Research report

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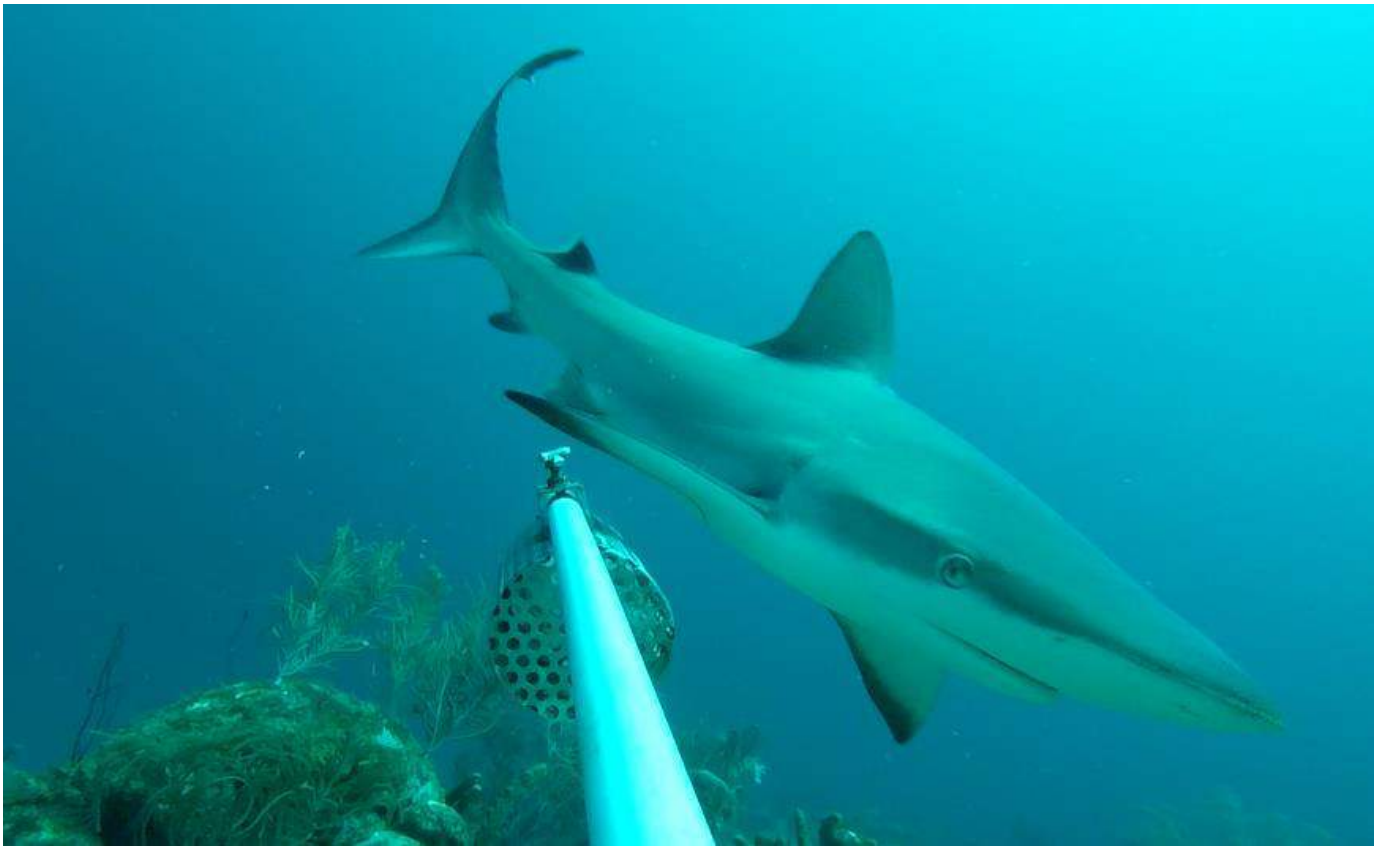
Species composition, distribution, and relative abundance



Mavelly Velandia

22nd of January 2018 on Bonaire

STINAPA BONAIRE NATIONAL PARKS FOUNDATION

DCNA DUTCH CARIBBEAN NATURE ALLIANCE

NATIONALE POSTCODE LOTERIJ

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Picture on front page: Sander Delacauw & Mavelly Velandia

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Summary

Elasmobranchs are suffering from habitat loss and are declining at a rapid pace. They are listed as "Data Deficient" on the IUCN Red List of Threatened Species, as there has not been enough research conducted on elasmobranchs. Contemporary and historical data are very limited. The worldwide decline of elasmobranchs is largely due to the Asian shark fin trade.

However, in the Dutch Caribbean, sharks do not get targeted for artisanal fisheries, but are mostly killed as bycatch. To conserve elasmobranch species, it is necessary to collect information related to their diversity, distribution, and abundance. Baited Remote Underwater Video (BRUV) is used to study marine environments and their inhabitants; it has become the standard approach to learn about elasmobranchs in their representative habitats. BRUV deployments were done along the East coast and a part of the West coast of Bonaire.

From the videos, the maximum numbers of individuals (MaxN) were counted. Also, a citizen science project was undertaken and the presence or absence of elasmobranch species was noted. Data from the video footage and the citizen science project were collected and used to compare Bonaire's shark and ray species compositions, distributions and abundances of the East coast with the West coast.

1. Introduction

Many marine species, populations, or entire functional groups are rapidly declining and suffering from habitat loss in regional ecosystems such as estuaries (Lotze et al., 2006), coral reefs (Pandolfi et al., 2003), and coastal (Jackson et al., 2001) and oceanic fish communities (Worm et al., 2005). The International Union for Conservation of Nature (IUCN) Red List assesses the global risk of extinction by established quantitative criteria for each species. According to Camhi et al. (2007), 32% of the world's elasmobranchs are threatened. Of these, 6% are endangered and 26% are vulnerable. However, the most basic information about elasmobranchs is lacking and 46% are listed as 'Data Deficient' on the IUCN Red List of Threatened Species (IUCN 2017). Elasmobranchs in ecosystems, such as coral reefs, are poorly known because contemporary and historical data are very limited (Dulvy et al., 2008). However, it is known that elasmobranchs use nearshore areas to target high quality prey which could be unavailable in oceanic waters (Heithaus et al., 2002). Nearshore areas contain highly productive habitats sustaining great abundances and diversities of fish and invertebrates (Beck et al., 2001) and are also used as nursery grounds (Heupel et al., 2007), where many elasmobranch species thrive.

Unfortunately, elasmobranchs populations have been rapidly declining worldwide (Myers & Worm, 2003) as a result of habitat degradation (Jennings et al., 2008), pollution (Gelsleichter et al., 2005), and climate change (Chin et al., 2010). However, the greatest threat to the decline of elasmobranchs is the Asian shark fin trade (Clark et al., 2006). In the Dutch Caribbean, elasmobranchs do not get targeted by artisanal fisheries, but are killed as bycatch and are considered nuisance species by some fisherman. As a result, the elasmobranchs are consumed locally, used as bait, or (reportedly) killed and discarded at sea (Van Beek et al., 2013). Elasmobranchs are particularly vulnerable because of their life history strategy: slow growth, late attainment of sexual maturity, long life span and low fecundity (Stevens et al., 2000). Large predators strongly influence smaller-bodied mesoconsumers

and the species that are eaten by mesoconsumers, and these processes demonstrate the importance of top-down processes (Heithaus et al., 2008). For example, a study conducted by Myers et al. (2007) in the northwest Atlantic Ocean found that the catch rate of cownose rays (*Rhinoptera bonasus)* increased 9% per year as large shark populations declined. The exploding ray populations are believed to have caused a rapid decline in bay scallop populations (*Argopecten irradians)*, which are an important food resource for that area.

Currently, not much is known about the presence of elasmobranchs in the Dutch Caribbean (Meesters et al., 2010). For the development of adequate management and conservation initiatives, it is necessary to collect ecological information related to the diversity, distribution, and abundance of elasmobranchs (Garla et al., 2006). For over 40 years, underwater imaging has been used to study marine environments and its inhabitants (Bailey et al., 2007). Baited Remote Underwater Video (BRUV) surveys have currently become the standard approach to capturing elasmobranchs in their representative habitats (Meekan et al., 2006). BRUV surveys provide many major benefits over traditional survey methods. BRUV surveys are non-invasive, nondestructive and cause minimal damage to the environment they are placed in (Brooks et al., 2011).

In a recent study conducted by Ruijs (2017) on elasmobranchs on Bonaire's reef, it was concluded that, in comparison to other islands in the Dutch Caribbean, Bonaire has a lower elasmobranch abundance. But the deployments with the BRUV systems were mostly conducted on the West coast of the island. During the same year, a citizen science project demonstrated a significant higher abundance of elasmobranchs on the East coast of the island than on the West coast.

The current elasmobranch species composition, distribution and relative abundance on the East coast and a small section of the West coast of Bonaire were collected during this study. Data were collected using the standardized BRUV base-line survey with stereo BRUV systems and single-camera BRUV systems. Aside from the BRUV base-line survey, dive guides from two dive centers (Bas Diving and Carib Inn) participated in a citizen science project in which they noted the presence or absence, location and abundance of elasmobranch species. Both the BRUV data and the citizen science data were used to compare shark and ray species composition, distribution and relative abundance on the East and West coasts of Bonaire.

2. Materials & methods

2.1 Area description

Bonaire's coastal waters, from the high tide line to a depth of 60 meters, are designated as the Bonaire National Marine Park. The park encircles Bonaire with 2,700 hectares of coral reefs, sea grass and mangrove ecosystems. The sheltered West coast of the island is highly developed. Here is where most local and touristic activities occur, because it is easily accessible. This is also where most dive sites are located (Appendix 1). The East coast of the island is less accessible and is exposed to constant eastern trade winds. It is difficult to access the reefs of the East coast, therefore there are no official dive sites around this area of the island.

The current study was conducted between September 2017 and December 2017 on Bonaire. This is the follow-up to the pilot study that was conducted by Nijs Ruijs throughout the period of September 2016 and December 2016. In 2016, a total of 110 BRUV deployments along most of the West coast and a part of the East coast were conducted (Fig. 1). This study completed a total of 12 BRUV deployments on the West coast and a total of 78 deployments on the East coast of the island in 2017 (Fig. 1).

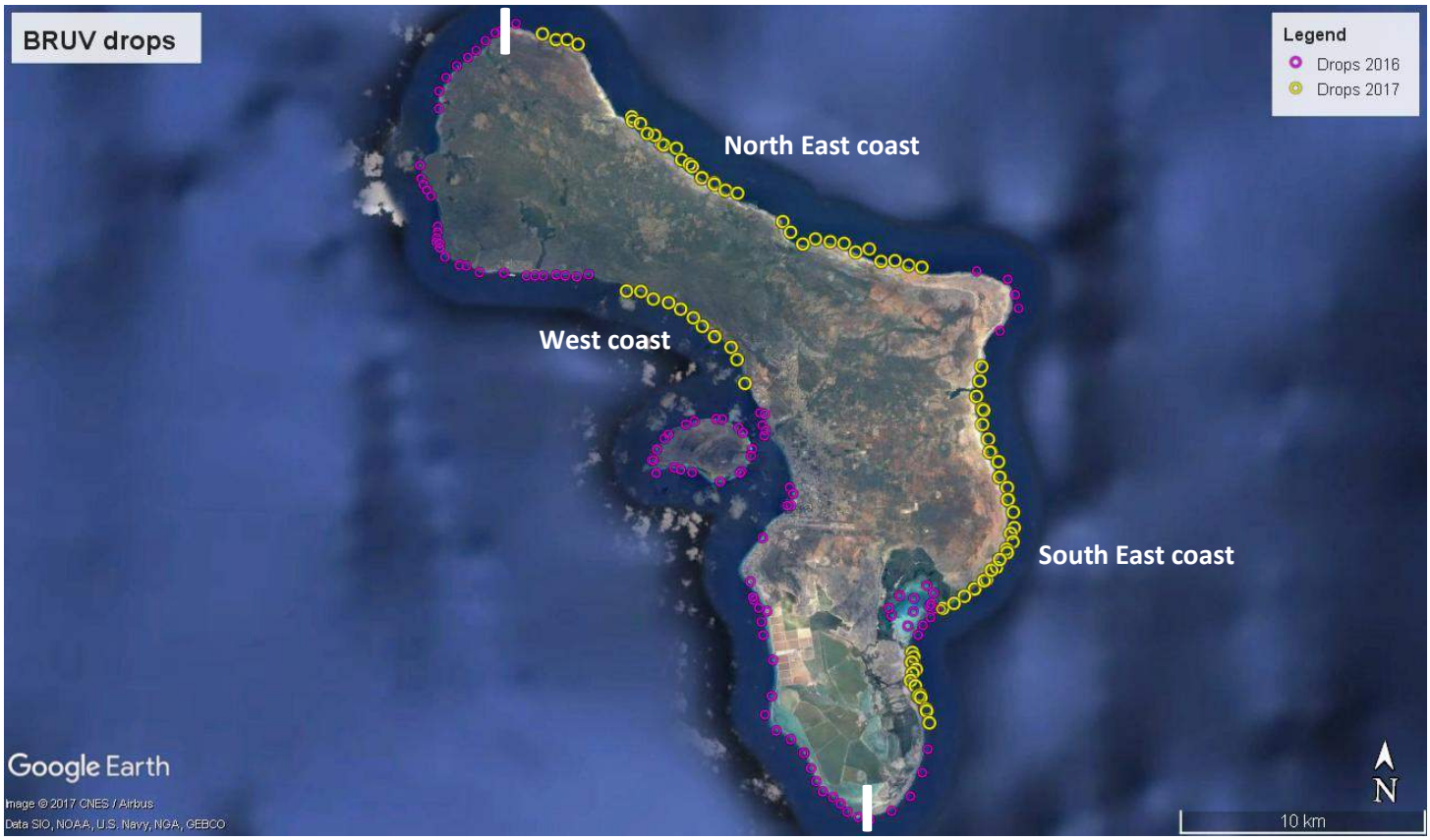

Figure 1: The purple circles indicate the BRUV drops done in the pilot study of 2016 by Nijs Ruijs. The yellow circles indicate the BRUV drops from this follow-up study, conducted throughout the period of September 2017 and December 2017 along the North-East, South-East, and West coast. The borders of the East coast and the West coast are displayed by the white markings on the top and the bottom of the island.

2.2 Baited Remote Underwater Video (BRUV)

To study elasmobranchs, a non-invasive method is used called the standardized Baited Remote Underwater Video base-line survey (Cappo et al., 2004). The standardized BRUV base-line survey was conducted using three stereo BRUV systems and three single-camera BRUV systems. Each stereo BRUV system consists of two Canon LEGRIA HF G10 cameras and each single-camera BRUV system consists of one GoPro HERO+ camera. Both systems were used to collect current elasmobranch abundance and distribution around the island of Bonaire. However, the stereo BRUV systems can also be used to compile species-specific length data (de Graaf et al., 2015), but will only be used in a further study to compare data with stereo BRUV surveys conducted on other Dutch Caribbean islands.

The BRUV systems were deployed during daylight hours (08:00-17:00). Each system was deployed to either the top of the coral reef drop-off (±10 m) or at the bottom of the coral reef (±40m) for approximately 90 min and contained a bait bag attached to the BRUV systems. The bait bag was positioned in front of the cameras with approximately 1 kg of tuna *(Thunnini)*. A bathyscope (for shallow drops) and a drop camera (for deep drops) were used to ensure that the BRUV systems landed on rock or sand, rather than living coral. Between each deployment on the same day, a distance of 500 m was maintained between drop sites to reduce overlap between bait odors (Willis & Babcock, 2000, Harvey et al., 2007, Heagney et al., 2007). Furthermore, for each drop, the depth, date, deployment time, and GPS coordinates were recorded. Wind speed, wind direction, percent cloud coverage and surface chop were also noted.

2.3 Analyzing video footage

The video footage of the BRUV systems were analyzed by using a relative abundance index. This is where the maximum number of individuals (MaxN) was counted within the frames of the videos (Cappo et al., 2006). Hereby, repeated counts of individual elasmobranch species re-entering the video frames were avoided. For each video, the visibility, management zone, habitat complexity, habitat type, bait type and weight were noted. Bonaire is divided into 6 management zones; West coast general use zone, which is divided into five sub zones: North-West coast 1, 2 & 3, Klein Bonaire, and South-West coast and the East coast general use zone, which is divided into two sub-zones: North-East coast and South-East coast. As well as the West coast no fishing zone, West coast no diving zone, and Lac Bay (Appendix 2). A 6-point scale (Polunin & Roberts, 1993) was used to determine the habitat complexity. Ranging from habitat category 0, bare substratum, to category 4, high complexity. Category 5, extreme complexity, was not observed (Fig. 2). The macro-habitat types are divided into four categories: sand, seagrass, macroalgae and coral reef.

Figure 2: A 6-point scale as described by Polunin and Roberts (1993) was used to determine the habitat complexity. 0=Bare substratum, 1=Low and sparse relief, 2=Low but widespread relief, 3=Moderate complexity, 4=High complexity and 5=Extreme complexity (5 was not observed in this study).

2.4 Citizen science project

Dive guides from two local dive centers collected elasmobranch presence or absence data for each dive they conducted during the period of the study. For each dive, the dive guide recorded the date, location, and the number and species of any elasmobranch species sighted, even if none were sighted.

2.5 Data analysis

The data collected from the BRUV survey and the citizen science project were analyzed and used to compare the species compositions, distributions and relative abundances on the West and East coasts of Bonaire.

3. Results

3.1 Shark species composition, distribution, and abundance

Out of a total of 83 BRUV drops on the East coast and a total of 92 drops on the West coast the distribution and relative abundance of sharks was determined (Fig. 3 & 4). Three shark species were found along the coasts of Bonaire; Caribbean reef shark *(Carcharhinus perezii)*, Nurse shark *(Ginglymostoma cirratum)* and Great hammerhead *(Sphyrna mokarran)*. On the East coast, there were 42 Caribbean reef sharks, 6 Nurse sharks and 4 Great hammerhead sharks observed and on the West coast, only 7 Caribbean reef sharks were observed, totalling 59 sharks (Appendix 3a).

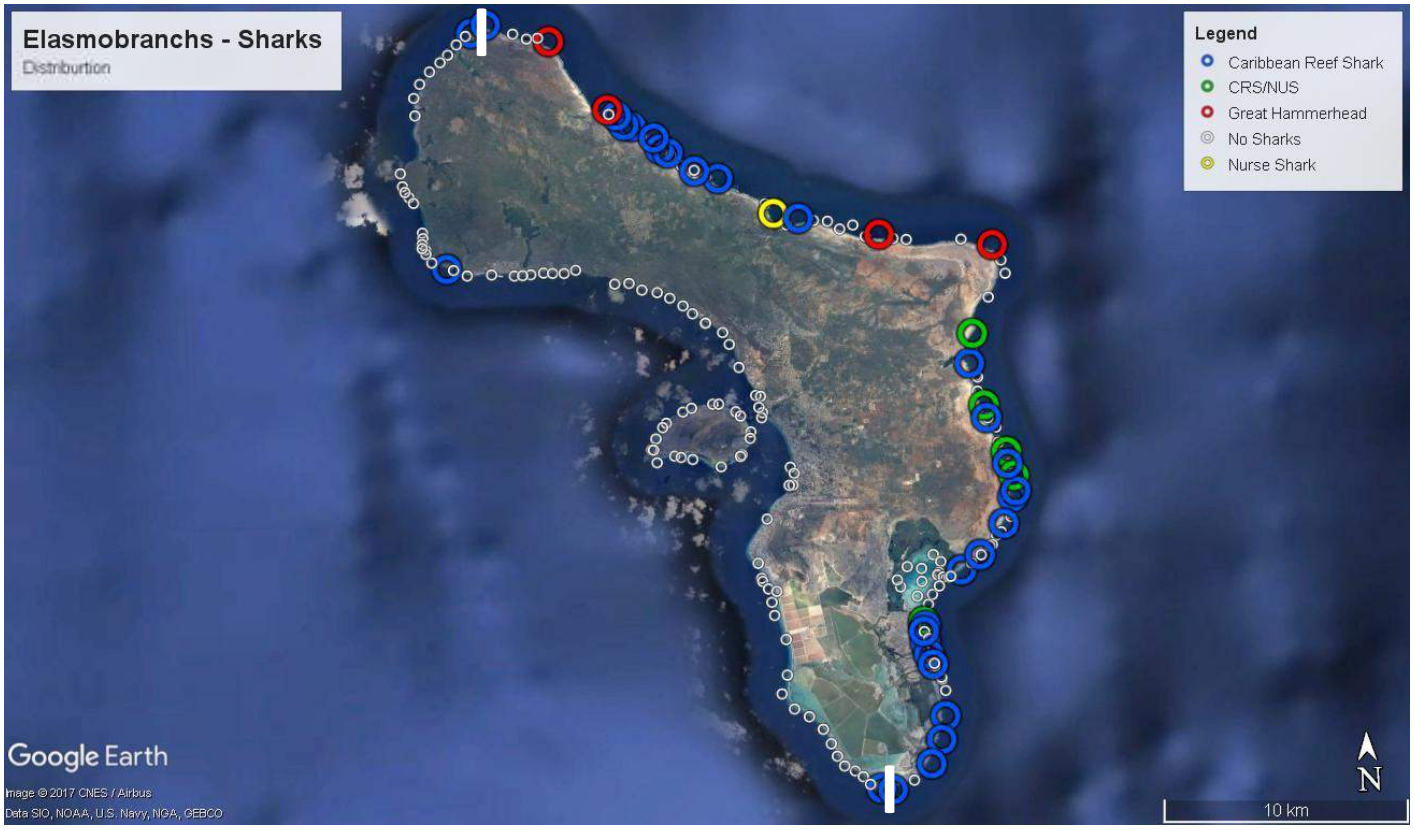

Figure 3: Shark species distribution along the coast of Bonaire. White circles indicate that there were no sharks seen on the BRUV video footage. Blue circles indicate that Caribbean reef sharks were present on the video footage, red circles for Great hammerhead sharks, yellow circles for Nurse sharks, and green circles for video footage that included Caribbean reef sharks (CRS) as well as Nurse sharks (NUS). The borders between the East coast and the West coast are indicated by the white markings on the top and the bottom of the island.

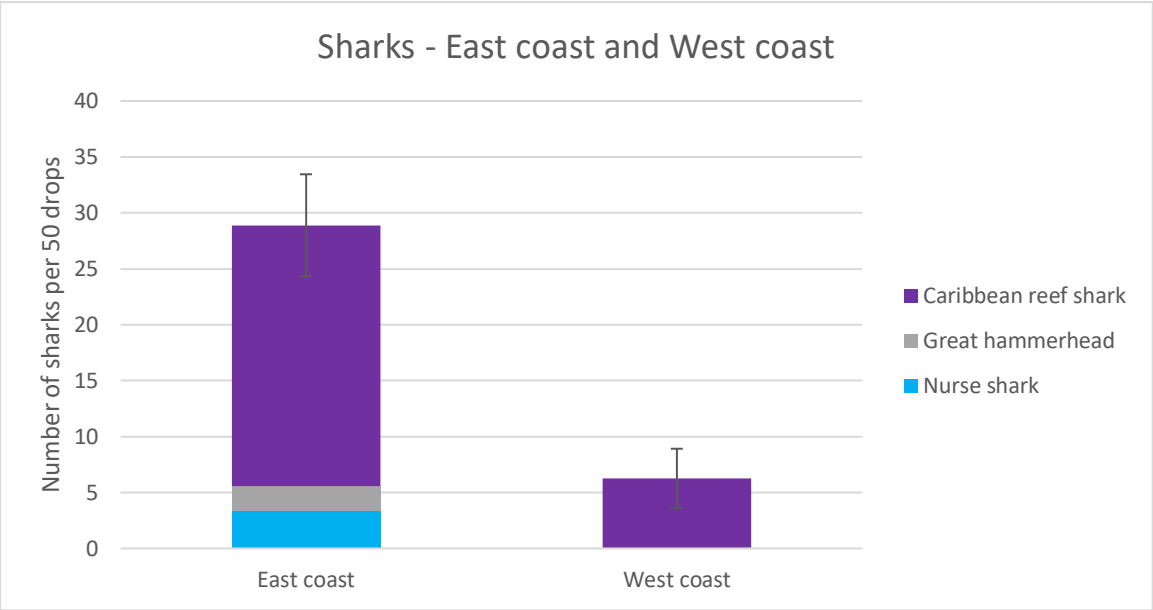

Figure 4: Mean number of sharks per 50 BRUV drops on the East coast and the West coast. A total of 59 sharks were observed.

3.2 Ray species composition, distribution, and abundance

Out of a total of 83 drops on the East coast and a total of 92 drops on the West coast, the distribution and relative abundance of rays was also determined (Fig. 5 & 6). Two ray species were seen in the BRUV footage from the coasts of Bonaire: Southern stingrays *(Dasyatis americana)* and Spotted eagle rays *(Aetobatus narinari)*. On the East coast, three Spotted eagle rays and one Southern stingray were on the BRUV footage. On the West coast, five Spotted eagle rays and six Southern stingrays (Appendix 3a) were recorded.

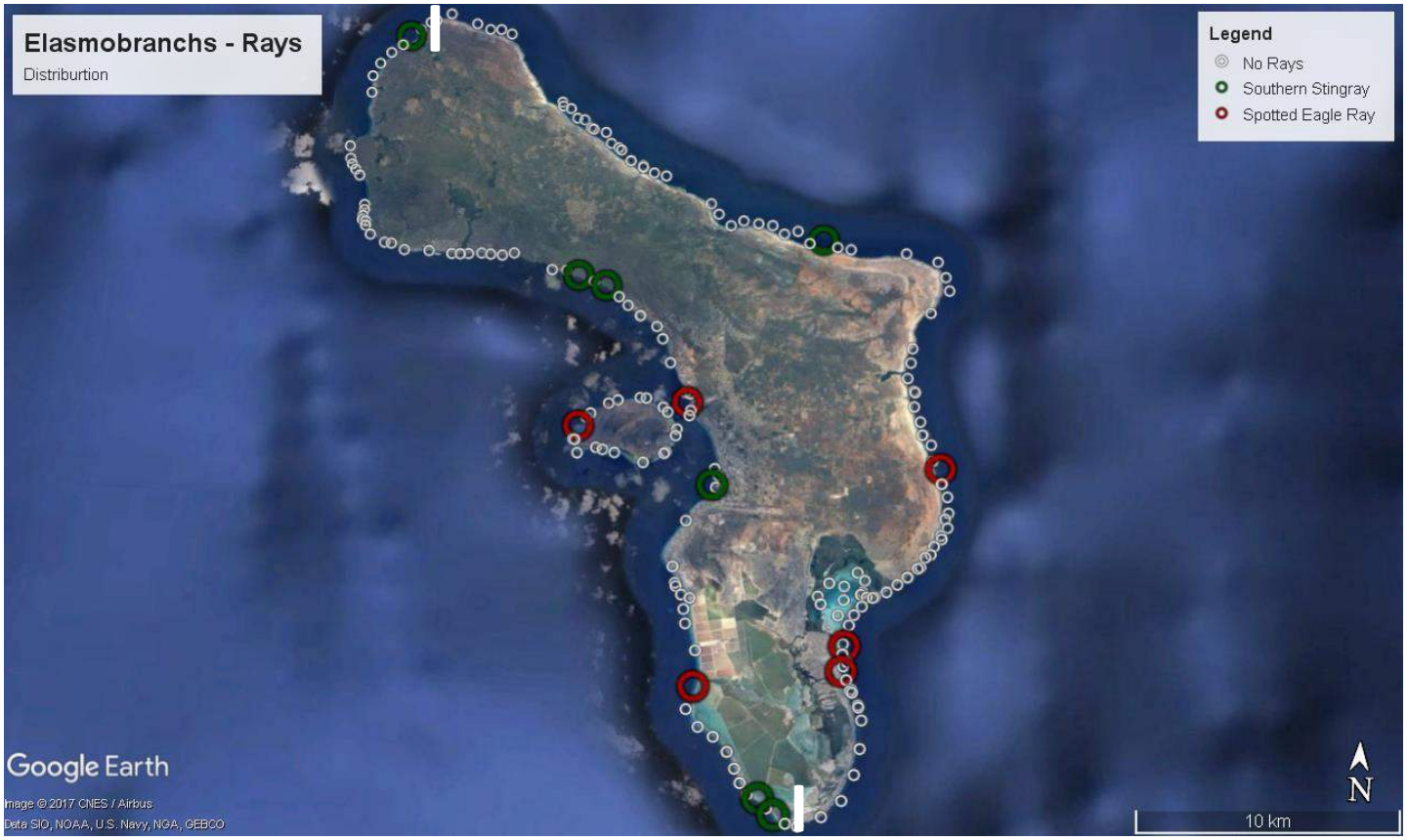

Figure 5: Ray species distribution along the coast of Bonaire. White circles indicate that there were no rays seen on the BRUV video footage. Red circles indicate that Spotted eagle rays were present on the video footage and green circles indicate the presence of Southern stingrays. The borders of the East coast and the West coast are indicated by the white markings on the top and the bottom of the island.

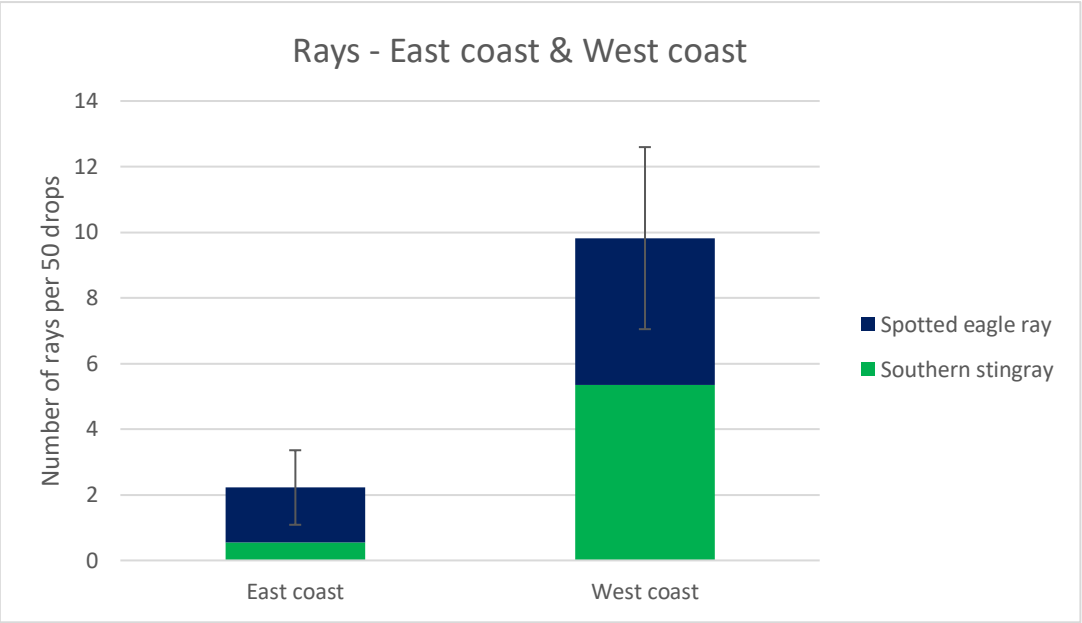

Figure 6: Mean number of rays per 50 BRUV drops on the East coast and the West coast. A total of 15 rays were recorded.

3.3 Citizen science project

Shark and ray sighting information was collected from a total of 301 dives on the East coast and 705 dives on the West coast by the dive centers that contributed to this project. Three shark species were sighted on the West coast: the Nurse shark *(Ginglymostoma cirratum)*, the Bull shark *(Carcharhinus leucas)* and the Caribbean reef shark *(Carcharhinus perezii).* On the East coast, the Nurse shark and Caribbean reef shark were the only shark species sighted (Fig. 7). On the West coast there were 10 Nurse sharks, 1 Bull shark, and 11 Caribbean reef sharks sighted. The East coast had 66 Nurse shark and 10 Caribbean reef shark sightings (Appendix 3b). This was a total of 98 shark sightings.
Furthermore, there were three ray species sighted on the West coast and also on the East coast. These ray species are: the Southern stingray *(Dasyatis Americana)*, the Spotted eagle ray *(Aetobatus narinari)*, and the Manta ray *(Manta sp.)* (Fig. 8). On the West coast, there were 68 Southern stingray, 79 Spotted eagle ray, and 6 Manta ray sightings. The East coast had a total of 102 Southern stingrays, 366 Spotted eagle rays, and 5 Manta rays sighted (Appendix 3b). This was of a total of 626 rays sightings.

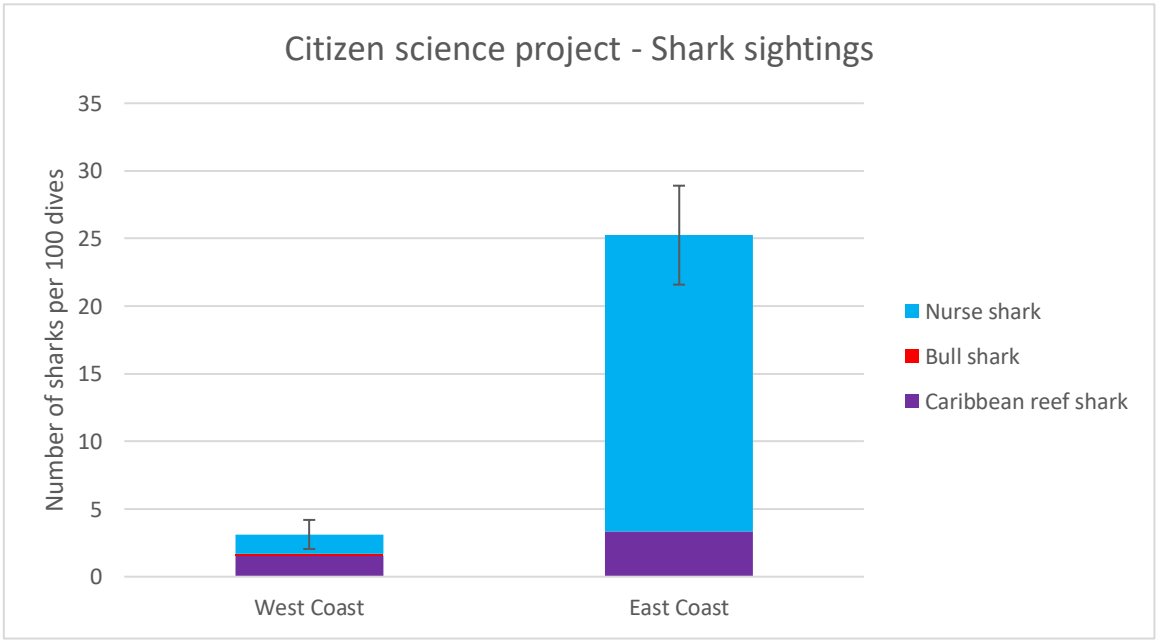

Figure 7: Mean number of sharks sighted per 100 dives on the East coast and the West coast of Bonaire. There was a total of 98 shark sightings.

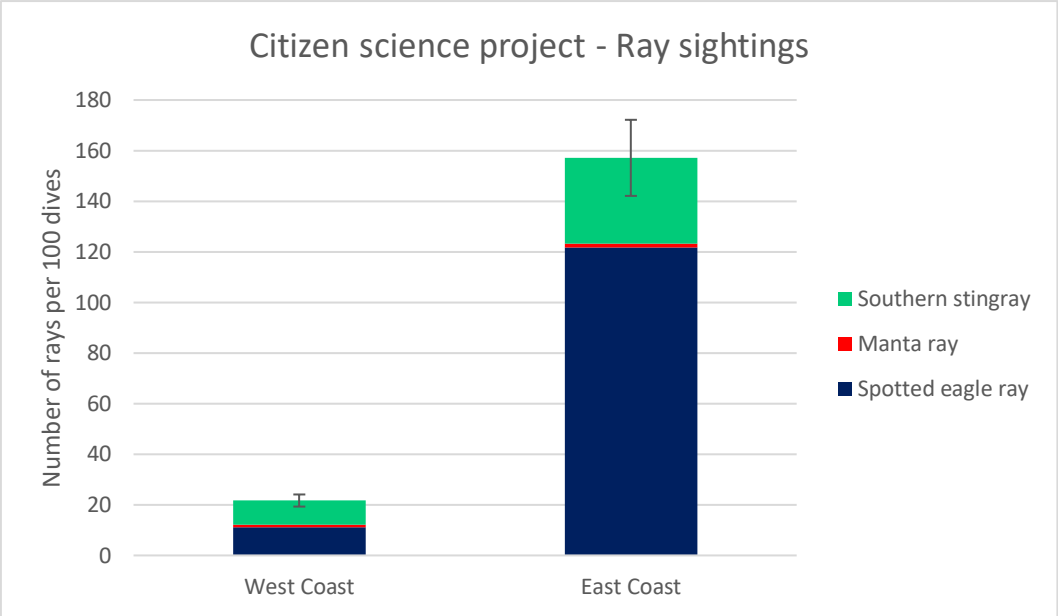

Figure 8: Mean number of rays sighted per 100 dives on the East coast and the West coast of Bonaire. There was a total of 626 rays sighted.

4. Discussion

In this study, we used BRUV surveys to compare the distribution and relative abundance of elasmobranchs on the East and West coasts of Bonaire. There were only 7 Caribbean reef sharks seen on the BRUV footage from the West coast, whereas on the East coast there were 6 Nurse sharks, 4 Great hammerheads and 42 Caribbean reef sharks seen on the BRUV footage. There was also a difference between the East and West coast in relative abundance of sharks during the citizen science project. A total of 22 sharks were sighted on the West coast, whereas a total of 76 sharks were sighted on the East coast. A study done by Graham (2011) in Punta Gorda, Belize, recorded the impact of divers and boat noise on sharks, which resulted in rapid evasive behavior of sharks. Since there are more boats and divers on the West coast, the impact of noise on sharks could be a reason there were fewer sharks sighted there.

Furthermore, there were hardly any rays encountered on the BRUV footage when compared to the number of rays observed during the citizen science project. This could be because rays were not attracted to the Tuna bait that was placed in the bait bag in front of the BRUV cameras. No Manta rays were seen on the footage, and the reason for this could be that Manta rays are planktivorous elasmobranchs (Marshall et al., 2009) and feed on small zooplankton (Couturier et al., 2013). A study on vertical movements of satellite-tracked Reef manta rays in eastern Australia showed that the longest periods of time were spent at depth in the epipelagic zone, which could be linked with their feeding activity (Couturier et al., 2013). Furthermore, the relative abundance of the Southern stingray seen on the BRUV footage differed from the sightings of the citizen science project. On BRUV footage, only six Southern stingrays were seen on the West coast and one on the East coast, whereas during the citizen science project, 102 Southern stingrays were seen on the East coast and 68 on the West coast. This could be because the Southern stingrays were not attracted to the bait. During a study on stomach contents of Southern stingrays, Wrasses *(Labridae)*, Gobbies *(Gobiidae)*, and Parotfish *(Scaridae)* were mostly found (David et al., 1993), which suggests that Southern

stingrays may not feed on Tuna. Spotted eagle rays are not believed to feed on fish, as concluded in multiple studies that monitored what this species fed on. A spotted eagle ray's diet consists largely of bivalve and gastropod mollusks (Ajeman et al., 2012 & Randall, 1967).

To discover more shark species around the island of Bonaire, BRUV surveys should be done during the evening hours when different species are active. This could lead to a better insight on the species richness of sharks around the island of Bonaire. Past studies have shown that sharks are most likely to be in deeper waters during the day and in shallower waters at night. Papastamatiou et al. (2015) studied daily routines in an ectothermic marine predator and found that sharks demonstrated a peak in activity between 19:00-21:00 and the lowest levels of activity was between 10:00-15:00. Another suggestion for future research would be the collection of information on the diet and trophic position of rays to improve the understanding of the movements and roles of rays within the ecosystem (Couturier et al., 2013).

Acknowledgement

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Appendix

Appendix 1

Figure 7: A map of Bonaire including dive sites.

Appendix 2

Figure 8: Management zones around Bonaire. West coast no diving zone (green), West coast no fishing zone (blue), Lac Bay (red), West coast general use zone (yellow) and East coast general use zone (white). West coast general use zone is divided into five sub zones: North-West coast 1, 2 & 3, Klein Bonaire, and South-West coast. East coast general use zone is divided into two sub zones: North-East coast and South-East coast.

Appendix 3

Appendix 3a

Table 1: Number of sharks and rays observed in BRUV video footage.

	East coast	West coast
Sharks		
Nurse shark	6	0
Great hammerhead	4	0
Caribbean reef shark	42	7
Rays		
Southern stingray	1	6
Spotted eagle ray	3	5

Appendix 3b

Table 2: Number of sharks and rays sighted during dives by dive guides.

	East coast	West coast
Sharks		
Caribbean reef shark	10	11
Bull shark	0	1
Nurse shark	66	10
Rays		
Spotted eagle ray	366	79
Southern stingray	102	68
Manta ray	5	6