Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, August 2023

GSA #47QRAA23D002Z

Delivery Order # N62742-23-F-9952

Prepared For

U.S. Navy
Commander, U.S. Pacific Fleet Environmental Readiness
250 Makalapa Drive
Pearl Harbor, HI 96860

Via
NAVFAC Pacific, EV51
258 Makalapa Drive, Suite 100
Pearl Harbor, HI 96860-3134

Prepared By

Normandeau Associates, Inc.
4581 NW 6th Street, Suite H
Gainesville, FL 32609
(352) 372-4747
www.normandeau.com

and

Air Data Solutions
502 Airport Road
Natchitoches, LA 71457
airdatasolutions.com

November 2023

This page intentionally left blank.

Contents

List of Tables

List of Figures

Executive Summary

An aerial digital survey of Kaula was conducted on August 3, 2023. Ultra-high resolution digital still images were collected using a manned turbo prop twin-engine survey aircraft. A vertical (nadir) survey covered 100% of the top of the island, and this survey was complemented by an oblique survey completed on the same day. Carrying out both surveys allows counts to be made of birds on the top of the island and those on the cliff faces.

Vertical survey imagery was collected at 1.5-cm resolution at sea level and at the higher elevation sections of the island; the flight guidance system facilitates raising or lowering of flight altitude depending on terrain. Oblique survey imagery was collected at better than 2.5-cm resolution.

This survey was conducted to meet the aims and objectives of the work required by the U.S. Navy to monitor the status of the seabird populations on the island. The images collected have been analyzed and quality assured, and the raw counts of animals recorded are presented in this report.

In total, 17,638 birds representing nine species were recorded during the survey with brown noddy being the most abundant species (n=11,034) followed by sooty tern (n= 2,440). Other species recorded included grey-backed tern, red-tailed tropicbird, Laysan albatross, great frigatebird, masked booby, brown booby, and red-footed booby. Ten fairly fresh-dead birds were observed during the surveys representing six species.

Numbers of great frigatebird (n=377) were lower than those recorded in August 2018 (n=719) and lower than July 2021 (n=1,375). Historically, numbers of great frigatebird have fluctuated, and this year's lower numbers could potentially be associated with weather conditions affecting timing of breeding and success.

Distributions of all species recorded remain similar to those of previous years.

At the time of the surveys, 13 Hawaiian monk seals were recorded resting on ledges on the west side of the island.

1 Introduction

Normandeau Associates was contracted by the U.S. Navy to provide ornithological data for the Pacific Island of Kaula, Hawaii, through the capture and analysis of georeferenced ultra-high resolution aerial digital imagery.

Kaula Island is a small (0.64 km^2), uninhabited crescent-shaped islet in the western chain of islands making up the Hawaiian Archipelago (Figure 1–1 and Figure 1–2). The islands closest to Kaula are Niihau (37 km northeast) and Kauai (approximately 111 km northeast). A mountain ridge runs along the length of Kaula Island (approximately 1,676 m), which at its highest point is 164.6 m above sea level (Palmer 1936). The terrain drops steeply from the ridge crest at a mean slope of 36°, and steep V-shaped ravines have been cut by ephemeral streams on the windward slopes such that the island has little level terrain (Elmer and Swedberg 1971). The northern horn of the island extends 762 m from the summit and ends at an elevation of approximately 85 m, while the southern horn extends 914 m from the summit and ends at an elevation of approximately 30 m (Palmer 1936).

Since 1952, the U.S. Navy has used the southeastern tip of the island (approximately 0.06 km^2) as a range to train aviators in air-to-surface and surface-to-surface weapons delivery. Both live and inert ordnance were used during training missions through 1980. Since 1981, munitions training by the U.S. Navy at Kaula has been restricted to inert ordnance delivery and aircraft gunnery (DON 2008; DON 2013).

Eleven land-based avian surveys were undertaken historically on the island, reviewed in Pepi et al. (2009), but due to safety reasons these were replaced with boat-based and aerial observations (2009–2011; Pepi et al. 2009; DON 2011).

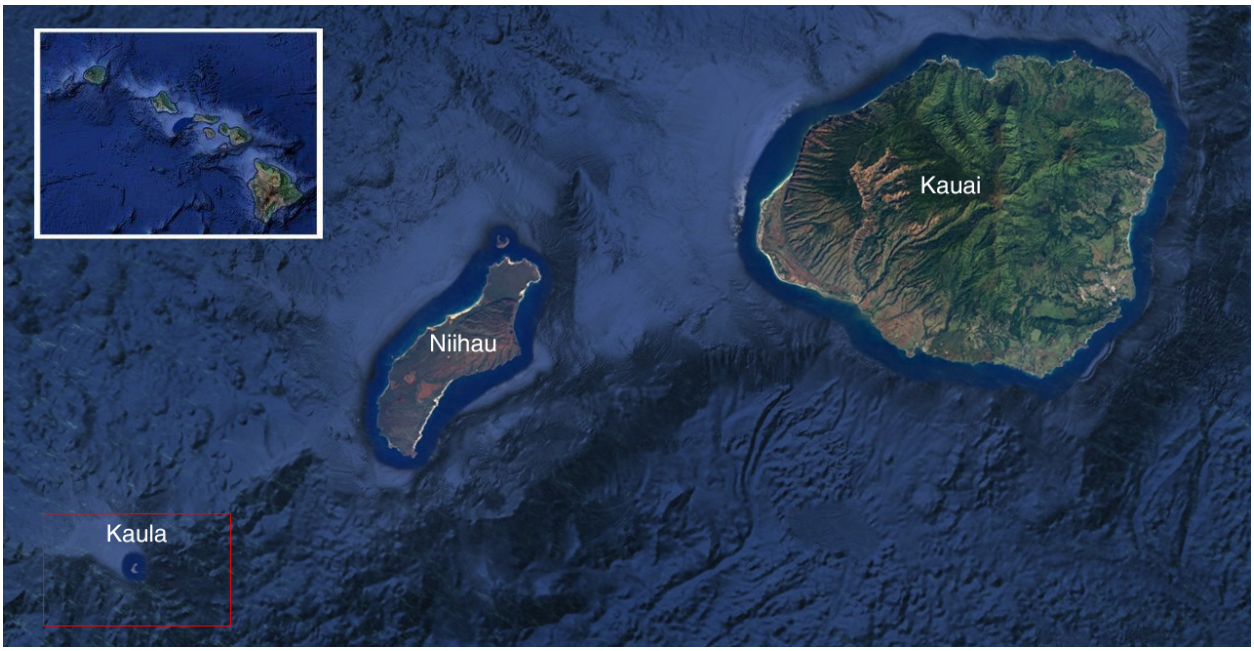

Figure 1–1. Location of Kaula Island relative to the main Hawaiian Islands (inset) and Kauai and Niihau (imagery from ESRI).

Figure 1–2. Topography of Kaula Island.

The U.S. Navy replaced the boat-based surveys in 2013 when digital aerial imagery using improved technology became available, and ten surveys of these have been conducted to date. This technology has resulted in the following improvements over prior efforts:

- Increased count accuracy through post-hoc, quantitative analysis of imagery rather than near-instantaneous live counts by observers in the field
- Increased count accuracy through elimination of bird disturbance effects from low-flying helicopters
- Increased count accuracy and bird identification ability on Kaula (previously surveyed by boat) because of increased visibility of the higher sections and slopes of the island.

2 Methods

2.1 Weather Conditions and Survey Limitations

This section explains some of the weather conditions and survey limitations encountered during the 2023 survey of Kaula.

Originally planned for July, the survey was postponed due to extreme weather patterns in the region. Category 3 hurricane Calvin impacted the suitability of survey conditions through increased cloud cover and variable wind conditions and brought rain to the region. The storm approached from the east and passed by Hawaii over two days on July 19 and July 20, 2023. Originally planned to occur between July 18 through July 21, the weather delay affected aircraft and crew availability, and the survey was rescheduled for between July 31 and August 4, 2023.

The equipment was installed into the aircraft on August 2, 2023, and a short test flight was successfully conducted the next morning. The survey of Kaula began at solar noon on August 3, 2023, to maximize solar illumination of both sides of the island, limit overshadowing from the island terrain.

Weather conditions were good with some high cloud cover later in the day and a mean wind speed of 15 knots from the southeast. Visibility was greater than 10 km during all surveys.

Only one flight was needed to complete the surveys.

2.2 Survey Design

This digital aerial survey of Kaula (August 3, 2023) included both vertical and oblique imagery capture.

Ultra-high resolution digital still images were collected using a manned turbo prop twin-engine survey aircraft (Cessna Caravan C208B), which has a higher safety rating than piston twin-engine aircraft. The camera system included an industry leading GPS-linked flight management system (PhaseOne Pas280) specifically configured to target high-resolution surveys for birds and marine mammals.

Flight planning software was used to define the required flying altitude and speed according to the camera, lens, and required pixel resolution. During the survey, each transect was flown using a GPS-guided management system, and the image acquisitions were automatically triggered at predefined positions.

Due to the wide range of topographical features on Kaula, two surveys were performed to ensure that high-quality imagery was achieved over the whole island (100% coverage), including capturing animals on horizontal and vertical ledges. The first complete aerial survey was performed at solar noon on August 3, 2023, at higher altitude (vertical survey). The second, low-altitude survey (oblique survey) was completed immediately after.

The vertical high-altitude survey was conducted between 12:00 and 13:00 at 335–396 m (1100–1300 feet) and flown in a north–south direction. This survey captured imagery at 1.5-cm resolution at sea level and at the higher elevation sections of the island; the flight guidance system facilitates raising or lowering of flight altitude depending on terrain.

The oblique survey was carried out between 13:00 and 14:00 at 274–366 m (900–1200 feet) by flying counterclockwise several times around the island. Although resolution of the oblique imagery varies, most images were collected at better than 2.5-cm resolution.

2.2.1 Vertical Surveys

As it is not technically possible to capture the entire island at 1.5-cm resolution in one single image, several flight transects were conducted to ensure full coverage of the island with imagery at 1.5-cm resolution. Approximately 392 vertical digital photographs were generated over approximately 1 hour. These images were processed and imported into Corrilator3D (Image Mosaic Software) and joined to create one large image mosaic for the whole island. Images with the highest resolution for each location on the island were selected to compile the mosaic, and any overlapping image sections were removed. This method was the most appropriate to minimize the risk of double counting that might have otherwise occurred by treating each individual image in isolation (due to overlapping areas). A small probability exists that the movement of birds between transects could result in double counting, however an equally small probability exists that a bird could be missed in both transects. On this basis, it is reasonable to

assume that the risk of double counting is equal to the risk of undercounting, and the effect on the population count is negligible.

Overall, this survey method produces a smaller margin of error compared with other visual census techniques for birds which encompass a higher degree of disturbance and longer duration.

The mosaic was loaded into Global Mapper and defined into 2,000 m^2 grid cells covering Kaula Island (Figure 2–1) and overlapping sections of imagery were removed. The images were further subdivided into 300 × 300-pixel grid cells (25 m × 25 m) representing 625 m^2. Each defined grid cell was then analyzed for animal identification.

Specially trained staff reviewed each grid cell to provide center-point locations for individual animals. An image (snag) was created around each point, with each snag representing an individual animal. These were then sent to Normandeau biologists for recording the following information:

- Bird/mammal species by common name (see Appendix I for scientific names)
- Behavior (sitting, flying)
- Association (nest, 1 adult, 2 adults, none)
- Age (adult, juvenile, nestling, non-breeding sub adult, unknown)
- Count (number of individuals)
- Position (easting, northing) of individuals
- Date and time stamp of image collection
- Comments (additional useful information)

Each grid cell was analyzed in GlobalMapper, a GIS software. The software allows the grid cells to be loaded in and georeferenced. As part of the identification process, a center point containing location information was dropped on each target identified. Two full scans of each grid cell are manually completed to find targets for identification and provide confirmation that nothing is missed. The resolution of the images is extremely high, such that the individuals can be identified to species with a high degree of certainty.

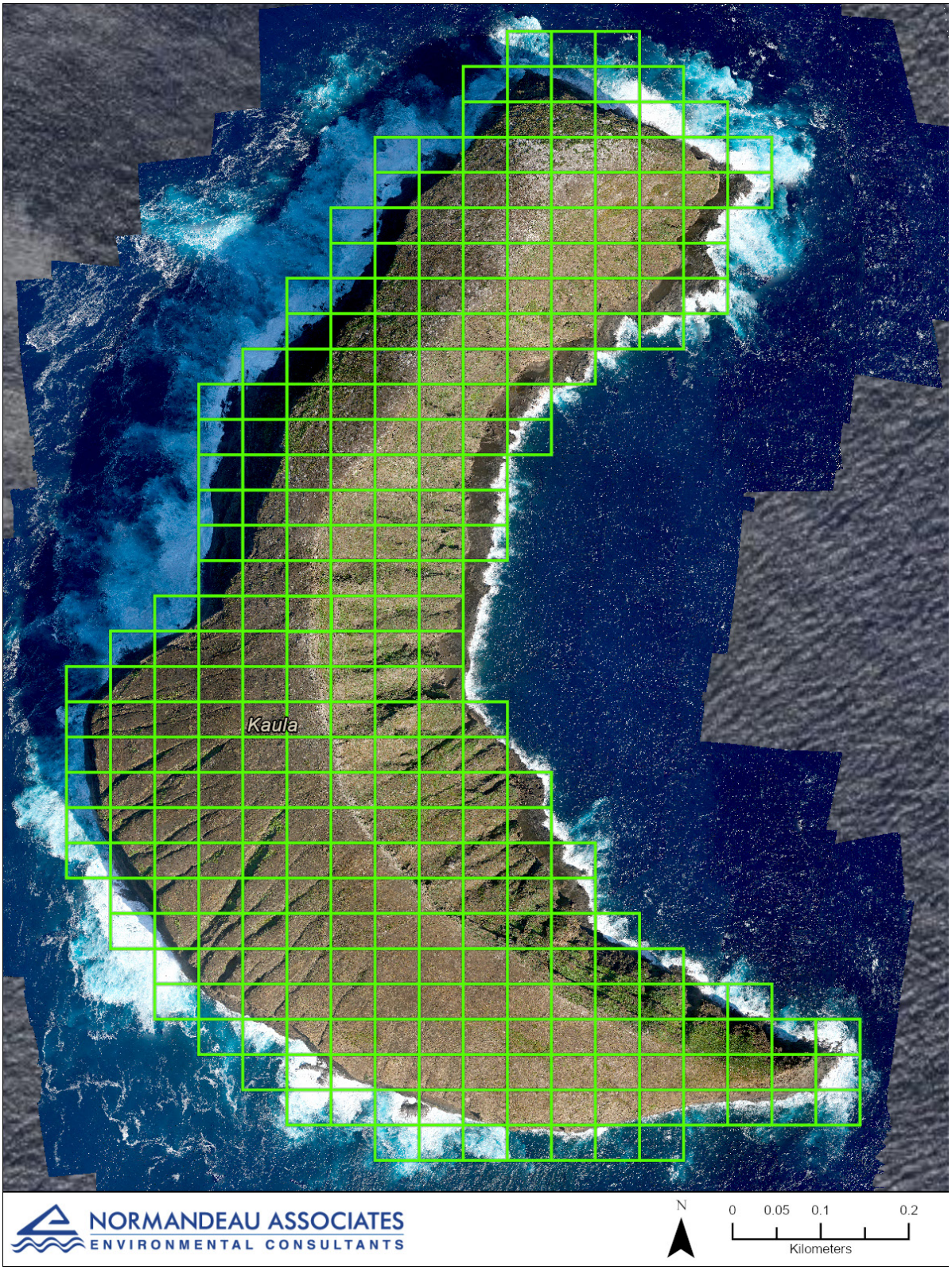

Figure 2–1. Kaula Island image analysis grid.

Compiled images from the vertical survey were joined to cover Kaula Island. The compiled image was analyzed in 296 grid cell sections (marked in green).

Survey data were analyzed to produce maps showing bird and marine mammal distribution in a GIS format. For each map, bird and mammal observations were composed of individual points geo-referenced to actual spatial locations at the time of sighting. Examples of vertical imagery can be found in Appendix II.

2.2.2 Oblique Surveys

The oblique images were spatially correlated against features in the vertical dataset to ensure correct spatial placement of each image. These images were then loaded into imagery software that tracks pixel X,Y values and snags were created from each animal's center-pixel X,Y value, with each snag representing an individual animal. Identification and enumeration of the number of birds and marine mammals in each image that could not have been seen from the vertical imagery due to the presence of steep cliffs, small caves, and overhanging rock ledges was based on these individual images. The results of the counts were subjected to a slightly different process than the vertical survey, as oblique imagery cannot be made into a mosaic. Quality assurance on oblique imagery included cross-reference of areas visible from the vertical survey to avoid double counting and was similarly completed by two manual reviews to confirm target extraction accuracy. Oblique imagery is not georeferenced and although these points are reported and enumerated, they are not mapped.

2.3 Identification and Quality Assurance

All bird and marine mammal species present in the images from Kaula Island were identified and quality assured using internal Normandeau processes.

All images containing birds and marine mammals were processed in each grid cell and then checked by Normandeau biologists. Normandeau's quality assurance manager is an experienced ornithologist and is responsible for maintaining and updating the image library, providing advice and guidance to the image analysis staff, and ensuring full quality control.

Known nesting habits of the booby species (*Sula*), such as nesting substrate and location, were used to aid identification of juvenile birds in nests where the physical characters that aid identification were not visible. Masked and brown boobies (*Sula dactylatra* and *S. leucogaster*) are known to nest on the ground often near breezy cliff edges or other take-off features. Red-footed boobies (*S. sula*) usually nest on small trees or shrubs and have a larger nest platform.

2.4 Data Analysis and Enumeration

Each bird observation was classified as an adult, juvenile, non-breeding sub adult, or unknown. For clarity and continuity of reporting, nestlings were grouped with juveniles. For each observation the following associations were identified: none, nest, 1 adult, or 2 adults. Dead birds are presented at the beginning of the results but are not included in any other analyses. Enumeration of each species occurred at three different levels:

1) Minimum and estimated maximum abundance counts for each species using both vertical and oblique survey images.
2) An estimated number of nesting pairs of each species using both vertical and oblique survey images.

3) Minimum and maximum densities of each species based on raw counts from the vertical survey only. Oblique images were not georeferenced; therefore, calculation of the survey area effort is not possible from these images.

Raw counts for each age group (adult, juvenile, unknown) are presented for each species .

The estimated number of nesting pairs were calculated by adding the total number of adults with nests, juveniles with adult, juveniles with 2 adults, juveniles with nests, and unknown aged birds with nests.

Calculations for pair density were made using the same approach but included only birds recorded during the vertical survey divided by the total area in the survey grid (590,000 m^2).

Minimum densities were calculated for individuals recorded in the vertical surveys by dividing the raw counts of each species observed by the total area in the survey grid (590,000 m^2). This follows the methodology used in Adams et al. (2022).

Maximum density calculations used the raw number of birds observed plus the following changes: adults with nests and unknown aged birds with a nest are multiplied by 2 to reflect the assumed other parent attending the nest; juveniles with nests are multiplied by 3 to include the juvenile and the assumed two adults attending the nest. This total was divided by the total area in the survey grid, thus presenting maximum abundance per m^2 as a density.

3 Results

3.1 Species Abundance

Thirteen marine mammals (one species) and 17,638 birds (nine species) were recorded on Kaula Island during the August 3, 2023 survey (Table 3–1). Scientific names are provided in Table 3–1 and Appendix I. Brown noddy (n=11,034) was the most abundant bird species, and Laysan albatross (n=3) was the least abundant species. Species abundance comparison with prior years is provided in Appendix III. Ten dead birds were observed during the surveys across six species and one species group: brown noddy (n=1), sooty tern (n=1), red-tailed tropicbird (n=1), masked booby (n=1), brown booby (n=3), red-footed booby (n=2), and masked/red-footed booby (n=1).

Table 3–1. Number of Birds (in taxonomic order) and Marine Mammals Recorded on Kaula Island by Vertical and Oblique Surveys on August 3, 2023

Species/Group	Scientific	Number Recorded		
		Vertical	Oblique	Total
Birds				
Brown Noddy	*Anous stolidus*	11,024	10	11,034
Sooty Tern	*Onychoprion fuscatus*	2,440	0	2,440
Gray-backed Tern	*Onychoprion lunatus*	5	0	5
Red-tailed Tropicbird	*Phaethon rubricauda*	206	0	206
Laysan Albatross	*Phoebastria immutabilis*	3	0	3
Great Frigatebird	*Fregata minor*	373	4	377

Species/Group	Scientific	Number Recorded		
		Vertical	Oblique	Total
Masked Booby	*Sula dactylatra*	738	1	739
Brown Booby	*Sula leucogaster*	1,100	88	1,188
Masked/Brown Booby	*Sula dactylatra / S. leucogaster*	41	1	42
Red-footed Booby	*Sula sula*	1,363	6	1,369
Masked/Red-footed Booby	*Sula dactylatra / S. sula*	205	23	228
Booby-species unknown		7	0	7
Total Birds		**17,505**	**133**	**17,638**
Marine Mammals				
Hawaiian Monk Seal	*Neomonachus schauinslandi*	13	0	13
Total Birds and Marine Mammals		**17,518**	**133**	**17,651**

3.2 Species Distribution

3.2.1 Occurrence of Birds and Marine Mammals

Figure 3–1 shows the location of all birds and marine mammals recorded on Kaula Island during the August 2023 aerial survey. Birds were widely distributed throughout the island. As in previous years, brown noddies were found in highest densities along the western side of the island close to the cliff edges. Sooty terns were also located on the western side of the island, forming dense groups among the noddies. Red-tailed tropicbirds and great frigatebird were recorded mainly along the eastern concave section. Boobies were widely scattered with most of the population occurring along the northern central ridge. Masked boobies were primarily observed along the higher areas of the island while brown boobies and red-footed boobies were more widely distributed. Hawaiian monk seals were found on the ledges along the west side of the island.

3.2.2 Brown Noddy

A total of 11,034 brown noddies (4,251 flying, 6,783 sitting) were recorded during the survey (Table 3–1, Table 3–2), with virtually all birds found along the western slopes near the cliff edges (Figure 3–2). Of the total recorded, 10 were identified in the oblique imagery and not visible in the vertical imagery (Table 3–1).

3.2.3 Sooty Tern

A total of 2,440 sooty terns were recorded during the survey, all identified in the vertical survey (Table 3–1), of which 781 were flying and 1,659 were sitting (Table 3–2). The majority were in dense groups among the brown noddies on the west and south sides of the island (Figure 3–3).

3.2.4 Grey-backed Tern

Five grey-backed terns (4 flying, 1 sitting) were recorded during the survey (Table 3–1), all of which were recorded in the vertical survey on the southwest side and at the northwest tip of the island (Figure 3–4).

3.2.5 Red-tailed Tropicbird

A total of 206 red-tailed tropicbirds were recorded during the vertical survey (Table 3–1), of which 163 were flying (Table 3–2). Most were found in the eastern concave section of the island (Figure 3–5) with fewer birds at the southern and northern ends.

3.2.6 Laysan Albatross

All three flying Laysan albatrosses were recorded during the vertical survey (Table 3–1, Table 3–2). Two were on the east-central part of the island and the other was offshore at the north end of the island (Figure 3–6).

3.2.7 Great Frigatebird

A total of 377 great frigatebirds were recorded during the survey (Table 3–1), 373 in the vertical survey and 4 in the oblique survey, of which 60 were flying (Table 3–2). Most were present along the eastern side of the island in the concave section (Figure 3–7) with just a few birds present on the west side. Of the 137 juveniles counted, 133 were in nests (Table 3–2).

3.2.8 Masked Booby

A total of 739 masked boobies were recorded during the survey of which only one was identified in the oblique imagery (Table 3–1). Thirty-four were flying (Table 3–2). Most were along the highest ridge running through the center of the island toward the northern end of the island (Figure 3–8). Of the 90 immature birds counted, 74 were in nests (Table 3–2).

3.2.9 Brown Booby

A total of 1,188 brown boobies were recorded during the survey (Table 3–1), of which 243 were flying and 74 were either immature or juvenile birds in nests (Table 3–2). They were widely distributed throughout the island (Figure 3–9). Of the total recorded, 88 were found in the oblique imagery and not visible in the vertical imagery (Table 3–1).

3.2.10 Masked Booby / Brown Booby

A total of 42 unidentified masked/brown boobies were recorded during the survey, of which only one was identified in the oblique survey (Table 3–1). Five were flying, 9 were immature, and 35 were on nests with no adults in attendance (Table 3–2). They were present on both slopes of the island (Figure 3–10).

3.2.11 Red-footed Booby

A total of 1,369 red-footed boobies were recorded during the survey, all but 6 in the vertical survey (Table 3–1), of which 415 were in flight (Table 3–2). Out of the 1,369 birds, 69 were juveniles in nests (Table 3–2). They were present across the island (Figure 3–11).

3.2.12 Masked Booby / Red-footed Booby

A total of 205 unidentified masked/red-footed boobies were recorded during the vertical survey and 23 in the oblique survey (Table 3–1). Twenty-three were juvenile flying birds (Table 3–2). Of the 288 unidentified boobies in this species group, 69 were juveniles on nests with no adults in attendance (Table 3–2 They were present across the island (Figure 3–12).

3.2.13 Booby Species Unknown

Seven unidentified boobies were recorded during the vertical survey (Table 3–1), two of which were flying (Table 3–2). Of the 7 unidentified boobies, 4 juveniles were on nests with no adults in attendance (Table 3–2). Distribution was spotty (Figure 3–13).

3.2.14 Dead Birds

Ten fairly fresh-dead birds representing six species were observed during the survey. They were brown noddy (n=1), sooty tern (n=1), red-tailed tropicbird (n=1), masked booby (n=1), brown booby (n=3), red-footed booby (n=2), and masked/red-footed booby (n=1). Distributions were spotty (Figure 3–14).

3.2.15 Marine Mammals

A total of 13 adult Hawaiian monk seals were recorded resting on ledges on the west side of the island (Table 3–1, Figure 3–15).

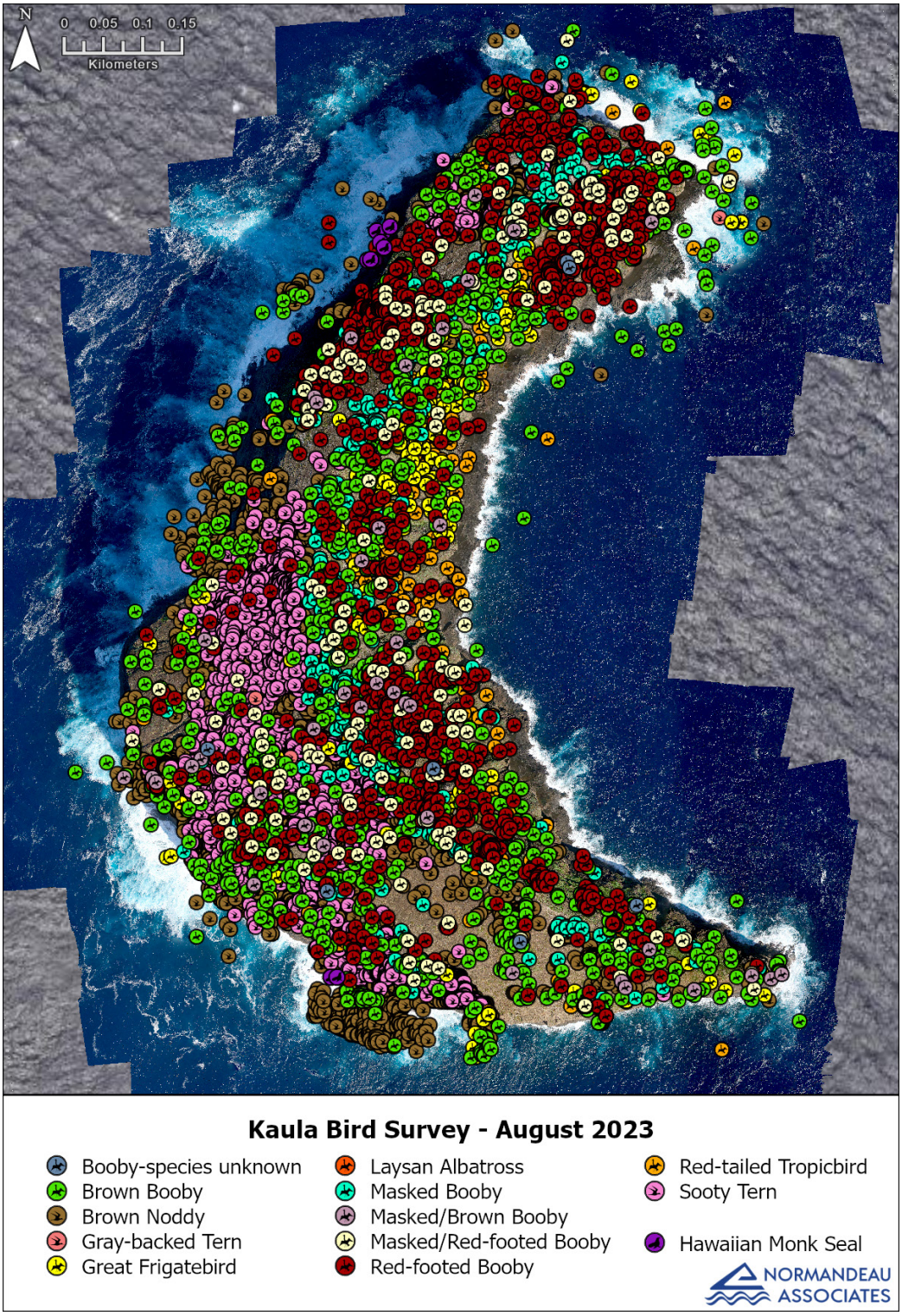

Figure 3–1. Distribution of all birds and marine mammals recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

Table 3–2. Comparison of Species, Age, and Numbers of Flying and Sitting Birds Recorded in July 2021 and August 2023 Aerial Surveys

Species/Group	July 2021					August 2023						
	Adult		Immature			Adult		Immature		Unknown		
	Flying	Sitting	Flying	Sitting	Total	Flying	Sitting	Flying	Sitting	Flying	Sitting	Total
Brown Noddy	37	3,419	—	—	**3,456**	3,433	6,221	152	187	666	375	**11,034**
Sooty Tern	16	2,507	—	—	**2,523**	694	1,464	14	100	73	95	**2,440**
Gray-backed Tern	—	—	—	—	**—**	3	1	—	—	1	—	**5**
Red-tailed Tropicbird	59	65	—	1	**125**	163	35	—	6	—	2	**206**
Laysan Albatross	—	—	—	—	**—**	2	—	1	—	—	—	**3**
Great Frigatebird	87	1,168	—	120	**1,375**	55	184	4	133	1	—	**377**
Masked Booby	9	1,019	—	234	**1,262**	18	630	16	74	—	1	**739**
Brown Booby	27	1,439	1	106	**1,573**	235	852	2	72	6	21	**1,188**
Masked/Brown Booby	—	—	—	—	**—**	—	2	1	8	4	27	**42**
Red-footed Booby	61	4,953	9	993	**6,016**	383	882	32	69	—	3	**1,369**
Masked/Red-footed Booby	—	—	—	160	**160**	3	74	23	121	—	7	**228**
Booby-species unknown	3	15	6	—	**24**	—	—	2	4	—	1	**7**
Total	**299**	**14,585**	**16**	**1,614**	**16,514**	**4,989**	**10,345**	**247**	**774**	**751**	**532**	**17,638**

*For the purpose of continuity of reporting, Immature in this table relates to juveniles

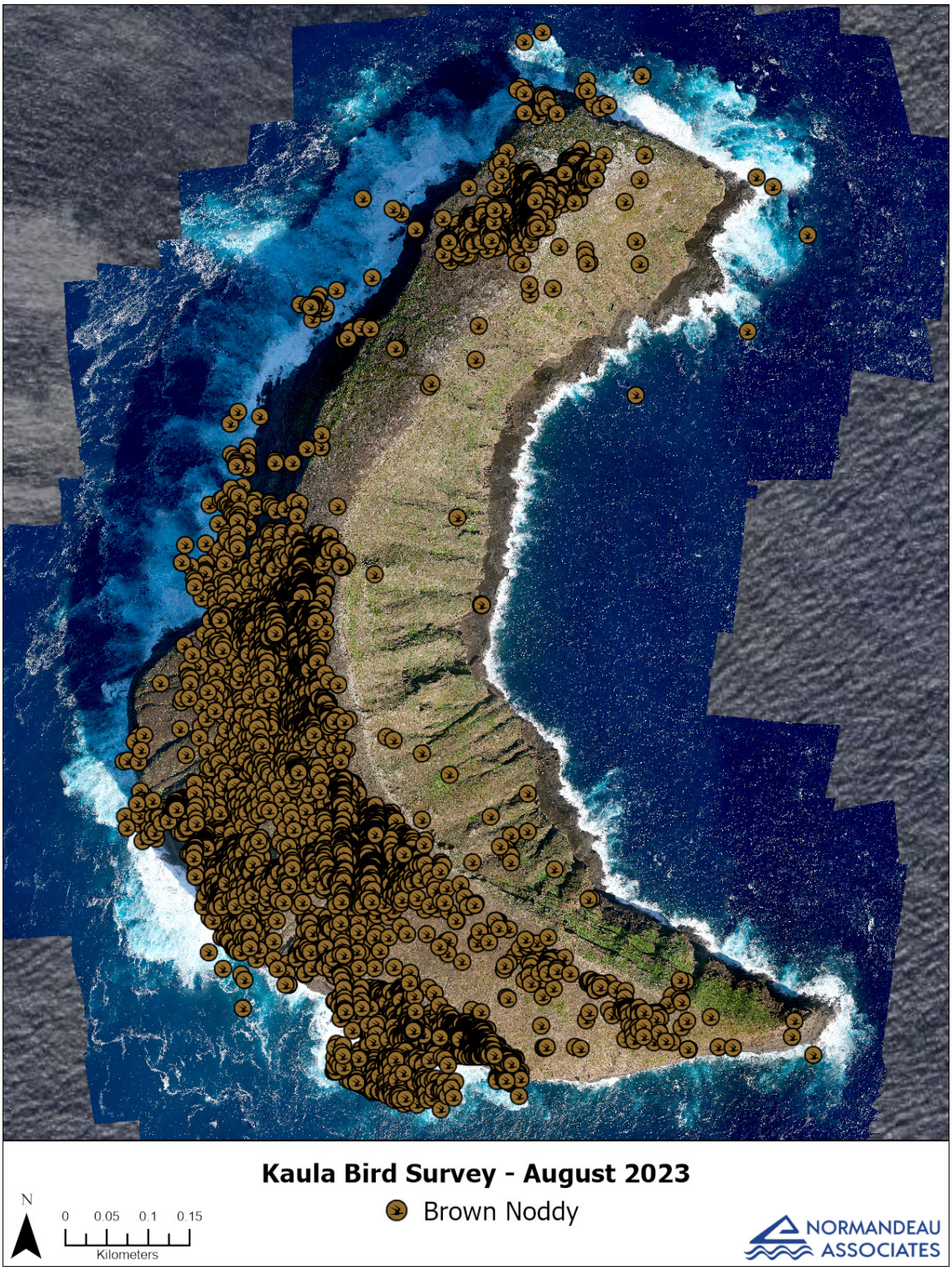

Figure 3–2. Distribution of brown noddy recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

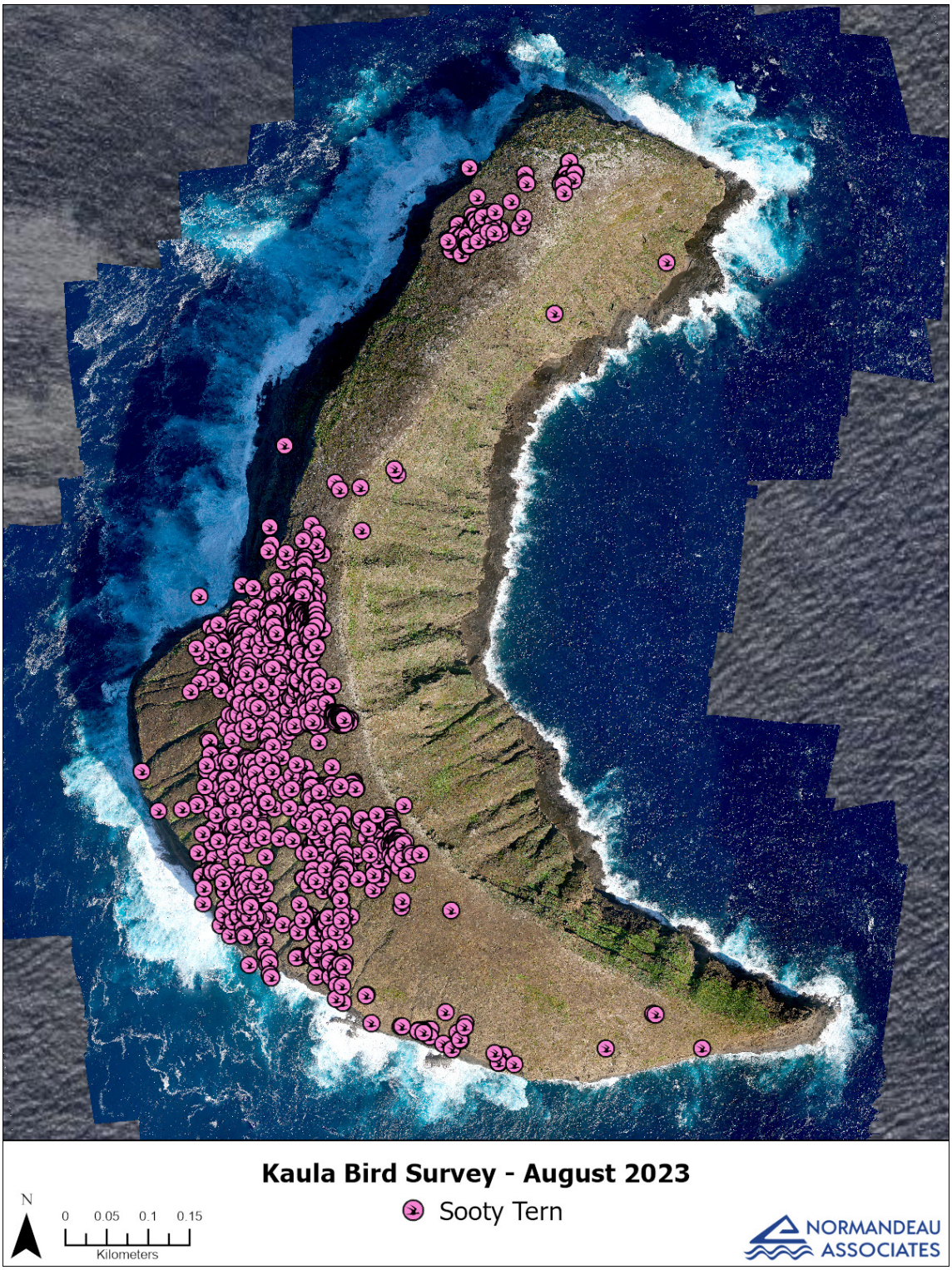

Figure 3–3. Distribution of sooty tern recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

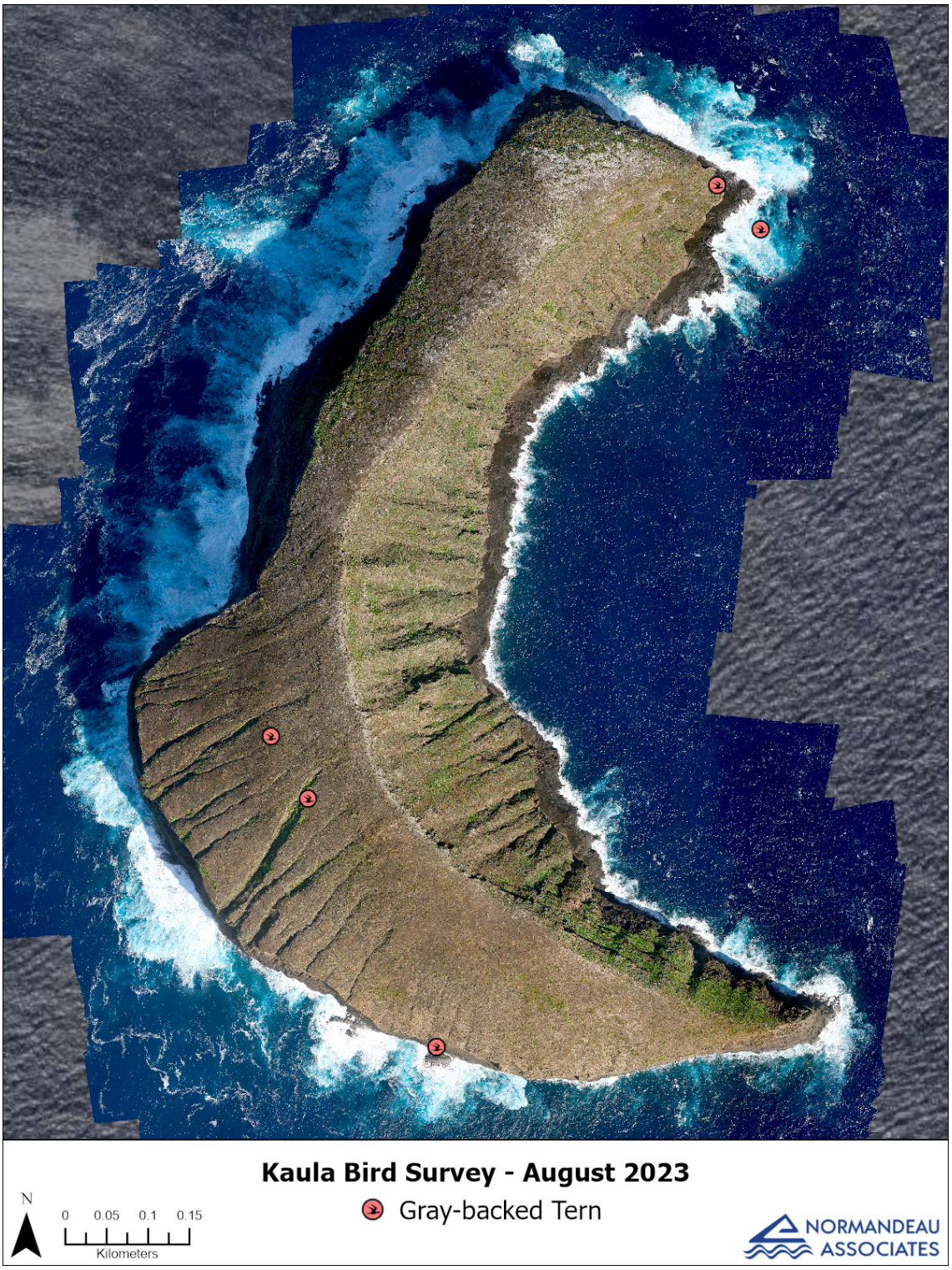

Figure 3–4. Distribution of grey-backed tern recorded on Kaula Island during the August 2023 survey.

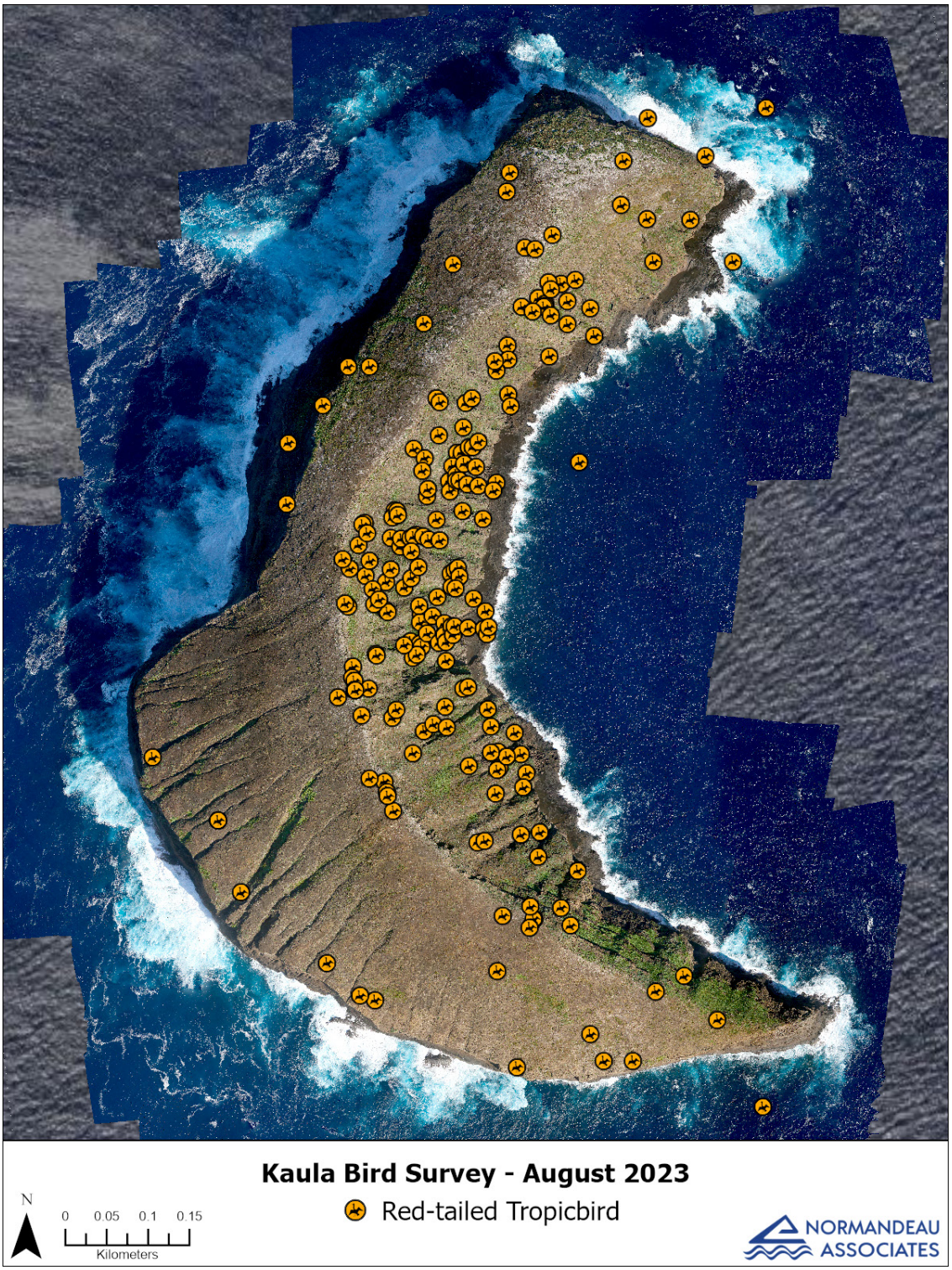

Figure 3–5. Distribution of red-tailed tropicbird recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

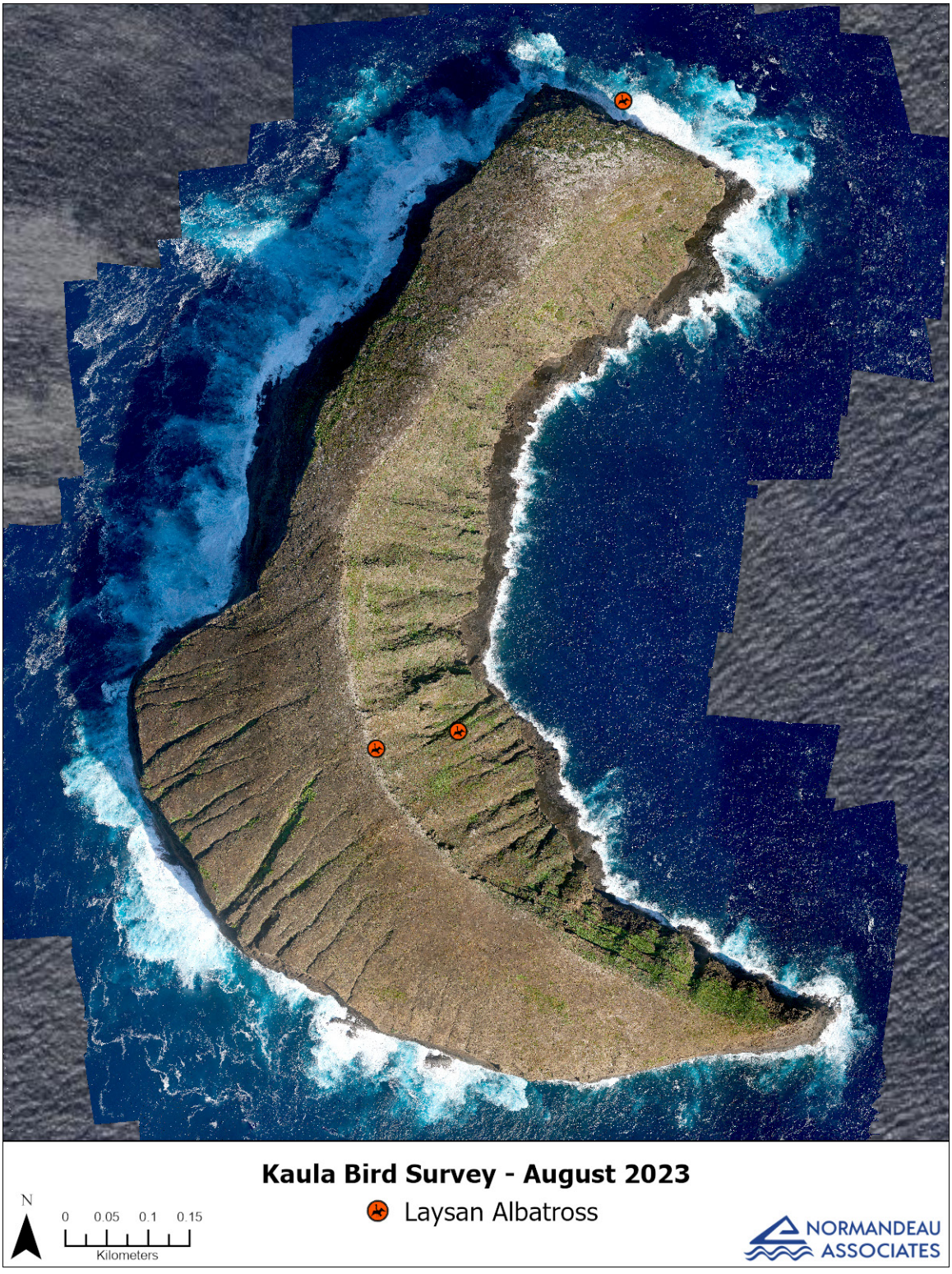

Figure 3–6. Distribution of Laysan albatross recorded on Kaula Island during the August 2023 survey.

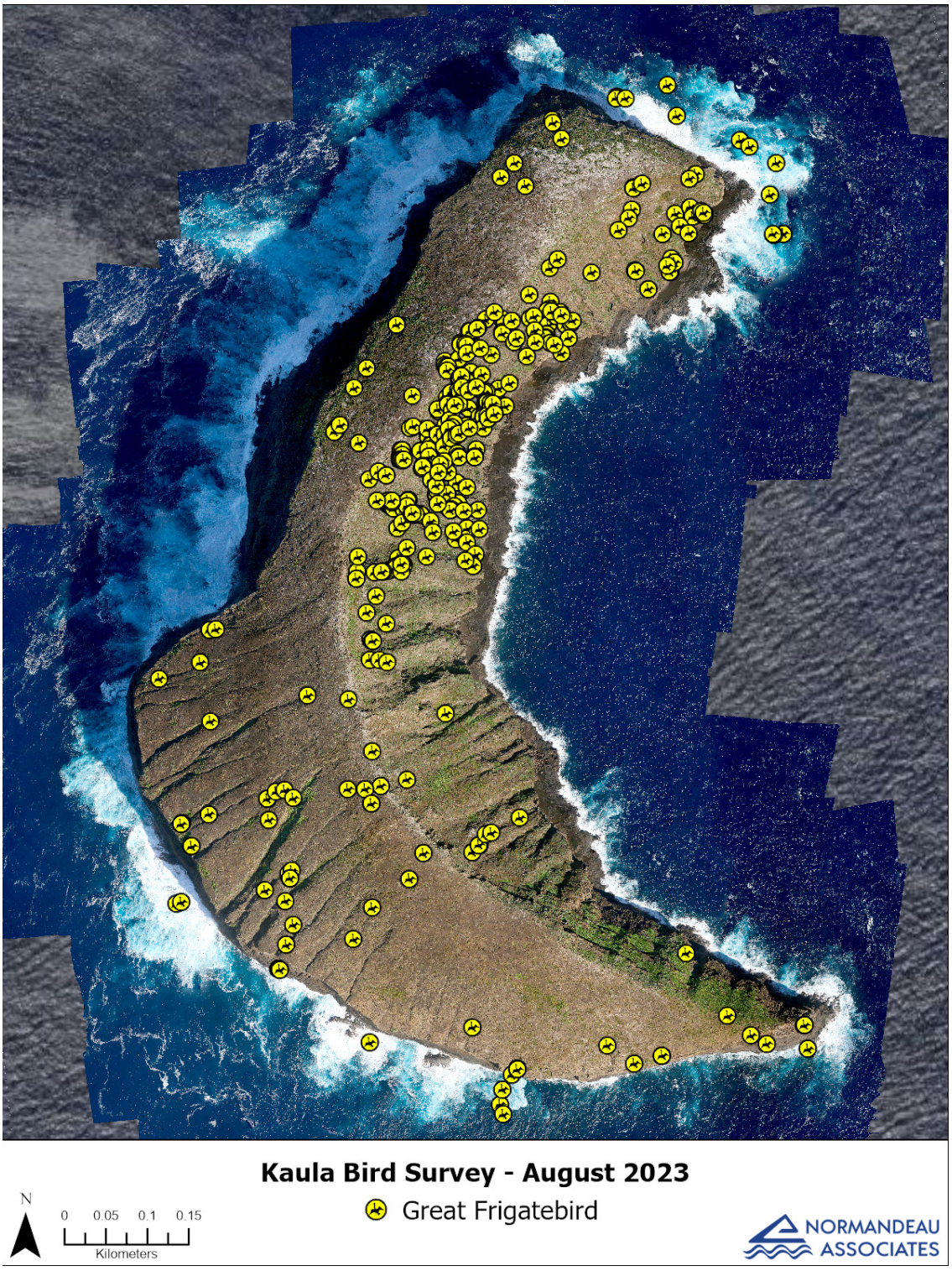

Figure 3–7. Distribution of great frigatebird recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

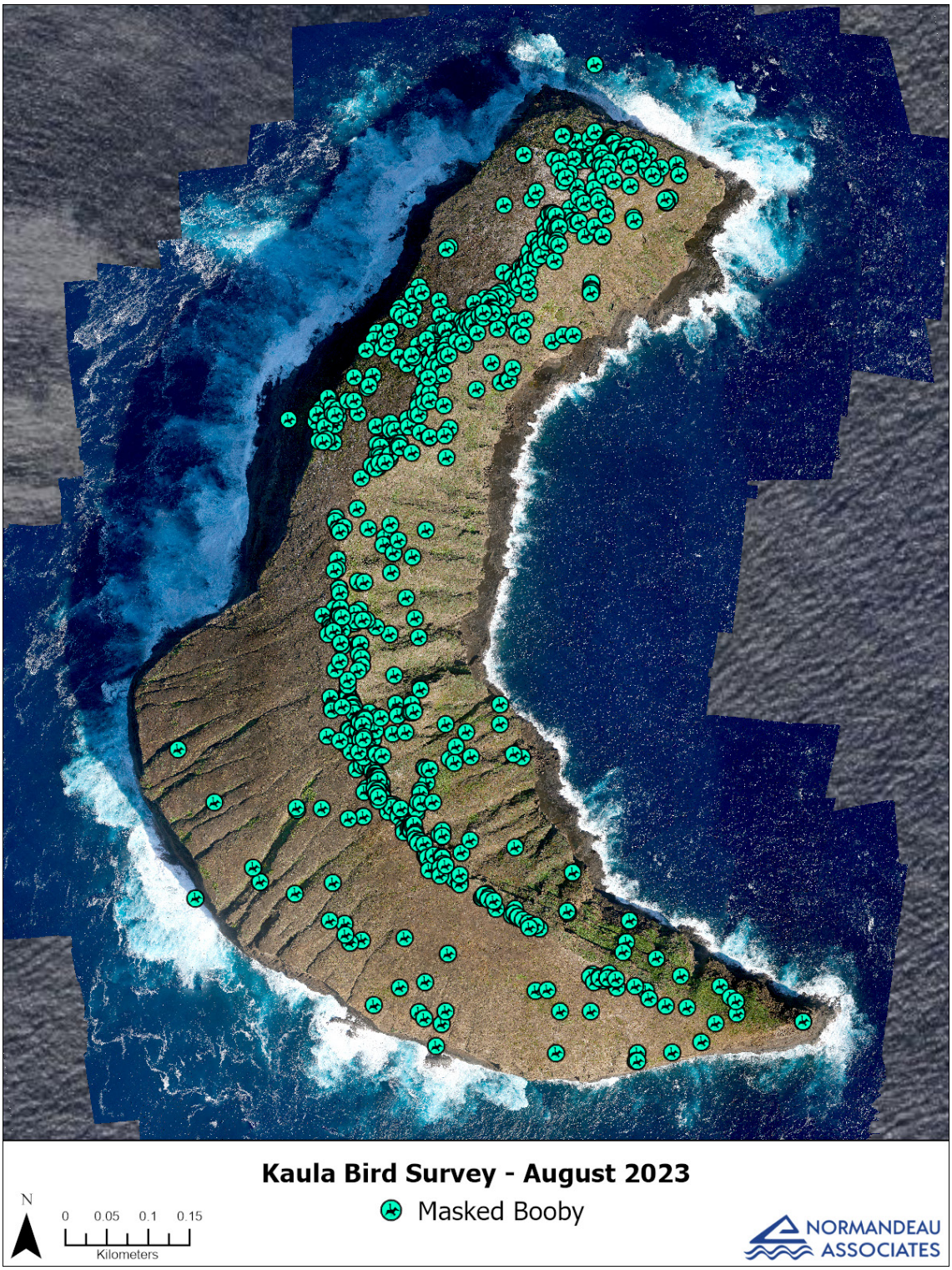

Figure 3–8. Distribution of masked booby recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

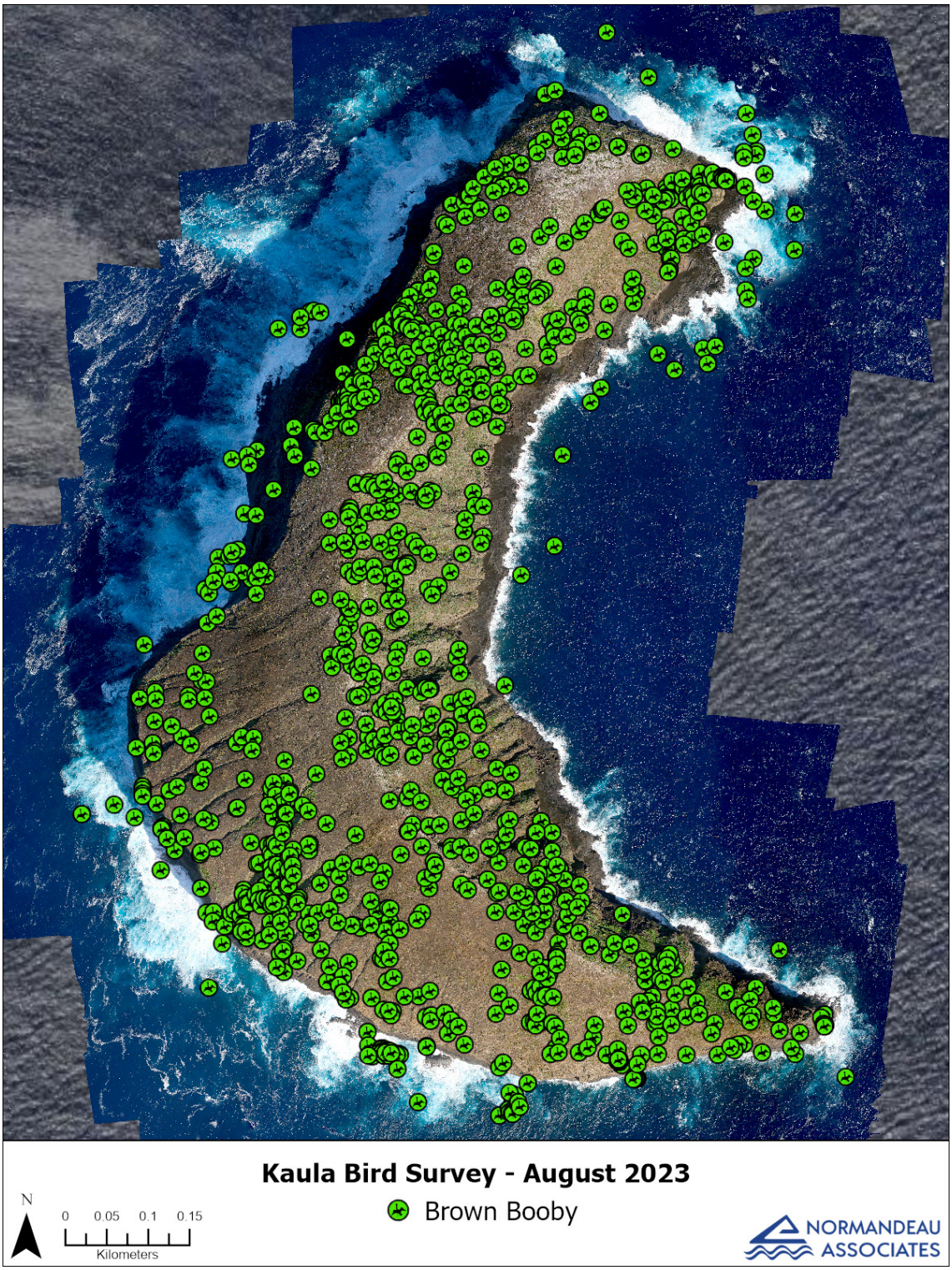

Figure 3–9. Distribution of brown booby recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

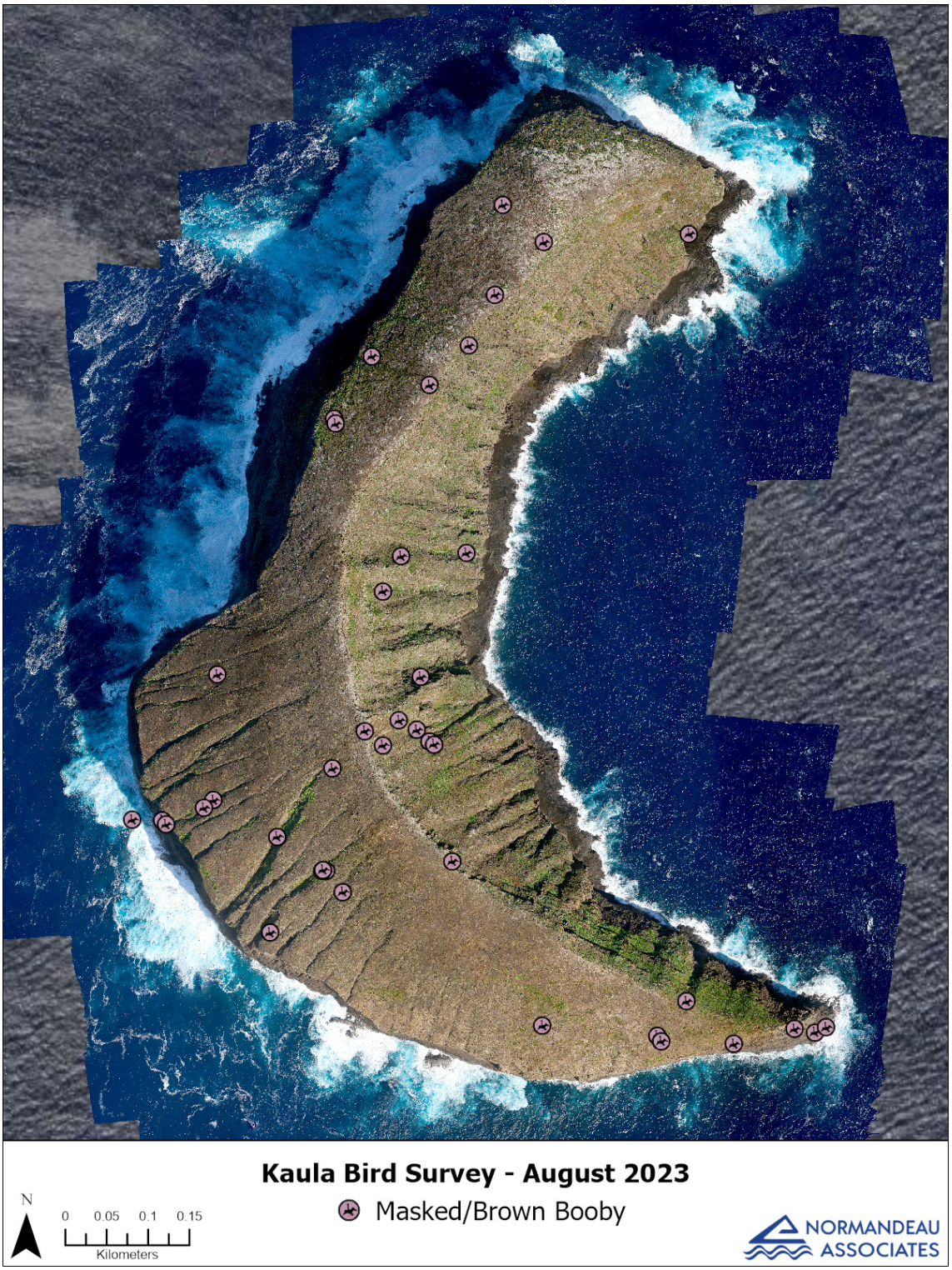

Figure 3–10. Distribution of masked/brown booby recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

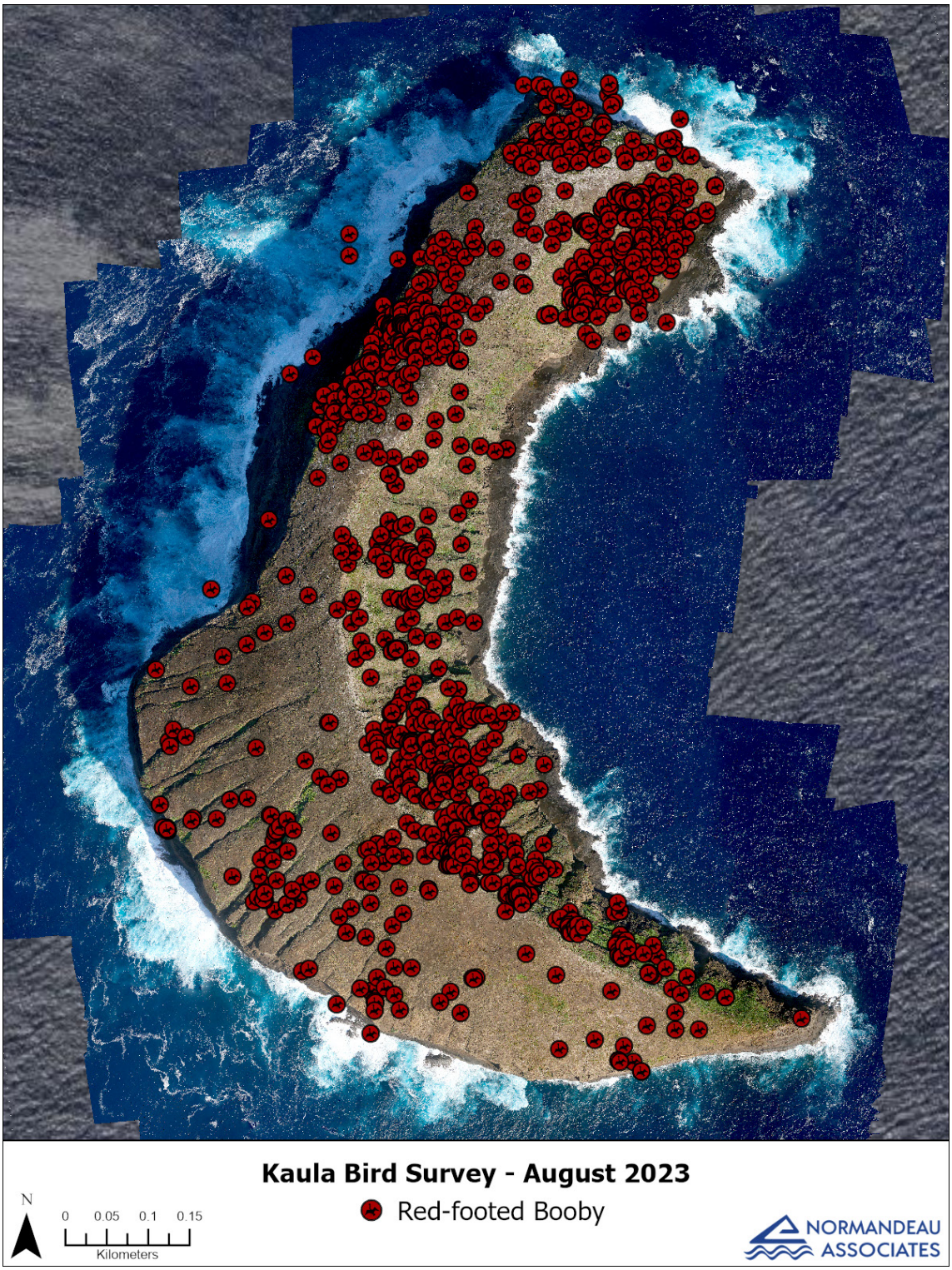

Figure 3–11. Distribution of red-footed booby recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

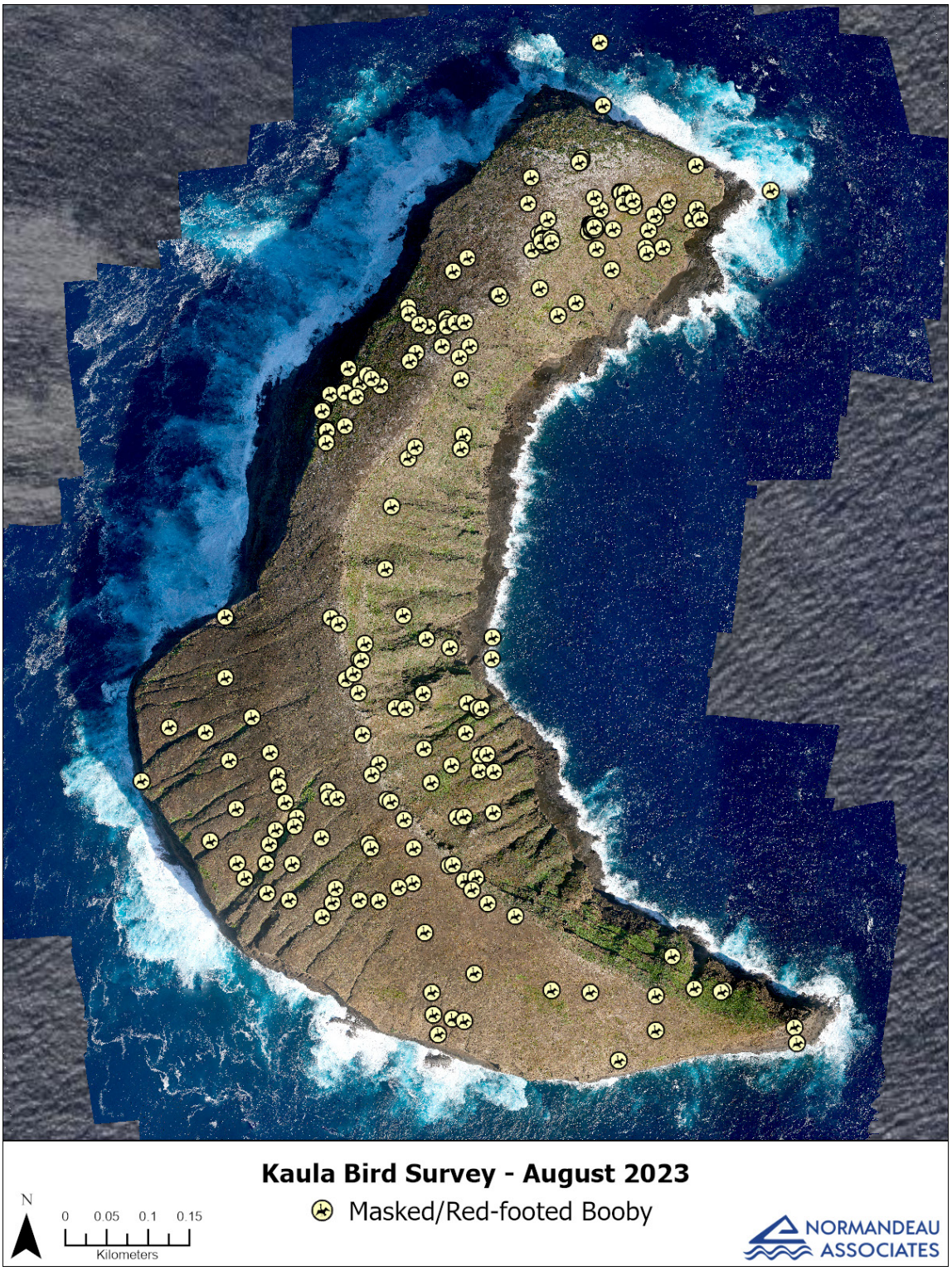

Figure 3–12. Distribution of masked/red-footed booby recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

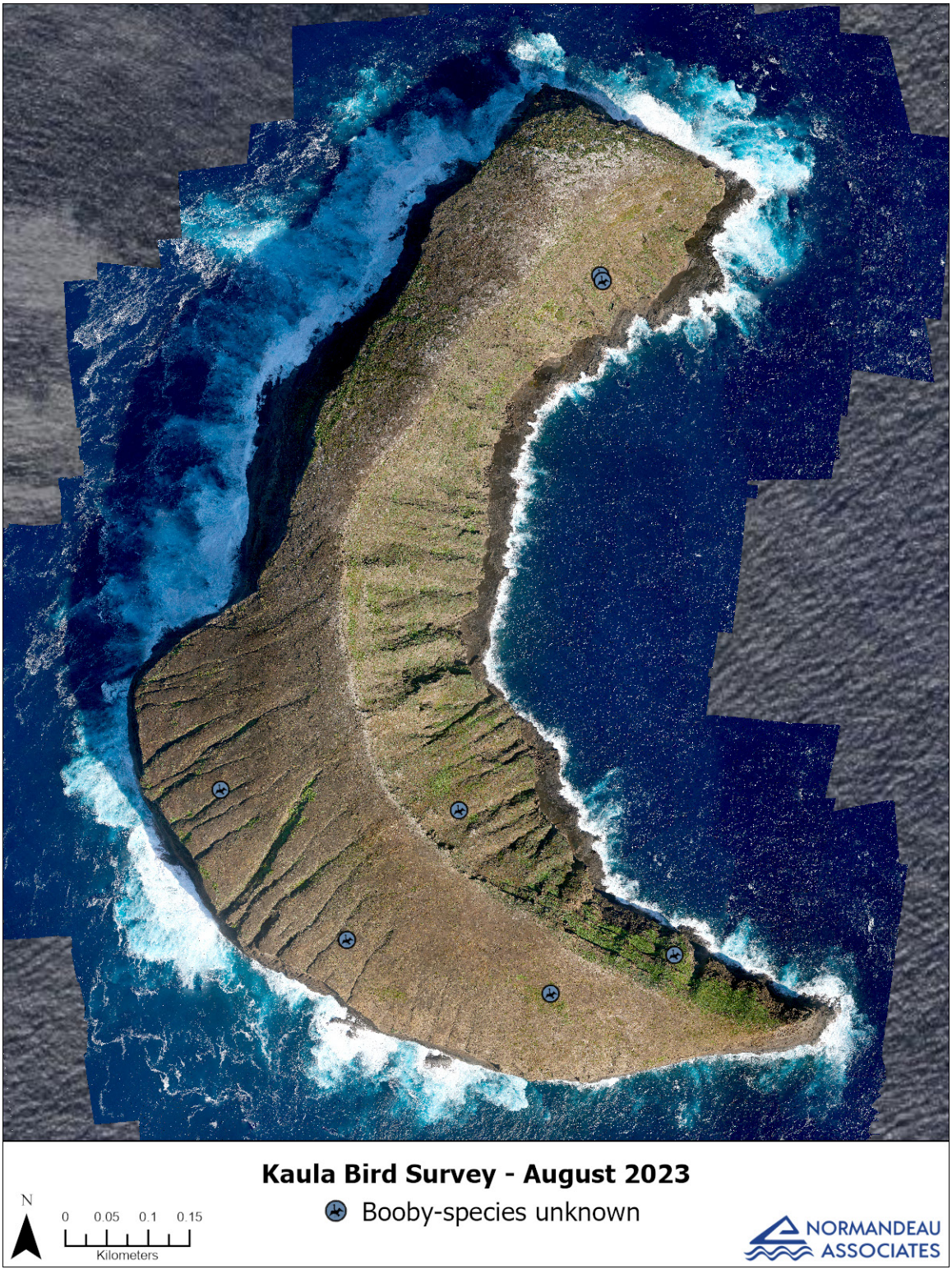

Figure 3–13. Distribution of booby species unknown recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

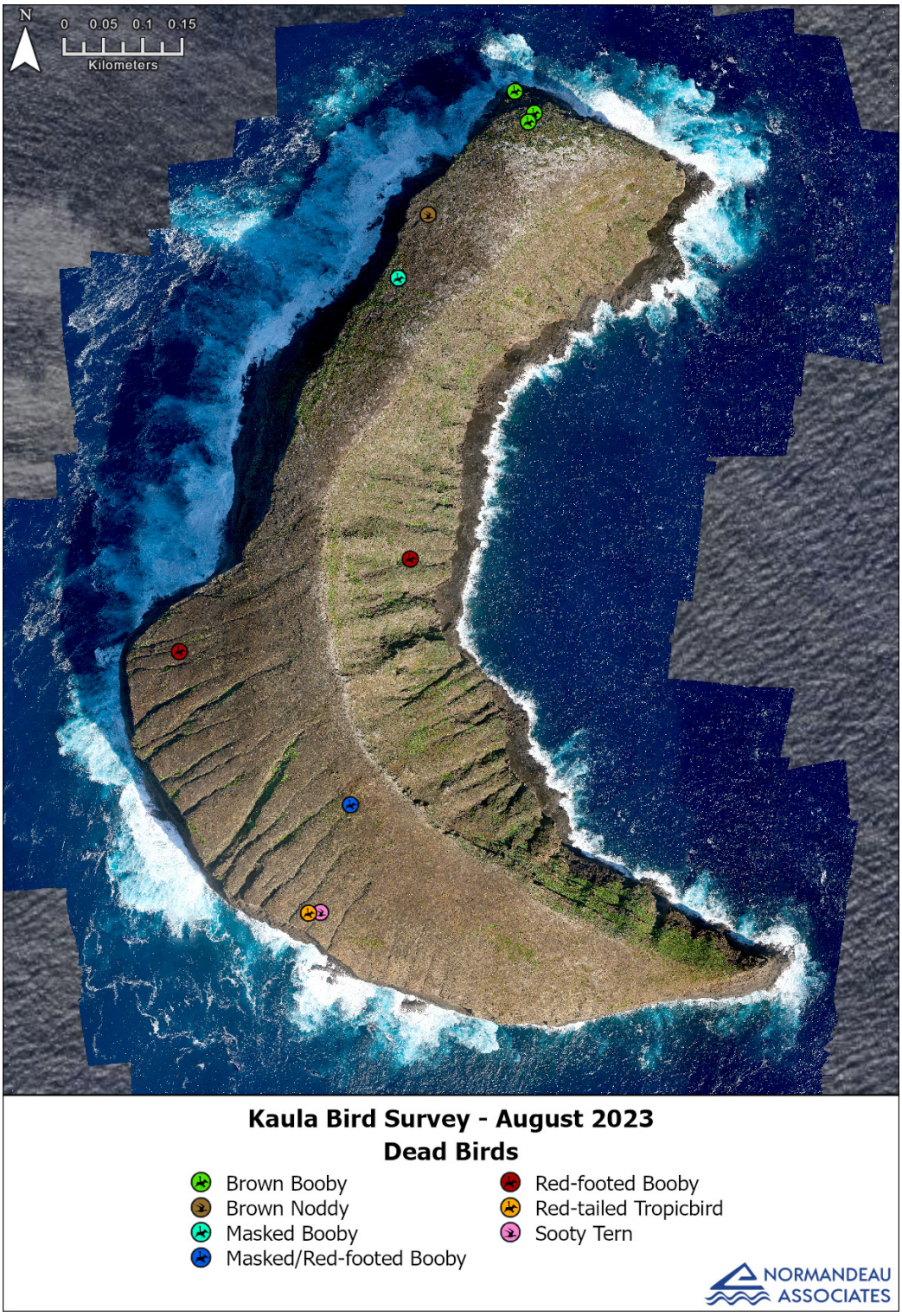

Figure 3–14. Distribution of dead birds recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

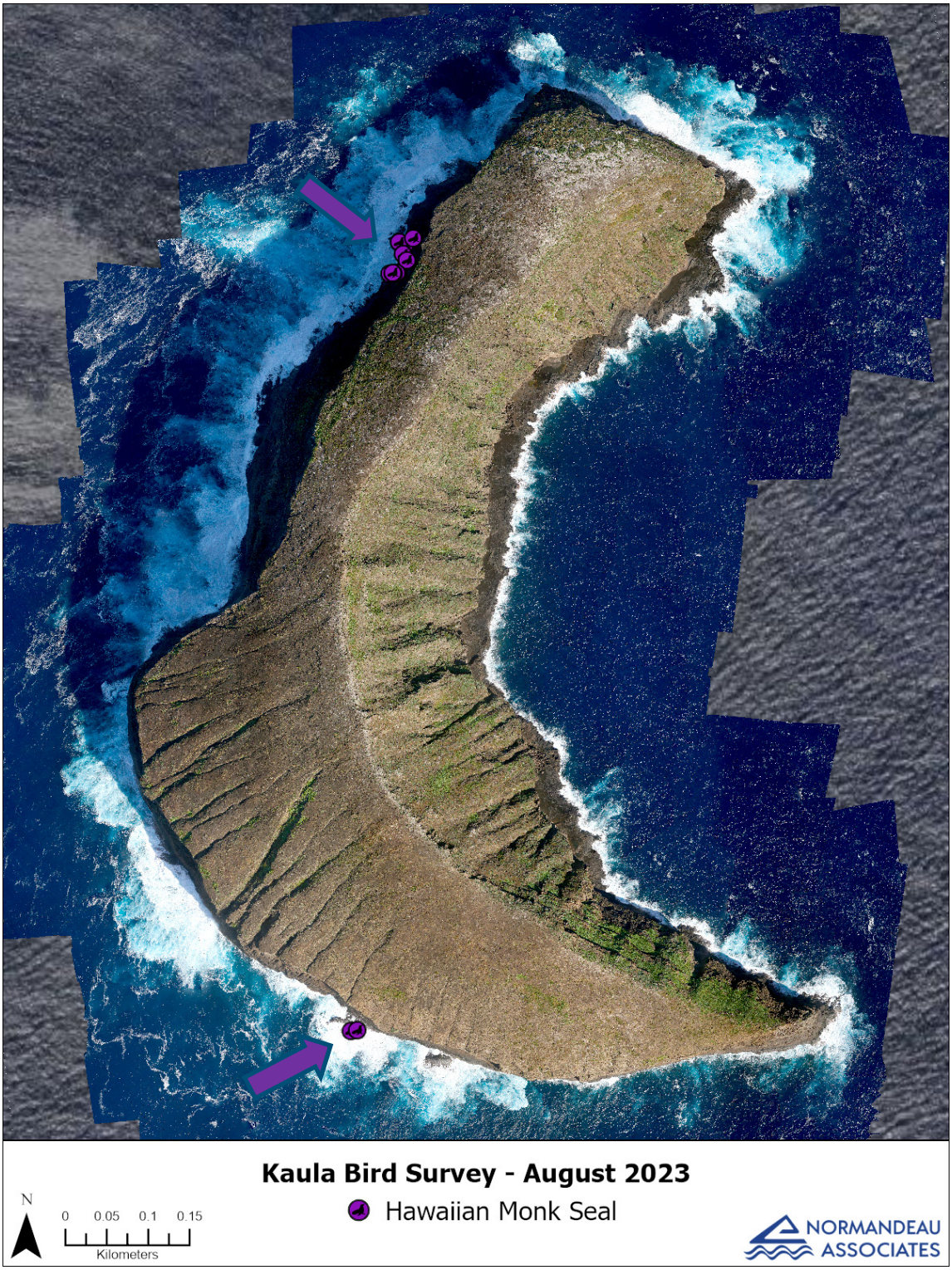

Figure 3–15. Distribution of Hawaiian monk seals recorded on Kaula Island during the August 2023 survey.

Note: The number of points visible on this figure is not necessarily equal to the total number of individuals recorded because some animals are very close to each other and at the scale required to display the whole survey area several points may overlap.

4 Discussion

During the August 3, 2023, vertical and oblique surveys, 17,638 birds and 13 Hawaiian monk seals were recorded at Kaula Island (Table 3–1). The nine bird species present were brown noddy, sooty tern, gray-backed tern, red-tailed tropicbird, Laysan albatross, great frigatebird, masked booby, brown booby, and red-footed booby. The most abundant species was brown noddy, accounting for 63% (n=11,034) of all seabirds recorded. The next most abundant species were sooty tern (n=2,440; 14%), red-footed booby (n=1,369; 8%), brown booby (n=1,188; 7%), and masked booby (n=739; 4%) (Table 3–1). Great frigatebird (n=377), red-tailed tropicbird (n=206), grey-backed tern (n=5), and Laysan albatross (n=3) were the least abundant species recorded. A total of 277 unidentified booby were also recorded (Table 3–2).

In general, relative abundance (most numerous to least numerous) is similar to previous survey results; although, overall abundance is higher than the survey conducted in July 2021 (Table 3–2) but lower than the previous survey conducted in August 2018 (Appendix III). In this report we have added per m^2 density estimates including estimated pair densities (Appendix IV).

The most abundant species during August 2023 were brown noddies, which were found concentrated along the western slopes and cliffs. They were again present on the lower "noddy ledges" halfway down the cliff face on the western side of the island. Numbers (n=11,034) were higher than those present during the aerial digital survey in July 2021 (n=3,456) and higher than the aerial digital survey performed August 2018 (n=7,612) (Table 3–2, Appendix III). As discussed in previous reports, noddies breed in proximity to each other so determining paired birds can be difficult, but the estimated number of pairs (n=6,562, Appendix IV) is lower than the most recent August survey (2018), when 13,970 pairs were estimated (Normandeau and APEM 2018). Higher densities with a lower number of breeding pairs can be attributed to the fact that 4,251 individuals were flying and not on nests. Minimum density (excludes individuals identified in the non-georeferenced oblique surveys) was estimated at 0.018685 per m^2, whereas pair density was estimated as 0.011107 per m^2 (Appendix IV). A visual comparison of part of the site between August 2023 and August 2018 shows the lower density of apparently occupied nests (Appendix V). Any black noddies present could potentially have been overlooked but no definite candidates could be located in the imagery. The last time this species was identified on the island was in August 2013 (n=22; Appendix III) and prior to 2013, 6 were seen in June 1993 (Appendix III).

Sooty terns (n=2,440; Table 3–2) were found on the west side of the island sitting among the colonies of noddies (Figure 3–3). The numbers present during this survey were similar to those recorded in July 2021 (n=2,523; Table 3–2; Appendix VI). Minimum sooty tern density was estimated at 0.004136 per m^2 (Appendix IV).

Red-tailed tropicbirds were mainly found along the eastern side of the island (Figure 3–5). Numbers recorded in this survey (n=206) were slightly lower than those recorded in August 2018 (n=245) but were higher than those recorded in July 2021 (n=125). Minimum red-tailed tropicbird density was estimated as 0.000349 per m^2 (Appendix IV).

Great frigatebirds were distributed mostly in the northeastern part of the island (Figure 3–7). This follows the same pattern recorded in previous aerial digital surveys. Numbers (n=377) were

lower than those recorded in August 2018 (n=719) and lower than July 2021 (n=1,375; Appendix VI). The reported great frigatebird numbers from July 2021 were the highest since the very first aerial digital survey (April 2013). Numbers recorded from aerial digital surveys have generally been much higher than those recorded in previous boat-based surveys. Boat-based surveys conducted between July 2009 and July 2012 averaged less than 200 birds per survey and this survey reported 377 (Appendix III). The minimum density for great frigatebird on August 3, 2023, was 0.000632 per m^2 (Appendix IV).

Of the booby species recorded, red-footed booby (n=1,369) was the most abundant during August 2023 followed by brown booby (n=1,188) and masked booby (n=739) (Table 3–2). The number of red-footed boobies during this survey is similar to previously recorded counts on the island. Estimated minimum density of red-footed booby is 0.002310 per m^2 with an estimated pair count of 893 (Appendix III).

Brown booby numbers (n=1,188) were similar to those in August 2018 (n=1,231) and lower than November 2021 (n=1,573; Table 3–2, Appendix III). Minimum density for brown booby in August 2023 was 0.001864 per m^2, with an estimated 916 breeding pairs (Appendix IV).

Masked boobies were distributed mainly along the elevated central ridge; results of this survey appeared similar to those of previous aerial digital surveys with very few birds located in the southwestern section (Figure 3–8). The total of 739 birds is lower than the August 2018 survey when an estimated 1,611 breeding pairs were reported (Normandeau Associates and APEM Ltd. 2018). The August 2023 estimate for breeding pairs is 676 (Appendix IV). The species is known to lay eggs between January and July (Richardson 1957; Nelson 1978). Most of the masked boobies were adults (n=648) with only 90 immature birds (Table 3–2). As the three largest counts of masked booby have occurred in either August or September on Kaula (Appendix III), this lower count could be the result of the extended bad weather pattern in 2023 affecting breeding success.

Seabirds can spend long periods at sea so single birds recorded during this survey may be half of a pair. Appendix IV shows the minimum estimated number of birds present based on the actual individuals recorded in the imagery and a maximum estimated number of birds derived from potential for being half of a pair. However, as the breeding season of seabirds in Hawaii is throughout the year, not all birds may be paired up in August.

Hawaiian monk seals are highly endangered, protected under the U.S. Endangered Species Act, the U.S. Marine Mammal Protection Act, Hawaii State Senate Bill 2441, and classed by IUCN as category C1. Thirteen Hawaiian monk seals were recorded on the west side of the island (Figure 3–15). Numbers have remained fairly consistent over the 11 aerial digital surveys between 2013 and 2023, although this is the highest number recorded during a single survey (Appendix VI).

Overall, the aerial survey method demonstrates that complete counts of seabirds can be obtained including the ability to accurately assess the number of birds on apparently occupied nests that would be almost impossible to record from boat surveys. Aerial imagery also creates a permanent record/snapshot of the area at a specific time, allowing users to revisit the imagery/data as often as required. It is important to note that survey techniques for Kaula Island

have differed historically and the results may not be directly comparable (see Appendix III for a list of all bird species previously observed and survey type).

5 References

Adams, J., Kelsey, E.C., Stenske, J., and Felis, J.J. 2022. Aerial counts for surface-nesting seabirds at Lehua Island and Moku Manu Islet and Ulupaʻu Crater, Oʻahu, in 2019: U.S. Geological Survey Data Report 1161, 20 p., https://doi.org/ 10.3133/ dr1161.

del Hoyo, J., A. Elliott, and J. Sargatal. 1992. Handbook of the Birds of the World. Vol. 1: Ostrich to Ducks. Lynx Edicions, Barcelona.

DON. 2008. Hawaii Range Complex FEIS/OEIS. Department of Navy, Commander Fleet Air Hawaii.

DON. 2009. Kaula Island Seabird Monitoring Plan. Department of Navy, Commander Fleet Air Hawaii.

DON. 2011. Kaula / Kauai field report, HRC marine species monitoring, February 15–20, 2011. Prepared for Commander Pacific Fleet by NAVFAC Pacific.

DON. 2013. Hawaii-Southern California Training and Testing EIS/OEIS. Department of Navy, Commander Fleet Air Hawaii.

Elmer, J. S., and G. Swedberg. 1971. Assessment of environmental impact, Kaula Island target. DON, Commander Fleet Air Hawaii.

Fujimoto, J., and F. Juola. 2012. *Kaula Island ship-based seabird survey, 6 July 2012*. Prepared for Commander Pacific Fleet by NAVFAC Pacific.

Nelson, J. B. (1978). The Sulidae, gannets and boobies. Oxford, U.K: Oxford University Press.

Normandeau Associates and APEM Ltd. 2018. Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii, August 2018. Report prepared for U.S. Navy Commander, U.S. Pacific Fleet Environmental Readiness, Pearl Harbor, HI.

Palmer, H. S. 1936. Geology of Lehua and Kaula islands. Bernice P. *Bishop Museum Occasional Papers* 12(13). (Referenced in Pepi et al. 2009)

Pepi, V. E., Kumar, A., Laut, M. E., Hallman, J., Kim, J., and Anders, A. D. 2009. *Kaula Island ship-based seabird and marine mammal surveys, 21-22 July 2009*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.

Richardson, F. 1957. The Breeding Cycles of Hawaiian Sea Birds. Bernice P. *Bishop Museum Bulletin* No. 218. Honolulu.

6 Appendices

Appendix I. Scientific Names of Relevant Bird and Mammal Species

Common Name	Scientific Name
Brown Noddy	*Anous stolidus*
Sooty Tern	*Onychoprion fuscatus*
Gray-backed Tern	*Onychoprion lunatus*
Red-tailed Tropicbird	*Phaethon rubricauda*
Laysan Albatross	*Phoebastria immutabilis*
Great Frigatebird	*Fregata minor*
Masked Booby	*Sula dactylatra*
Brown Booby	*Sula leucogaster*
Masked/brown Booby	*Sula dactylatra / S. leucogaster*
Red-footed Booby	*Sula sula*
Masked/red-footed Booby	*Sula dactylatra / S. sula*
Booby-species unknown	
Hawaiian Monk Seal	*Neomonachus schauinslandi*

Appendix II. Survey Imagery: Vertical Image Examples

Figure 6–1. Red-tailed tropicbird during the August 2023 survey.

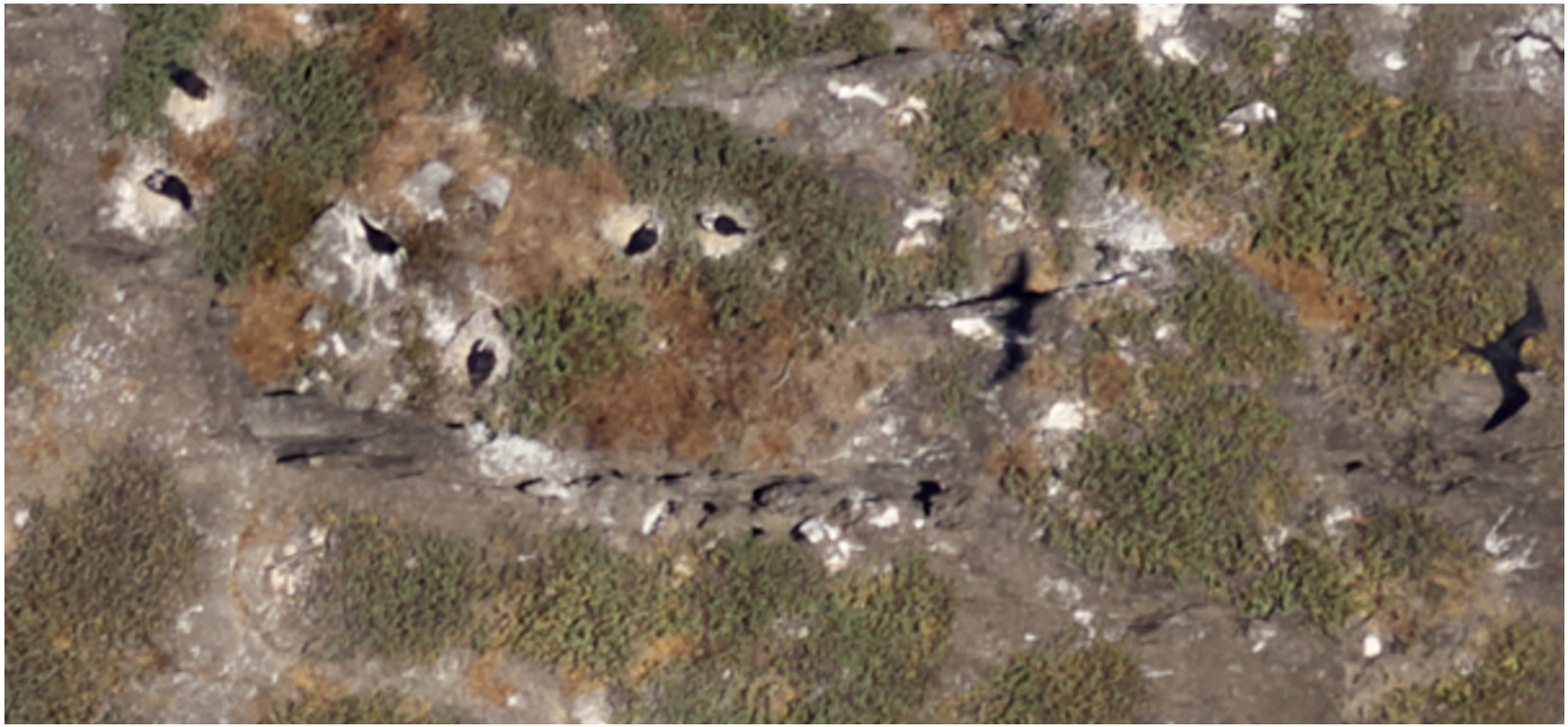

Figure 6–2. Great frigatebird during the August 2023 survey.

Figure 6–3. Masked and red-footed booby during the August 2023 survey.

Figure 6–4. Five Hawaiian monk seals resting on ledges during the August 2023 survey.

Appendix III. Results of Bird Surveys Conducted on Kaula Island, Hawaii (1932–2023)*

	Land-Based Survey (A)											Boat-Based Survey (A, B, C)				Aerial Digital Survey (D)											
Common Name ***Scientific Name***	**Aug 1932**	**Aug 1971**	**Jan 1976**	**Sep 1976**	**Mar 1978**	**Aug 1978**	**Mar 1979**	**Jun 1980**	**Apr 1984**	**Jun 1993**	**Nov 1998**	**Jul 2009 (B)**	**Jun 2010 (A)**	**Jun 2011 (C)**	**Jul 2012 (C)**	**Apr 2013**	**Aug 2013**	**Jan 2014**	**Jan 2015**	**Jul 2015**	**Mar 2016**	**Jul 2017**	**Aug 2018**	**Nov 2019**	**July 2021**	**Aug 2023**
Pacific golden plover *Pluvialis fulva*	several	-	10	14	-	1	2	-	21	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruddy turnstone *Arenaria interpres*	-	50	5	20	-	4	24	1	7	1	12	-	-	-	-	-	-	-	-	-	-	-	_	-	-	-
Wandering tattler *Heteroscelus incanus*	-	-	5	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	_	-	-	-
Brown noddy *Anous stolidus*	most numerous	67,700	-	7,000	7,000	10,000	1,000	10,560	3,950	5,778	-	-	-	-	-	57	3,713	-	-	7,137	4,115	7,871	7,612	-	3,456	11,034
Black noddy *Anous minutus*	-	100	20	100	75	200	-	-	207	6	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-	-
Brown/black noddy *Anous species*	-	-	-	-	-	-	-	-	-	-	-	711	705	306	597	-	-	-	-	-	-	-	-	-	-	-
Blue-grey noddy *Procelsterna cerulea*	small colony	-	-	200	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
White tern *Gygis alba*	uncommon	10	10	200	40	10	-	9	12	9	-	10	9	9	12	6	-	-	-	1	-	-	-	-	-	-
Sooty tern *Onychoprion fuscatus*	common	16,800	2,500	1,000	130,000	2,500	50,000	28,850	83,680	27,255	200	6,169	3,382	9,745	4,509	14,635	7	-	-	147	40,814	768	6,535	-	2,523	2,440
Grey-backed tern *Onychoprion lunatus*	uncommon	2,800	-	250	1,250	50	300	4,110	1,467	35	-	1	3	-	-	4	-	-	-	-	1	-	5	-	-	5
White-tailed tropicbird *Phaethon lepturus*	-	3	1	1	-	1	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-tailed tropicbird *Phaethon rubricauda*	common	950	-	450	60	100	40	276	209	146	15	31	3	5	1	314	85	-	1	100	23	502	245	1	125	206
Laysan albatross *Phoebastria immutabilis*	-	1 old egg	150	-	100	-	100	9	33	44	60	-	-	-	-	20	11	81	100	-	21	-	-	17	-	3
Black-footed albatross *Phoebastria nigripes*	1 old egg	-	100	-	75	-	75	-	2	4	10	-	-	-	-	3	-	11	3	-	4	-	-	-	-	-
Bonin petrel *Pterodroma hypoleuca*	1 chick	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-

Common Name *Scientific Name*	Land-Based Survey (A)											Boat-Based Survey (A, B, C)				Aerial Digital Survey (D)										
	Aug 1932	Aug 1971	Jan 1976	Sep 1976	Mar 1978	Aug 1978	Mar 1979	Jun 1980	Apr 1984	Jun 1993	Nov 1998	Jul 2009 (B)	Jun 2010 (A)	Jun 2011 (C)	Jul 2012 (C)	Apr 2013	Aug 2013	Jan 2014	Jan 2015	Jul 2015	Mar 2016	Jul 2017	Aug 2018	Nov 2019	July 2021	Aug 2023
Bulwer's petrel *Bulweria bulwerii*	several	100	-	100	-	50	-	100	580	100	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Wedge-tailed shearwater *Puffinus pacificus*	Many burrows	4,100	-	4,000	-	800	-	1,415	980	400	200	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Christmas shearwater *Puffinus nativitatis*	-	450	-	250	-	100	25	20	60	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Great frigatebird *Fregata minor*	common	950	250	800	400	250	250	134	155	701	650	131	430	105	26	1,415	1,369	621	748	1,078	1,005	777	719	316	1,375	377
Masked booby *Sula dactylatra*	common	1,000	300	1,200	125	200	400	236	202	567	350	-	-	-	-	550	219	65	84	526	183	514	1,312	217	1,262	739
Brown booby *Sula leucogaster*	common	1,700	50	1,000	75	60	200	212	169	397	60	112	1	6	40	101	109	3	2	867	179	969	1,231	185	1,573	1,188
Masked/brown booby *Sula dactylatra / S. leucogaster*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	-	-	42
Red-footed booby *Sula sula*	uncommon	1,300	100	150	85	200	400	344	222	1,375	1,200	-	-	-	-	1,690	191	98	209	3,693	1,319	2,650	4,764	1,196	6,016	1,369
Masked/red-footed booby *Sula dactylatra / S. sula*	-	-	-	-	-	-	-	-	-	-	-	820	850	1,859	912	-	-	-	-	27	-	24	-	-	-	228
Booby species *Sula species*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	713	159	184	7
Barn owl *Tyto alba*	-	1	3	3	-	1	6	4	2	7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warbling white-eye *Zosterops japonicus*	-	-	2	3	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern mockingbird *Mimus polyglottos*	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scaly-breasted Munia *Lonchura punctulata*	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
House finch *Haemorhous mexicanus*	-	6	15	40	-	20	6	-	1	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern cardinal *Cardinalis cardinalis*	-	2	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Land-Based Survey (A)											Boat-Based Survey (A, B, C)				Aerial Digital Survey (D)										
Common Name ***Scientific Name***	**Aug 1932**	**Aug 1971**	**Jan 1976**	**Sep 1976**	**Mar 1978**	**Aug 1978**	**Mar 1979**	**Jun 1980**	**Apr 1984**	**Jun 1993**	**Nov 1998**	**Jul 2009 (B)**	**Jun 2010 (A)**	**Jun 2011 (C)**	**Jul 2012 (C)**	**Apr 2013**	**Aug 2013**	**Jan 2014**	**Jan 2015**	**Jul 2015**	**Mar 2016**	**Jul 2017**	**Aug 2018**	**Nov 2019**	**July 2021**	**Aug 2023**
Total Estimated Number of Birds	-	98,022	3,521	16,811	139,285	14,548	52,831	46,280	91,959	36,847	2,785	8,001	5,385	12,035	6,097	18,795	5,733	879	1,145	13,576	47,664	14,075	23,187	2,091	16,514	17,638
Total Number of species	16	19	16	24	12	19	17	15	19	19	15	11	11	8	8	11	9	6	7	8	10	7	8	7	8	9

*Data sourced from:

A DON. 2011. Kaula / Kaua'i field report, HRC marine species monitoring, February 15-20, 2011. Prepared for Commander Pacific Fleet by NAVFAC Pacific.

B Pepi, V. E., A. Kumar, M. E. Laut, J. Hallman, J. Kim, and A. D. Anders. 2009. *Kaula Island ship-based seabird and marine mammal surveys, 21-22 July 2009*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.

C Fujimoto, J. & Juola, F. 2012. *Kaula Island ship-based seabird survey, 6 July 2012*. Prepared for Commander, Pacific Fleet by NAVFAC Pacific.

D Normandeau Associates and APEM Ltd. 2013. Aerial Survey of Seabirds and Marine Mammals at Kaula Island, Hawaii. Prepared for Commander, Pacific Fleet through a contract with NAVFAC Pacific.

Appendix IV. Estimates of Seabird Numbers and Estimated Densities per m^2 During the August 2023 Aerial Digital Survey of Kaula Island, Hawaii

Species/Group	Minimum Abundance[1]	Maximum Abundance[2]	Estimated Pairs[3]
Brown Noddy	11,034	17,700	6,562
Sooty Tern	2,440	4,132	1,626
Gray-backed Tern	5	6	1
Red-tailed Tropicbird	206	253	41
Laysan Albatross	3	3	0
Great Frigatebird	377	810	309
Masked Booby	739	1,457	676
Brown Booby	1,188	2,140	916
Masked/brown Booby	42	85	37
Red-footed Booby	1,369	2,307	893
Masked/red-footed Booby	228	550	201
Booby-species unknown	7	16	5

1 Minimum abundance is the raw number of birds observed.

2 Maximum abundance is the raw number of birds observed plus the following changes: adults with nests and unknown aged birds with a nest are multiplied by 2 to reflect the other parent attending the nest; juveniles with nests are multiplied by 3 to include the juvenile and the assumed two adults that are attending the nest

3 Estimated pairs are calculated by adding the adults with nests, juveniles with adult, juveniles with 2 adults, juveniles with nets and unknown aged birds with nests

Appendix IV: Estimated Density (per m^2) of Animals Using the Vertical Imagery Only

Density was calculated by dividing the number of each species observed in the vertical surveys by the georeferenced vertical survey area (590,000 m^2)

Species	Minimum Density	Maximum Density	Estimated Pair Density
Brown Noddy	0.018685	0.029968	0.011107
Sooty Tern	0.004136	0.007003	0.002756
Gray-backed Tern	0.000008	0.000010	0.000002
Red-tailed Tropicbird	0.000349	0.000429	0.000069
Laysan Albatross	0.000005	0.000005	0.000000
Great Frigatebird	0.000632	0.001363	0.000520
Masked Booby	0.001251	0.002468	0.001146
Brown Booby	0.001864	0.003336	0.001410
Masked/brown Booby	0.000069	0.000141	0.000061
Red-footed Booby	0.002310	0.003892	0.001507
Masked/red-footed Booby	0.000347	0.000853	0.000302
Booby-species unknown	0.000012	0.000027	0.000008

Appendix V. Survey Imagery: Density Comparison Image Examples

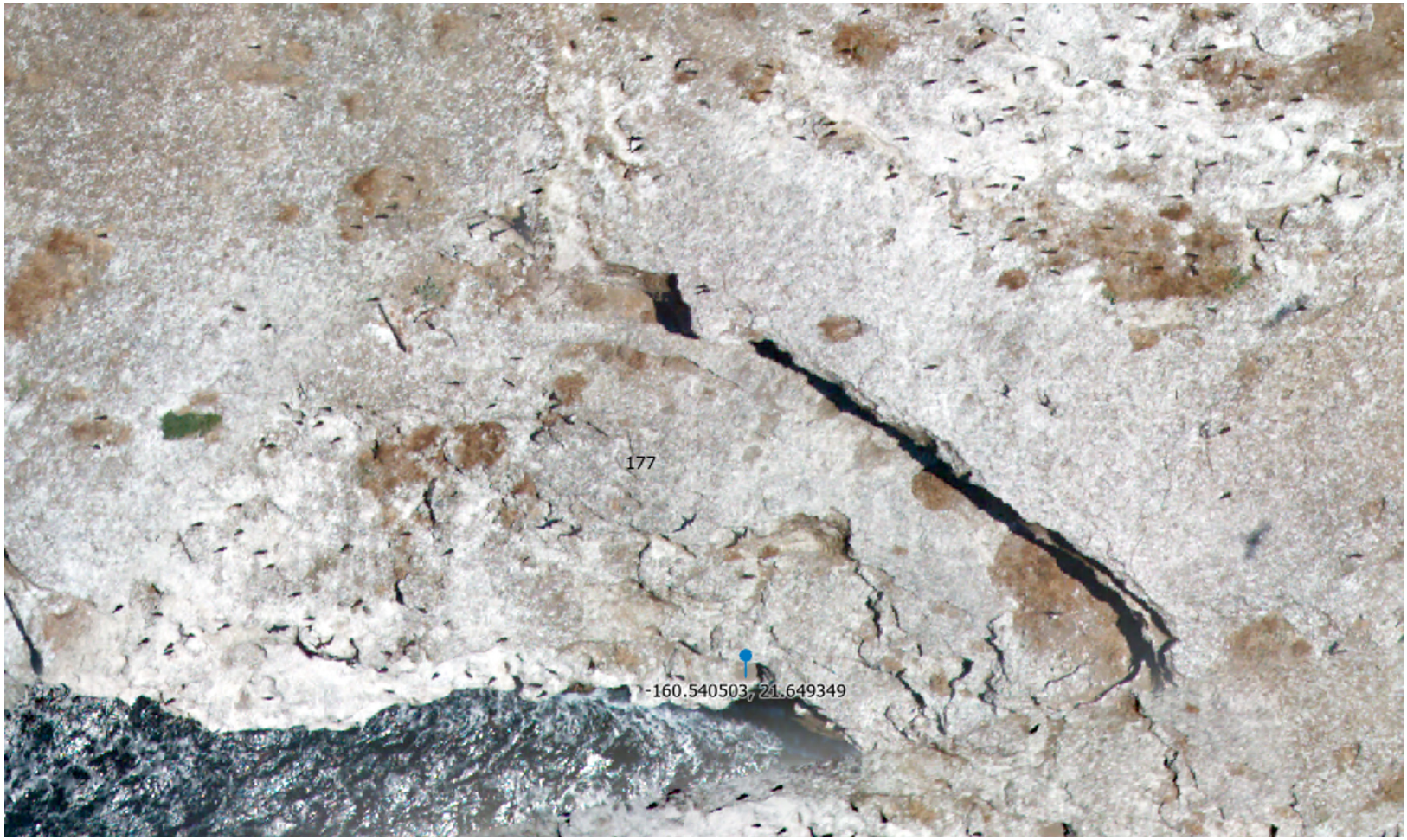

Figure 6–5. Brown noddy densities during the August 2018 survey.
Georeferenced location data were not included in the 2021 survey

Figure 6–6. Brown noddy densities in same location during the August 2023 survey.

Appendix VI. Results of Aerial Digital Surveys of Kaula Island, Hawaii (2013–2023)*

Common Name	Scientific Name	Global Population	Regional Population[2] (Hawaii) Breeding Pairs	Apr 2013	Aug 2013	Jan 2014	Jan 2015	July 2015	Mar 2016	July 2017	Aug 2018	Nov 2019	July 2021	Aug 2023
Brown noddy	*Anous stolidus*	500,000-1,000,000 breeding pairs[2]	112,000	57	3,713	-	-	7,137	4,115	7,871	7,612	-	3,456	11,034
Black noddy	*Anous minutus*	1-1.5 million breeding pairs[2]	12,000	-	22	-	-	-	-	-	-	-	-	-
White tern	*Gygis alba*	Likely exceeds 100,000 breeding pairs[2]	15,000	6	-	-	-	1	-	-	-	-	-	-
Sooty tern	*Onychoprion fuscatus*	60-80 million breeding pairs[2]	>1,000,000	14,635	7	-	-	147	40,814	768	6,535	-	2,523	2,440
Grey-backed tern	*Onychoprion lunatus*	Likely 70,000 breeding pairs[2]	44,000	4	-	-	-	-	1	-	5	-	-	5
Red-tailed tropicbird	*Phaethon rubricauda*	> c.32,000 individuals[1]	9,000-12,000	314	85	-	1	100	23	502	245	1	125	206
Laysan albatross	*Phoebastria immutabilis*	1,600,000 mature individuals[3]	590,000	20	11	81	100	-	21	-	-	17	-	3
Black-footed albatross	*Phoebastria nigripes*	139,800 individuals[3]	57,000	3	-	11	3	-	4	-	-	-	-	-
Great frigatebird	*Fregata minor*	500,000-1,000,000[2]	10,000	1,415	1,369	621	748	1,078	1,005	777	719	316	1,375	377
Masked booby	*Sula dactylatra*	>100,000 birds[2]	2,500	550	219	65	84	526	183	514	1,312	217	1,262	739
Brown booby	*Sula leucogaster*	> c.200,000 individuals[1]	1,400	101	109	3	2	867	179	969	1,231	185	1,573	1,188
Masked/brown booby	*Sula species*	-	-	-	-	-	-	-	-	-	51	-	-	42
Red-footed booby	*Sula sula*	> c.1,000,000 individuals[1]	7,000-10,500	1,690	191	98	209	3,693	1,319	2,650	4,764	1,196	6,016	1,369
Masked/red-footed booby	*Sula species*	-	-	-	-	-	-	27	-	24	-	-	-	228
Booby species	*Sula species*	-	-	-	-	-	-	-	-	-	713	159	184	7
Hawaiian monk seal	*Neomonachus schauinslandi*	1,209 individuals of all age classes[4]	632 sexually mature seals[4]	11	7	5	7	9	10	8	7	8	10	13
Total Estimated Number of Birds				**18,795**	**5,733**	**879**	**1,147**	**13,576**	**47,664**	**14,075**	**23,187**	**2,091**	**16,514**	**17,638**
Total Number of Avian Species				**11**	**9**	**6**	**7**	**8**	**10**	**8**	**9**	**7**	**9**	**10**

[1] del Hoyo et al. 1992

[2] Hawaii Department of Land and Natural Resources (http://dlnr.hawaii.gov/wildlife/cwcs/hawaii/species/fact-sheets/)

[3] Birdlife International http://www.birdlife.org/datazone/

[4] IUCN Red List http://www.iucnredlist.org/details/13654/0