Political Science, 50*, n°1. https://doi.org/10.1080/10361146.2014.989385

Ostrom, E. (2009). A General framework for analyzing sustainability of social-ecological systems, requin à La Réunion. Géoconfluences ecological systems. *Science, 325*, 419. https://doi.org/10.1126/science.1172133

Ottino, P., & Condominas, G. (1972). Rangiroa: parenté étendue, résidence et terres dans un atoll polynésien. Retrieved from http://www.documentation.ird.fr/hor/fdi:03816

Pinel, R., Segrado Pavón, R. G., & Collantes-ChávezCosta, A. (2021). Valores, Creencias y Normas de los Prestadores de Servicios Turísticos y conservación del Parque Nacional Arrecifes de Cozumel, México. 90–112. https://doi.org/10.1344/ara.v10i1.28765

Pirog A., Blaison A., Jaquemet S., Soria M., & Magalon H. (2015) . Isolation and characterization of 20 microsatellite markers from Carcharhinus leucas (bull shark) and cross-amplification in Galeocerdo cuvier (tiger shark), Carcharhinus obscurus (dusky shark) and Carcharhinus plumbeus (sandbar shark). *Conservation Genetics Resources*. https://doi.org/10.1007/s12686-014-0308-3

Rard, M. (1999). *Inventaire réunionnais des attaques de requin*. http://omar.fr/wp-content/uploads/2013/10/IRAR-InventaireReunionAttaqueRequins-OMAR2013.10.27.pdf

Rard M., & Menou A. (2011). Bilan sur les activités nautiques à l'île de La Réunion. Saint-Denis, Observatoire marin de La Réunion, 80 p. http://omar.fr/wp-content/uploads/2014/05/RardEtMenou2011-RapportActivit%C3%A9sNautiquesPr%C3%A9fecture.pdf

Réchou, A., Flores, O., Jumaux, G., Duflot, V., Bousquet, O., Pouppeville, C., & Bonnardot, F. (2019). Spatio-temporal variability of rainfall in a high tropical island: Patterns and large-scale drivers in Réunion Island. https://doi.org/10.1002/qj.3485

Rivers, N., Strand, M., Snow, B., Metuge, D., Lemahieu, A., & Benkenstein, A. (2023). Integrating indigenous and local knowledge in marine spatial planning. *South African Institute of International Affairs*. http://www.jstor.org/stable/resrep49178

Schirrer, M. (2008). L'eau et les réunionnais: De l'importance des histoires socioculturelles. *Études Rurales, 181*, 149–162. https://doi.org/10.4000/etudesrurales.8701

Shabtay, A., Lagabrielle, E., Plot, V., Potin, G., & Guyomard, D. (2020). Marine spatial planning provides a comprehensive framework for building evidence-based shark risk management policies with sea-users. *Environmental Science Policy*. https://doi.org/10.1016/j.envsci.2020.05.014

Sheridan, K., O'Riain, J., & Needham, M. (2021). Recreationist perceptions of lethal and non-lethal management of sharks in two of South Africa's marine areas. *Marine Policy, 132*. https://doi.org/10.1016/j.marpol.2021.104633

Solesbury, W. (1976). *The Environmental Agenda: An Illustration of How Situations May Become Political Issues and Issues May Demand Responses from Government: Or How They May Not*. https://doi.org/10.1111/j.1467-9299.1976.tb00256.x

Soria, M., Jaquemet, S., Trystram, C., Chabanet, P., Bourjea, J., et al. (2015). Étude du comportement des requins bouledogue (Carcharhinus leucas) et tigre (Galeocerdo cuvier) à La Réunion. [Rapport de recherche] Programme CHARC. 2015. ⟨hal-01487167⟩.

Soria, M., Heithaus, M. R., Blaison, A., Crochelet, E., Forget, F., & Chabanet, P. (2019). Residency and spatial distribution of bull sharks Carcharhinus leucas in and around Reunion Island marine protected area. *Marine Ecology Progress Series, 630*, 101–113. https://doi.org/10.3354/meps13139

Taglioni, F., & Guiltat, S. (2015). Le risque d'attaques de requins à La Réunion. *EchoGéo*. https://doi.org/10.4000/echogeo.14205

Thiann-Bo Morel, M., & Duret, P. (2013). Le risque requin, mise en risque de la pratique du surf à la Réunion. *Staps, 99*(1), 23. https://doi.org/10.3917/sta.099.0023

Thiann-Bo, M. (2019). Tensions entre justice environnementale et justice sociale en société postcoloniale. Le cas du risque requin. VertigO: La Revue Électronique en Sciences de l'Environnement, https://doi.org/10.4000/vertigo.24299. ⟨hal-02171538⟩.

Tsing, A. (2022). Proliferations. Paperback. Wildproject. ISBN-13978–2381140308.

Vergès, F. (2008). *Les transformations des « post-colonial studies »* (p. 41–44). https://doi.org/10.4267/2042/24172

Walker, N., Sullivan, B., Debski, I., & Knowles, K. (2016). Development and testing of a novel seabird mitigation option, the Hook Pod, in New Zealand pelagic longline fisheries | Bycatch WCPFC-SC12–2016/ EB-IP-06.

Wolfson, N. (1976). *Speech events and natural speech: some implications for sociolinguistic methodology*. Language in Societyn°5, 2, repr. inN. Coupland & A. Jaworski 1997, 116–25. https://api.semanticscholar.org/CorpusID:145806865