STATUS OF CRAVERI'S MURRELET *SYNTHLIBORAMPHUS CRAVERI* IN THE MIDRIFF ISLANDS, GULF OF CALIFORNIA, MEXICO

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ABSTRACT

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The Craveri's Murrelet *Synthliboramphus craveri* is an endangered seabird (family Alcidae) endemic to northwestern Mexico, where it breeds on rocky islands throughout the Gulf of California (GOC). Nesting records are scarce for most of these islands, and much of the available information relies on historical data collected more than 50 years ago. Beginning in 2009 through to 2023, we performed intermittent nest searches on five islands in the Midriff Islands of the GOC. Starting in 2018 on Alcatraz Island and starting in 2022 on San Pedro Mártir Island, we monitored nests to determine average clutch size and hatching success. We also performed nocturnal spotlight surveys around San Esteban Island and San Pedro Mártir to estimate breeding populations. On Alcatraz, we observed breeding behavior from December to April and chicks departing nests as early as January. During 2020–2023, average clutch size on Alcatraz was 1.6 eggs per active nest and average hatching success was 1.02 eggs, with eggs hatching in 68% of active nests. While we observed numerous murrelets in the waters surrounding some islands, we did not find much evidence of nesting on islands with invasive rodents. On San Pedro Mártir, where invasive rodents were exterminated in 2007, we estimated the breeding population to range from 38 pairs in 2022 to 99 in 2023. Future studies are needed to further quantify the breeding population and to better understand the specific impacts of both invasive rodents and variation in ocean climate upon murrelet nesting. Finally, it is important to examine the causes of variation in nesting success rates and phenology over the years to increase the effectiveness of conservation efforts.

Key words: Alcatraz, Alcidae, breeding, Gulf of California, spotlight census, *Synthliboramphus craveri*

INTRODUCTION

The Craveri's Murrelet *Synthliboramphus craveri* is an endangered seabird that breeds on islands throughout the Gulf of California (GOC) and a few islands along the Pacific coast of Baja California, Mexico (DeWeese & Anderson, 1976; Mlodinow et al., 2024; Velarde et al., 2011; Whitworth et al., 2018). It is the most southerly breeding alcid (Gaston & Jones, 1998) and the only one that breeds in the GOC (DeWeese & Anderson, 1976; Velarde et al., 2011). Despite their status as Endangered in Mexico (Secretaría De Medio Ambiente Y Recursos Naturales, 2010) and Vulnerable on the International Union for the Conservation of Nature (IUCN) Red List (BirdLife International, 2008), the Craveri's Murrelet is the least studied of all the alcids (Whitworth et al., 2018). Reliable population estimates are not available, but the most recent global population estimate of 8,000 individuals (Partners in Flight, 2020) is significantly less than the 1990s estimates of 15,000–22,000 individuals (Gaston & Jones, 1998; Pitman et al., 1995) and the 2000s estimates of 10,000–20,000 individuals (BirdLife International, 2000, 2008; Velarde et al., 2011). The compiling of published nesting records on many islands began over 50 years ago (Velarde et al., 2011), but a lack of data makes it difficult to determine the timing of the breeding season and nesting activity.

Difficulties in studying the Craveri's Murrelet are partially due to their reclusive nature and breeding biology. Unlike many seabirds (but like some other murrelets), they are not colonial nesters. In addition, they tend to nest on offshore islands, away from human activity. Their small size makes them inherently vulnerable to a wide range of predators, and their specific nesting habitat requirements reflect this: they nest in small, enclosed crevices with entrances narrow enough to exclude large avian predators (Breese et al., 1993; Hurley & Blinick, 2011). The mean clutch size of Craveri's Murrelet has been recorded as 1.88, which is like other *Synthliboramphus* murrelets in that it is significantly higher than other seabirds, most of which lay just one egg (Gaston, 1990). Craveri's Murrelets leave and return to their nesting sites under the cover of night and are not seen on land outside of their nesting locations. Like other *Synthliboramphus* murrelets, they are among the most precocial seabirds (Carter et al., 2005; Murray et al., 1983). Indeed, flightless chicks leave the nest within two days of hatching (Breese et al., 1993) and stay with their parents for their first few months (DeWeese & Anderson, 1976). Parent-chick groups are most often observed with two adults and one or two chicks, and adults are thought to remain paired year-round, traveling together at sea (DeWeese & Anderson, 1976). Nesting has been documented between December and April (Carter et al., 2005; Hurley & Blinick, 2011; Murray et al., 1983). The only observation of fledging behavior was recorded on 11 March 2009 on Alcatraz Island in the GOC (Hurley & Blinick, 2011).

The species is inherently vulnerable to invasive ground predators that have been introduced to many islands in their breeding range, such as Ship Rats *Rattus rattus*, House Mice *Mus musculus*, and Domestic Cats *Felis catus* (Velarde et al., 2011). As a result of rodent introductions, the species has been extirpated from several of the 15 islands where invasive rodents have been recorded

(Samaniego-Herrera et al., 2011). This includes House Mice on Alcatraz Island and Ship Rats on nearby San Esteban Island. The Grupo de Ecología y Conservación de Islas (GECI) searched nine islands in the Midriff Island Region of the GOC for invasive mammals in 2018, and they found no invasive mammals on the islands of Estanque, Rasa, Partida, Las Ánimas, San Pedro Mártir, Salsipuedes, Dátil, and Cholludo, but confirmed House Mice on Alcatraz (Bedolla-Guzmán et al., 2019). Rodent eradications carried out in recent decades have greatly benefitted murrelets and other seabird species on several GOC islands, including Rasa and San Pedro Mártir (Aguirre-Munoz et al., 2018; Samaniego-Herrera et al., 2009, 2011).

GECI started conducting surveys for Craveri's Murrelets on Alcatraz in 2015, and any nests found were monitored throughout 2016 and 2017. In 2017, GECI also surveyed Partida and San Pedro Mártir. In 2018, GECI surveyed Alcatraz, Partida, and San Pedro Mártir again, along with five more islands in the Gulf: Cholludo, Estanque, Rasa, Las Ánimas, and Salsipuedes. Nests were found on each of the eight islands, and nocturnal spotlight surveys at sea found individuals present in the waters surrounding each island except for Cholludo, though an individual was seen off the south shore of nearby Dátil (Bedolla-Guzmán et al., 2019).

While there has been nesting evidence found on several islands since 2011, a lack of data on productivity and phenology has made it challenging to determine population size and evaluate nesting success. The lack of at-sea sightings around islands at which they are known to breed (e.g., Alcatraz), as well as the abundance of sightings near islands without significant nesting evidence (e.g., San Esteban), raises critical questions about the feeding behavior and life history of the species. These observations raise questions about the location and size of possible "floating populations" of adult non-breeders in the GOC (Ainley et al., 2024). To effectively conserve this species, recent and thorough nesting surveys of islands within the breeding range are needed, along with a more thorough understanding of their total populations, including individuals that have yet to find a nest (i.e., prospective "floaters").

In 2009, the Prescott College Kino Bay Center for Cultural and Ecological Studies (hereafter, Prescott) began conducting surveys for Craveri's Murrelets on several islands in the Eastern Midriff Island Region of the GOC. In 2017, a more systematic study was initiated. The goals of this paper are to summarize the results of Prescott's survey efforts and to infer areas of importance and timing for future studies from observations of nest location and phenology. Our specific objectives were to 1) summarize the results of our nest search efforts in the Eastern Midriff Island Region; 2) track nesting success and phenology on Alcatraz Island during 2017–2023 and on San Pedro Mártir Island in 2023; 3) describe habitat preferences and the relative locations of nests on the islands surveyed; 4) map nest locations and at-sea sightings during nocturnal spotlight surveys; and 5) estimate the number of nesting pairs per island based on spotlight-survey data.

STUDY AREA AND METHODS

This study is centered on five islands in the Eastern Midriff Island Region of the central GOC, between 28.3°N, 111.9°W and 28.8°N, 112.7°W, including San Esteban, San Pedro Mártir, Alcatraz, Dátil, and Cholludo islands (Fig. 1) (Comisión Nacional de Áreas Naturales Protegidas [CONANP], 2000; Hildago-González & Alvarez-Borrego, 2008). This is the narrowest section of the GOC and includes several of the largest islands in the Gulf. Areas of intense upwelling are created by strong tides and winds that affect the deep and narrow ocean basins between the northern and central GOC. These upwellings accelerate the mixing of water masses and bring cold, nutrient-rich waters to the surface, resulting in increased primary productivity. Ultimately, this creates and maintains rich feeding grounds for murrelets and other marine life (CONANP, 2000, 2007).

Alcatraz Island is 0.5 km^2 in size and lies 1.4 km offshore in Kino Bay in the state of Sonora, Mexico (Pfister et al., 2005; Samaniego-Herrera et al., 2011). The northeastern part of the island is a saline flat that ends at sandy beaches along the coast and is characterized by dense halophytic vegetation with patches of more sparsely distributed desert shrubs (Felger, 1966; Pfister et al., 2005). The southwestern side of the island is largely devoid of vegetation and characterized by a ridgeline ~130 m above sea level, with coastlines that transition from rocky shores to steep sea cliffs (Felger, 1966; Pfister et al., 2005). The island supports 14 species of nesting waterbirds, with nesting seasons extending over 11 months of the year (Gaeta et al., 2018).

San Esteban Island is about 43 km^2 in size and lies about 12 km southwest of Tiburón Island (Felger, 1966). It is the third largest island in the GOC (Calmus et al., 2008) and is an ancestral home to the Comcaac (Seri) people. The interior of the island is divided by Limantour wash, which flows from the northwestern end of the island to the eastern shore. The shoreline is characterized mostly by high vertical cliffs. There are five species of endemic reptiles present and one endemic mouse (Felger, 1966). The waters around San Esteban are known for strong tidal currents, which create favorable feeding conditions for murrelets and other seabirds (Velazquez-Muñoz & Filonov, 2021).

Dátil Island (about 1.25 km^2 in size) and Cholludo Island (about 0.025 km^2) are connected to Tiburón Island via a submerged reef extending approximately 5 km from Tiburón's southeastern shore (Wilder et al., 2008). Dátil features a prominent north-south mountain ridge with a peak elevation of 180 m. Its shoreline is dominated by high sea cliffs, and beaches are sparse. Cholludo slopes from the northern shore upward to steep cliffs about 75–100 m above sea level on the southern side of the island (Felger, 1966). The island is covered with dense stands of Cardon Cactus *Pachycereus pringlei*.

San Pedro Mártir Island is about 2.9 km^2 in size and lies 61 km from mainland Sonora in the middle of the GOC (CONANP, 2007). The island is ringed by steep sea cliffs ~150 m in elevation (Tershy et al., 1997). The island, its two adjacent islets, and its surrounding waters were declared as a national biosphere reserve in 2002 by presidential decree; it is also listed as a UNESCO World Natural Heritage Site and a Ramsar site (CONANP, 2007). The island is home to two endemic lizards and large colonies of Cocos Booby *Sula brewsteri* and Blue-footed Booby *Sula nebouxii*, and it supports one of the GOC's largest colonies of Red-billed Tropicbirds *Phaeton aethereus* (Piña-Ortiz et al., 2018). Invasive rodents were eradicated from the island by aerial broadcast of rodenticide in 2007 (Samaniego-Herrera et al., 2011).

Nest searches and monitoring

Nest searches and monitoring involved walking along the shorelines and looking for potential nesting cavities in all areas that appeared to be suitable habitat for Craveri's Murrelets. All suitable cavities

Fig. 1. The Gulf of California, Mexico, with the study area outlined and enlarged.

were checked with a flashlight for evidence of active nesting. We defined an active nesting cavity as one containing either adults, chicks, eggs, or eggshells from the current season. If any nesting evidence was covered with dust or spider webs, indicating that it was quite old, the cavity was considered inactive. Using a handheld GPS receiver (Garmin eTrex 20x; Olathe, USA), coordinates and nesting evidence were recorded for all nests found. Nest checks were made as carefully and quickly as possible to minimize disturbance, and we recorded the start and end times of each survey. Nest searches were conducted during the breeding season (January–March) over 11 years between 2009 and 2023, with most effort occurring on Alcatraz. In 2010, Cholludo, Dátil, San Esteban, and San Pedro Mártir were searched as well (Table 1).

Nest monitoring, which consisted of periodic examination of previously found nests, was conducted on Alcatraz two to four

TABLE 1
Results of nest searches in the Gulf of California, Sonora, Mexico from 2009 to 2023 showing number of new cavities with evidence of nesting found through nest searches and monitoring

		Number of active nests found by year										
Island	Total	2009	2010[b]	2013	2014	2017	2018	2019	2020	2021	2022	2023
Alcatraz	20[a]	8	14	8	9[c]	8	12[c]	8	6	11	10[c]	8
Cholludo	1	–	1	–	–	–	–	–	–	–	–	–
Dátil	1	–	1	–	–	–	–	–	–	1[b]	–	–
San Esteban	6	–	0	–	–	–	–	–	3	3	–	–
San Pedro Mártir	27	–	0	–	–	–	–	–	–	–	22[b]	17

[a] This number is based on data from 2018 to 2023
[b] Nest searches only
[c] Nest monitoring only
– No searches conducted

times during the breeding season (December–April) in 2009, 2013, 2014, and 2017–2020, then once per week from January to April in 2021–2023. Any new nests found during searches at Alcatraz were added to the sample of monitored nests. Nest monitoring at San Pedro Mártir was conducted in 2023 only. In both searching and monitoring, each cavity was recorded as either active or inactive (see above).

Breeding phenology

To better understand the phenology and the nesting activity of the Craveri's Murrelets on Alcatraz Island, nests were also monitored with camera traps during the 2021/22 and 2022/23 seasons. Cameras were placed at several nests that were safely accessible by researchers and had easily identifiable cavity entrances. During the weekly visits to the nests, the battery life was checked on every camera and the SD memory cards were switched to upload the footage to computers and ensure there was enough space on the cards for the subsequent week. When a nest was no longer occupied, the camera was moved to another nest so we could monitor as many nests as possible during the season. The camera traps recorded the dates and times of any murrelet activity, including the parents' first visit to the nesting cavities, incubation exchanges, and the departure of the chicks. Laying dates of the first eggs and the last observed activity for each clutch were determined through the weekly checks. The total number of days a cavity was occupied and the average number of days between incubation exchanges were determined through a combination of camera footage and nest checks. The average incubation period was calculated by dividing the total number of occupation days by the number of clutches for each season. The average number of days between incubation exchanges was calculated by dividing the total number of occupation days by the number of exchanges for each clutch.

HATCHING SUCCESS

Clutch fate was evaluated as Hatched or Failed based on the nesting evidence found during monitoring and the images recorded by camera traps installed at nests on Alcatraz in 2021–2023 (described above). A clutch was considered hatched when hatched eggshells were found or camera traps recorded images of chicks leaving a nest. A clutch was considered failed when abandoned or broken eggs were found or if eggs went missing before the earliest possible hatch date. We calculated average clutch size (number of eggs laid per number of clutches) and three measures of hatching success (Whitworth et al., 2018; Wolf et al., 2005): (1) egg-hatching success metric 1 = number of hatched eggs per total number of clutches, (2) egg-hatching success metric 2 = number of hatched eggs per total number of total eggs laid, and (3) clutch hatching success = number of clutches with at least one hatched egg per total number of clutches. The two measurements of egg-hatching success were analyzed to maximize data comparison from year to year. Any nesting evidence was removed at the end of the season, so that nest monitoring efforts in future seasons would encounter nesting evidence belonging to only the current study season.

Habitat preference and relative nest location

Features of nesting habitat were recorded, including approximate distance from the high-tide zone, the general appearance of the area, the elevation above sea level, and the depth of the cavity.

Nocturnal spotlight surveys

We conducted nocturnal spotlight surveys to estimate the number of Craveri's Murrelets breeding on San Esteban in 2021 and on San Pedro Mártir in 2022 and 2023. Surveys at San Esteban were conducted on 10 February, 14 March, and 08 April 2021, and at San Pedro Mártir on 02 March 2022 and 23 February 2023. These surveys were based on the methodology developed at Anacapa Island, California, USA, and used for Scripps's Murrelet *Synthliboramphus scrippsi* by Whitworth & Carter (2014); this method was also used for Craveri's Murrelet, Scripps's Murrelet, and Guadalupe Murrelet *Synthliboramphus hypoleucus* in western Baja California in 2002–2008 (Whitworth et al., 2020). Nocturnal surveys were conducted on darker nights around the new moon from an 8-m-long skiff with two 115 horsepower (HP) outboard engines circumnavigating the island at a speed of 5–8 km/h. The skiff was crewed with two people: one person in the front of the boat handled the spotlight and counted murrelets, while the other recorded counts on the data sheet along with GPS location. A searchlight (Braun 400 Lumen Waterproof Rechargeable LED Spotlight; Calabasas, USA) was slowly swept from the port beam to the bow and then again from the starboard beam to the bow, to minimize missing or double-counting birds. The number of adults and chicks, if present, was recorded for each sighting, as well as whether they were on the water or flying.

Based on these nocturnal counts, the number of Craveri's Murrelet nests were estimated using a correction factor determined for Scripps's Murrelets at Santa Barbara Island, California, USA: 1.60 nests per murrelet (95% confidence interval (CI) 1.10–2.89) (Darrell Whitworth, unpublished data cited in Whitworth et al., 2018). These data were used to quantify the relationship between the mean number of murrelets counted around the islands and the number of nests on the adjacent shoreline.

RESULTS

Nest searches

The number of new nests found on the five islands was predictably the highest during the first season in which searches were conducted on each island (Table 1). Between 2009 and 2017, the nests on Alcatraz were monitored sporadically and often treated as independent nest searches, so it cannot be determined if certain "historical" nests were the same cavities found multiple times. Therefore, the number of total nests reported on Alcatraz in Table 1 represents data from 2018 and onward.

Nest monitoring

The number of clutches on Alcatraz between 2018 and 2023 ranged from five to 11 with an average of eight nests per year. Clutch size ranged from 1.33 to 1.75, averaging 1.6 eggs per clutch. Hatching success ranged from 0.60 to 1.22, averaging 1.02 hatched eggs per clutch, while clutch hatching success ranged from 40% to 83% of clutches hatching at least one egg, with an average of 68% (Table 2). The percentage of eggs that hatched out of the eggs that were laid ranged from 57% to 88%, with an average of 70%. There were eight clutches in the 2022/23 season on Alcatraz.

On San Pedro Mártir during the 2022/23 season, there were 17 clutches, from which 13 had at least one hatched egg. From the 20 eggs laid, 13 chicks left the nest. Average clutch size

TABLE 2
Craveri's Murrelet *Synthliboramphus craveri* nesting success on Alcatraz Island & San Pedro Mártir Island in the Gulf of California, Sonora, Mexico, 2018–2023

		Eggs					Clutches			
Year	Clutches	Total	Hatched	Success[a]	Success[b]	Clutch size	Chicks	Total	Hatched	Success[c]
2018	9	–	11	1.22	–	–	11	9	7	78%
2019	5	–	3	0.60	–	–	3	5	2	40%
2020	6	8	7	1.16	88%	1.33	7	6	5	83%
2021	11	18	12	1.09	67%	1.64	12	11	8	73%
2022	10	16	11	1.1	69%	1.60	11	10	6	60%
2023	8	14	8	1.0	57%	1.75	8	8	6	75%
2023[d]	17	20	13	0.76	65%	1.18	13	17	13	76%

[a] Egg-hatching success metric 1: Total number of hatched eggs divided by the total number of clutches
[b] Egg-hatching success metric 2: Total number of hatched eggs divided by the total number of eggs laid (given as a percentage)
[c] Clutch success metric: Total number of clutches that hatched at least one egg divided by the total number of total clutches (given as a percentage)
[d] San Pedro Mártir Island only

in 2022/23 was 1.18 eggs per nest, with a hatching success of 0.76 eggs hatched from active nests. The percentage of clutches that hatched at least one egg was 76%. Out of the eggs laid, 65% hatched (Table 2). The main causes for egg failure were abandonment and failure to hatch.

Phenology

On Alcatraz, camera traps were used to monitor 10 nests during the 2021/22 breeding season and eight nests during the 2022/23 season (Fig. 2, Table 3). The last chicks of the season for each year were observed in early April of 2022 and in late April of 2023. The cameras were first deployed in 2021 and during this season, we determined that some of the cavities were visited as early as late December, almost a month before eggs were laid (Fig. 2). We call this first period the "scouting stage." After this, pairs laid their eggs and their incubation period started. During the 2021/22 and 2022/23 breeding seasons, the average (CI) number of days a nest was occupied was 33 d (19–39 d) and 38 d (28–54 d), respectively. The average number of days between nest visits was 3.4 d (2.3–3.8 d) for 2021/22, and 4.5 d (2.3–8.0 d) for 2022/23. The time between nest visits did not appear to influence nest success. Figure 3 shows two pairs of chicks leaving their crevices; once chicks leave the nest, they do not return.

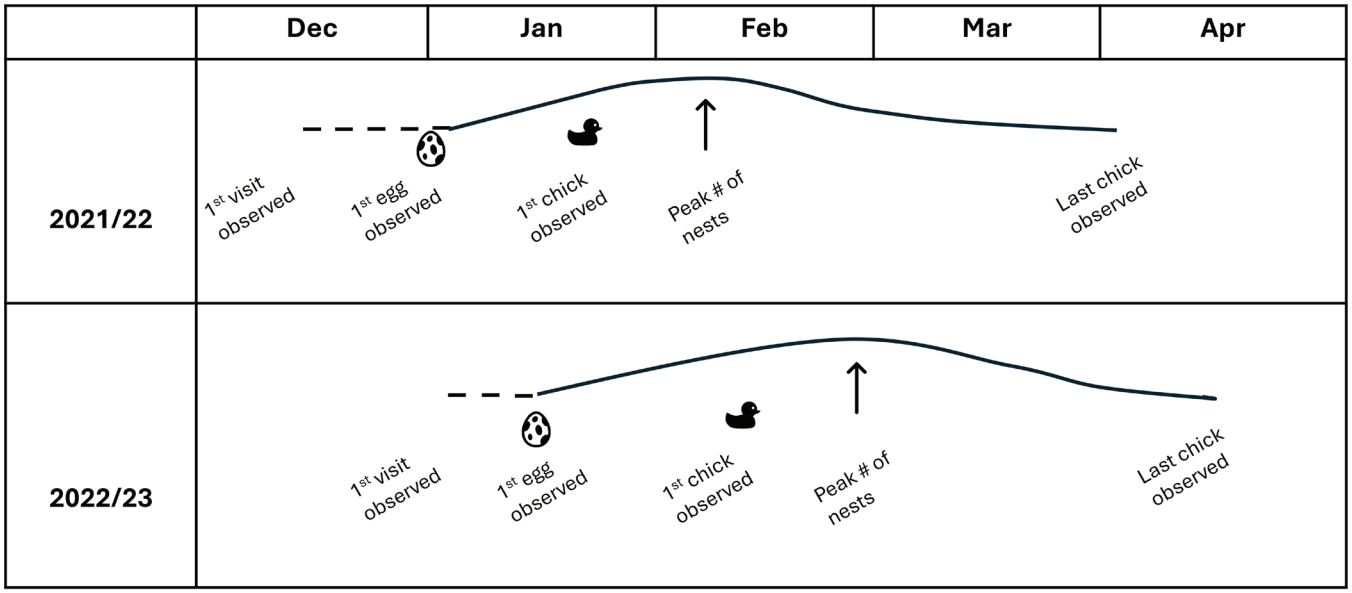

Fig. 2. Timeline of all active nests on Alcatraz Island, Sonora, Mexico for the 2021/22 and 2022/23 breeding seasons. The dotted lines represent the earliest visiting periods recorded (before eggs). The solid lines start when the first egg was recorded and show the arc of how many nests were active throughout the season. The arrows represent the times with the peak number of active nests. As chicks leave the nest mere days after hatching, any indication of a chick observed indicates a chick leaving the nest.

TABLE 3
Summarized Craveri's Murrelet *Synthliboramphus craveri* phenology data collected using camera traps during the 2021/22 and 2022/23 breeding seasons on Alcatraz Island, Gulf of California, Sonora, Mexico

Phenology Data	2021/22 Season[a]	2022/23 Season[b]
Average incubation/occupation period (days)	33	38
Average time of chick leaving nest (hours:minutes)	21:00	20:30
Average days between visits by adults to nests	3.7	4.5
Month with majority of nesting starts	January	January
Month with majority of chicks leaving nest	March	March
Earliest date of observed nest visitation	22 Dec 2021	12 Jan 2023
Earliest date of observed incubation	21 Jan 2022	13 Jan 2023
Latest date of chicks leaving nest	20 Apr 2022	24 Apr 2023
Overall occupation on Alcatraz Island	Dec–Apr	Jan–Apr

[a] Data collected from ten active nests
[b] Data collected from eight active nests

Nesting habitat and characteristics

Alcatraz Island

Most nests were found under rocks or in small crevices or caves along rocky sections of the northwestern portion of the island. The majority of nests found on the southwestern side of the island had not been active for the past year. While the deepest cavity was about 0.5 m deep, most cavities were shallower. Nests were found 1–15 m above the high-tide line.

San Pedro Mártir Island

Most nests were found on the southern and eastern shorelines, as well as on two islets to the southeast. The nesting zones were characterized by cliffs and small inlets separated by large rocks protruding into the ocean. Most nests were found within cavities, under rocks or within crevices close to the high-tide line, all at observed elevations of no more than approximately 5 m. Many of these nests were found inside small, deep, and protected caves. Nests found on the islets had the same characteristics, although

Fig. 3. A pair of Craveri's Murrelet *Synthliboramphus craveri* chicks leaving their nest with their parents on Alcatraz Island, Sonora, Mexico, on 22 January 2022.

they were higher above the high-tide line, at observed elevations of 8–12 m. Nests at lower elevations are more exposed to waves and therefore are less protected against storm events. During the breeding season, the dominant winds and waves come from the north. These natural influences have transformed the northern section of the island into a rugged landscape with steep and exposed cliffs, reducing acceptable habitat for the murrelets.

Estimated nesting pairs per island

We counted 27, 6, and 3 murrelets during the nocturnal spotlight surveys at San Esteban on 10 February, 14 March, and 08 April 2021. The first survey was conducted during the peak of nesting season, and we estimated a breeding population of 43.2 pairs. Two nocturnal surveys were performed around San Pedro Mártir, during which we counted 24 individuals on 02 March 2022 and 62 individuals on 23 February 2023 (Table 4; Figs. 4, 5). The estimated breeding population, with the correction factor applied, ranged from 26–179 pairs at San Pedro Mártir in 2022/23.

TABLE 4
Nocturnal spotlight-survey results of Craveri's Murrelet *Synthliboramphus craveri* around San Esteban Island and San Pedro Mártir Island in the Gulf of California, Sonora, Mexico, 2021–2023

Island	Date	No. of adults sighted	Estimated breeding population (pairs)
San Esteban	10 February 2021	27	43.2
San Esteban	14 March 2021	6	9.6
San Esteban	08 April 2021	3	4.8
San Pedro Mártir	02 March 2022	24	38.4
San Pedro Mártir	23 February 2023	62	99

DISCUSSION

The importance of both San Pedro Mártir and Alcatraz islands as nesting sites for this rare and endangered species is clear. The average number of days a nest was occupied (33 in 2022, 38 in 2023) was similar to figures reported for the Scripps's and Guadalupe murrelets (both previously known as Xantus's Murrelet), which was 34.3 d (Zepeda-Domínguez, 2007). The average clutch size of 1.6 eggs/nest on Alcatraz was similar to the mean of 1.8 recorded for other *Synthliboramphus* murrelets and, as noted, significantly higher than

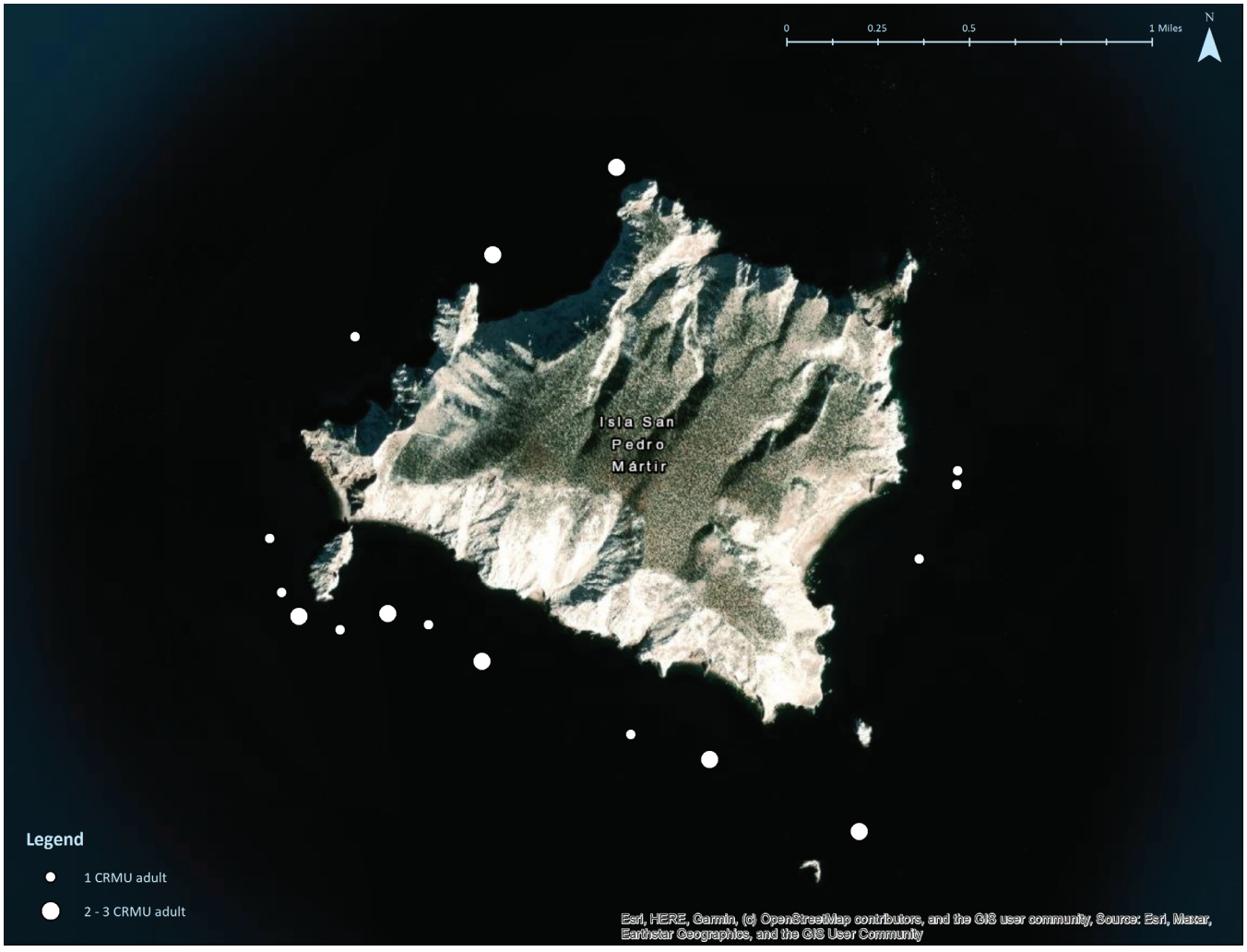

Fig. 4. Craveri's Murrelet *Synthliboramphus craveri* (CRMU) nocturnal survey sightings around San Pedro Mártir Island, Sonora, Mexico, on 02 March 2022; larger dots indicated 2–3 adults.

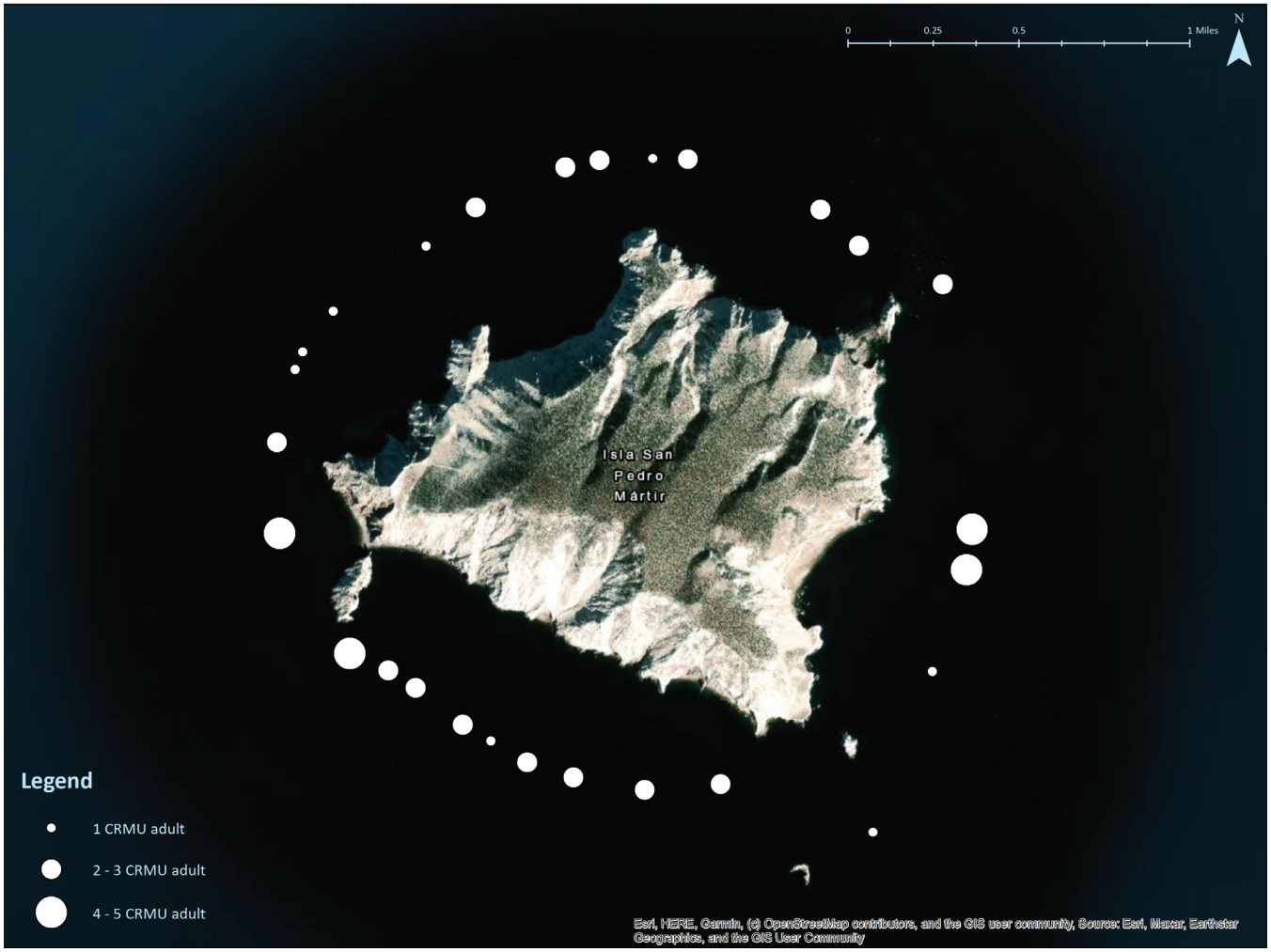

Fig. 5. Craveri's Murrelet *Synthliboramphus craveri* (CRMU) nocturnal survey sightings around San Pedro Mártir Island, Sonora, Mexico, on 23 February 2023; the largest dots indicate 4–5 adults.

many other seabirds (Gaston, 1990). The proportion of eggs hatching has decreased from 88% to 57% from 2020-2023. Hatching success over the four years of the study on Alcatraz fell from 83% in 2020 to 60% in 2022 before rising to 75% in 2023, with an average success rate of 68%. The lower success rate in 2022/23 could have been due to hurricanes, earthquakes, predation, and other factors that require further study. In the years during which nest cavities were damaged by these natural events, we recorded new nests in previously unused cavities, but we do not know if these nests were occupied by individuals whose historic nests were destroyed. On Alcatraz, winter winds blow directly against the southwestern side of the island, which hosts the majority of murrelet nests. While erosion from these winds and the resulting surf can create the rocky shorelines and cavities that these birds favor, high waves can also pose a threat. Future banding studies could help track those changes and the movements of the individuals within the populations. Additionally, the use of satellite transmitters to track murrelets in their post-breeding season would be an excellent option to further understand breeding success and at-sea distributions. While more conclusive data are needed about the time between hatching and leaving the nest, observations from this study lead us to believe that the period lasts 1–3 days. This is consistent with observations made in 2011 when two chicks were seen leaving the nest just after sunset, 33 hours and 20 minutes after the second chick had hatched (Hurley & Blinick, 2011). Future studies deploying smaller cameras could aid in confirming the time between hatching and leaving the nest.

This study confirms the nesting recovery of Craveri's Murrelets on San Pedro Mártir after the 2007 eradication of Ship Rats. An increase in the population from zero to ~179 individuals in 14 years raises questions about where these birds came from and the role of external populations in recruitment. For example, Ainley et al. (2024) references Guadalupe Murrelets rapidly colonizing newly established nest sites from an apparent floating population of non-breeding adults. Since a large portion of potential breeding habitat on San Pedro Mártir is inaccessible to researchers, the nest searches on land could underestimate the actual total breeding population present, which may be better represented by the estimate from the nocturnal surveys. Continued nest monitoring is important to estimate productivity year by year, as well as to identify trends and potential threats over time.

The majority of eggs that failed were either abandoned or simply did not hatch. We did not observe direct egg predation on either island, but we documented predation on adult murrelets from American Barn *Tyto furcata* and Burrowing Owl *Athene cunicularia* owls on

Alcatraz, which caused the abandonment of at least one nest in 2023. We also captured footage of House Mice entering cavities containing adults and eggs, but we observed mice eating only eggs that had already been broken. A study is currently underway to document the interesting relationship between murrelets and Chuckwalla lizards *Sauromalus* sp. that utilize the same cavities on Alcatraz, to see whether the lizards pose a threat to murrelet hatching success. Future studies analyzing abandoned or unhatched eggs could shed light on underlying factors that may be affecting egg viability.

We intend to continue this study and expand it to other islands to get a clearer estimate of the murrelet nesting population for the Eastern Midriff Island Region. We are particularly curious about why we recorded high concentrations of murrelets on the water around San Esteban but have not recorded significant nesting activity on that island. This could be because of the presence of introduced predators such as the Ship Rat.

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AUTHOR CONTRIBUTIONS

FJMR: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, visualization, writing-review & editing. **LD**: Conceptualization, data curation, formal analysis, investigation, methodology, project administration, visualization, writing-original draft, writing-review & editing. **LM**: Conceptualization, formal analysis, funding acquisition, methodology, project administration, supervision, visualization, writing-original draft, writing-review & editing. **PdLCG**: Data curation, formal analysis, investigation, writing-original draft, writing-review & editing. **NLO**: Data curation, investigation, literature review, writing-original draft, writing-review & editing.

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