Final Field Report

Aerial and Ground-based Shoreline Surveys for Marine Mammals and Sea Turtles in the Hawaii Range Complex: SCC 12-13 August 2013

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Naval Facilities Engineering Command Pacific
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Hawaiian monk seal (*Neomonachus schauinslandi*), photographed at Niihau on 20 August 2013 by Morgan Richie, NAVFAC Pacific.

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14. ABSTRACT

This report documents the findings of a pilot study conducted in 2013 to investigate the efficacy of ground-based surveys as a potential alternative to, or in supplementation of, aerial surveys in detecting strandings of marine mammals and sea turtles (MM/ST) on remote shorelines, in this case the Island of Niihau. In this study, aerial (helicopter) and ground-based (vehicle and horseback) shoreline surveys were conducted concurrently in order to compare the efficacy of each method. Observers scanned the shorelines of Kauai and Niihau, adjacent to PMRF, for stranded and near-stranded marine mammals and sea turtles within one week after an SCC training event that involved mid-frequency active sonar in August 2013. Surveys circumnavigated the islands of Kauai and Niihau by helicopter on 20 and 22 August 2013, and by vehicle/horseback on 20 August 2013 on the island of Niihau. At Niihau, where both aerial and ground-based surveys occurred, the relative detectability of animals from each of these platforms was compared using the recorded number and location of Hawaiian monk seals (Monachus schauinslandi), which served as a "proxy" for stranded marine mammals. In addition, survey teams assessed the feasibility of circumnavigating Niihau while maintaining continual visual coverage of shoreline areas, and identified potential coastal routes appropriate for patrolling the shoreline on a regular basis. Detailed Hawaiian monk seal data, including identification of individuals from unique tags and markings, were collected during the ground-based survey at Niihau. The ground-based survey was more effective at detecting hauled-out Hawaiian monk seals, while aerial surveys provided superior nearshore coverage of in-water sightings. Aerial survey effort recorded 71 MM/ST sightings (334 individuals); the most commonly observed species was the monk seal, followed by unidentified sea turtles. Ground-based survey effort documented 31 sightings; the vast majority (93.5 percent; n=29 sightings) of these were of monk seals and a sighting of a group of spinner dolphins and a group of

unidentified cetaceans in the same general area.

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Acronyms and Abbreviations

ER	encounter rate
GPS	Global Positioning System
h	hour(s)
HMS	Hawaiian monk seal
HRC	Hawaii Range Complex
HST	Hawaii Standard Time
km	kilometer(s)
m	meter(s)
MFAS	mid-frequency active sonar
MHI	Main Hawaiian Islands
min	minute(s)
MM/ST	marine mammals and sea turtles
NAVFAC	Naval Facilities Engineering Command
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
SCC	Submarine Commanders Course
U.S.	United States

Section 1 Introduction

The islands of Kauai and Niihau are adjacent to the Pacific Missile Range Facility, where the United States (U.S.) Navy conducts anti-submarine warfare training using mid-frequency active sonar (MFAS). As documented in previously conducted aerial surveys (e.g., Mobley and Milette 2010), a variety of marine mammal and sea turtle (MM/ST) species are commonly seen associated with these islands, including spinner dolphins (*Stenella longirostris*), bottlenose dolphins (*Tursiops truncatus*), green turtles (*Chelonia mydas*), and Hawaiian monk seals (HMS; *Neomonachus schauinslandi*). During winter months (November through April), humpback whales (*Megaptera novaeangliae*) are also present (Mobley et al. 1999). HMSs use the sandy beaches and lava benches[1] of both islands to haul out (i.e., come on land), rest, and nurse their pups (Baker and Johannos 2004).

Since 2009, aerial surveys have been conducted in the Hawaii Range Complex (HRC) subsequent to U.S. Navy training events, in order to monitor for any potential strandings of MM/ST (HDR 2012). This report documents the findings of a pilot study conducted in 2013 to investigate the efficacy of ground-based surveys as a potential alternative to, or in supplementation of, aerial surveys in detecting strandings of MM/ST on remote shorelines, in this case the island of Niihau. Surveys were conducted in order to address the monitoring question: "Do marine mammals strand along shorelines of the Main Hawaiian Islands (MHI) within 1 week following naval training events?" Due to time and budget constraints, ground-based surveys were conducted only at Niihau, whereas at Kauai, only aerial surveys were conducted. Specific survey objectives included the following:

1. Detect any strandings or near-strandings of cetaceans that may have occurred in response to U.S. Navy training events in the vicinity of the islands of Kauai and Niihau.
2. Assess the relative detectability of animals from aerial and ground-based survey platforms by comparing the number and location of HMS (which served as a "proxy" for stranded marine mammals) detected by both survey methods, conducted simultaneously, at Niihau.
3. Assess the feasibility of circumnavigating Niihau while maintaining continual visual coverage of shoreline areas.
4. Identify potential coastal routes appropriate for patrolling the shoreline on a regular basis.

Aerial and ground-based shoreline surveys for MM/ST were conducted subsequent to U.S. Navy training event in the HRC. These surveys circumnavigated the islands of Kauai and Niihau (**Figures 1 and 2**) by helicopter and also by vehicle/horseback on the island of Niihau (**Figure 3**). The Submarine Commanders Course (SCC) training event involved the use of MFAS and took place from 12 to 13 August 2013. Following the event, shoreline surveys were conducted on 20 and 22 August. Aerial and ground-based surveys were performed simultaneously for Niihau on 20 August, while only aerial surveys were performed on 22 August 2013.

[1] A *lava bench* is defined as a volcanic landform with a horizontal surface raised above the level of the surrounding area.

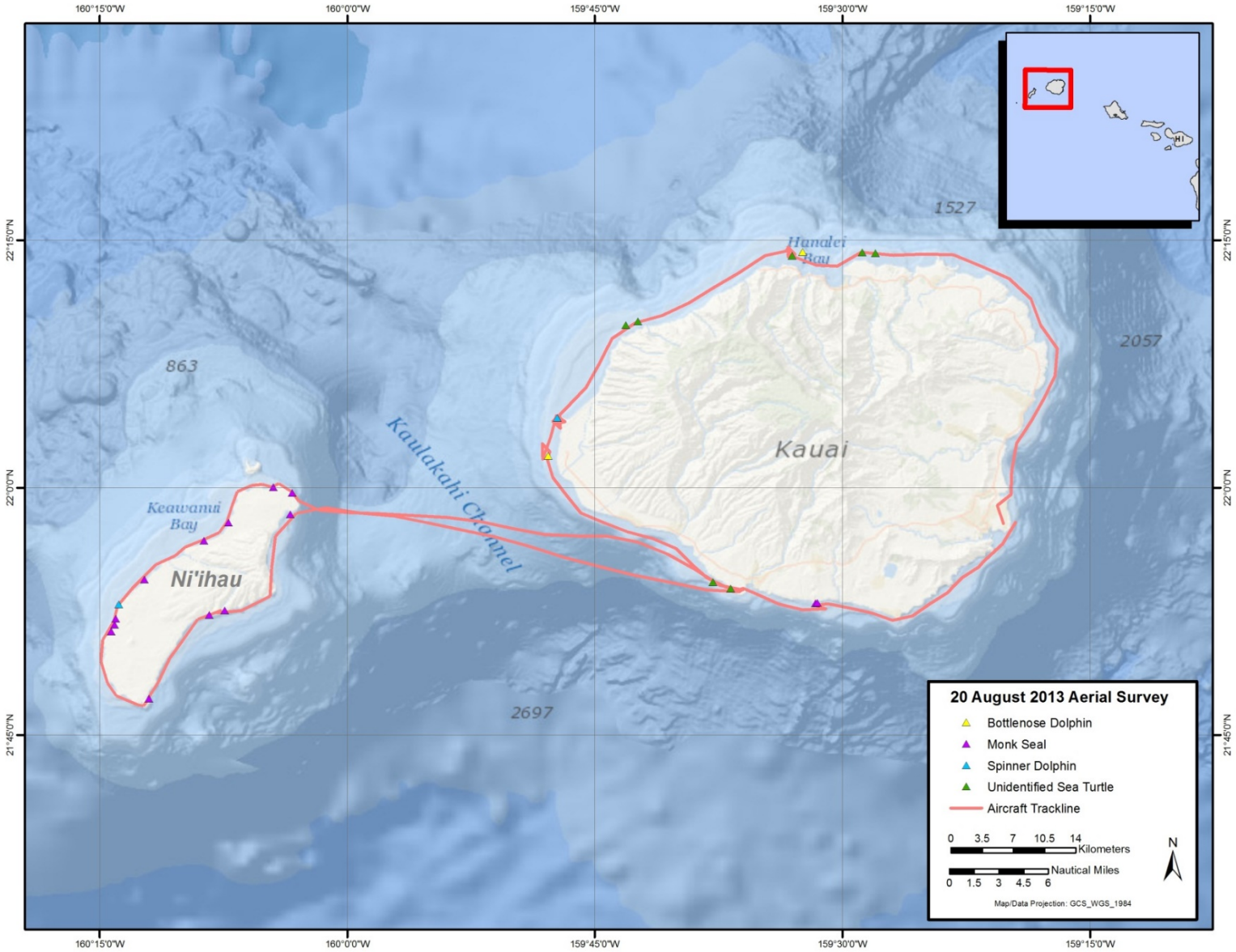

Figure 1. Aerial shoreline survey sightings and effort: 20 August 2013.

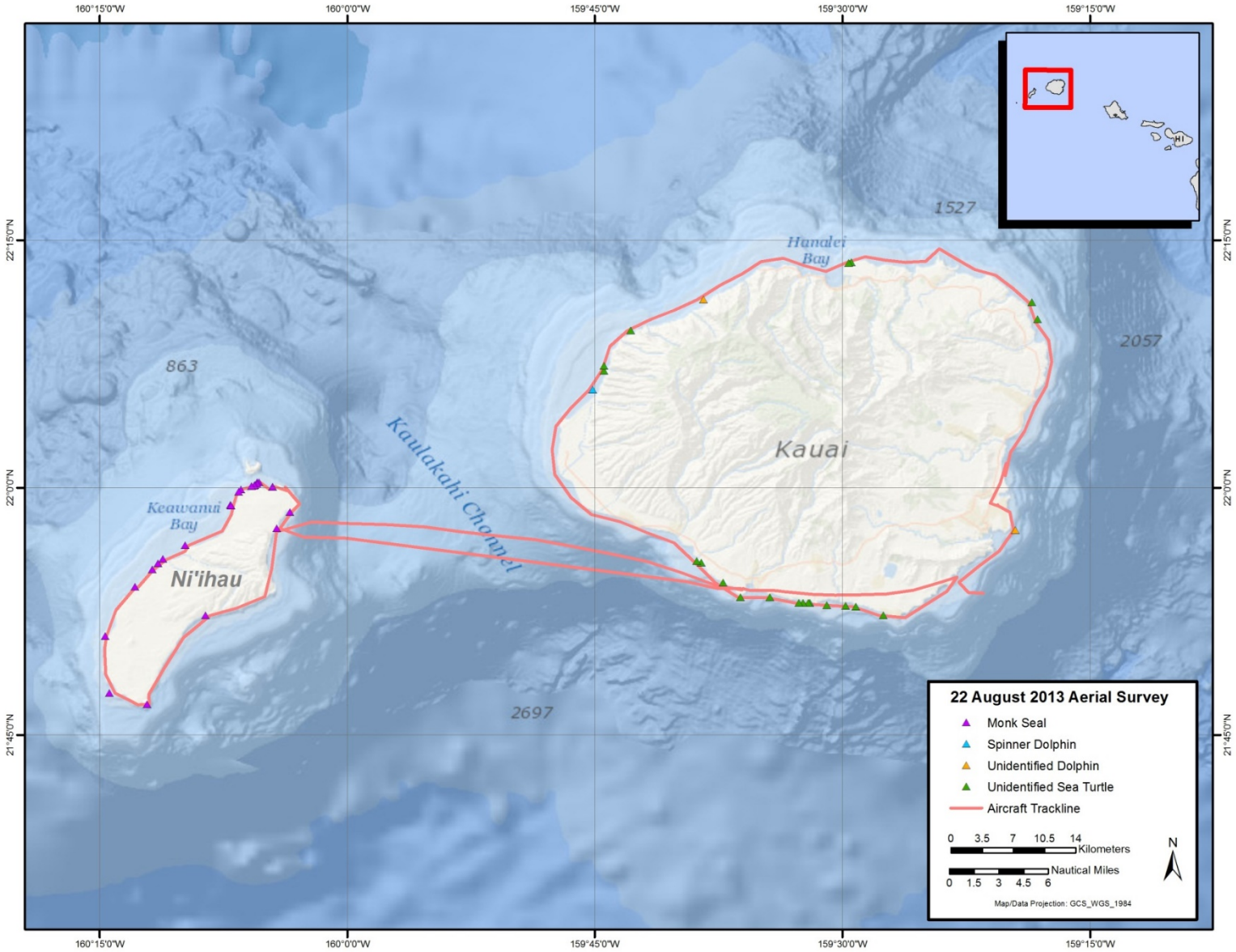

Figure 2. Aerial shoreline survey sightings and effort: 22 August 2013.

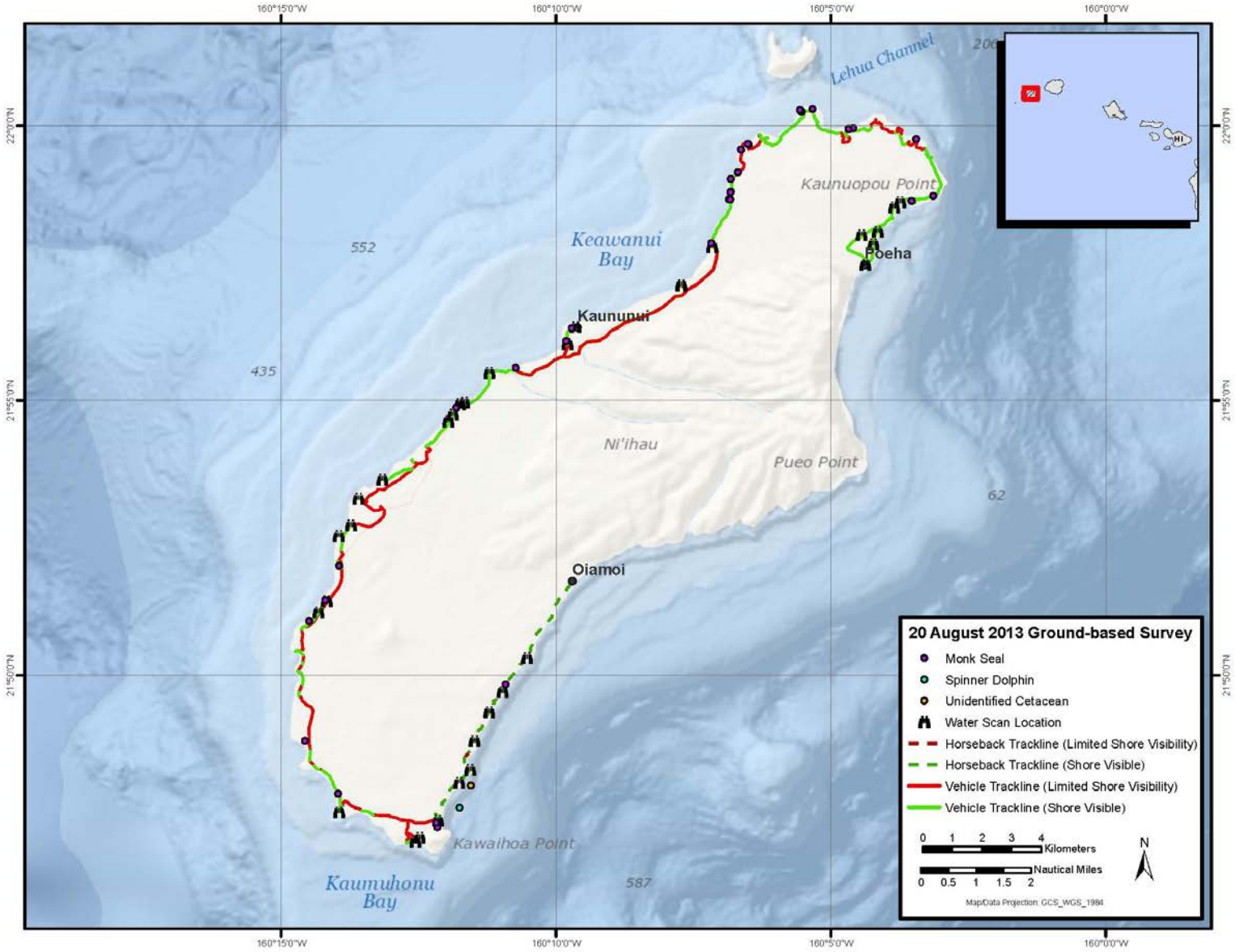

Figure 3. Sightings, effort, and shoreline visibility for ground-based survey: 20 August 2013.

The broad objective of these surveys was to monitor for "stranded" MM/ST subsequent to training events. Given the low probability of encountering stranded[2] animals during shoreline surveys, for this pilot study, HMS sightings were used as a "proxy" for strandings, and their potential visibility from aerial and ground-based platforms was evaluated. HMS observations on Niihau (and elsewhere in the MHI) are also important due to the federally endangered status of the species. Niihau in particular may provide a refuge from anthropogenic disturbance for HMS, since the island is relatively undeveloped and sparsely populated. Recent evidence suggests that the MHI are becoming important HMS habitat, with less-populated regions, such as Niihau, appearing as favored haul-out locations (Baker and Johannos 2004).

Section 2 Methods

Aerial Survey Methods

The shoreline and nearshore waters of both Kauai and Niihau were surveyed by helicopter. This involved 2 days of survey effort on 20 and 22 August 2013, flying an A-Star AS350 (20 August) and Robinson 44 (22 August) helicopter around the shoreline of Kauai, and an A-Star AS350 (20 August) and an Agusta A109 (22 August) helicopter around the shoreline of Niihau. At both Niihau and Kauai, helicopters flew at 111 to 167 kilometers/hour (km/h) (60 to 90 knots) and at approximate altitude of 244 meters (m). All work was performed under National Oceanic and Atmospheric Administration (NOAA) permit #14451. On 20 August, the aerial team surveyed Kauai first, and then circumnavigated Niihau, in order for the latter to coincide with the ground-based survey. On 22 August, this was reversed, and the Niihau shoreline was surveyed first, then the Kauai shoreline.

Observers documented the positions and behavior of all MM/ST seen within 3 km of shore. All observers were highly experienced and familiar with MM/ST species encountered in the HRC. Those participating in the project, in alphabetical order, were: Joseph Mobley (University of Hawaii), Michael Richlen (HDR, Inc.) and Alexis Rudd (HDR, Inc.). Collected data variables included: species, time, sighting angle, latitude/longitude position, altitude, group size, side of aircraft, presence/number of calves/pups, sea state and behavior. Additionally for seals, they included: in-water vs. hauled out, and presence of flipper tags. Numbers and locations of target species (marine mammals and sea turtles), as well as the platform's trackline, were recorded and plotted using Geographical Information System software. Animal locations were calculated using observer (platform) location, distance and bearing to each sighting. Sighting data were evaluated along with data collected by the ground-based team to compare the number and position of animals detected, and relative encounter rates (ERs) of each survey platform. Subsequent comparisons of results were used to assess the feasibility of relying on ground-based surveys as a supplement and/or replacement for aerial shoreline surveys.

[2] The legal definition for a MM "stranding" within the United States (U.S.) is that "(A) a marine mammal is dead and is (i) on a beach or shore of the U.S.; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the U.S. and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the U.S. (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance." (16 U.S. Code [U.S.C.] section 1421h).

Ground-based Survey Methods

The ground-based survey was conducted at Niihau on 20 August 2013. It was conducted simultaneously with the aerial shoreline survey of the island. Aerial circumnavigation of Niihau took less than an hour, while ground-based circumnavigation took slightly over 8 h. The ground-based crew was split into three teams, consisting of 3 to 4 people each, in order to circumnavigate the entire island overland in one day. Two teams surveyed the shoreline from 4-wheel-drive vehicles, and the third from horseback. The teams in vehicles covered the north, west, and southern portions of the Niihau shoreline, and the horseback team covered rough terrain on the east side of the island inaccessible by vehicle. Observers participating in the project, in alphabetical order, were: Kristen Ampela (HDR, Inc.), Morgan Richie (NAVFAC [Naval Facilities Engineering Command] Pacific), Julie Rivers (COMPACFLT) and Robert Uyeyama (NAVFAC Pacific).

All marine mammal sightings were recorded, whether pinniped or cetacean, in-water or hauled out (i.e., on land). Observers monitored the shoreline constantly when in view, and scanned the water periodically for sightings (**Figure 3**). In-water sightings up to 1 km offshore were recorded by ground-based observers. Distance to in-water sightings was recorded using handheld 7 × 50 reticle binoculars (Fujinon FMTRC-SX). Distance to hauled-out seal sightings was obtained using a laser range-finder. Magnetic bearing to each sighting, in degrees, was obtained using a digital compass. Collected data fields included, but were not limited to, species, number of animals, presence of pups/calves, observer location, distance to sighting, bearing to sighting, presence of flipper tags, and behavior. High-resolution, georeferenced photos were taken of each seal sighting using a digital single-lens reflex camera (Canon 7D) equipped with an EF 100 to 400-millimeter f/4.5-5.6L IS USM zoom lens, available 1.4x or 2x teleconverters, and camera-mounted global positioning system (GPS) receivers (GP-E2) to append location metadata to all photographs. Each team carried a handheld GPS unit (Garmin GPSMAP 60CSx) configured to record trackline points every 30 seconds. Waypoints were also entered for each sighting and for areas of interest related to terrain, shoreline accessibility, etc. Applicable MHI HMS observation protocols were followed at all times. Survey crew coordinated with appropriate National Marine Fisheries Service (NMFS) staff prior to the start of the survey to ensure that data collection protocols, including collection of photographs/video, complemented NMFS protocols. Appropriate permissions were obtained from the Niihau Robinson family to survey on Niihau, and residents of the island served as guides for the ground-based team when circumnavigating the island.

Because this was a pilot study, successes or challenges encountered on the ground-based survey were thoroughly documented. For example, areas that were difficult to survey by vehicle due to rough terrain, absence of roads, obstructions, or other factors were recorded by the ground-based teams descriptively, and also by entering waypoint locations into handheld GPS units identifying these landscape features. Relative visual availability of these areas from ground-based platforms was then compared to visibility of these areas from a helicopter during data analysis. Comparisons were also made of the number and location of animals sighted from land vs. from the air, as a way to assess the relative detectability of animals using both techniques.

Three teams performed the ground-based surveys, dividing the island shoreline roughly into thirds. The northeastern shoreline from Poeha to Oiamoi is characterized by mountainous terrain and rocky cliffs, and following the recommendation of the Niihau Robinson family,

ground-based teams did not attempt to survey this area (**Figure 3**, approximately 16 km in length). The total length of the Niihau shoreline is approximately 72 km. The southeast shoreline was surveyed from horseback. Each team consisted of a marine biologist/observer, and two to three Niihau residents who served as guides. Per-team shoreline coverage (**Figure 3**) was divided roughly as follows:

Team 1 (Vehicle): Poeha to Keawanui Bay, 25 km
Team 2 (Horseback): Oiamoi to Kawaihoa Point, 11 km
Team 3 (Vehicle): Kawaihoa Point to Kaununui, 52 km.

Since the teams were required to remain 91 m away from seals in accordance with NMFS guidelines, actual seal locations were calculated indirectly using: (1) estimated distance to sighting; (2) magnetic bearing to sighting, in degrees; and (3) observer location. For offshore marine mammal sightings, a fourth data point, observer elevation, was used to calculate sighting location using appropriate trigonometric functions (Bailey and Lusseau 2004, Frankel et al. 2009). Observer elevation was collected in the field using an altimeter, and then ground-truthed in a geographic information system (Esri ArcMap 10.1) using a digital U.S. Geological Survey topographic map of Niihau (http://www.usgs.gov/pubprod/maps.html). All sighting and effort information was entered into a geodatabase; animal locations were calculated and plotted, and effort was mapped with coastline accessibility indicated by trackline color.

Prior to arrival on Niihau, the ground-based crew was required to freeze and/or disinfect clothes, shoes, and other gear to avoid the introduction of non-native species to the island. All gear was visually inspected for visible soil, mold, spores, fungus, seeds, eggs, insects, or other animals. Gear was either frozen for 48 h prior to landing on Niihau or soaked in disinfecting solution for at least 10 minutes (min) before washing and drying and packaging in clean luggage or containers. Biosecurity methods were adapted from those developed for visitors to Palmyra Atoll (Hathaway and Fisher 2010).

Section 3 Results

Aerial Surveys: Sightings and Effort

A total of 71 MM/ST sightings (334 individuals) was recorded across 429 km of shoreline effort (291 and 138 km for Kauai and Niihau, respectively) (**Table 1**). The overall ER for aerial surveys was 0.17 sightings/km. The ERs for Kauai and Niihau were 0.12 and 0.25, respectively. The most commonly observed species was the HMS, followed by unidentified sea turtles (**Table 1**). Ninety-four percent (n=51) of HMS were hauled out on the beaches of Niihau, which is consistent with their reported preference for secluded areas in the MHI (Baker and Johannos 2004). More HMS sightings occurred at Niihau on 22 than on 20 August (n=23 and 11, respectively).

On 20 August, aerial surveys began at 0849 on and concluded at 1157, with a total on-effort survey time of 2 h and 20 min. On 22 August, aerial surveys began at 0600 and ended at 1241, with a total on-effort survey time of 6 h and 41 min. The average on-effort Beaufort sea state was 2.7 on 20 August, and 3.7 on 22 August.

Table 1. Sightings and encounter rates during aerial surveys conducted on 20 and 22 August 2013

Species	Island (Day)	No. Groups	No. Individuals	ER* (sightings/km)
Bottlenose Dolphin	Kauai (20 Aug)	2	18	0.06
	Kauai (22 Aug)	0	0	
	Total	*2*	*18*	
	Niihau (20 Aug)	0	0	0
	Niihau (22 Aug)	0	0	
	Total	*0*	*0*	
Hawaiian Monk Seal	Kauai (20 Aug)	3	3	0.01
	Kauai (22 Aug)	0	0	
	Total	*3*	*3*	
	Niihau (20 Aug)	11	17	0.37
	Niihau (22 Aug)	23	34	
	Total	*34*	*51*	
Spinner Dolphin	Kauai (20 Aug)	1	12	0.20
	Kauai (22 Aug)	1	45	
	Total	*2*	*57*	
	Niihau (20 Aug)	1	130	0.01
	Niihau (22 Aug)	0	0	
	Total	*1*	*130*	
Unidentified Dolphin	Kauai (20 Aug)	0	0	0.10
	Kauai (22 Aug)	2	30	
	Total	*2*	*30*	
	Niihau (20 Aug)	0	0	0
	Niihau (22 Aug)	0	0	
	Total	*0*	*0*	
Unidentified Sea Turtle	Kauai (20 Aug)	7	7	0.16
	Kauai (22 Aug)	20	38	
	Total	*27*	*45*	
	Niihau (20 Aug)	0	0	0
	Niihau (22 Aug)	0	0	
	Total	*0*	*0*	
GRAND TOTAL:		**71**	**334**	

Ground-based Survey: Sightings and Effort

There were 31 sightings made during the ground-based survey. The vast majority (93.5 percent; *n*=29 sightings) of these were of HMS (**Table 2**). Forty-three individual seals were recorded, and eight seal sightings were of mother-pup pairs (see **Appendix B**). All HMS sightings were of animals hauled out on land, or in the shallows within 5 m of shore. One mother-pup pair was observed nursing. All other HMS sightings were of animals resting, with the exception of two sightings of three seals foraging in shallow water, swimming in tight circles and turning over rocks to find food. Team 3 sighted a group of about 40 spinner dolphins north of Keanahake Bay approximately 750 m offshore at 1008 (**Figure 4**). Team 2 sighted a group of unidentified cetaceans in the same general area approximately 250 m offshore at 1059, and this was likely the same group of spinner dolphins sighted by Team 3. Both sightings occurred in a Beaufort sea state of 3, indicating that large wavelets and scattered whitecaps were present. (Sea state was not recorded for any monk seal sighting, since these sightings were all on land, or in shallow water close to shore.) The total ER for the ground-based survey, calculated as the number of sightings per kilometer of effort, was 0.35 sightings/km. Team 1 had an ER of 0.73 sightings/km, Team 2 (on horseback) had an ER of 0.09 sightings/km, and Team 3 had an ER of 0.23 sightings/km.

Table 2. Comparison of sightings from aerial and ground-based platforms at Niihau on 20 August 2013

Species	Survey Type	No. Groups	No. Individuals	ER* (sightings/km)
Hawaiian Monk Seal	Aerial	11	17	0.16
	Ground	29	43	0.33
Spinner Dolphin	Aerial	1	130	0.01
	Ground	1	40	0.01
Unidentified Cetacean	Aerial	0	0	0
	Ground	1	-	0.01
Total		**45**	**231**	

Note: *Based on shoreline effort only (not including transits)

Three seals were observed with identifying tags/bleach marks (see **Figures B-1, B-2** and **B-3**). At latitude 21.97765882, longitude -160.1137188 (decimal degrees), Team 1 observed an adult female seal with an "N14" bleach mark on her flank. According to a website maintained by NMFS' Pacific Islands Fisheries Science Center, this animal, also referred to as "RK28," was first documented on Kauai in 2003. At 21.99275, -160.110533, Team 1 also observed an adult female with a "V14" bleach mark on her flank. This animal, also referred to as "RK14," was first documented in 2006, and was last seen on the north shore of Kauai in March 2011. At 21.81346958, -160.2426181, Team 3 observed a seal with an orange flipper tag that read "7GY." Tag identification revealed this animal to be an adult male, also referred to as T21M, who was relocated to the MHI from Laysan Island in the Northwestern Hawaiian Islands (Littnan et al. 2012). As part of a U.S. Pacific Fleet--funded study of HMS habitat use and behavior in the HRC, T21M was captured on 15 July 2011 on Oahu and instrumented with flipper tags (7GY/7GZ) as well as a cell phone tag (#11813), which recorded this animal's movements over the course of several months (Littnan et al. 2012). Tag data revealed that T21M traveled extensively amongst Oahu, Kauai, and Niihau, with dive depths ranging from 17 to 38 m and durations of 6 to 8 min (Littnan et al. 2012).

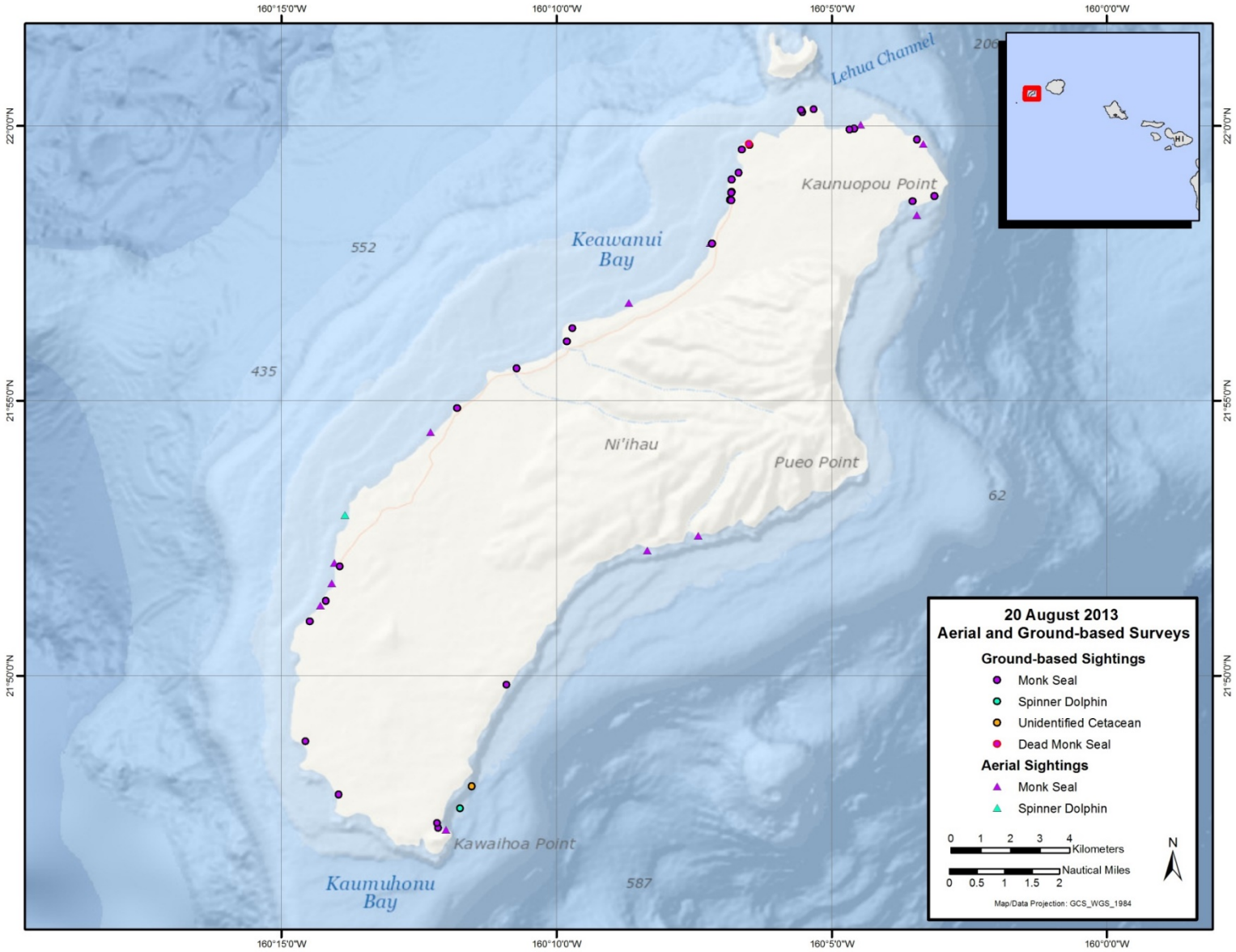

Figure 4. Comparison of sightings from aerial and ground-based survey platforms: 20 August 2013.

At 1512, Team 1 observed a dead HMS at the water's edge at 21.99445255, -160.1084496 (see **Figures C-1 and C-2**). The carcass was heavily parasitized, had been mummified and rehydrated, and likely did not die in the spot where it was found. The carcass was wrapped in plastic and later brought to a NMFS facility in Honolulu for necropsy. The carcass was x-rayed and revealed no evidence of bullets or fish hooks. Two teeth remained in the lower jaw, analysis of which revealed that the animal was a juvenile male, approximately 2 years old, in good body condition at the time of death. The cause of death could not be determined (J. Thomton 2015).

The ground-based survey began at 0942 on 20 August and concluded at 1747, for a total survey time of 8 h and 5 min. The three teams covered roughly 78 percent of the total island shoreline. Team 1 (in vehicle/on foot) covered 24.66 km, Team 2 (on horseback) covered 10.72 km, and Team 3 (in vehicle/on foot) covered 51.96 km, for a total trackline length of 87.34 km (54.27 miles). Of these, 9.08 km were identified as having limited shoreline accessibility (red trackline coloration, **Figure 3**). Typically, when roads or tracks did not permit an unobstructed view of the shore, the crew would exit the vehicle and access the beach on foot, then return to the vehicle to resume the survey. This resulted in frequent "backtracking" to ensure no animals or shoreline portions were missed, which resulted in the total effort (87.34 km) exceeding the total island circumference (72 km). Tracklines colored red in **Figure 3** did not indicate that observers were unable to access the shoreline at these points; rather, that visual coverage was not possible from the platform in question and the observers had to either dismount or exit the vehicle to gain visual coverage of the shore and nearshore waters.

Platform Performance Comparison

On 20 August, when both aerial- and ground-based surveys were conducted, ground teams recorded more HMS sightings than did aerial observers (n=29 and 11 sightings, respectively) as well as more sightings overall (n=31 vs. 12 sightings, respectively, **Table 2**). The ground-based crew also found a carcass of an HMS, which the aerial team did not detect, although this may be a result of the highly decomposed nature of the carcass (the nearest aerial sighting was at a distance of 3.6 km). Even from the ground, HMSs were often difficult to distinguish when on dark-colored reefs and lava outcroppings that characterize the northern and western shorelines of Niihau (see **Figure B-3**). Observers on the ground were better able to distinguish seals in these areas than observers in the aircraft (**Figure 4**). The familiarity of resident guides with the terrain, and their knowledge of regular haul-out sites, may have played an important role in the number of HMS detected by the ground-based teams. At 1008, Team 3 (ground survey) sighted a group of about 40 spinner dolphins north of Keanahake Bay, approximately 750 m offshore of the east side of the island (**Figure 4**). Team 2 (ground survey) sighted a group of unidentified cetaceans in the same general area at 1059, and this was likely the same group of dolphins sighted earlier by Team 3. This dolphin group was not recorded by the aerial team (**Figure 4**). At 1054, the aerial team did see a group of approximately 130 spinner dolphins approximately 250 m offshore of Nonopapa, on the west side of the island (**Figure 4**). The ground-based team did not detect these animals, since Team 3, which was responsible for covering that area, did not arrive at this location until later in the afternoon. The aerial survey of Niihau began and ended at Kii Point, on the northeastern shoreline (**Figure 2**). The aircraft flew clockwise around the island in 47 min, beginning at 1029 and ending at 1116. The ground-based crew, by contrast, took over 8 h to circumnavigate Niihau, and was unable to survey an approximate 16-km portion of the shoreline. The substantially longer duration of the ground-based surveys vs. aerial surveys may also account for the comparatively higher number of sightings recorded by ground-based observers.

Section 4 Discussion

The overall objective of aerial and ground-based shoreline surveys was to answer the monitoring question, "Do marine mammals strand along shorelines of the MHI within 1 week following naval training events?" Therefore, the relative ability of observers on each of these platforms to detect animals on/near the Niihau shoreline is the primary criterion by which these platforms should be evaluated in this context. Observers on the ground platforms recorded more sightings (but fewer total individuals) than those in the helicopter on 20 August (*n*=31 sightings of 83 individuals, and 12 sightings of 147 individuals, respectively; **Table 2**). Aerial observers recorded 23 HMS sightings of 34 individuals on 22 August, closer to the number seen by the ground crew on 20 August (*n*=29 sightings of 43 individuals). This is likely because Keith Robinson, a member of the Niihau Robinson family, was part of the aerial crew on 22 August (but not on 20 August) and provided local knowledge of where HMSs typically haul out on Niihau. The pilot consequently focused on these areas, slowing speed to allow the observer to obtain HMS counts and more detailed sighting information than would normally be dictated by aerial shoreline survey protocol. Even though these sighting numbers cannot be compared directly, since different numbers of seals may have been present at Niihau on each of these days, it is possible that if the aerial survey on 20 August focused effort on known haulout sites (as it did on 22 August), higher numbers of HMS could have been detected.

On 20 August, more individual seals were seen on the ground than from the air (*n*=43 and 17 sightings, respectively; **Table 2**). Additionally, the ground survey team found the HMS carcass on the northern coast of Niihau, while the aerial observers did not. Overall, more individual animals were seen from the air than on the ground (*n*=147 and 83, respectively), although 130 animals composed a single sighting (i.e., group) of spinner dolphins (**Table 2**). The aerial survey, however, circumnavigated Niihau in less than 1/8 the amount of time required for the ground-based survey. The ground teams were able to gather more detailed HMS sighting data, including photos, flipper tag markings, and behavioral information, but seals were used primarily as a proxy for stranded animals, and these data (although useful) were not central to the goals of this study. All photographs were provided to the NMFS Pacific Island Fisheries Science Center's Hawaiian Monk Seal Research Program.

The aerial survey protocol required monitoring nearshore areas up to 3 km offshore, whereas ground-based teams only monitored waters up to 1 km offshore. The aerial observers therefore had more expanded visual coverage of nearshore waters. The legal definition of a stranding states that these can occur in "waters under the jurisdiction of the United States (including any navigable waters)." Therefore, although ground-based observers achieved superior coverage along the island shoreline, they did not attempt broad coverage of nearshore waters. However, it should be noted that the farthest offshore sighting made by the aerial survey team was only 735 m from shore.

It is likely that, for the portion of the island shoreline surveyed (~78 percent), ground-based teams achieved thorough coverage of the shoreline and nearshore waters of Niihau. However, in order to achieve this coverage, it was often necessary for observers in vehicles to exit the vehicle and conduct frequent side trips on foot to maintain shore visibility. Therefore, although it was possible to maintain continual visual coverage of the shoreline, the process was effort-intensive and time-consuming. However, the ability of the ground crew to slow down or stop in order to look for sightings improved the ER on the ground. Likewise, the ability to inspect complex

coastal areas, particularly dark-colored reefs and lava outcroppings, was a significant advantage and resulted in an improved ability to distinguish HMSs, which were sometimes cryptic against the shorescape.

Lessons Learned

With the help of Niihau residents, the ground-based survey teams were able to identify coastal island routes which maximized shoreline accessibility throughout the survey, although the teams' progress was relatively slow and involved frequent backtracking. These routes, identified in **Figure 3**, could be appropriate for patrolling the shoreline on a regular basis. One lesson learned during this pilot study was that the Niihau shoreline might be more efficiently surveyed using four, rather than three, teams. More time on the ground may have provided observers with more opportunities to determine the sex of monk seals, and possibly record additional marks or features that would allow further identification of individual animals. Although the ground-based survey took more than 8 h to complete, observers were challenged to complete their portion of shoreline coverage on schedule, and at times had to forego detailed data collection to ensure the three teams were able to reconvene at the pre-assigned time and location at survey completion. For example, the observer in Team 2 was not able to dismount frequently in order to record detailed effort/terrain data. Team 3 observers were delayed by the sighting of the dead HMS, since it took approximately 20 min to communicate with NMFS, to make arrangements for a necropsy, and to bag the animal for transport to Oahu. Team 3 in turn was required to cover an additional approximate 16 km along the shoreline of Keawanui Bay, which was originally assigned to Team 1. As a result, the Team 1 observer was somewhat rushed, and in many cases did not have enough time to record distance and bearing to HMS sightings. In these cases, animal positions were estimated from observer position. Team 3 encountered multiple sections of road that were either far from the beach or otherwise inaccessible to the shoreline. In these cases, the observer exited the vehicle and covered the survey leg on foot. Therefore, survey gear was constrained to what could be easily carried. More than half of Team 3's time budget was comprised of hiking along areas of shoreline inaccessible to the survey vehicle.

In summary, results of the pilot study indicated the following:

- A ground-based survey is more likely to detect HMS or dead/stranded marine mammals on the beach or in nearshore waters
- An aerial survey is more likely to detect stranded or distressed animals 1 to 3 km from shore
- Niihau residents' local knowledge of terrain and haul-out sites likely contributed to the number of HMS sightings during aerial surveys on 22 August
- Likewise, residents' local knowledge of terrain and haul-out sites likely contributed to the number of HMS sightings during the ground survey on 20 August
- Scent is an additional cue for detecting dead marine mammals during ground surveys vs. aerial surveys
- Aerial surveys cover more terrain than ground-based surveys in less time.

Section 5 Acknowledgements

The authors would like to thank the Niihau Robinson family for their guidance and assistance with this project; Dr. Charles Littnan for providing guidance on HMS observation and data collection protocols; pilots Bernard "Brodi" Brodigan and Dana Rosendal; and U.S. Navy personnel from U.S. Pacific Fleet Environmental and Naval Facilities Engineering Command Pacific for their support, coordination, and facilitation in the implementation of these surveys. Special thanks are due to Jamie Thomton and Tracy Wurth at NMFS PIFSC, and to aerial observers Michael Richlen and Alexis Rudd. All aerial survey observations were made in accordance with NOAA permit no. 14451 issued to Joseph R. Mobley, Jr.

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Appendix A: Locations of Sightings

Table A-1: Aerial Sightings

Date	Time (HST)	Species	# Individuals	Latitude (N)	Longitude (W)
8/20/2013	9:12:18	Unid Sea Turtle	1	22.236646	-159.466502
8/20/2013	9:12:42	Unid Sea Turtle	1	22.237627	-159.479735
8/20/2013	9:15:34	Unid Sea Turtle	1	22.233944	-159.550527
8/20/2013	9:16:35	Bottlenose Dolphin	16	22.238075	-159.546952
8/20/2013	9:26:31	Unid Sea Turtle	1	22.167889	-159.703776
8/20/2013	9:26:57	Unid Sea Turtle	1	22.163967	-159.715228
8/20/2013	9:33:28	Spinner Dolphin	12	22.070419	-159.782133
8/20/2013	9:38:27	Bottlenose Dolphin	2	22.031926	-159.798535
8/20/2013	9:51:10	Unid Sea Turtle	1	21.904204	-159.627766
8/20/2013	9:52:10	Unid Sea Turtle	1	21.89798	-159.610745
8/20/2013	10:33:21	Monk Seal	1	21.972953	-160.055679
8/20/2013	10:38:54	Monk Seal	3	21.875628	-160.126513
8/20/2013	10:40:24	Monk Seal	2	21.871253	-160.142042
8/20/2013	10:45:35	Monk Seal	1	21.786565	-160.202691
8/20/2013	10:52:40	Monk Seal	1	21.854579	-160.240619
8/20/2013	10:52:57	Monk Seal	1	21.861282	-160.237146
8/20/2013	10:53:21	Monk Seal	2	21.867417	-160.235711
8/20/2013	10:54:26	Spinner Dolphin	130	21.881997	-160.229592
8/20/2013	10:57:59	Monk Seal	1	21.907053	-160.207629
8/20/2013	11:01:21	Monk Seal	1	21.946345	-160.146799
8/20/2013	11:04:10	Monk Seal	2	21.964478	-160.121889
8/20/2013	11:09:28	Monk Seal	2	22.000338	-160.075613
8/20/2013	11:11:35	Monk Seal	1	21.994559	-160.056457
8/20/2013	11:41:34	Monk Seal	1	21.882881	-159.523828
8/20/2013	11:41:46	Monk Seal	1	21.883522	-159.521973
8/22/2013	9:38:00	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:39:27	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:43:16	Monk Seal	2	21.989327	-159.29527
8/22/2013	9:43:39	Monk Seal	2	21.989327	-159.29527
8/22/2013	9:44:54	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:45:28	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:46:09	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:46:29	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:46:53	Monk Seal	2	21.989327	-159.29527

Date	Time (HST)	Species	# Individuals	Latitude (N)	Longitude (W)
8/22/2013	9:47:13	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:48:05	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:48:38	Monk Seal	2	21.989327	-159.29527
8/22/2013	9:50:00	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:50:19	Monk Seal	2	21.989327	-159.29527
8/22/2013	9:53:18	Monk Seal	3	21.989327	-159.29527
8/22/2013	9:54:56	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:55:29	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:55:55	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:57:19	Monk Seal	1	21.989327	-159.29527
8/22/2013	9:59:40	Monk Seal	2	21.989327	-159.29527
8/22/2013	10:02:51	Monk Seal	1	21.989327	-159.29527
8/22/2013	10:05:07	Monk Seal	2	21.989327	-159.29527
8/22/2013	10:09:08	Monk Seal	3	21.989327	-159.29527
8/22/2013	11:07:35	Unid Sea Turtle	6	21.989327	-159.29527
8/22/2013	11:08:23	Unid Sea Turtle	4	21.989327	-159.29527
8/22/2013	11:09:14	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:09:39	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:10:03	Unid Sea Turtle		21.989327	-159.29527
8/22/2013	11:10:14	Unid Sea Turtle	4	21.989327	-159.29527
8/22/2013	11:10:26	Unid Sea Turtle	3	21.989327	-159.29527
8/22/2013	11:10:58	Unid Sea Turtle	2	21.989327	-159.29527
8/22/2013	11:11:31	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:12:17	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:13:50	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:14:42	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:14:47	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:24:58	Spinner Dolphin	45	21.989327	-159.29527
8/22/2013	11:25:34	Unid Sea Turtle	3	21.989327	-159.29527
8/22/2013	11:25:59	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:27:47	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:30:53	Unid Dolphin	22	21.989327	-159.29527
8/22/2013	11:37:30	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:37:52	Unid Sea Turtle	2	21.989327	-159.29527
8/22/2013	11:47:35	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	11:48:09	Unid Sea Turtle	1	21.989327	-159.29527
8/22/2013	12:36:45	Unid Dolphin	8	21.989327	-159.29527

Table A-2: Ground-based Sightings

Date	Time (HST)	Species	# Individuals	Latitude (N)	Longitude (W)
8/20/2013	10:42:25	Monk Seal	1	21.97716	-160.058778
8/20/2013	11:19:31	Monk Seal	1	21.97871	-160.05222
8/20/2013	12:05:28	Monk Seal	2	21.99586	-160.057446
8/20/2013	13:06:28	Monk Seal	2	21.99921	-160.076491
8/20/2013	13:19:20	Monk Seal	2	21.999	-160.07791
8/20/2013	14:21:18	Monk Seal	1	22.00505	-160.088814
8/20/2013	14:28:03	Monk Seal	1	22.00424	-160.092134
8/20/2013	14:29:40	Monk Seal	1	22.00477	-160.09267
8/20/2013	15:07:16	Monk Seal	1	21.99422	-160.108182
8/20/2013	15:12:18	Monk Seal*	1	21.99445	-160.108450
8/20/2013	16:02:39	Monk Seal	4	21.99275	-160.110533
8/20/2013	16:36:39	Monk Seal	1	21.98586	-160.111517
8/20/2013	16:47:41	Monk Seal	2	21.98378	-160.113622
8/20/2013	17:03:05	Monk Seal	2	21.98	-160.11361
8/20/2013	17:05:52	Monk Seal	2	21.97978	-160.11376
8/20/2013	17:14:41	Monk Seal	2	21.97762	-160.114177
8/20/2013	17:20:51	Monk Seal	2	21.97754	-160.113818
8/20/2013	10:59:58	Unid Cetacean		21.79979	-160.192442
8/20/2013	13:15:11	Monk Seal	1	21.83053	-160.181912
8/20/2013	9:52:34	Monk Seal	1	21.78718	-160.202587
8/20/2013	10:04:56	Monk Seal	1	21.78857	-160.202921
8/20/2013	10:08:06	Spinner Dolphin	40	21.79313	-160.195879
8/20/2013	11:45:34	Monk Seal	1	21.79736	-160.232671
8/20/2013	12:12:17	Monk Seal	1	21.81342	-160.242719
8/20/2013	13:07:32	Monk Seal	1	21.86648	-160.232415
8/20/2013	13:27:36	Monk Seal	1	21.85603	-160.236566
8/20/2013	13:48:33	Monk Seal	1	21.84972	-160.241488
8/20/2013	15:22:28	Monk Seal	1	21.91439	-160.196873
8/20/2013	16:34:24	Monk Seal	2	21.93464	-160.163598
8/20/2013	16:44:37	Monk Seal	1	21.93864	-160.161878
8/20/2013	17:38:00	Monk Seal	4	21.96431	-160.119576

*Sighting at 15:12:18 was of a monk seal carcass.

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Appendix B: Photographic Catalog of Hawaiian Monk Seals Observed on Niihau, 20 August 2013

(Photo credit by individual animal: #1-2 & #6-28 J. Rivers, COMPACFLT; #29 M. Richie, NAVFAC PAC; #3-5 & #30-43 R. Uyeyama, NAVFAC PAC)
(Age-sex class and bleach/tag identifications provided by Tracy Wurth, NMFS PIFSC, pers. comm.)

Identified animals (via unique markings or tags):

Figure B-1(a) and (b). Nursing adult female RK14 (individual #1, bleach mark V14, [a]), and the same female with pup (individual #2, sex unknown, [b]).

Figure B-2(a) and (b). Nursing adult female RK28 (individual #3, bleach mark N14, [a]), and the same female with male pup (individual #4, [b]).

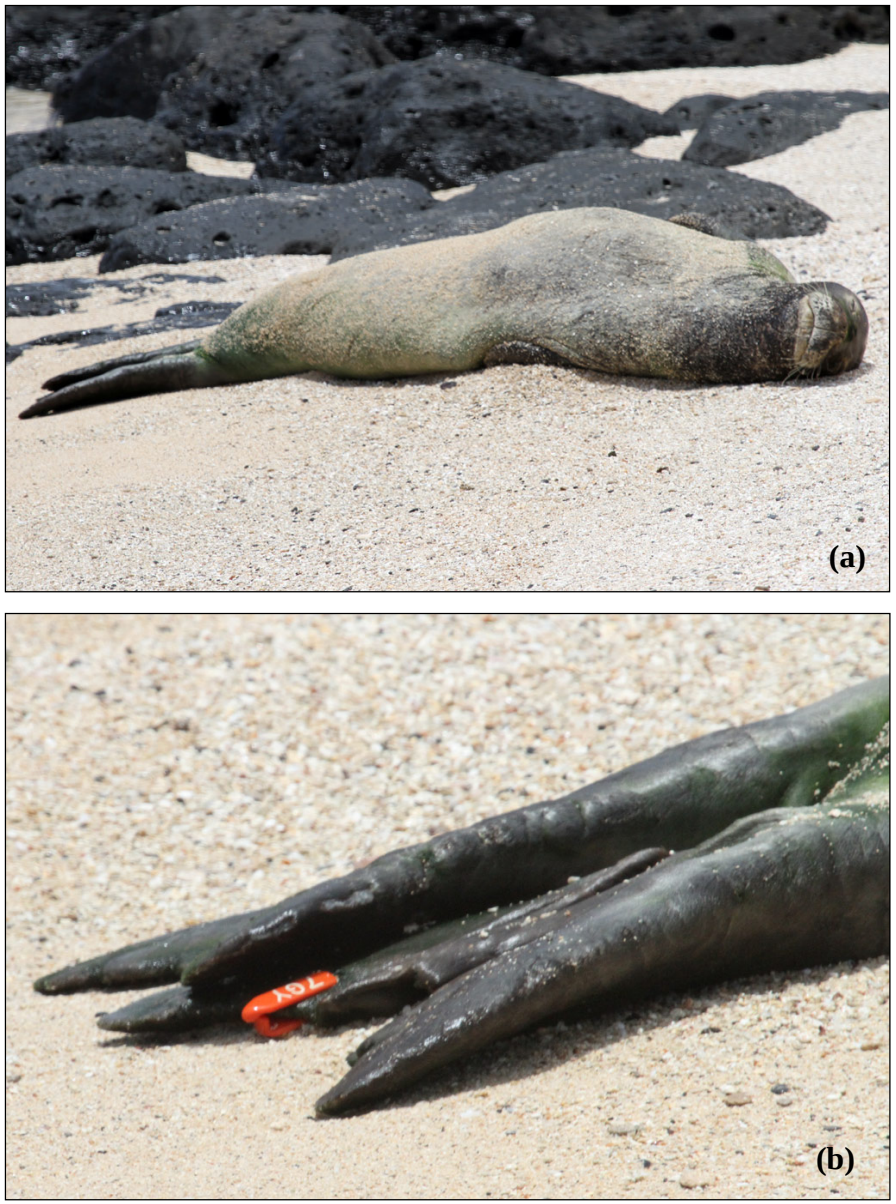

Figure B-3(a) and (b). Adult male T21M, individual #5 (flipper tag 7GY).

Unidentified animals:

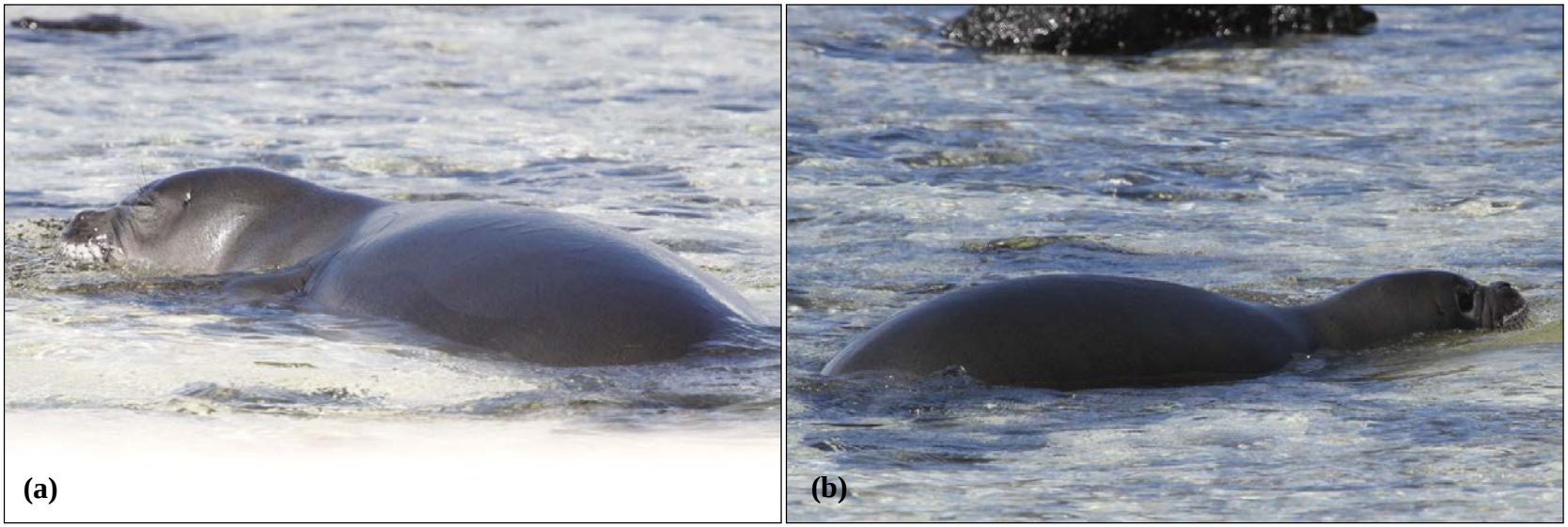

Figure B-4(a) and (b). Weaned pup (individual #6, sex unknown).

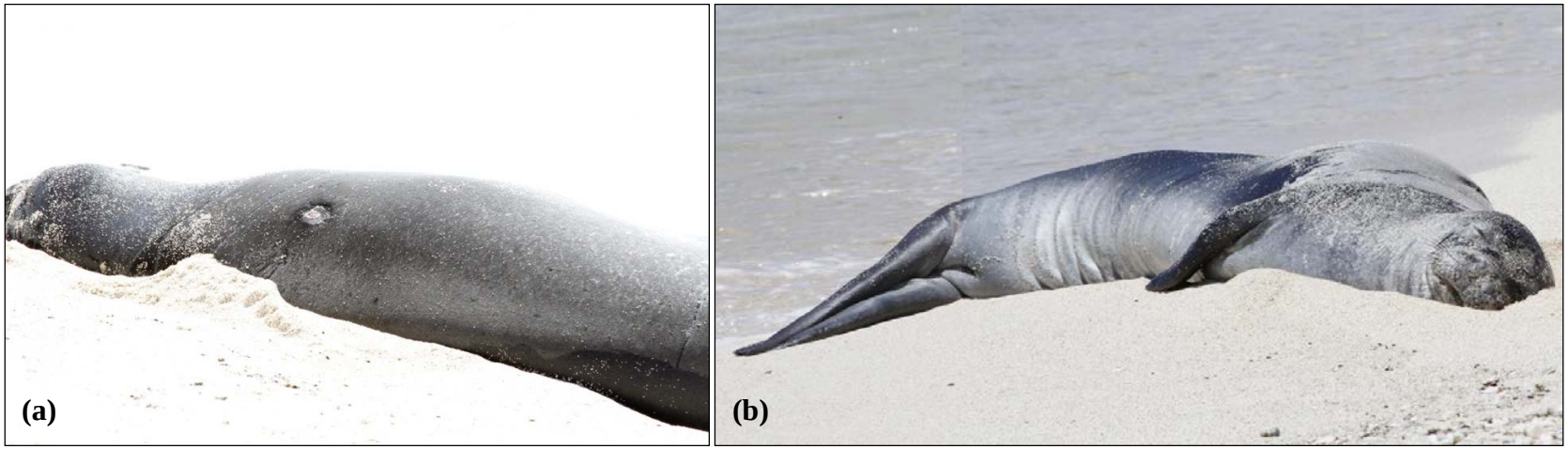

Figure B-5(a) and (b). Adult female, individual #7.

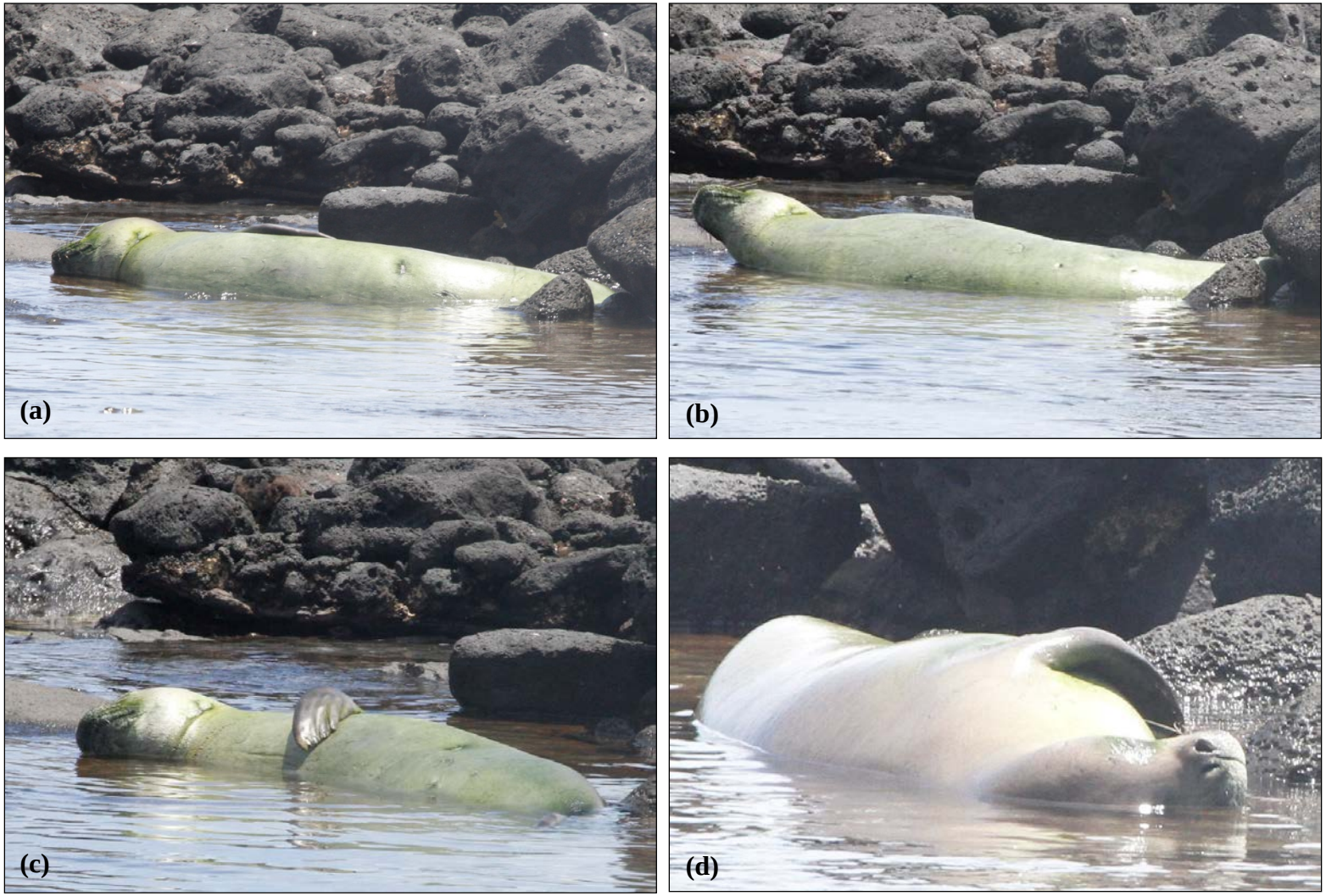

Figure B-6 (a-d). Juvenile female, individual #8.

Figure B-7(a) and (b). Adult (individual #9, sex unknown).

Figure B-8(a) and (b). Adult female (individual #10, [a]) with pup (individual #11, [b]).

Figure B-9. Nursing adult female (individual #12) and pup (individual #13, sex unknown).

Figure B-10. Immature (individual #14, sex unknown).

Figure B-11(a) and (b). Adult male, individual #15.

Figure B-12. Adult male, individual #16.

Figure B-13(a) and (b). Female (individual #17, unknown age class).

Figure B-14. Adult female (individual #18) and pup (individual #19).

Figure B-15(a) and (b). Adult (individual #20, sex unknown).

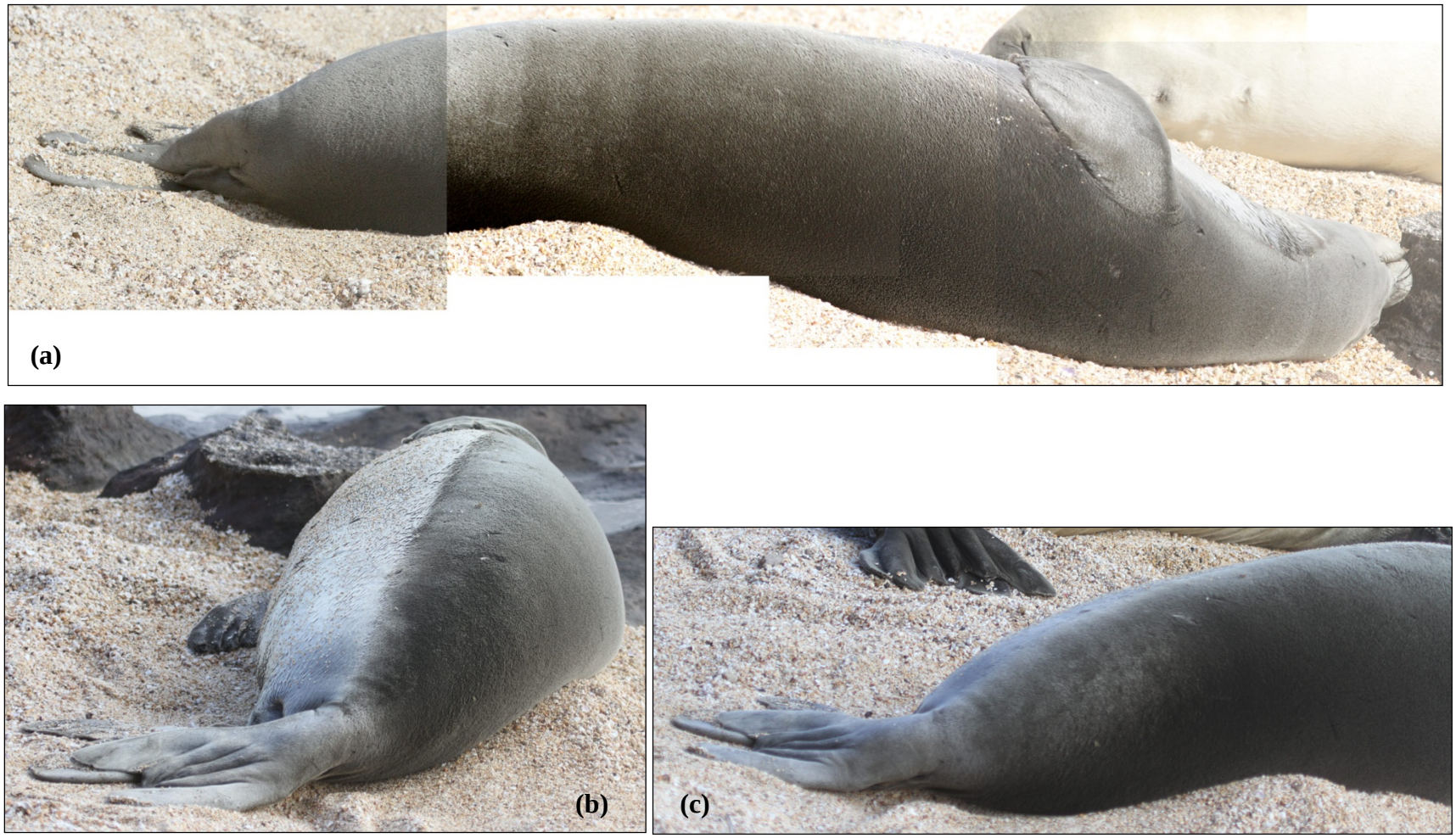

Figure B-16(a-c). Weaned pup (individual #21, female).

Figure B-17(a) and (b). Weaned pup (individual #22, male).

Figure B-18(a) and (b). Adult female (individual #23) and pup (individual #24, sex unknown).

Figure B-19. Weaned pup (individual #25, sex unknown).

Figure B-20. Weaned pup (individual #26, sex unknown).

Figure B-21(a) and (b). Weaned pup (individual #27, sex unknown, [a]) and the same animal with an immature (individual #28, sex unknown, [b]).

Figure B-22(a-c). Juvenile female, individual #29.

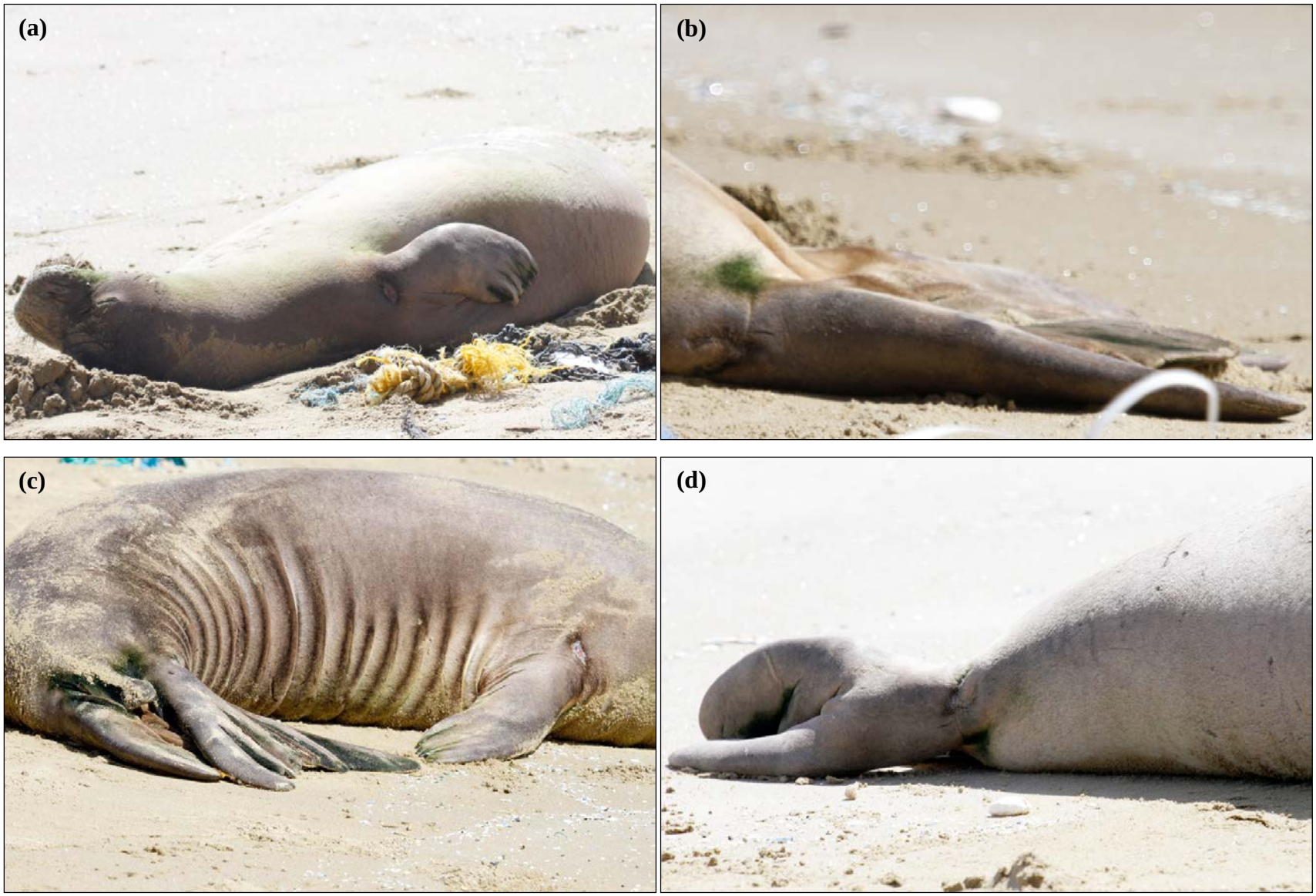

Figure B-23(a-d). Adult (individual #30, sex unknown).

Figure B-24(a-d). Juvenile male, individual #31.

Figure B-25(a) and (b). Individual #32 (unknown age class and sex).

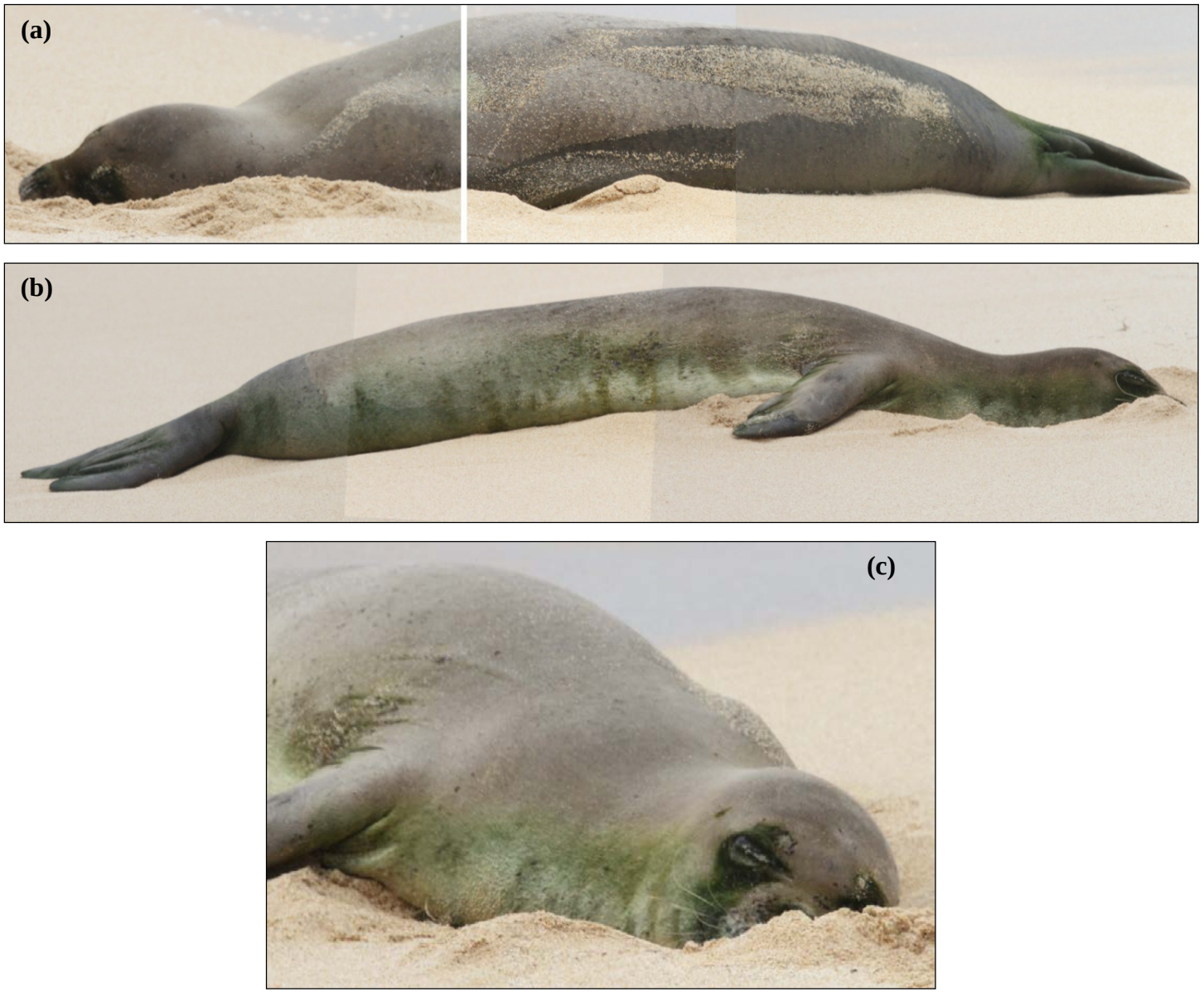

Figure B-26(a-c). Adult (individual #33, unknown sex).

Figure B-27(a) and (b). Adult (individual #34, unknown sex).

Figure B-28(a-c). Adult male, individual #35.

Figure B-29(a) and (b). Juvenile male, individual #36.

Figure B-30(a) and (b). Individual #37 (unknown age class and sex).

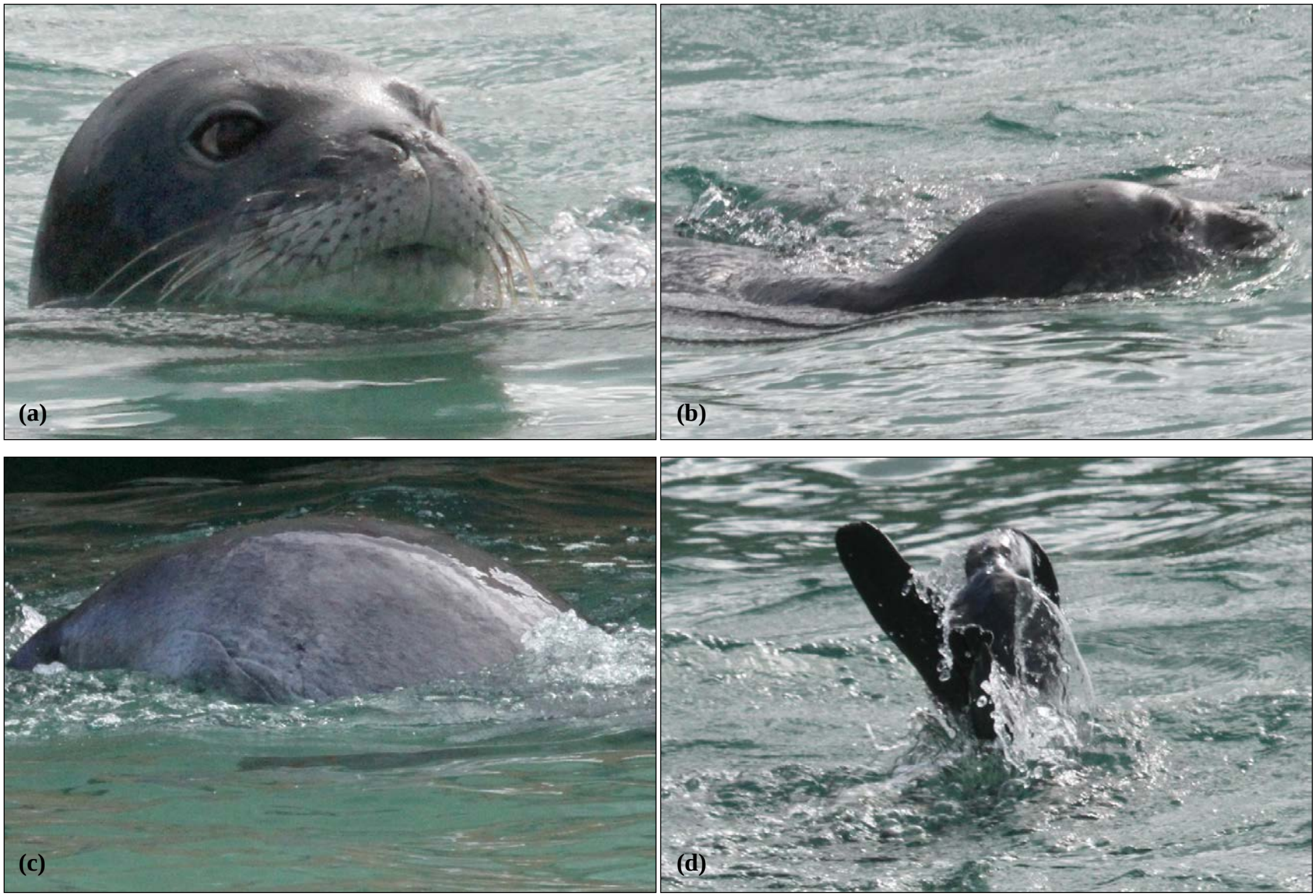

Figure B-31(a-d). Individual #38 (unknown age class and sex).

Figure B-32(a-c). Juvenile (individual #39, unknown sex).

Figure B-33(a-d). Adult female (individual #40, [a-d]) with pup (individual #41, [d]).

Figure B-34(a) and (b). Male pup (individual #41, mother is individual #40).

Figure B-35(a-c). Adult female, individual #42.

Figure B-36(a) and (b). Pup (individual #43, sex unknown, mother is individual #42).

Appendix C: Other Photos

Figure C-1. Hawaiian monk seal carcass found on the northwest shoreline of Niihau. Photographed 20 August 2013, by J. Rivers, COMPACFLT.

Figure C-2. Monk seal carcass found on the northwest shoreline of Niihau.
Note that the carcass is quite cryptic against the rocky shoreline and might easily be missed by aerial survey crews.
Photographed 20 August 2013, by J. Rivers, COMPACFLT.

Figure C-3. Spinner dolphin observed during ground-based survey. Photographed 20 August 2013, by R. Uyeyama, NAVFAC PAC.

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