RADAR SURVEYS FOR BLACK-CAPPED PETRELS ON GUADELOUPE: RESULTS FROM AN EXPEDITION DURING JANUARY 2020

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INTRODUCTION

The Black-capped Petrel (*Pteredroma hasitata*) is a seabird species in the genus Gadly Petrel. Current distribution of the species includes known nesting colonies on the island of Hispaniola where the species nests on the Cordillera Central, the Sierra de Bahoruco, Massif de la Selle, and Massif de la Hotte (Simons *et al,* 2013; Brown, 2017). Radar and night-vision surveys on Dominica in 2015 and again in 2020, detected petrel-like targets as well as observed flying petrels in multiple locations (Brown, 2015). Radar and night vision surveys in Jamaica in 2016 detected 2 petrel-like targets in the Blue Mountains (Brown, 2016). At-sea distribution of the petrel includes the western northern Atlantic, mostly between the Caribbean and Cape Hatteras and the Caribbean Sea, most often near Hispaniola but often ranging southwards to the Caribbean coast of South America (Satge *et al* 2019).

In Guadeloupe, the Black-capped Petrel previously was wide-spread on the highest peaks, most importantly the areas in and around the Soufriere volcano. Pere Labat, in his journal of time spent on Guadeloupe (1693-1705), wrote about a hunt for Black-capped Petrels, known as the "Diable", in late Spring of 1696. Labat joined a team of bird hunters up the steep slopes of the Soufriere volcano in search of the "*Diable*". At an elevation of 4,813 ft, Soufriere is the highest peak in the Lesser Antilles. The hunt took over 24-hours, starting from the coastline and following a stream bed all the way to the treeless slopes on the upper flanks of Soufriere near the village of Nez Casse. Once on the slopes, the team of hunters located *Diable* nests with the help of sniffer dogs. To tease the birds out of their deep burrows, the hunters would take a long stick and place it as far into the nest burrow as possible, and when successful, the *Diable* would bite the stick and not let go as the hunters slowly pulled the stick out of the nest burrow, bringing the *Diable* with it. On that one night's hunt, Labat recorded 213 adult *Diable* captured and killed. (Labat, 1724)

During Labat's time on Guadeloupe, the *Diable* on Guadeloupe were commonly found on the slopes of Soufriere, down as low as the village of Camp Jacob at 1,500 ft, well below the upper slopes of the volcano (Labat, 1724). However, it is believed that as humans developed Guadeloupe and in turn, trees were removed and mammals introduced, *Diable* were driven back to the steepest slopes on Soufriere. By the 1800's it was believed the only place the *Diable* were breeding was near Nez Casse, on the north slopes of Soufriere (Murphy, 1936).

The likely final decline of the *Diable* on Guadeloupe happened in 1847, an immense earthquake, estimated at a magnitude of 8.3, shook the entire island of Guadeloupe, causing widespread damage to human inhabitations, killing an estimated 5,000 residents and causing extensive damage to natural areas throughout the island. During the earthquake event, the entire north slope of Soufriere, near Nez Casse, collapsed, destroying the last known areas for breeding *Diable* on Guadeloupe and perhaps killing the last population of breeding *Diable* with it (Murphy, 1936).

Many years later, in 2004, over 150 years since the great earthquake of 1847, the French ornithologist Anthony Levesque, with the French Reserve Naturelle, doing surveys of seabirds migrating by Guadeloupe, spotted seven *Diable* fly by the island of Guadeloupe (Levesque and Yesou, 2005). A few years following, inland near Col des Mamelle, two staff with the Guadeloupe National Parc, during early morning wildlife surveys, possibly heard and saw two *Diable* as they flew over from the coast towards Soufriere (*pers. comms.* A. Chabrolle). In 2016 and 2017, Antoine Chabrolle deployed remote listening devices on the slopes of Soufriere during the *Diable* breeding season, in hopes of hearing *Diable* calling on their historic nesting grounds. Antoine did not hear any *Diable* during his surveys (Chabrolle, 2017).

Following these sightings, the next step for surveys was to use marine radar to search for flying Black-capped Petrels flying overland between potential nest sites and the sea. The methods, results, and discussion sections below, detail the radar research carried out in January 2020.

METHODS

At all survey sites, our staff simultaneously identified petrels using radar and audio/visual methods. Data collected during previous surveys for petrels on the island of Hispaniola, Dominica, and Jamaica, allowed us to better understand the timing of movements of petrels in and around nesting areas. Based on this data, surveys began at sunset, when petrels become active at the nesting area and flight corridors and ended 3 hours later, when petrel activity slowed (Brown, 2017).

For surveys, we set up our radar within 1.5km of the potential nesting sites or flight corridors. Although radar can detect targets at much greater distances, resolution suffers greatly. Setting the range at 1.5 km is standard practice when surveying for seabirds as it allows the surveyor to detect targets at a substantial range while recording a clear and powerful target on the radar (Brown, 2017). A laptop computer was attached to the radar unit and we recorded all radar images, for subsequent review and analysis.

The radar operator monitored all targets that appeared on the radar's monitor, and recorded time, direction of flight (to the nearest degree), flight behavior (e.g. straight, erratic), velocity (to the nearest 5 km/hr), and if known, noted species and number of individuals detected.

A second surveyor was stationed at the base of the potential nesting areas or along flight corridors with 10x binoculars for observations during dusk observations and a night-vision scope when daylight is insufficient. This observer, the audio/visual (A/V) crew, constantly visually scanned the airspace above potential nesting habitat and flight corridors as focused on all visible sky for flying petrels and listened for calling petrels.

The radar and A/V crew communicated during the survey. When the radar crew detected a target that was potentially a petrel it alerted the A/V crew, allowing the A/V crew to locate and identify the target. Similarly, the A/V crew communicated to the radar crew any flying species that it detected, including birds, bats, and large insects. This enabled us to more accurately define the radar image of a Black-capped Petrel and to distinguish it from other nocturnal flying species.

Following each survey, we downloaded data and reviewed the recorded images of the radar survey. During this review, we re-analyzed all targets measuring flight speed, flight direction, and target size. This second evaluation of the survey assured researchers that no targets were missed or incorrectly measured.

Radar survey sites were chosen based on available access and proximity to historical nesting areas, likely historical flight corridors, and/or recent potential observations.

RESULTS

While on Guadeloupe, we surveyed on nine nights, including seven stations one time each and an eighth station two times. Five stations were adjacent to potential flight corridors and three stations were adjacent to potential nest areas (FIGURE ONE and FIGURE TWO).

Over the nine surveys, we detected 13 Black-capped Petrel-like targets with radar. Petrel-like targets were detected at two survey stations while at seven survey locations, we detected zero petrel-like targets (TABLE ONE).

The petrel-like targets were detected at Soufriere (n=9) and at Nez Casse (n=4)

We visually observed no confirmed Black-capped Petrels with either binoculars or night-vision scope. At GUA-08 on the south slopes of Soufriere, Antoine Chabrolle observed a potential flying Black-capped Petrel east to west about 10m from the station. The wingspan of the flying target was approximately 0.5m. More details regarding this observation are below in the specific station activity description.

The peak period of petrel activity was between 30 minutes and 191 minutes after sunset (FIGURE THREE and FIGURE FOUR).

Herein below, we detail the petrel activity at each station.

GUA-01
Location: Soufriere at Savane des Mulets
Dates Surveyed: 17 January 2020
Elevation: 1,147m
Distance from Sea: 9.18 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This station was located just below the southwest slopes of the Soufriere volcano, on the large asphalt area below the main trail to the summit. The weather at this station was marginal as we had rain off and on throughout the whole survey. We did detect a small number of targets that were flying below the speed threshold and in all cases were flying along the slopes of the volcano. Based on speed and flight direction, we determined these targets were not petrel-like targets.

While we did not detect any petrels at this station, this site would be a good radar station location if there were nesting petrels on the southwest slopes of Soufriere as it allows for visibility of multiple valleys leading to these slopes.

GUA-02
Location: Nez Casse at Matouba
Dates Surveyed: 18 January 2020
24 January 2020
Elevation: 862m
Distance from Sea: 7.10 km
18 January 2020
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0
24 January 2020
Black-capped Petrel-like Targets: 4
Black-capped Petrels Observed Visually: 0

This station was located at an area where the valley leading to the peaks around Nez Casse starts to get less wide and becomes well-defined. The station, located 2.6km from the peaks that define the head of the valley, has visibility of the smaller valleys that funnel up from the Caribbean Sea towards Nez Casse. The peak of Nez Casse historically had nesting Black-capped Petrels (see Introduction above).

Our first night of surveys at this location, there was strong wind blowing down the valley and all the targets were detected to be flying down the canyon with the wind. On this night, we had no petrel-like targets.

Based on the history of petrels nesting near this survey site, we decided to survey it a second time, on a night with no wind. On this night, we were joined by staff from Parc National Guadeloupe. For the first 164 minutes of the survey, we detected no petrel-like targets. At 2044 (165min after sunset), we detected a petrel-like target flying up the valley from the Caribbean Sea towards Nez Casse. At 2055 (176min after sunset), we detected a second petrel-like target flying up the valley from the sea towards Nez Casse. Per protocol, we typically end the survey at 180min after sunset, but based on the late nature of the two previous petrel-like targets, we continued to survey for another 60min after sunset. At 2104 (185min after sunset), we detected a petrel-like target flying down the valley from Nez Casse towards the Caribbean Sea. At 2110 (191min after sunset), we detected another petrel-like target flying down the valley from Nez Casse towards the sea.

No Black-capped Petrels were observed with night-vision optics or binoculars.

GUA-03
Location: Grand Riviere at Vanibel
Dates Surveyed: 19 January 2020
Elevation: 575m
Distance from Sea: 4.61 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This survey site was located on the south rim of the large and well-defined Gran Riviere valley. This large valley is the most well-defined valley that leads from the Caribbean Sea to the highest peaks on Guadeloupe. We had unimpeded radar detectability straight across the valley as well as down the valley. We detected hundreds of bats and insects at this site, but no petrel-like targets. On 23 January 2020, we surveyed from the north rim of the Grand Riviere valley (GUA-07) and did not detect any targets.

No Black-capped Petrels were observed with night-vision optics or binoculars.

GUA-04
Location: Soufriere at Citerne
Dates Surveyed: 20 January 2020
Elevation: 1,145m
Distance from Sea: 6.57 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This survey station is located adjacent to the communication towers on the southeast slopes of the Soufriere volcano. This site is on a ridge top and provided the radar with the ability to detect targets coming from both the east and west valleys.

The night we surveyed, it was very windy (~30 k/hr) and all the targets we detected were flying with the wind. This “with the wind” flight direction coupled with the strong winds, discounted the few targets that were detected flying at the speed threshold for petrels. The flight behavior we detected was all coming from the east towards the west. Despite discounting the few petrel-like targets due to the high winds, the survey left us curious to re-visit this site or an adjacent site on a windless night to see if there was similar flight activity without wind. On 25 January 2020, we visited a site (GUA-08) approximately 0.64km to the northwest and had several petrel-like targets.

We did not see any petrels with night-vision optics or binoculars.

GUA-05
Location: Fond Bernard
Dates Surveyed: 21 January 2020
Elevation: 717m
Distance from Sea: 6.75 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This survey station was located on the small sub-ridge on the south side of the river valley in Fond Bernard. This valley connects the Caribbean Sea to the prominent peaks on the north side of the Soufriere volcano and Nez Casse. The survey site had a limited radar window due to it being inside the valley. Our survey visibility was directly across the valley and a small portion up the valley. For this specific valley, this was the best site possible for surveying due to the nature of it being heavily wooded in other areas.

The weather during the survey was rain off and on. The wind speed was also highly variable, and the wind picked up prior to and during the passing rainstorms. The rain, when around, limited our radar visibility. The wind was blowing down valley.

All the targets detected at this site were flying down the valley, in the same direction as the prevailing wind. The few targets we did detect, which were flying at the speed threshold for petrels, we observed during heavy wind events and therefore had to be negated due to the wind-aided flight velocity.

No petrels were observed with night-vision optics or binoculars.

GUA-06
Location: Col des Mamelle
Dates Surveyed: 22 January 2020
Elevation: 7598m
Distance from Sea: 4.43 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This radar station is near where the Park National Guadeloupe staff previously observed multiple possible Black-capped Petrels in flight during early morning hours. The site has visibility to a distinct valley to the north of the station as well as the east and west slopes of the peaks in the vicinity of the station. This location was the furthest distance away from the high peaks of Soufriere and Nez Casse.

We had no petrel-like targets on radar or seen with night-vision optics or binoculars.

GUA-07
Location: Grand Riviere at Bel-Air
Dates Surveyed: 23 January 2020
Elevation: 614m
Distance from Sea: 4.00 km
Black-capped Petrel-like Targets: 0
Black-capped Petrels Observed Visually: 0

This radar station is located on the north rim of the Grand Riviere valley. This station is across the valley from radar station GUA-03. The Grand Riviere valley is the most prominent valley that connects the Caribbean Sea to the high peaks near Soufriere and Nez Casse. Our detectability at this site was directly across and up the valley from the station. The weather on this survey included little to no wind and no rain.

No petrel-like targets were detected nor were petrels observed with night-vision optics or binoculars.

GUA-08
Location: Echelle at Soufrierre
Dates Surveyed: 25 January 2020
Elevation: 1,146m
Distance from Sea: 7.36 km
Black-capped Petrel-like Targets: 9
Black-capped Petrels Observed Visually: 0 (potentially 1)

This radar station is located on the southeast slopes of the Soufriere volcano on the road between the main summit trail and Citerne. From this location, we were able to observe flights along the main valleys on the south side of Soufriere, targets that come through a gap between the east and west side of Soufriere, as well as potential petrel nesting habitat on the south slopes of the volcano.

The weather during this survey was optimal for radar, with little to no wind and no rain. With radar, we observed nine petrel-like targets. At 1830 (30min after sunset), we observed two petrel-like targets flying in close proximity out of a shallow valley on the Soufriere volcano adjacent to the radar station and flying towards the Caribbean Sea. At 1831 (31min after sunset), we observed a single petrel-like target flying out of the same shallow canyon on Soufriere as the previous two targets, towards the Caribbean Sea. At 1840 (40min after sunset), we observed a single petrel-like target flying out of the same shallow canyon on Soufriere as the previous targets and flying towards the Caribbean Sea. At 1855 (55min after sunset), we observed two petrel-like targets flying in close proximity from the Caribbean Sea towards the Soufriere volcano. At 1917 (77min after sunset), we observed a single petrel-like target flying out of the same shallow valley as previous seaward bound petrel-like targets. At 1918 (78min after sunset), we observed a single petrel-like target flying towards Soufriere from the gap near Citerne. At 1934 (94min after sunset), we observed our final petrel-like target of the night, this target was flying towards Soufriere from the gap near Citerne.

Visually, we had no confirmed sightings of Black-capped Petrels, however, at 1905 (65min after sunset), Antoine Chabrolle, with night-vision scope, observed a flying target with a wingspan that was approximately 0.5m, flying away from Soufriere, east to west, towards the Caribbean Sea. The target was approximately 10m west of Antoine when it was observed. No call was heard. We did not see this target on the radar.

DISCUSSION

The radar data collected during this expedition, coupled with the anecdotal data of birds observed at-sea near Guadeloupe and potentially over-land, lead us to believe that there is some level of Black-capped Petrel activity centered around Guadeloupe. The habitat at the locations we detected petrel-like targets on radar, is similar to that found in some Black-capped Petrel nesting locations on Hispaniola.

Herein, we will discuss specific locations on Guadeloupe for their potential suitability for nesting Black-capped Petrels.

The tallest peak on Guadeloupe, the **Soufriere volcano**, is a historical nesting site for the Black-capped Petrel. The upper flanks of the mountain are mixed rocky terrain, wet forest, and elfin cloud forest (FIGURE FIVE). The mountain itself has numerous valleys on multiple faces as well as craters. There is a large and well-maintained trail that climbs from the mid-flanks to the summit, circling the peak. The petrel-like activity that we detected with radar near Soufriere, was on the southeast slopes of the volcano. We had targets coming from/heading towards two places. The first was a shallow valley on the southeast flanks of Soufriere, northwest of our radar station (FIGURE SIX). This valley appears to be accessible from the road near the radar station, although the vegetation looks to be quite thick throughout. We had a number of targets associated with this valley, including what appeared to be a pair of targets flying out of the valley together. The second area of interest was the low gap in the ridge shoulder between Soufriere and Citerne. We detected several petrel-like targets flying through this gap, both in an easterly and westerly direction (FIGURE SIX). The east side of this gap leads to a valley that is the closest distance to the sea from Soufriere.

The mountain of **Nez Casse** is the last known nesting site for Black-capped Petrels on Guadeloupe (FIGURE SEVEN). In recent years, song-meters have been placed at its summit and people have spent the night on the summit, all listening and looking for Black-capped Petrel activity. The valley on the west side of Nez Casse is very well defined and surrounded by high peaks and steep sided valley walls. The valley walls, including the flanks of Nez Casse, are heavily vegetated with elfin cloud forest (FIGURE EIGHT and FIGURE NINE). This area is often engulfed in cloud cover and buffeted by strong winds, making audio and visual surveys difficult. The radar unit detected two petrel-like targets heading up the valley from the sea towards Nez Casse and then later, two petrel-like targets heading down valley from the Nez Casse area (FIGURE 10). The slopes on the west side of Nez Casse, appear to be appropriate nesting habitat for Black-capped Petrels as the slopes are very steep and heavily vegetated. Access to the slopes can be gained from the summit, but will likely require ropes, anchors, and rappelling equipment to be safely surveyed.

RECOMMENDATIONS

Future radar surveys: Additional radar surveys in the areas of Nez Casse and around the Soufriere volcano would allow for further data on flight activity of potential petrel-like targets in these historic nesting areas. If possible, the radar unit could be transported to the summit of Soufriere and surveys could take place from this site to detect activity simultaneously on all slopes of the volcano. The use of the small cement house near the summit, as a dry and wind-free base of operations would make surveys more comfortable. Equipment might even be able to be left at this site and only batteries to power the unit would need to be transported for surveys.

Future audio/visual surveys: Up until now, visual surveys have been done with binoculars and night-vision optics and audio surveys have been done with song-meters and sitting at sites, actively listening. For audio, we recommend deploying a suite of song-meters at multiple sites including the ridge tops near Nez Casse as well as areas along the main summit trail of Soufriere and in the shallow valley on Soufriere where we detected petrel-like activity. For these song-meter units, we recommend following the programming structure that is currently used for sites on Hispaniola. This programming structure can be provided by contacting Conservation Metrics, our audio conservation partner for the overall Black-capped Petrel conservation effort. For visual surveys, we strongly recommend using thermal cameras. These cameras have been used with great success at other petrel nesting areas, including recently at Reunion

Island where the thermal cameras discovered a new nesting colony of petrels. The optics of thermal cameras is more effective at observing flying objects at a further distance than are night-vision optics.

Future nest searching: The steep, tall, well-vegetated walls of the well-defined valley near Nez Casse appear appropriate for nesting Black-capped Petrels. Starting on the slopes below Nez Casse, we recommend searching for nesting petrels. Additionally, we recommend searching in the valley near GUA-08 where we had numerous petrel-like targets fly from. We recommend an exchange with the Black-capped Petrel nest monitoring team on Hispaniola, who has experience with finding nesting petrels. Finding nesting Black-capped Petrels should be a high priority for determining if petrels persist on Guadeloupe.

Introduced mammal trapping: While it is still uncertain if Black-capped Petrels persist on Guadeloupe, starting the assessment of potential threats to a possible population is worthwhile. We suggest a mammal trapping regiment that allows land managers to assess the status of mammalian predators in areas of potential petrel nest colonies. These areas would include along the ridge tops in the valley near Nez Casse as well as along the hiking trail to the summit of Soufriere as well as the shallow valley we observed petrel-like targets with the radar unit. Collecting this data will allow conservationists to better understand the threats to a potential petrel population and strategize a plan for eradication.

Finally, we encourage continuing surveys for Black-capped Petrels on Guadeloupe as well as continued integration into the larger petrel working group. We encourage the local conservation foundations, the local conservation agencies, and the regional conservation teams to continue efforts to determine the nesting status of Black-capped Petrels on Guadeloupe.

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FIGURES AND TABLES

FIGURE ONE: Radar station locations on Guadeloupe. The cluster of station near Soufriere and Nez Casse is in more detail in figure below.

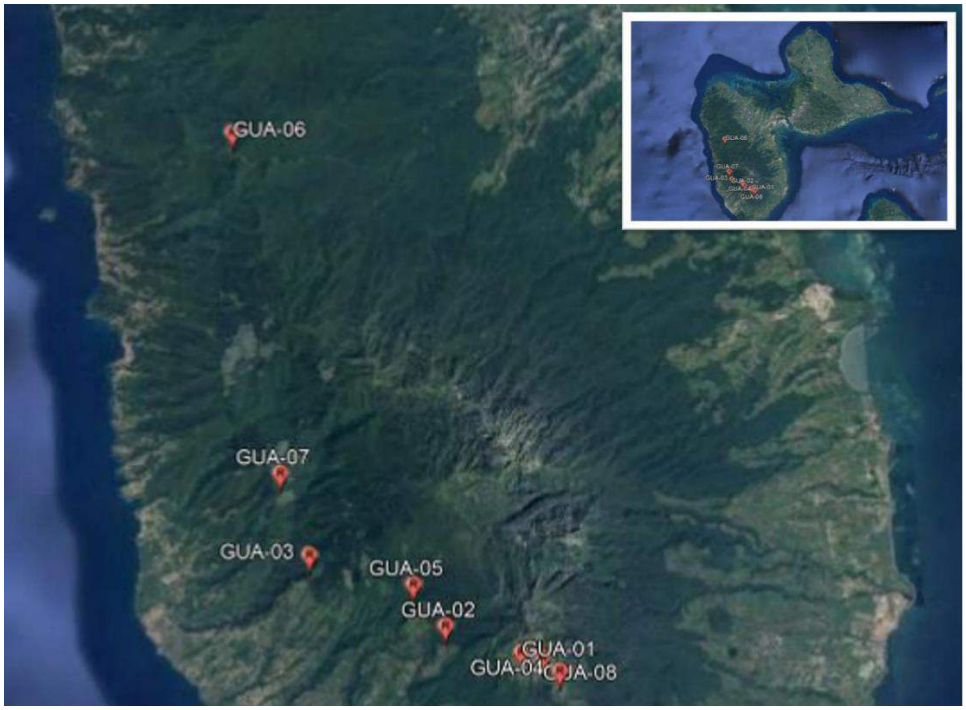

FIGURE TWO: Radar station locations adjacent to Soufriere and Nez Casse.

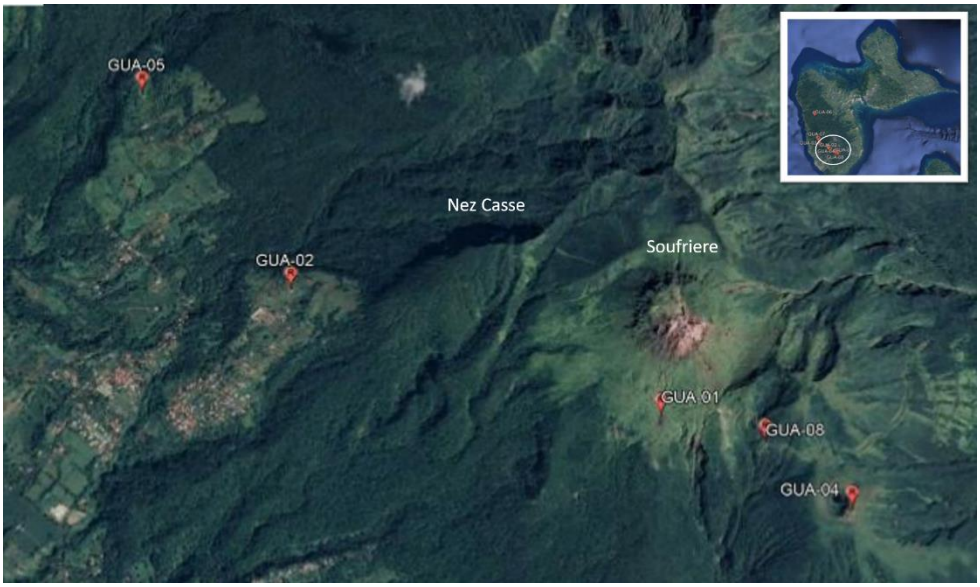

FIGURE THREE: Timing of petrel-like targets at GUA-02 which is located near Nez Casse.

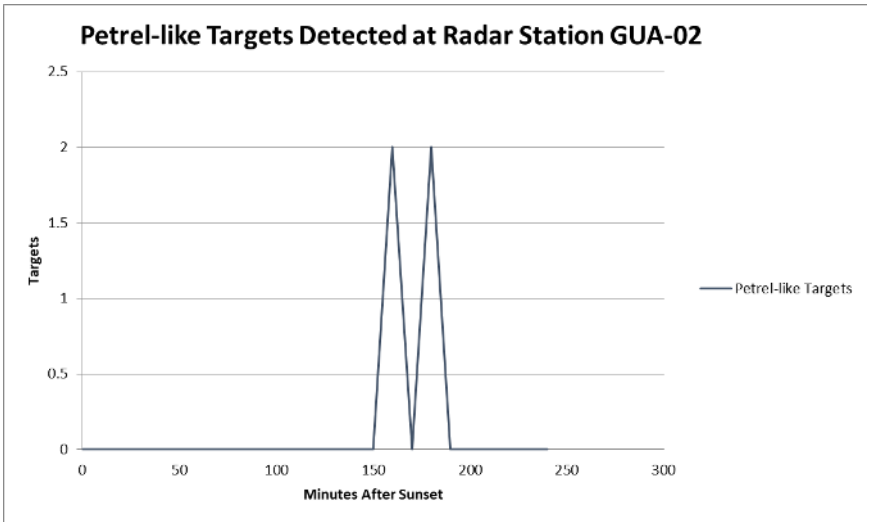

FIGURE FOUR: Timing of petrel-like targets at GUA-08, which is located near Soufriere.

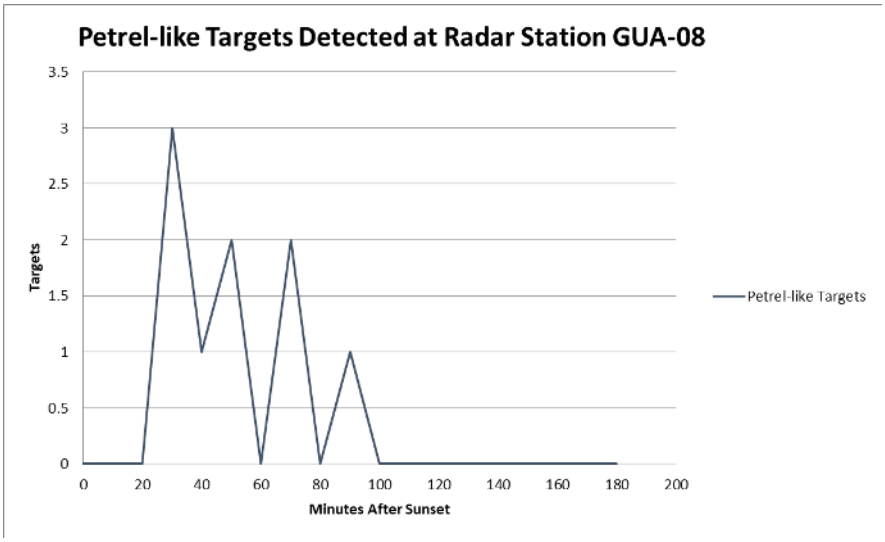

FIGURE FIVE: The radar at the Soufriere volcano.

FIGURE SIX: Activity of petrel-like targets in proximity to Soufriere. Circled area is valley where several targets were detected, and the red arrow is an additional flight corridor where petrel-like targets were detected flying through the saddle on the ridgeline between Soufriere and Citerne.

FIGURE SEVEN: The location of radar station GUA_02, which is at mouth of the valley leading towards Nez Casse.

FIGURE EIGHT: The summit of Nez Casse. A songmeter recording unit was placed at the rock in the photo by Antoine Chabrolle. The slopes on the left side of the photo connect the summit and the valley in the previous photo.

FIGURE NINE: The view from the summit of Nez Casse towards the southeast and the lower slopes of Soufriere.

FIGURE 10: The flight patterns (orange arrows) of the four petrel-like targets detected from the radar station at GUA-02.

TABLE ONE: Radar station locations, altitudes, and petrel-like targets detected on radar at each station.

Station	Date	Location	Lat	Lon	Altitude (m)	Heading	Petrel-like targets	Petrels Observed
GUA-01	1/17/2020	Sufriere at Savane des Mulets	16.03861	-61.66522	1147	12	0	0
GUA-02	1/18/2020	Nez Casse at Matouba	16.04664	-61.6857	862	350	0	0
GUA-03	1/19/2020	Grand Riviere at Vanibel	16.06724	-61.72202	575	165	0	0
GUA-04	1/20/2020	Sufriere at Citerne	16.03312	-61.65499	1145	330	0	0
GUA-05	1/21/2020	Fond Bernard	16.05799	-61.69379	717	340	0	0
GUA-06	1/22/2020	Col des Mamelle	16.18181	-61.7368	598	40	0	0
GUA-07	1/23/2020	Grand Riviere at Bel-Air	16.08929	-61.72879	614	308	0	0
GUA-02	1/24/2020	Nez Casse at Matouba	16.04664	-61.6857	862	336	4	0
GUA-08	1/25/2020	Echelle at Soufrierre	16.03694	-61.6595	1146	34	9	0
		TOTAL					**13**	**0**