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Characterization of visitation of the remote Conception Island National Park using daily satellite imagery

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Abstract

Conception Island National Park is a remote park in the central Bahamas. It is administered by the Bahamas National Trust, an NGO tasked with managing the National Park system of the Commonwealth of the Bahamas. Conception Island is known as a "paper park" since it has no monitoring system, no warden, and no way of tracking visitation or visitor activity. I used daily satellite imagery from the company Planet® to characterize boat traffic visitation to Conception Island nearly every day going back to 2016. I obtained a total of 3,003 observations, with 1,200 vessels located, from which I was able to map each vessel that visited the island over this time period, as well as the length of the vessels. This provides the first analysis of visitation to Conception Island and will be extremely useful as management plans are formalized for the Park. I was able to discover that peak visitorship to the island occurs in the spring when migrating songbirds arrive at the island, and when white-tailed tropicbirds are using the island for mating. I also found that visitorship remains constant around the year, but drops sharply during the hurricane season. I hope this data collection method can be used in combination with knowledge of the island's wildlife to aid park personnel in choosing when and how they allow access to the island, and gain more knowledge of threats to the island such as poaching and drug trafficking.

1. Introduction

Conception Island is one of the 32 national parks managed by the Bahamas National Trust (BNT), a quasi-non-governmental, non-profit organization funded in part by the Commonwealth of the Bahamas, but also in large part by donations from individuals and corporate partners such as Fidelity, Scotiabank, Bahamas Telecommunications Company, and JS Johnson. The Bahamas National Trust oversees these 32 parks via authority vested unto them by the Commonwealth of the Bahamas. Conception Island is one of the most remote National Parks in the BNT system, and a member of the Lucayan Archipelago, the swathe of Bahamas islands extending downward from Florida's peninsula. It is home to 63 bird species and is the largest White-tailed Tropicbird nesting colony in the Bahamas as well as a nesting area for the regionally-important Audubon's Shearwater[1,2,3,4]. The island is home to a number of amphibian and reptile species[6,7], including the world's most endangered boa, the Conception Bank Silver Boa or Silver Boa (*Chilabothrus argentum*)[9]. It has varied environments including grassy areas, coastal shrubland, sand-beach strand, tidal flats, salt ponds, and mangrove communities[7]. Visitors to the park are permitted to set foot on the island, but only on the beaches. Shotgun shells have been found on Booby Cay, a smaller island composed of the same landmass, likely from bird hunting[4]. Evidence of poaching activity was also recorded in 2021 showing a mothership and around one dozen skifs. Though Conception Island is managed by the BNT, the island struggles with management for a few core reasons: the island has no cell phone signal, has poor marine radio signal, and is never visited by park rangers or wardens. With these disadvantages, the Conception Island National Park does not have the facilities to conduct remote monitoring unless through the use of satellite communications links, which is prohibitively expensive.

This means that the BNT has no way to monitor visitation to the Park, no way to assess visitor numbers or where visitors are going, or any knowledge of what time of year most visitation occurs. This is crucial information to know, not least of all because the island is so important to wildlife breeding that is highly seasonal, such as the summer nesting of the White-tailed Tropicbird[4].

This study sought to determine whether the use of remote sensing data obtained from satellite imagery could be used to provide a base-level understanding of Park visitation to assist the BNT in making management decisions. Specifically, some new companies use satellites to image portions of the Earth daily at high-resolution, a relatively new resource for non-governmental or non-corporate entities. One of these is the company Planet® (Planet Labs Inc.). Planet Labs was founded in 2010 and has 400 employees and more than 200 operational satellites. Planet® offers multiple services, including high resolution real-time monitoring, high frequency mosaic base maps, and high-resolution image tasking. While their image access is intended for corporate customers, and hence is prohibitively expensive, we applied for and were awarded a Research Access Grant that provided no-cost access to the image database. This is the first study to attempt to characterize visitation and use of a remote National Park in the Lucayan Archipelago using satellite imagery. Such studies are necessary to determine proper management plans to move these parks from "paper parks" to well-managed and well-protected assets.

Figure 1. Map of the Lucayan Archipelago obtained from Planet®, comprising the islands of the Bahamas and the Turks and Caicos, showing the location of Conception Island National Park with the orange arrow.

2. Methods

Because there is no ability to monitor visitation to the park on the ground, the only option is to use remote sensing techniques. The company Planet® uses Dove CubeSat® satellites to take images up to 3.7 m resolution in four multispectral bands (RGB and near infrared). These images are aggregated in Planet's online database, and images are interactively searchable using a map of satellite image areas. We searched all available imagery for the Conception Island Bank and logged daily photos from January 1st, 2016 to December 31st, 2021. Days that were still registered in Planet but were unable to be viewed either because the satellite did not pass the island or the island was obscured

by clouds were marked “na”. The satellites do not make a direct overhead pass every day, and so days that were not available on the database were marked “unavailable”. For observable days, the main island and Booby Cay (Fig. 2) were visually scanned for vessels starting at the northeast corner of the island and then around the island in a counterclockwise motion. Observable days with no vessels were marked “none”. Vessels were recorded using the latitude and longitude in decimal degrees provided by Planet’s pinpoint tool. The pinpoint was placed as close to the center as possible for each vessel listed. Length-over-all (LOA) in meters was obtained by measuring from bow to stern with Planet’s distance measuring tool. The measuring tool’s smallest increment was 10 m, so all boats smaller than the smallest increment were marked in the 10 m category. The general position of each vessel relative to the island was also noted (west bay, east bay, etc.). On days where observation of the island was limited by being partially obscured by clouds, I judged by eye if the clouds were covering more than 50% of the observable area and a note was left for that day (Ex. “cloud west”). All vessels still able to be marked on those days were noted. Vessels 10 m or smaller were labeled as “boat” and those 20 m or larger were labeled as “yacht”. Depending on the tide, exposed sandbars can give the appearance of a vessel, in these cases, the area was compared to the sand on the island. Similarly, windy days can produce whitecaps that resemble vessels. To reduce the possibility of miscalling waves for vessels, I took note of days when whitecaps appeared to be present, and then checked a database of historical wind speeds for the area for the date(s) in question using timeanddate.com. If wind speeds confirmed that whitecaps would be present (sustained winds >30kts), and if the wind direction corresponded to the expected location of whitecaps, then ambiguous observations were not counted as vessels.

After parsing all images, I then mapped each vessel observation onto a satellite image of the island using ArcGIS Pro®. I used the “import x,y coordinates” tool and adjusted the size of the points to allow most points to be seen, creating a heat map of traffic to the island.. I then imported the data matrix into R in RStudio (R Core Team 2022). I plotted a histogram of the vessel sizes observed to determine the most frequent vessel types that were visiting the island over the course of the study. I then created a barplot of vessel frequency per month of the year, aggregating across the six years of the study to determine when visitor numbers were highest, as well as characterize seasonal visitation patterns. I also created a boxplot comparing the LOA of vessels through each month of the year and tested for a relationship between LOA and month using a 1-way ANOVA test (function aov() in RStudio).

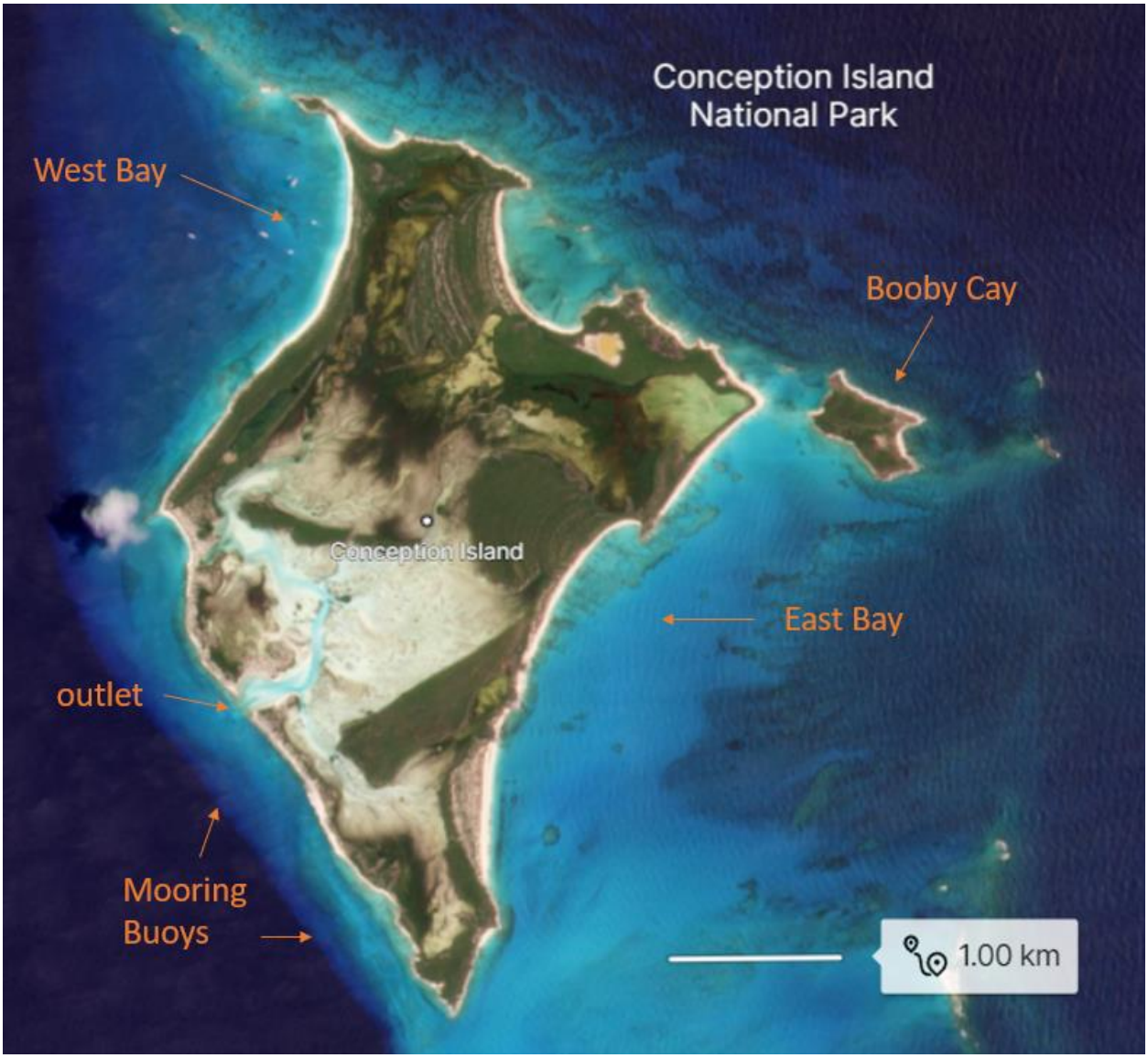

Figure 2. Map of Conception Island National Park, showing key features, mooring areas for diving, and sensitive habitat areas.

3. Results

I was able to obtain satellite images from a total of 2,192 days across six years. Of those days, 280 were unavailable because there were no images loaded into Planet's database for that day, 81 were unavailable because the Bank was more than 50% blocked by clouds, and 938 did not have a satellite pass over the island that day, leaving 893 days to be observed between 2016 and 2021. I observed a total of 1,200 vessels over the period of six years. The average LOA was 17.7 m (range 10-100 m), which suggests a mean vessel size capable of open ocean travel in calm water. But the most frequent vessel observed was in the range of 10 m or less LOA (mode LOA = 10 m, median LOA = 10 m), which represents what would be regarded as a small vessel for making a trip to this region. This category (10 m LOA), most likely includes a combination of small sailing vessels, outboard-powered fishing boats, and small craft used to make runs back and forth from a larger ship known as vessel tenders. It is likely that on many days, the presence of both large and small LOA vessels represents both a mothership and its tender, and hence I expect that I am overcounting vessels relative to independent operators, but there is no way to parse between a mothership and its tender with the

resolution offered in the Planet images. The vast majority of vessels visiting the island dropped anchor in safe harbor places like the west bay or at mooring buoys on the shelf (Fig. 3). All boats on the eastern side of the island and Booby Cay were small boats, due to the water being extremely shallow on that side. Vessels would not be expected to moor there on most occasions, as the prevailing winds (SSE to NNW) make the island a dangerous lee shore (Reynolds pers. observ.).

The vast majority of vessels were 10 m or shorter (Fig. 4), with the largest vessel measured at 100 m in length (Fig. 4). Visitations spiked in the spring, particularly between February and April (Fig. 5). Visitorship was lowest during September and October, which is peak hurricane season for the area (Fig. 5). Vessel LOA varied by month, with the summer months generally hosting larger vessel LOA (ANOVA = 10.9, P <0.001; Fig. 6).

Over a period of a few days in February of 2021, I captured photos of what appeared to be a possible poaching fleet using the Western bay as refuge from the heavy wind that day (Fig. 6). Viewing the island day by day revealed other interesting finds. Drifting piles of *Sargassum* seaweed were large enough to be picked up by the satellite, and were being carried by the current around the Eastern side of the island's shelf (Fig. 7).

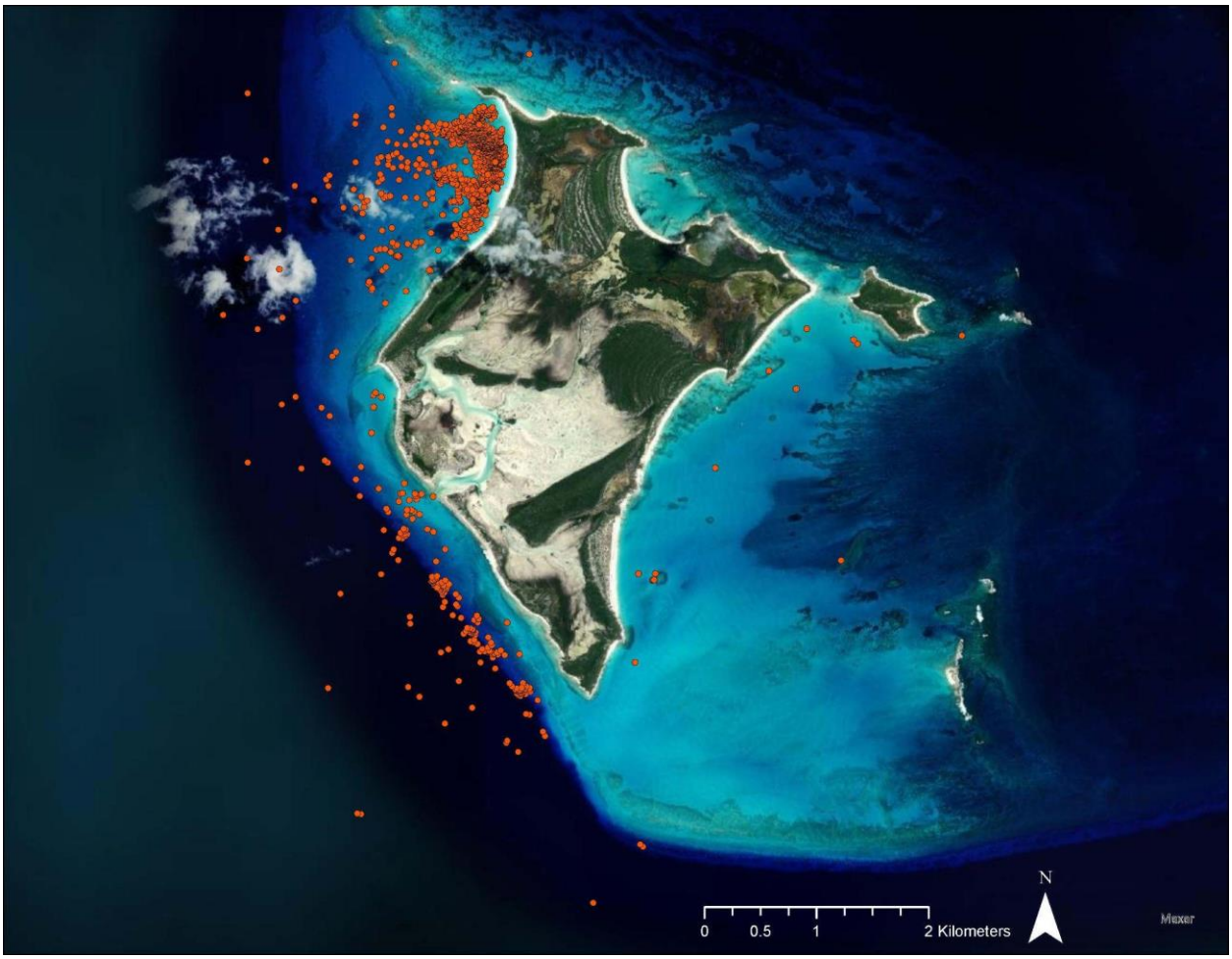

Figure 3. Map of all 1,200 vessel locations obtained during the course of the study. Each orange dot represents one vessel. Note that the majority, over 900 of the observations, are located in the West Bay anchorage area. Another large proportion are moored along the mooring buoys along the western margin of the Bank.

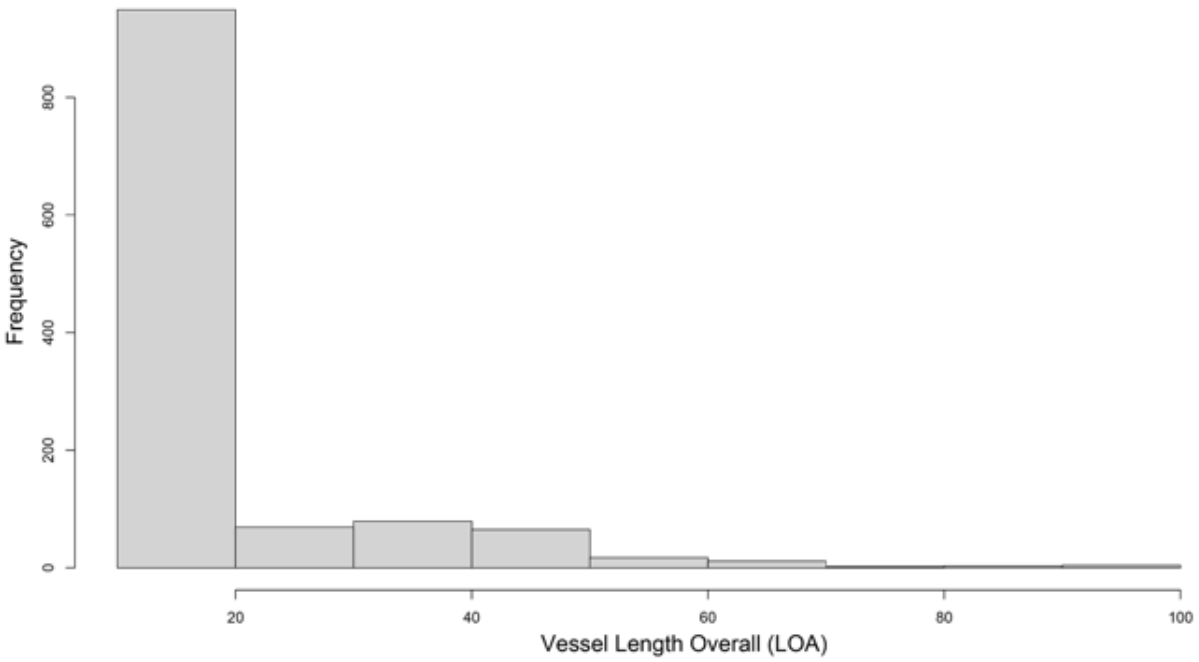

Figure 4. Histogram showing the frequency of vessels given their size (length-overall, LOA) visiting Conception Island National Park.

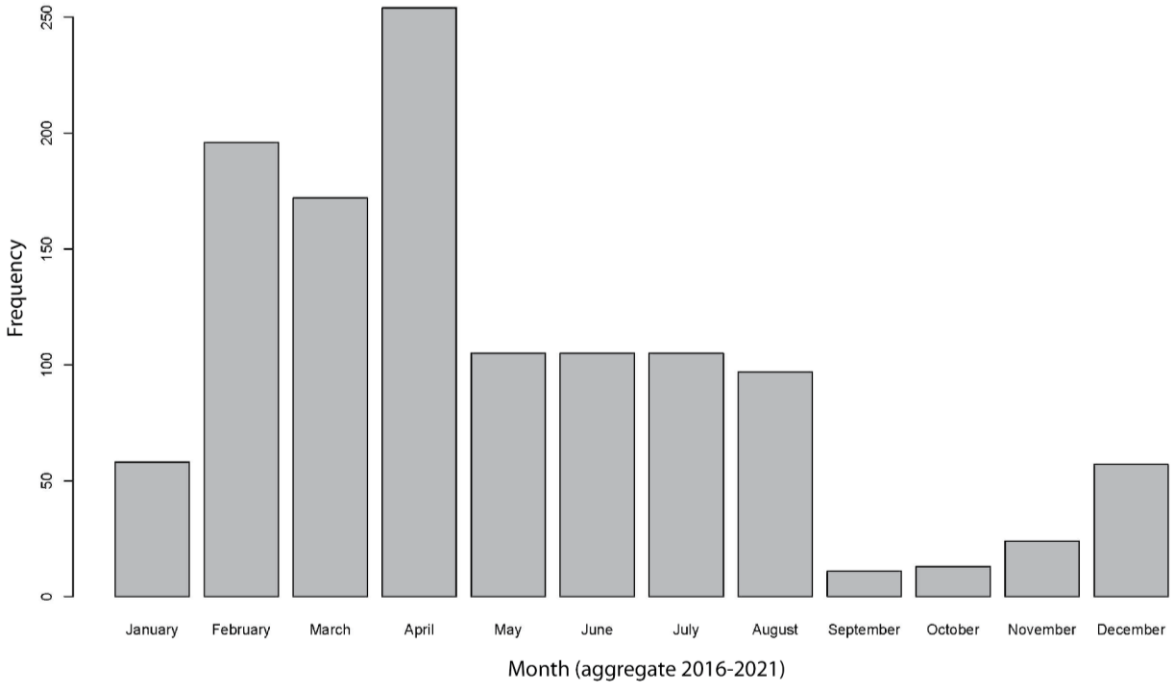

Figure 5. Barplot of monthly visitation to Conception Island National Park. Note that September and October are the peak hurricane season in the Bahamas, hence visitor numbers are expected to be low, but they are not zero.

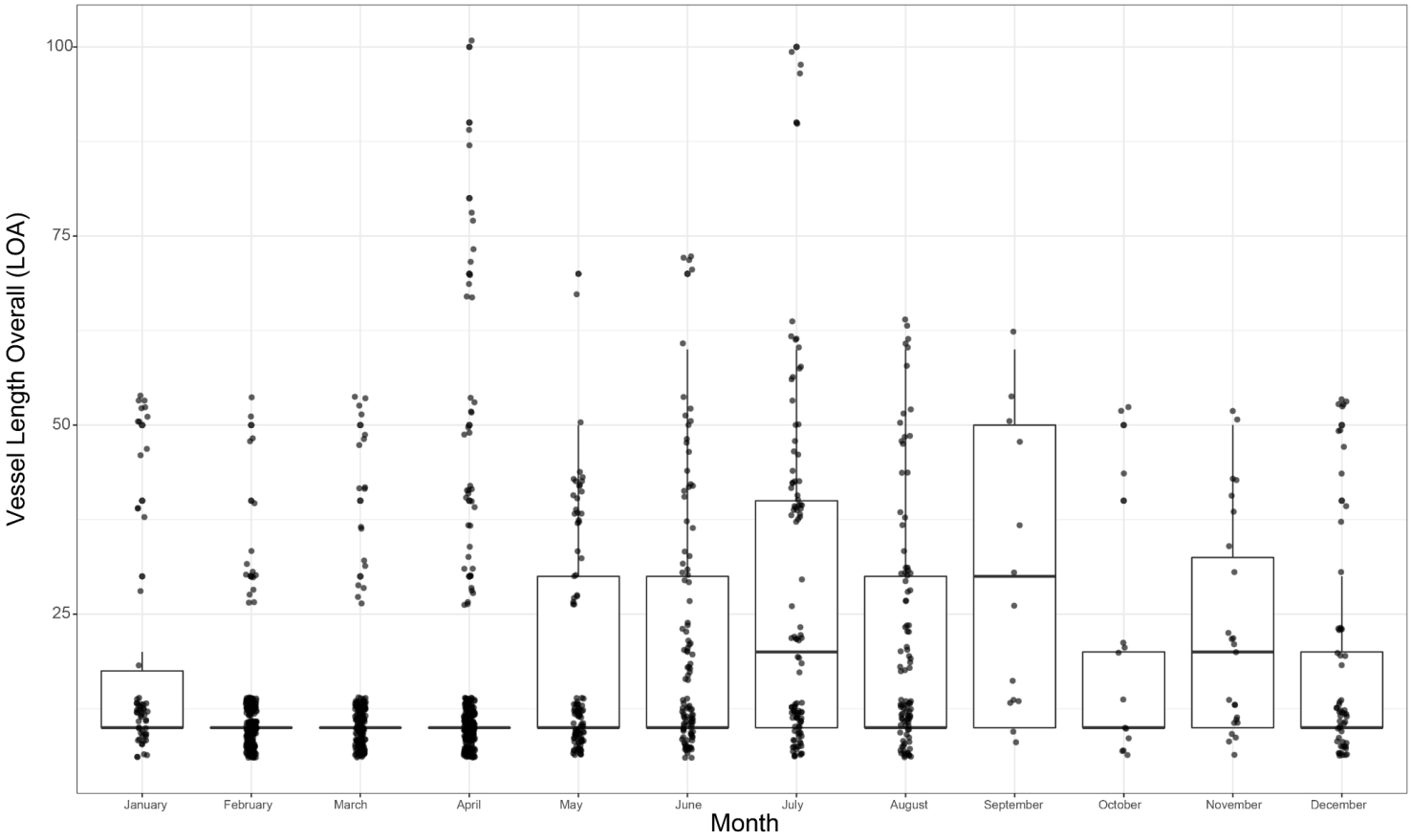

Figure 6. Boxplots of vessel sizes by month for Conception Island National Park.

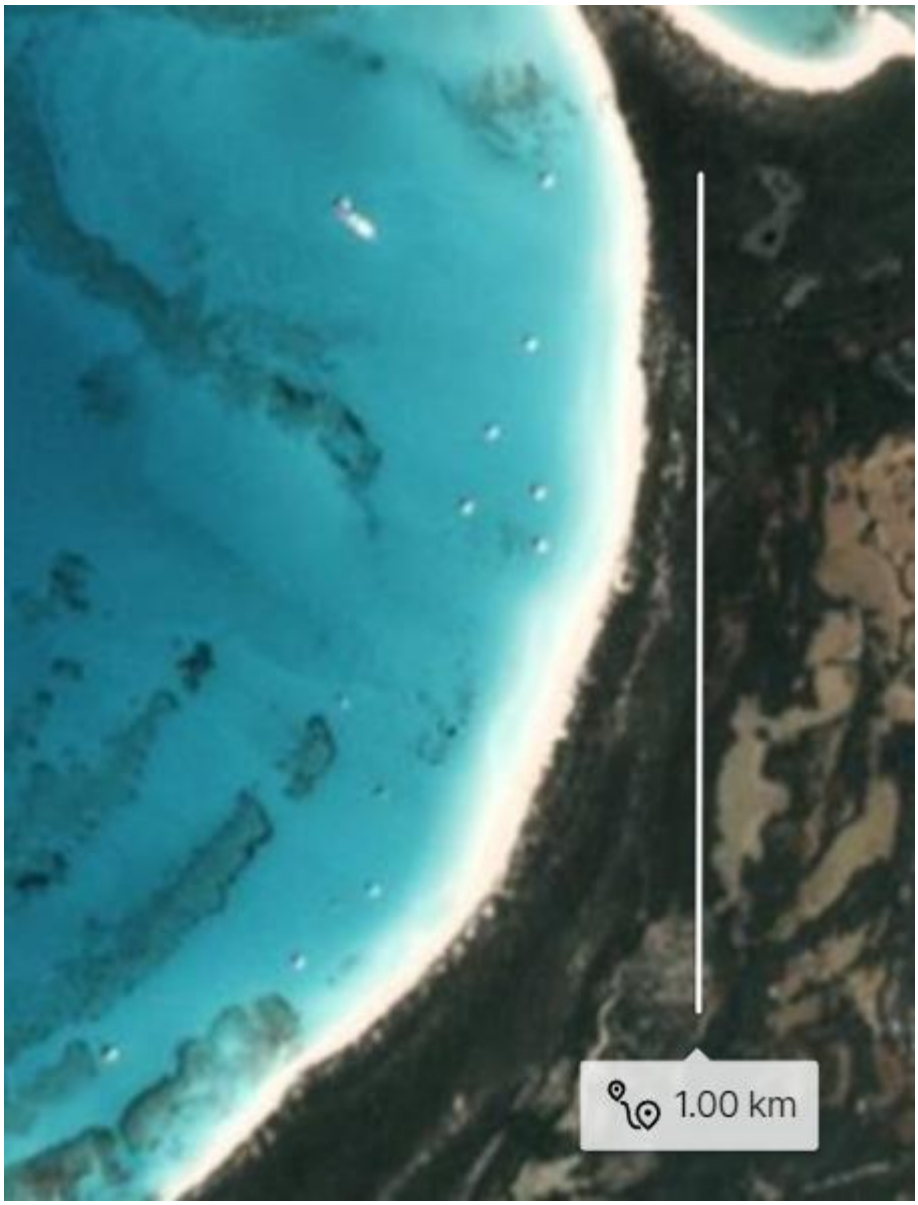

Figure 6. Example of a plausible poaching vessel observed February 08, 2021. Note the presence of the mothership and at least 1 dozen fishing skiffs.

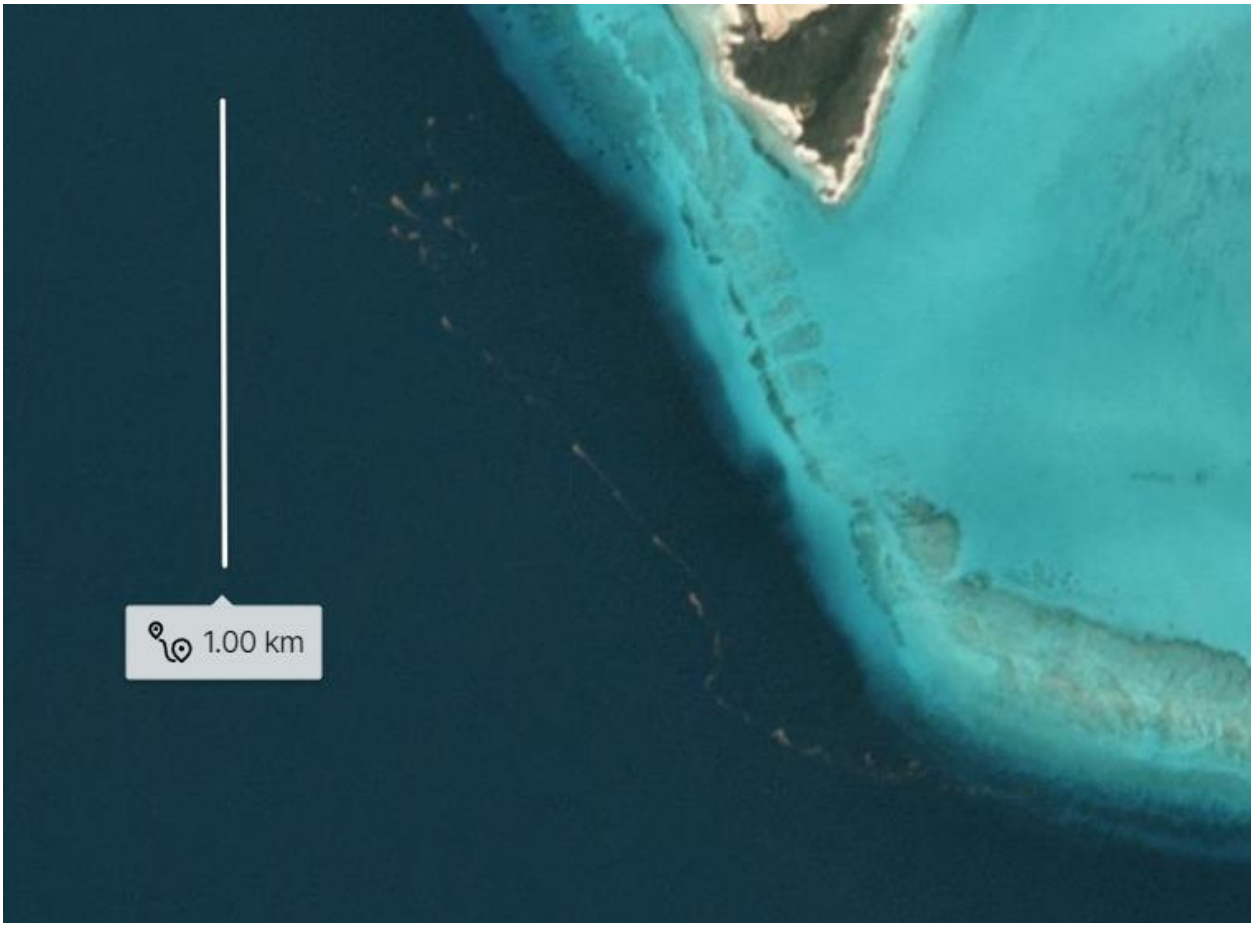

Figure 7. February 25, 2019. Example of what is believed to be a series of large *Sargassum* mats being carried by the current around the southwestern margin of the Bank. *Sargassum* sp. has proliferated in the northern Caribbean in the last seven years and is potentially damaging to beach habitat areas.

4. Discussion

This was the first study to characterize visitation and use of a remote National Park in the Lucayan Archipelago. The foremost goal of this study was to characterize boat traffic around Conception Island National Park, in hopes that this method can be used by park service personnel to understand visitorship to their remote parks and help form management plans for them. This is particularly important, as the island is home to rare and endangered species. The island is also a significant breeding area for sensitive species such as White-tailed tropicbirds, a rookery area for juvenile green sea turtles, and the last remaining habitat for the critically endangered Silver Boa[2,4,5,8].

I was able to characterize, for the first time, the visitation rates and seasonality for Conception Island National Park. I showed that dozens of vessels visit the island every month, and an average of 240 vessels per year are mooring at the island. Further, I showed that most visitation occurs in the spring, a season when migratory songbirds are arriving to the island and white-tailed tropicbirds are mating. Visitation drops off in the peak of the hurricane season, as expected, but surprisingly does not go to zero. Traveling to Conception Island in a small vessel during the peak of hurricane season can be extremely risky, but it is apparently being done regularly. I also showed that the vast majority of vessels are small sailboats or powerboats, likely representing small groups of people stopping at the island on their way to other destinations. I also documented several ships up to 100 m LOA, which is the size of a superyacht or small cruise ship and can carry dozens of guests and crew. Finally, I documented what is likely to be significant poaching activity taking place (Fig. 6). It is well known that mothership vessels from the Dominican Republic visit Bahamian territorial waters and discharge over a dozen smaller boats that fan out to collect marine life illegally. This was not

known to have happened in Conception Island National Park but is now documented. Further, this poaching activity is taking place during times when lots of other visitors are arriving to the island, which could set up a potential for dangerous conflict.

I noted a few areas that might be improved in future studies. The measuring tool of Planet's software gives a rough approximation, but is probably accurate to within 5 meters or so. A possible weakness of this data collecting method is that nighttime photos are not taken, and that may be a missing source of important information. Booby Cay is a known spot for drug traffickers, and it is highly unlikely that they would move during the day, the boats would also not stay long, which is not a problem for other boat logs since most boats moored for touristic reasons stay parked for a large portion of the day, and are likely to be detected by the satellite. Altogether, I hope this experiment will prove to be a useful means of gathering data for parks that do not have conventional means of characterizing visitor data.

5. Acknowledgements

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