Cetacean and Seabird Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July–December 2017

Kymberly M. Yano, Erin M. Oleson, Jennifer L. Keating, Lisa T. Ballance, Marie C. Hill, Amanda L. Bradford, Ann N. Allen, Trevor W. Joyce, Jeffrey E. Moore, and Annette Henry

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Pacific Islands Fisheries Science Center
NOAA Technical Memorandum NMFS-PIFSC-72

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Ocean Energy Management
OCS Study BOEM 2018-044

https://doi.org/10.25923/7avn-gw82
August 2018

Cetacean and Seabird Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July–December 2017

Kymberly M. Yano[1], Erin M. Oleson[2], Jennifer L. Keating[1], Lisa T. Ballance[3], Marie C. Hill[1], Amanda L. Bradford[2], Ann N. Allen[2], Trevor W. Joyce[3], Jeffrey E. Moore[3], and Annette Henry[3]

[1]Joint Institute for Marine and Atmospheric Research
University of Hawai‘i
1000 Pope Road
Honolulu, HI 96822

[2]Pacific Islands Fisheries Science Center
National Marine Fisheries Service
1845 Wasp Boulevard
Honolulu, HI 96818

[3]Southwest Fisheries Science Center
National Marine Fisheries Service
8901 La Jolla Shores Drive
La Jolla, CA 92037

NOAA Technical Memorandum NMFS-PIFSC-72
August 2018

U.S. Department of the Interior
Bureau of Ocean Energy Management
OCS Study BOEM 2018-044

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Oceanic and Atmospheric Administration
RDML Tim Gallaudet, Ph.D., USN Ret., Acting NOAA Administrator

National Marine Fisheries Service
Chris Oliver, Assistant Administrator for Fisheries

Recommended citation:

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July–December 2017. NOAA Tech. Memo. NMFS-PIFSC-72, 110 p. https://doi.org/10.25923/7avn-gw82.

Copies of this report are available from:

Science Operations Division
Pacific Islands Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
1845 Wasp Boulevard, Building #176
Honolulu, Hawai‘i 96818

Or online at:

https://www.pifsc.noaa.gov/library/

https://marinecadastre.gov/espis/#/

The content of this report, in part, fulfills the requirements of an Interagency Agreement between the Bureau of Ocean Energy Management and the National Marine Fisheries Service (BOEM Agreement Number M17PG00024; NOAA Agreement Number NMFS-PIC-17-005).

Cover: Photo of a false killer whale (*Pseudorca crassidens*) in the foreground and the NOAA Ship *Oscar Elton Sette* in the background. Photo courtesy of NOAA Fisheries/Paula Olson.

Table of Contents

List of Tables

List of Figures

Project Overview

The Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) of 2017 was a large-scale ship survey for cetaceans and seabirds within U.S. waters surrounding the Hawaiian Islands. HICEAS 2017 was the third of its kind using many of the same methods and encompassing the same study area as surveys which occurred in 2002 (Barlow *et al.* 2006) and 2010 (Bradford *et al.* 2017). The 2017 survey represented the first Cetacean and Ecosystem Assessment Survey conducted as part of the Pacific Marine Assessment Program for Protected Species (PacMAPPS), a partnership between NOAA Fisheries, Bureau of Ocean Energy Management (BOEM), U.S. Navy, and U.S. Fish and Wildlife Service. PacMAPPS includes rotational ship surveys in regions of joint interest throughout the Pacific designed to estimate the abundance of cetaceans and seabirds and to assess the ecosystems supporting these species.

HICEAS 2017 was a collaborative survey between the Pacific Islands and Southwest Fisheries Science Centers (PIFSC and SWFSC). The survey took place from 6 July to 1 December 2017, aboard the NOAA Ships *Oscar Elton Sette* and *Reuben Lasker* (hereafter referred to as the *Sette* and the *Lasker*, respectively), spanning 7 survey “legs” and 179 days-at-sea across both ships.

Survey Objectives

The primary goals of HICEAS 2017 were to collect data required to estimate the abundance and distribution, examine the population structure, and understand the habitat of cetaceans within U.S. waters around the Hawaiian Islands. There were 5 major research components to HICEAS 2017:

- visual observations for cetaceans following a line-transect survey design;
- passive acoustic monitoring for cetaceans using towed hydrophone arrays, sonobuoys, and autonomous drifting acoustic recorders;
- collection of photographs and tissue samples and deployment of satellite tags for select cetacean groups;
- visual observations for seabirds following a strip-transect survey design; and
- ecosystem measurements for assessment of cetacean and seabird habitat.

Study Area

The HICEAS 2017 study area included the waters surrounding the northwestern and main Hawaiian Islands out to 200 nmi (370.4 km) from shore, which is the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands (or Hawai‘i EEZ). The Hawai‘i EEZ was subdivided into 4 strata (Figure 1) that pertained to addressing PacMAPPS objectives or meeting regulatory and permitting requirements. The “main Hawaiian Islands (MHI) focal area” was delineated as a convex hull around a 50-nmi (92.6-km) radius of the MHI. The MHI focal area includes the known ranges of several island-associated populations of cetaceans, and additional survey effort in this region was intended to provide finer-scale data on the abundance and distribution of those populations. Such data are of interest to PacMAPPS partners, given the geographic focus of planned and ongoing activities, including potential sites for future wind-farm development by BOEM and current naval training and testing areas. The MHI focal area also formed the study area for deploying Drifting Acoustic Spar Buoy Recorders (DASBRs), passive acoustic instrumentation enabling finer-scale data collection for deep-diving and other species of vocalizing cetaceans.

The “Papahānaumokuākea Marine National Monument (PMNM) stratum” was defined as the original boundaries of the PMNM, or the waters within 50 nmi of shore of the northwestern Hawaiian Islands (NWHI). The PMNM was established in 2006 by Proclamation 8031, amended in 2007 by Proclamation 8112, and expanded in 2016 by Proclamation 9478. Although the PMNM was expanded in 2016, the management of the original and expanded areas remained somewhat separate in 2017, requiring separate tracking of effort and sightings inside and outside of the original PMNM. The PMNM stratum has also been the focus of prior cetacean assessment surveys, including finer-scale survey effort during HICEAS 2010 and the Papahānaumokuākea-Associated Cetacean and Ecosystem Survey (PACES) in 2013. The “PMNM offshore stratum” was defined as the expanded PMNM area, which includes waters from 50 nmi around the NWHI out to the 200 nmi Hawai‘i EEZ boundary, and extending eastward to 163^{o} W. The “MHI offshore stratum” was designated as the area outside of the MHI focal area, the PMNM stratum, and the PMNM offshore stratum that is within the Hawai‘i EEZ.

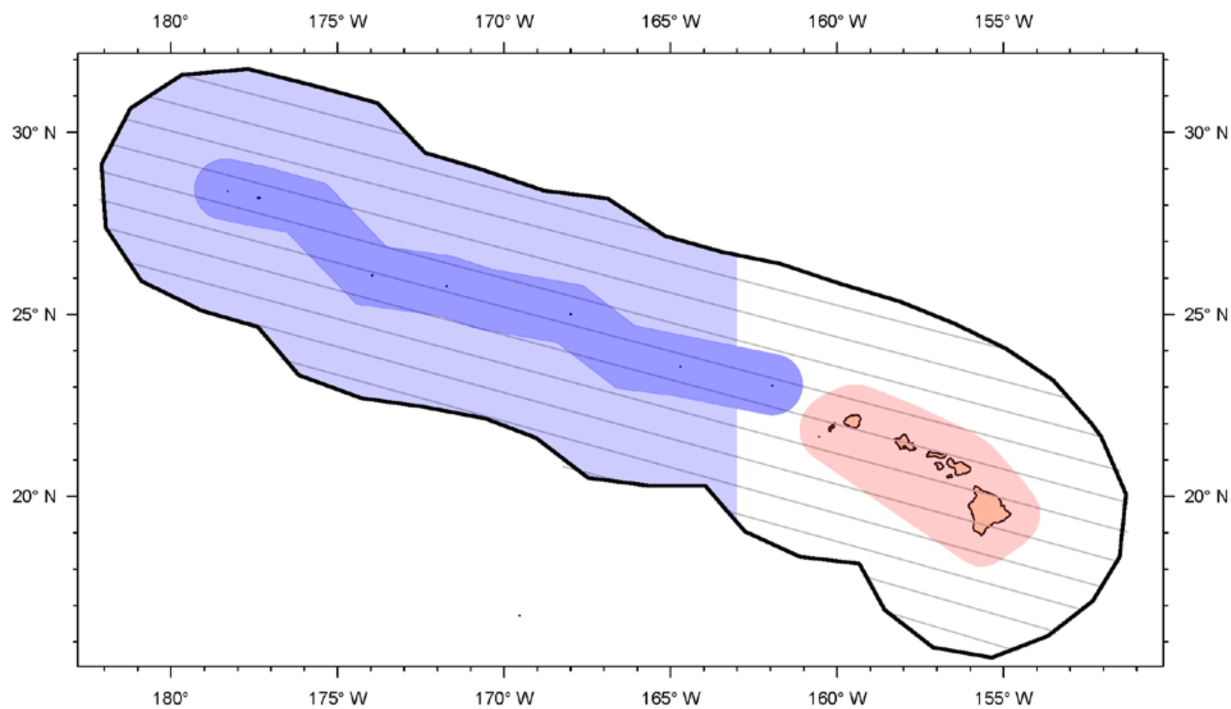


Figure 1. The HICEAS 2017 study area.

The study area was bounded by the Hawai‘i EEZ (black outline) and subdivided into the MHI focal area (red shading), the PMNM stratum (dark blue shading), the PMNM offshore stratum (light blue shading), and the MHI offshore stratum (no shading). The parallel transect lines (gray lines) formed the basis for the line-transect survey effort.

Equipment and Methods

HICEAS 2017 consisted of cetacean and seabird visual surveys during daylight hours, passive acoustic monitoring during daylight hours, passive acoustic recording at night, and oceanographic sampling while underway and at predetermined locations (fixed stations).

Cetacean Survey Operations

Ship-based visual and passive acoustic survey effort for cetaceans generally occurred along parallel transect lines (or tracklines), which were spaced 85 km apart and traversed the study area from WNW to ESE (Figure 1). The full span of an individual transect line was generally not surveyed within a single survey leg of the *Sette* or the *Lasker*, but rather portions of each line were divided among 2 or more legs (see Results and Discussion, Visual Effort). Survey effort across legs and ships was designed to provide broad coverage of the study area during each leg to avoid any seasonal bias in animal movement during the survey period.

Visual Observations

The cetacean visual survey methods used during HICEAS 2017 were developed by the SWFSC and have been used for the last 3 decades, including during HICEAS 2002 and 2010 (Barlow 2006, Bradford *et al.* 2017). These methods have been described in detail elsewhere (e.g., Kinzey *et al.* 2000), so will be summarized here. A continuous watch for cetaceans was carried out by a team of 6 cetacean observers from the flying bridge of each ship (approximately 15 m above the sea surface) during daylight hours (sunrise to sunset). The observer team rotated through 3on-effort roles (port and starboard observers and a center observer/data recorder), searching for cetaceans ahead of the vessel from the starboard beam (90° right) to the port beam (90° left) using 25×150 mounted binoculars (port and starboard observers) and 7×50 handheld binoculars or unaided eyes (center observer). Each ship followed the survey tracklines at a speed of 10 kt (18.5 km/h). When glare, rain, or other environmental conditions obscured the view along the trackline, the observer team could request a change in course up to 20° from the established transect. If viewing conditions improved, or if this deviation led the ship to 5 nmi (9.3 km) away from the trackline, the ship was directed to turn back toward the trackline at an angle of ≤ 20°. During visual search effort, observers rotated every 40 min. At each rotation, the center observer recorded which observers were on watch in each position, as well as basic environmental data (e.g., Beaufort sea state, swell height, visibility). Survey effort was suspended if conditions were unworkable (e.g., heavy precipitation, sea state of Beaufort 7 or higher).

In most cases, when a cetacean group was sighted within 3 nmi (5.6 km) of the trackline (perpendicular distance) by an on-effort observer, search effort was suspended, and the ship diverted from the trackline toward the sighting so that species identity, species composition (for mixed-species groups), and group size could be determined. If the species identity could not be determined for a sighting, the lowest possible taxonomic category was applied (e.g., unidentified beaked whale, unidentified small dolphin). At the conclusion of each sighting, the on-effort observers recorded their independent estimates of group size (“best,” “high,” and “low”) in their observer log books. Estimates of group size were not discussed among observers at any time. Note that group-size estimation protocols varied for two species, false killer whales (*Pseudorca crassidens*) and sperm whales (*Physeter macrocephalus*), see Species-Specific Protocols.

Following group-size estimation, some groups were pursued for additional data collection, including photo-identification, biopsy sampling, or satellite tagging, from either the ship's bow or a small boat launched from the ship. On occasion, cetacean groups were sighted during a small boat launch and not pursued by the ship. For these sightings, the observers on the small boat discussed and agreed on a "best" group size estimate. Small-boat sightings are not used for density estimation, such that the independent assessment of group size by individual observers was not necessary.

Once scientific operations for a sighting were complete, the ship returned to the trackline either at or ahead of the previous sighting location, depending on the area covered by these operations, to avoid repeat survey effort of the same area. The start and end times and locations of transect effort were recorded so that total transect length could be calculated (as needed for density estimation) to accommodate these breaks in search effort.

Visual Effort

The visual team was considered to be on-effort once the 3-person observer team was on the flying bridge actively searching for cetaceans. Survey effort was divided into 3 on-effort categories: standard, non-standard, and fine-scale. Standard survey effort occurred when the observer team surveyed for cetaceans along the established parallel transects (Figure 1). Non-standard and fine-scale effort were carried out using the same visual survey protocols used during standard effort but did not occur along the standard transect lines. Non-standard effort was search effort that occurred while transiting to and from port, between transects, or while circumnavigating islands. Fine-scale effort occurred within the MHI focal area en route to deploying or recovering DASBRs. Fine-scale effort occurred at random with respect to environmental features or animal density; thus, cetacean sightings during fine-scale search effort may be used for abundance estimation within the MHI focal area. Any other effort configuration was recorded as off-effort. A common off-effort configuration was when observers were on a "weather watch," which occurred when viewing conditions were unworkable (e.g., Beaufort 7 sea state or higher, visibility less than a mile, more than 50% of the horizon obscured), with only the center observer monitoring the weather for improved viewing conditions. Searching that continued during pursuit of a cetacean sighting or feature of interest was also considered to be off-effort.

Survey effort was also divided into 2 on-effort modes: closing and passing. In closing mode, the observer team went off-effort when a cetacean group was sighted to focus on species identification, group-size estimation, or other data collection. The observer team could request the ship to change course off the trackline or change speed to facilitate these operations. The majority of HICEAS 2017 survey effort was conducted in closing mode. In passing mode, search effort was continuous even after a sighting was made. When a sighting was made by an on-effort observer, that observer estimated the group size of the sighting as quickly as possible and then continued searching. Passing mode was rare during HICEAS 2017, generally occurring only when the ship was required to be somewhere at a specific time.

Visual Data

The center observer recorded search effort, environmental conditions, and cetacean sightings using WinCruz, a computer program developed at the SWFSC specifically for line-transect survey operations. A computer running WinCruz was connected to the ship's global positioning system (GPS), and the time, latitude, and longitude were recorded each time an event was logged. The program also automatically recorded the GPS location of the ship at a regular time interval (every 2 min). Environmental factors (e.g., sun height and angle, Beaufort sea state, swell height and direction), visibility, and the position of the observers were entered manually by the center observer at each observer rotation or when effort was resumed following a sighting. At the time of a sighting, the bearing and binocular reticle to the sighting were recorded. This information was used by WinCruz to calculate the perpendicular distance of the sighting location from the trackline. WinCruz also provided a graphics display of the sighting location relative to the ship, with lines connecting any re-sightings of the same group. A detailed list of data collected within WinCruz is presented in Appendix E.

For each cetacean sighting, additional sighting information was collected on electronic forms within a FileMaker database running on iPads. Individual iPads were networked to provide real-time access to observers working on the flying bridge, biopsy sampling from the ship's bow, or editing data in the lab. The sighting data form included the WinCruz sighting number, species name, observer who first saw the cetacean, closest approach distance, mixed species indication, encounter description, group composition and behavior, small boat launch indication, photo details (if collected), and information required for reporting under applicable permits. A separate biopsy sampling form (electronically linked to the sighting data form) collected details about each biopsy attempt including hit or miss, location of a hit, behavioral reaction of the target animal and others nearby, age class, sex, sample number, and photo details (if collected).

At the end of each day, the WinCruz data were first checked by the Senior Observers for errors or omissions and then by the Cruise Leader before being backed-up and archived nightly. All electronic sighting form entries were checked and compared to WinCruz data by the Senior Observers and Cruise Leader.

Photography

Digital single-lens reflex (SLR) cameras with telephoto zoom lenses (100-400 mm and 70-200 mm) were used for taking photographs from both the ship and small boat to aid in species identification, individual identification, and health and injury assessment. Photographic efforts for individual identification were focused on obtaining dorsal fin and fluke images, while images of the body and head were taken for species identification and body condition assessment (health and injury).

Biopsy Sampling

Biopsy samples were collected from both the ship and small boat using Barnett RX-150 or Wildcat crossbows and Ceta-Dart bolts with sterilized, stainless steel biopsy tips (25 mm long × 8 mm diameter for small to medium odontocetes and 40 mm long × 8 mm diameter for large cetaceans). Tissue samples were stored in separate cryovials and placed either in a -80°C freezer (aboard the *Lasker*) or in a Dewar of liquid nitrogen (aboard the *Sette*). At the end of the project, all samples were transported aboard the *Lasker* in a -80°C freezer to the SWFSC for tissue archiving and processing.

Satellite Tagging

Satellite tags were deployed from the small boat during select *Sette* sightings. Satellite tagging was conducted using a Dan Inject air rifle and deployment arrows designed by Wildlife

Computers. Wildlife Computers location-only SPOT tags and location-depth SPLASH tags were deployed in the Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) configuration. The tags were attached to the dorsal fin with two 6.5-cm sterilized, titanium darts with backward facing petals.

Passive Acoustic Operations

Towed Hydrophone Array

A towed hydrophone array was deployed approximately 300 m behind each ship. Towed hydrophone array components and the data acquisition system on each ship were designed to be as similar as possible to ensure the acoustic recordings would be comparable between the two ships. This system was comprised of a modular towed array (Rankin *et al.* 2013), SailDAQ soundcard (www.sa-instrumentation.com), laptop computers, and PAMGuard software v. 2.00.10fa (Gillespie *et al.* 2008). The towed array contained an in-line and an end-array with a total of six HTI-96-min hydrophones (14-85 kHz ± 5 dB at -158 dB re V/µPa) and custom-built pre-amps providing 37 dB (2-50 kHz ± 2 dB) of gain and with high-pass filters at 1500 Hz to reduce low-frequency flow noise and ship noise. Such filtering prevented detection of low-frequency baleen whale sounds, and all other noise below 1500 Hz. The SailDAQ sampled all six channels simultaneously at 500 kHz sample rate and applied 0-12 dB of gain to the incoming signal from each hydrophone. The inline and end arrays also contained a Kellar (PA7FLE) or Honeywell (PX2EN1XX200PSCHX) depth sensor, with a depth recorded every second with a voltage MicroDAQ (www.microdaq.com). Hydrophones were spaced 1 m apart within each array section. The inline and end array sections were separated by approximately 30 m of cable.

PAMGuard was set up on multiple laptops to manage data archiving and real-time monitoring of vocalizing cetaceans. PAMGuard interfaces with the SailDAQ to record incoming acoustic data and with the MicroDAQ to record depth data. The PAMGuard logger module was used to record all other real-time metadata about the array, effort type, sightings, and other information arising in the field. A second laptop was used to monitor real-time cetacean echolocation clicks, burst pulses, and whistles. The real-time tracking system used a click classification design based on custom specifications (Keating and Barlow 2013) and the whistle and moan detector module to provide angles for tracking cetaceans.

Acousticians monitored the towed array from sunrise to sunset. Two acousticians monitored incoming data during the day and were occasionally assisted by a third acoustician during acoustic detections of false killer whales. Each acoustician worked 3 h on-effort shifts followed by a 1.5 h break. During daytime effort, acoustic detections of vocal cetaceans were localized in real-time using PAMGuard. For most acoustic detections, the acoustics team did not provide information about detected species to the visual team to avoid bias in the visual sighting data. Note that the acoustics protocol varied for false killer whales and sperm whales, see Species-Specific Protocols.

Following the evening Conductivity, Temperature, and Depth (CTD) cast (see Ecosystem Sampling), the towed hydrophone array was redeployed, and incoming passive acoustic data were recorded to a hard drive using PAMGuard as the ship traveled, generally continuing down the established transect lines (Figure 1). Nighttime acoustic data were not monitored in real-time by the acoustics team. Approximately 1.5 h prior to sunrise, the towed array was recovered to allow time for a CTD cast and then redeployed 15 min prior to sunrise. The acoustics team was ready to resume acoustic detection effort before sunrise, when visual survey effort commenced, which maximized the overlap of visual and acoustics survey effort.

Sonobuoys

Sonobuoys are autonomous floating passive acoustic sensors that relay data to the ship via VHF carrier frequency (reviewed by Miller *et al.* 2018). During HICEAS, Directional Fixing and Ranging (DIFAR) type 53F sonobuoys were deployed on sightings of baleen whales and during select evening CTD casts. DIFAR sonobuoys use two vector sensors and an internal compass to enable estimation of the direction of the received signal. The VHF signal from the sonobuoy was received at the ship using an omni-directional VHF antenna cabled into a WinRadio dialed to the VHF frequency specified for an individual sonobuoy. Two WinRadios were available to receive signals from two separate sonobuoys deployed simultaneously. The signal from the WinRadio was digitized at 48 kHz sample rate with a RME Fireface UC soundcard, and fed into a Logisys computer where it was recorded for later analysis using PAMGuard. There were insufficient sonobuoys to conduct listening stations at every evening CTD cast, so station dates were randomly generated prior to the start of HICEAS based on the number of available sonobuoys. A sonobuoy was also deployed during baleen whale sightings when the ship approached the group within 1 nmi and generally when the visual observers had identified the group to species.

Species-Specific Protocols

During HICEAS 2017, modified data collection protocols were implemented for false killer whales and sperm whales because significant differences in their social or diving behavior, respectively, necessitated more detailed data collection approaches. These data collection protocols are summarized as follows, with each protocol included in its entirety as an appendix to this report.

False Killer Whales

Research on false killer whales in the MHI has revealed the tendency for this species to associate in small, coordinated subgroups that can span tens of miles (Baird *et. al* 2008). The spatial arrangement of these subgroups violates line-transect assumptions and requires a different data collection approach, where subgroups (and not groups) are the detection unit (Bradford *et al.* 2014). Under the False Killer Whale Protocol, individual subgroups were recorded as separate visual detections using the subgroup functionality within WinCruz. Subgroup detection and subgroup-size estimation were separated into two protocol phases.

“Phase 1” focused on the detection of false killer whale subgroups. Phase 1 was initiated when either the visual or acoustics teams detected false killer whales. During this phase, the ship continued along the trackline in passing mode until all false killer whale subgroups were past the beam of the ship. The ship did not divert toward any subgroups during this phase to ensure both teams had an opportunity to detect subgroups along the trackline. The visual and acoustics teams worked independently during Phase 1, separately detecting and tracking subgroups. Primary observers recorded subgroup size estimates if they felt they had a good look at an individual subgroup. Secondary (off-effort) observers assisted with collecting subgroup size estimates during Phase 1.

Following the completion of Phase 1, the ship was directed by the acoustics team to go back through the center of the group so that observers could determine sizes for as many subgroups as possible. The goal of "Phase 2" was to obtain subgroup size estimates. Since the ship was unable to turn during Phase 1, subgroup counts were not always feasible. There was no attempt to link subgroups between protocol phases.

For more detailed information on the False Killer Whale Protocol, see Appendix G.

Sperm Whales

Sperm whales can be spread over several miles and commonly contain smaller subgroups. Within a group, these subgroups commonly exhibit asynchronous dive behavior, with each subgroup diving for 20-60 min followed by an 8-12 min surface period. Extended group counts are necessary because of the asynchrony and long durations of these dives.

When a sperm whale group was sighted, the acoustics team was alerted. If the acoustics team reported that they had detected and localized the sighted group, then the visual team went off-effort and turned toward the sperm whale group to initiate the Sperm Whale Protocol, which involved an extended group size count. If the acoustics team had not yet detected or localized the sighted group, effort continued along the trackline until the sighted group was past the beam or the acoustics team reported that they had localized the sighted group. If the visual team thought that the group contained only a single individual, they could request confirmation from the acoustics team. Upon such confirmation, the extended count was skipped. If either team suspected that the group contained more than one individual, the extended count was initiated. If the acoustics team detected and localized a group of sperm whales within 3 nmi of the trackline and that group was not sighted by the visual survey team, the acoustics team alerted the visual team (once the detection was passed the beam) and the ship was turned toward the group to initiate the extended count.

Under this Protocol, the on-effort visual team began a 10-min observation period after which they independently recorded their group size estimates. At the end of 10 min, a fourth observer joined the team, and they collectively began a 60-min observation period. During this period, the team openly discuss the location, behavior, composition, and size of individual subgroups, although each observer independently recorded their overall group size estimate. The visual team uses the mapping functions within WinCruz to track individually-sighted subgroups and attempt to prevent double-counting by linking subgroups that dove and then resurfaced.

Sperm whale group counts during PIFSC surveys have typically lasted 60 min. However, comparisons of 60-min and 90-min sperm whale counts from SWFSC surveys in the eastern Pacific have suggested that 60-min counts may still lead to underestimates of group size. Given that sperm whales are one of the most frequently sighted cetacean species during ship surveys in Hawaiian waters (Barlow 2006, Bradford *et al.* 2017), 90-min counts for all sperm whale sightings could impede trackline progress. However, to assess if 60-min counts underestimated sperm whale group size during HICEAS 2017, a sample of 90-min counts was made for comparison. At the first sighting or acoustic detection of sperm whales on each day, a 90-min count was carried out.

For more detailed information on the Sperm Whale Protocol, see Appendix H.

Seabird Visual Observations

Seabird observers collected two separate data sets: (1) seabird distribution and abundance and (2) seabird feeding flock distribution, abundance, and composition.

Seabird Distribution and Abundance

Seabird distribution and abundance data were collected using strip transect methods (Ballance 2007 and references therein) and a default strip width of 300 m. The strip width was modified according to an “Observation Conditions” code. The seabird observer searched the forequarter, from directly in front of the ship to the beam on the side with best visibility conditions out to 300 m and recorded seabirds (and other animals or objects of interest) entering this area in real-time. Seabird observers used handheld binoculars ranging from 7× to 20× power to identify birds, and occasionally, to scan the survey area. Mounted 25×150 binoculars were used to identify distant birds (and to collect seabird flock data).

Radial distance from the ship to individual birds entering the quadrant was estimated using a range-calibrating device based on Heinemann (1981). Briefly, equations based on observer height above the water surface and arm length were used to calculate the distance from the observer to the horizon. The top of a pencil was aligned with the horizon at arm’s length. Marks scribed at calculated distances on the pencil, below the horizon, corresponded to 300, 200, and 100 m, respectively.

Data were recorded in the form of "transects," defined as a period of effort during which all observation conditions were constant, and the ship was on the pre-determined trackline. A transect ended each time conditions changed (e.g., change in seabird observer, ship’s course, sea state, side of ship from which observations were made), and a new transect would begin.

Weather permitting, data collection began just after sunrise and ended just before sundown each day. Two seabird observers worked in rotating 2 h shifts, with 1 observer on-effort at any one time throughout the day. The target vessel survey speed was 10 kt through the water, though this speed varied by up to several kt at times (range 8–12 kt). In sea states above Beaufort 7, heavy fog, rain, or any other conditions which significantly impaired visibility, the seabird survey was suspended until conditions improved. Seabird survey effort was also suspended when the ship closed on a cetacean sighting.

Data were collected from a station at the front of the vessel’s flying bridge using SeeBird, a computer program developed at the SWFSC specifically for collecting strip transect seabird survey data. The date, time, and location of seabird sightings (and feeding flocks, see below) were recorded within SeeBird when a sighting was entered, and additional data including species identification, radial distance from the ship, flight direction, and behavior were entered manually during the sighting by the seabird observer. Environmental data (wind speed and direction) as well as factors affecting visibility were manually entered as those conditions changed or when a new observer started a watch. A detailed list of data collected within SeeBird is presented in Appendix E.

Distribution, Abundance, and Composition of Seabird Feeding Flocks

Data to quantify distribution, abundance, and composition of seabird feeding flocks were collected using strip transect methods with a 2 reticle strip width. Seabird observers recorded flocks when they were seen within a radial distance of 1 reticle (etched inside 25× power binoculars) on either side of the ship. A flock was defined as an aggregation of 5 or more feeding or foraging seabirds. When the port or starboard cetacean observer detected a seabird flock that was within 1 reticle of the ship using the mounted 25×150 binoculars, the seabird observer on watch was notified. The seabird observer then used handheld 20× or mounted 25× power binoculars to determine the species composition and number of individuals in each flock. Effort data for the seabird feeding flock data was identical to the cetacean effort data. Seabird feeding flock data collected in SeeBird included time, angle and radial distance to the flock, species identification, and flock behavior.

Ecosystem Sampling

Two primary types of ecosystem data were of interest during HICEAS 2017. Typically, two CTDs were conducted every day: 1 h before sunrise and another 1 h after sunset. Some CTD stations were omitted due to time constraints or proximity to the previous station. The CTD was cast to 1000 m (or to within 100 m of the seafloor if at depths shallower than 1000 m). The CTD sampled temperature, salinity, dissolved oxygen, and fluorescence from the ocean surface to depth. The CTD was equipped with a WetLab profiling and Seapoint flow-through fluorometer and redundant dissolved oxygen sensors. Cast descent rates were 30 m/min for the first 100 m of the cast and then 60 m/min after that, including the upcast. Additional CTD casts were deployed in areas of special interest, such as at Cross Seamount (see Ancillary Projects).

The scientific Simrad EK60 single beam echosounder was used to assess acoustic backscatter, a proxy for biomass and composition of organisms in the water column. The system was operated continuously and collected backscatter data at 38 kHz, 70 kHz, 120 kHz, and 200 kHz (*Lasker* only) using the maximum transmission power and a ping rate of 512 µs for each frequency. Data were logged to a maximum depth of 1200 m. Backscatter data were not monitored or processed in real-time. During specific periods, such as during beaked whale encounters, the passive acoustics team requested to secure some or all frequencies. The ship’s 12-kHz navigational depth sounder was generally secured during underway operations and used only during CTD casts to monitor bottom depth.

Sightings of marine turtles and monk seals were noted when seen by the cetacean or seabird observers. Date, time, location, and species (when possible) of turtle were noted within WinCruz or SeeBird records.

Autonomous Drifting Acoustic Recorders

DASBRs were used during HICEAS 2017 to listen for cetaceans throughout the MHI. The DASBR is a free-floating autonomous passive acoustic monitoring system developed at the SWFSC (Griffiths and Barlow 2015, 2016). As drifting recording units, DASBRs have several unique capabilities not available in the other acoustic systems employed during HICEAS 2017. DASBR hydrophones may be deployed at deeper depths than a towed hydrophone array and are not subject to ship and flow noise while freely drifting, allowing them to monitor signals at lower frequencies. Overall, DASBRs record across a broad frequency range, which enables the detection of most cetacean species, from baleen whales to dolphins. DASBRs can more intensively survey an area after the ship has left, as well as detect animals that may avoid passing ships.

DASBRs were primarily used during HICEAS 2017 to augment cetacean encounter rates within the MHI focal area, especially from deep-diving beaked whales and *Kogia* species, which are infrequently encountered during ship-board surveys. These species are especially hard to see, particularly during marginal or poor weather, and are often difficult to approach for species identification when they are seen. Most beaked whales can be identified to species by their characteristic sounds, making a drifting acoustic array an ideal instrument to detect the presence of beaked whales and ultimately estimate their abundance.

The DASBRs used during HICEAS 2017 were modified from the design employed during prior SWFSC efforts. The buoy included a polyvinyl chloride (PVC) spar surface buoy housing an NAL Research Iridium transmitter (www.nalresearch.com). The 1.4-m spar buoy was constructed to survive vessel collisions and to pose no hazards to navigation. The Iridium transmitter provided real-time updates of the buoy location via email, allowing for both recovery of the buoy and GPS tracking of its drift. These GPS locations will also be used for geographic referencing of any detected cetaceans. Each DASBR included an array of 2 hydrophones, separated by 10 m vertical distance, forming a short vertical array at ~150 m depth. This depth and spacing combination allows for the depth and distance of the detected cetacean to be calculated (Barlow and Griffiths 2017). The acoustic data were logged either on an Ocean Instruments SoundTrap recorder or a Wildlife Acoustics SM3M recorder. The SoundTrap acoustic data were duty cycled, recording 2 of every 10 min, and were sampled at a rate of 288 kHz. The SM3M data were continuously recorded at a sampling rate of 256 kHz.

Tri-axial accelerometer and depth data were also logged, either on a Loggerhead Instruments OpenTag or a combination of the SoundTrap built-in accelerometer and a Lotek LAT time-depth recorder. The accelerometer data are used to calculate the tilt angle of the hydrophone array in the water, an essential measure for calculating the correct depth and distance of a vocalizing cetacean.

DASBRs were deployed from the ship at randomly chosen locations around the MHI and allowed to drift for 10-50 days before retrieval. They were retrieved by the ship with the use of a grappling hook and an on-board pulley system. Upon retrieval, all data were downloaded and archived, the Iridium transmitter and acoustic recorder were charged, and the system was prepped for re-deployment.

Ancillary Projects

Several ancillary projects were conducted during HICEAS 2017. Ancillary projects included opportunistic sampling or instrument servicing that could be accomplished while the ship was in a particular region or at specific times of interest during the course of the survey. Such ancillary projects included: 1) recovery and deployment of High-Frequency Acoustic Recording Packages (HARPs) at Hawaiʻi sites within the Pacific Islands Passive Acoustic Network; 2) recovery and deployment of the Ocean Noise Reference Station (NRS04) north of Oʻahu (see Haver *et al.* 2018); 3) collection of aerial photographs of cetacean groups using a rotary-wing hexacopter; and 4) concurrent acoustic sampling and water collection for an attempt to use environmental DNA (eDNA) to identify an unidentified beaked whale that was acoustically detected first at Cross Seamount (Johnston *et al.* 2008), and later at other locations in the Pacific Islands (Baumann-Pickering *et al.* 2014), but has not yet been linked to a known species. Ancillary projects are not discussed further in this report, as they are generally part of other larger sampling efforts or unique projects that will be described in partner reports or papers.

Results and Discussion

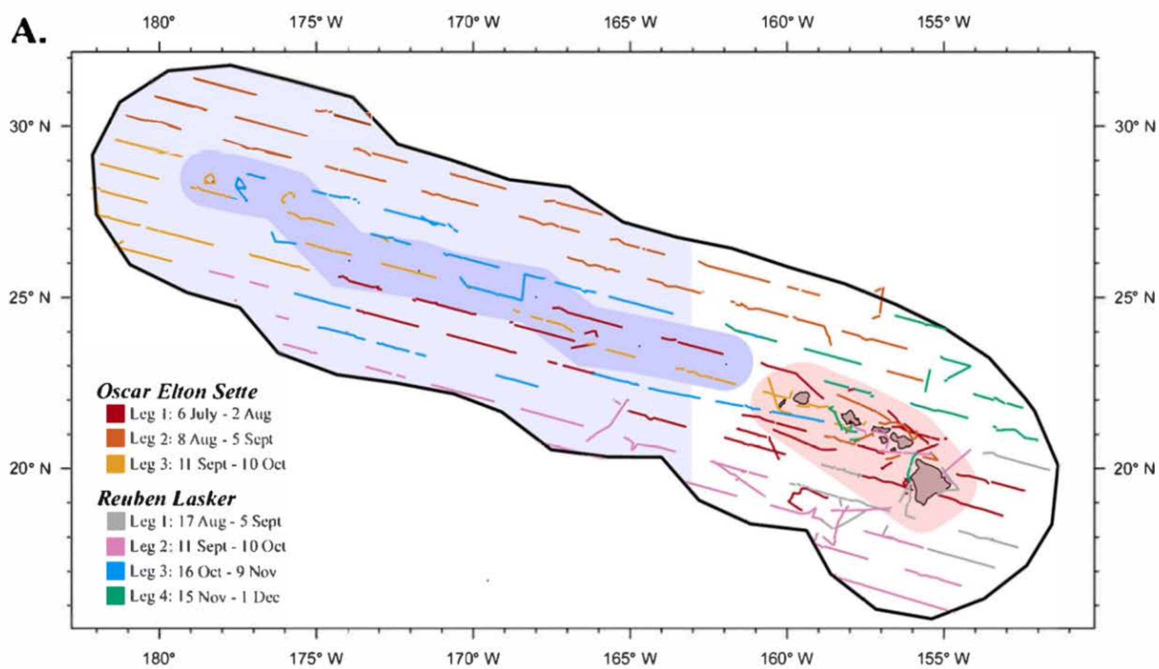
Cetacean Survey

Visual Effort and Sightings

During 179 days-at-sea, the *Sette* and *Lasker* collectively surveyed approximately 24,000 km of on-effort trackline across all effort categories over 161 on-effort survey days (Figure 2, Table 1). Only a small proportion of survey effort (5.7%, 1,357 km) occurred in calm conditions (Beaufort sea states 0–2). Approximately 12.8% (3,046 km) of effort took place in Beaufort 3, 33.4% (7,931 km) in Beaufort 4, 31.7% (7,535 km) in Beaufort 5, and 16.4% (3,889 km) in Beaufort 6. Visual survey effort comprehensively covered the Hawai‘i EEZ study area, including in all 4 strata (Figure 1).

There were 345 sightings of cetacean groups during HICEAS 2017 across all effort types (including off-effort; Table 1), representing at least 23 cetacean species (Table 2). Within the Hawai‘i EEZ, there were 326 sightings of cetacean groups, representing at least 21 species (Appendix B). Short-finned pilot whale (*Globicephala macrorhynchus*) was the most frequently sighted species in the Hawai‘i EEZ (n=35 sightings). The only species known to regularly occur in the Hawai‘i EEZ that were not seen during HICEAS 2017 were blue (*Balaneoptera musculus*), sei (*B. borealis*), and dwarf sperm (*Kogia sima*) whales. Rough-toothed dolphins (*Steno bredanensis*) and short-finned pilot whales were encountered in mixed species sightings (n=4 and n=3, respectively) more than any other species. The remaining 19 sightings occurred during the Lasker’s transit from San Diego, California, to Honolulu, Hawai‘i on 18–25 August (Appendix B). Striped dolphin (*Stenella coeruleoalba*) was the most frequently sighted species during the transit (n=6 sightings). Blue whales and short-beaked common dolphins (*Delphinus delphis*) were sighted during the transit, but not within the Hawai‘i EEZ.

Approximately 36,000 photos of 21 cetacean species were collected during 140 sightings. A total of 111 biopsy samples were collected during 28 sightings of 7 species, including bottlenose dolphin (*Tursiops truncatus*), pantropical spotted dolphin (*Stenella attenuata*), rough-toothed dolphin, short-finned pilot whale, false killer whale, sperm whale, and humpback whale (*Megaptera novaeangliae*) (Table 3). Satellite tags were deployed on false killer whales (n=4) and short-finned pilot whales (n=3) (Table 3).



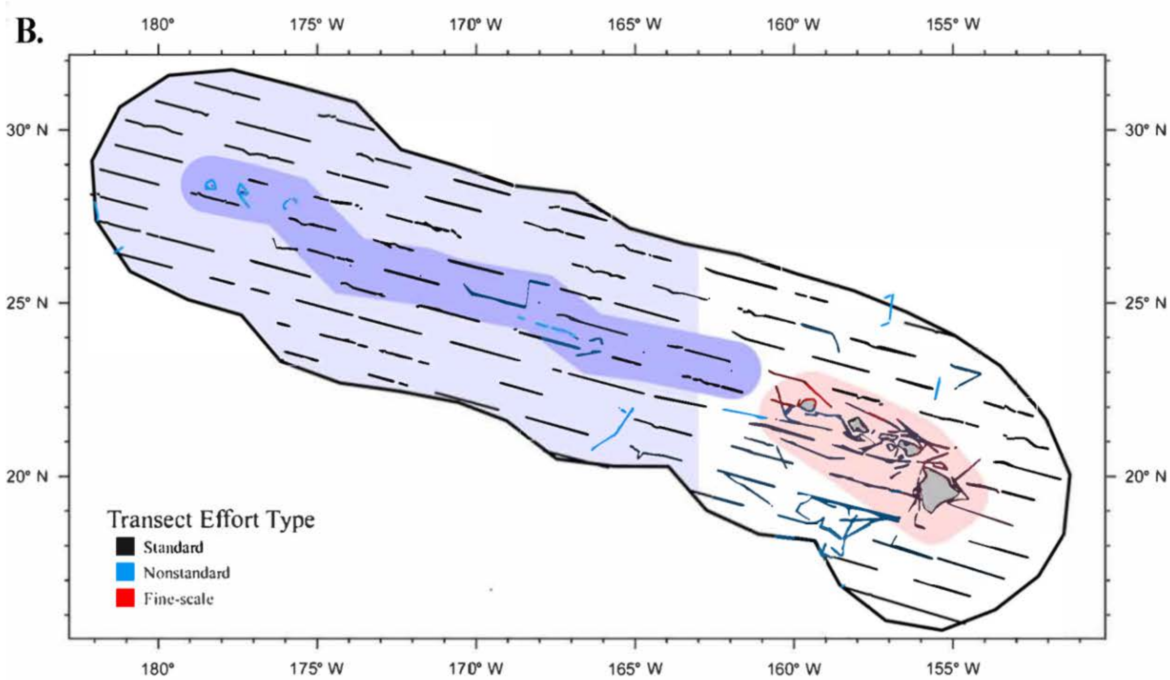


Figure 2. Daytime sighting effort within the Hawai‘i EEZ (black outline), including (A) seven ship legs and (B) three on-effort categories.

A. The sighting effort for the *Sette*’s Leg 1-3 (lines in red, orange, and yellow, respectively), and the *Lasker*’s Leg 1-4 (lines in gray, pink, blue, and green, respectively).

B. The sighting effort by transect type: standard (black lines), non-standard (blue lines), and fine-scale (red lines). Survey strata are defined in Figure 1.

Table 1. Summary of survey effort (km) and all sightings of cetacean groups by Beaufort sea state and effort category.

Standard effort occurred along established tracklines (Figure 1). Fine-scale effort occurred within the Main Hawaiian Islands focal area. Non-standard effort occurred during island circumnavigations, transits in and out of port, and between standard tracklines.

Beaufort Sea State	**Effort (km)**				**Sightings**				
	Standard	Fine-scale	Non-standard	TOTAL	Standard	Fine-scale	Non-standard	Off	TOTAL
0	12.6	0.0	0.0	12.6	0	0	0	0	0
1	153.3	56.4	42.7	252.3	9	3	4	6	22
2	686.6	10.6	394.8	1092.0	16	0	20	20	56
3	2002.2	286.5	757.0	3045.6	38	6	16	25	85
4	5200.7	626.4	2103.8	7930.9	42	4	28	19	93
5	5690.7	268.4	1575.9	7535.0	30	2	14	13	59
6	2794.8	342.4	751.4	3888.6	13	6	3	6	28
7	0.8	0.0	0.8	1.6	0	0	0	2	2
TOTAL	16541.7	1590.7	5626.3	23758.7	148	21	85	91	345

Table 2. Summary of cetacean species sighted across all effort types (standard, non-standard, fine-scale, and off).

Species seen as part of mixed species groups are counted once for each species, such that the total number of sightings in this table does not match the total number of group sightings listed in Table 1.

Cetacean Species			**Effort**				**Total Groups**
Code	Scientific Name	Common Name	Standard	Fine-scale	Non-standard	Off	
002	*Stenella attenuata*	pantropical spotted dolphin	10	0	12	3	25
013	*Stenella coeruleoalba*	striped dolphin	18	0	7	2	27
015	*Steno bredanensis*	rough-toothed dolphin	9	3	5	8	25
017	*Delphinus delphis*	short-beaked common dolphin	0	0	1	0	1
018	*Tursiops truncatus*	bottlenose dolphin	0	1	2	1	4
021	*Grampus griseus*	Risso's dolphin	6	0	5	1	12
026	*Lagenodelphis hosei*	Fraser's dolphin	2	0	0	1	3
031	*Peponocephala electra*	melon-headed whale	3	0	2	2	7
032	*Feresa attenuata*	pygmy killer whale	2	1	0	0	3
033	*Pseudorca crassidens*	false killer whale	9	3	3	12	27
036	*Globicephala macrorhynchus*	short-finned pilot whale	5	7	11	12	35
037	*Orcinus orca*	killer whale	1	0	0	0	1
046	*Physeter macrocephalus*	sperm whale	14	2	4	4	24
047	*Kogia breviceps*	pygmy sperm whale	3	0	0	0	3
049	*Ziphiid* whale	unidentified beaked whale	9	1	5	9	24
051	*Mesoplodon* sp.	Mesoplodon beaked whale	5	0	0	2	7
059	*Mesoplodon densirostris*	Blainville's beaked whale	0	1	3	4	8
061	*Ziphius cavirostris*	Cuvier's beaked whale	6	0	3	2	11
065	*Indopacetus pacificus*	Longman's beaked whale	4	0	1	2	7

Cetacean Species			Effort				Total Groups
Code	Scientific Name	Common Name	Standard	Fine-scale	Non-standard	Off	
070	*Balaenoptera* sp.	unidentified rorqual	5	0	1	2	8
071	*Balaenoptera acutorostrata*	common minke whale	1	0	0	0	1
072	*Balaenoptera edeni*	Bryde's whale	2	0	0	0	2
074	*Balaenoptera physalus*	fin whale	1	0	0	1	2
075	*Balaenoptera musculus*	blue whale	0	0	2	0	2
076	*Megaptera novaeangliae*	humpback whale	2	0	3	1	6
077	----	unidentified dolphin	11	1	1	5	18
078	----	unidentified small whale	3	0	0	2	5
079	----	unidentified large whale	3	0	4	2	9
080	*Kogia* sp.	pygmy/dwarf sperm whale	3	0	1	1	5
096	----	unidentified cetacean	2	0	0	3	5
098	----	unidentified whale	2	1	0	0	3
099	*B. borealis/edeni*	sei/Bryde's whale	1	0	1	3	5
102	*Stenella longirostris*	Gray's spinner dolphin	0	0	2	1	3
177	----	unidentified small dolphin	7	0	7	6	20
277	----	unidentified medium dolphin	3	0	4	1	8
		TOTAL	152	21	90	93	356

Table 3. Biopsy samples collected and satellite tags deployed on cetaceans, in descending order of total biopsy samples.

Scientific Name	Common Name	Biopsy Samples	Sightings with Biopsy Samples	Tags Deployed	Sightings with Tags
Pseudorca crassidens	false killer whale	38	6	4	3
Globicephala macrorhynchus	short-finned pilot whale	32	6	3	2
Steno bredanensis	rough-toothed dolphin	26	8	0	0
Stenella attenuata	pantropical spotted dolphin	6	3	0	0
Physeter macrocephalus	sperm whale	4	1	0	0
Tursiops truncatus	bottlenose dolphin	4	3	0	0
Megaptera novaeangliae	humpback whale	1	1	0	0
	TOTAL	111	28	7	5

Passive Acoustics

During HICEAS 2017, there were 766 acoustic detections of separate cetacean groups during daytime monitoring of the towed hydrophone array. Of the 766 towed array detections, 188 were linked to visually sighted groups (Figure 3). In several instances, more than one species was detected during a single encounter, which resulted in 197 species detections (Table 4). Paired visual sighting and acoustic detection data provided visual confirmation of species identification of detected sounds for 23 cetacean species (Appendix B). Forty of the 766 detections were recorded outside of the Hawai‘i EEZ, during the transit between San Diego and Honolulu.

Acoustic species identification was not conducted in real-time for any detection not accompanied by a visual observation, with a few exceptions. Clicks produced by sperm whales and “boings” produced by minke whales (*B. acutorostrata*) are well described and were readily identifiable by the acoustics team, so identified to species in real-time. Upswept clicks commonly produced by beaked whale species were also identified in real-time and were assigned a species classification of unidentified beaked whale. Species-specific identification of beaked whales is feasible with acoustic detection data and will be conducted during post-processing of this dataset.

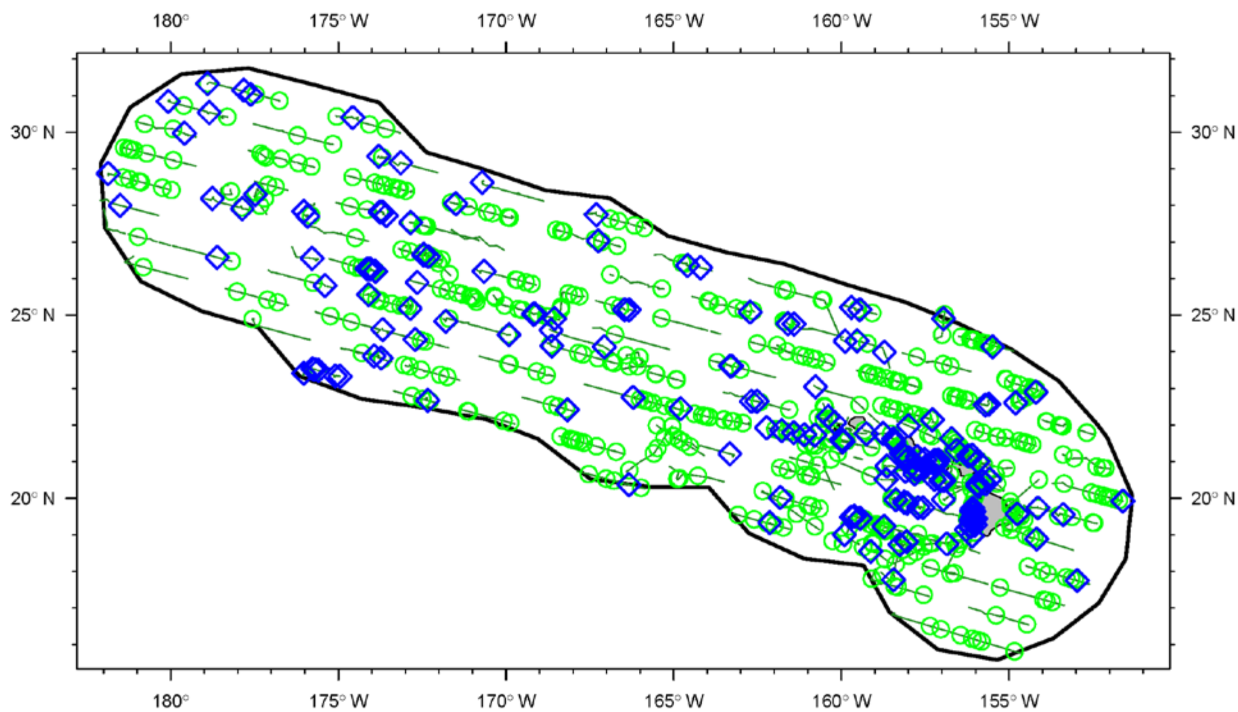


Figure 3. Real-time acoustic monitoring effort (dark green lines) and acoustic detections made in the Hawai‘i EEZ (black outline).

Concurrent sightings and acoustic detections are shown as blue diamonds (repeated from prior figures). Acoustic detections without a concurrent visual sighting are shown as green circles. All detections are shown, independent of survey effort type. Daytime acoustic monitoring effort is similar, but not identical, to visual survey effort (Figure 2).

Table 4. Comparison of cetacean species sighted and acoustically detected during daylight hours.

Acoustic species-identification was not confirmed in real-time for most species. The 'Acoustic Only' column includes only those species detections that the acoustics team could aurally classify to species with high confidence (see text). Species seen or heard as part of mixed species groups are counted once for each species, such that the total number of sightings in this table match those by species in Table 2, but not the total number of group sightings listed in Table 1.

Cetacean Species			**Number of Detections**		
Code	Scientific Name	Common Name	Concurrent Visual & Acoustic	Visual Only	Acoustic Only
002	*Stenella attenuata*	pantropical spotted dolphin	19	6	--
013	*Stenella coeruleoalba*	striped dolphin	22	5	--
015	*Steno bredanensis*	rough-toothed dolphin	20	5	--
017	*Delphinus delphis*	short-beaked common dolphin	1	0	--
018	*Tursiops truncatus*	bottlenose dolphin	4	0	--
021	*Grampus griseus*	Risso's dolphin	11	1	--
026	*Lagenodelphis hosei*	Fraser's dolphin	3	0	--
031	*Peponocephala electra*	melon-headed whale	7	0	--
032	*Feresa attenuata*	pygmy killer whale	3	0	--
033	*Pseudorca crassidens*	false killer whale	26	1	--
036	*Globicephala macrorhynchus*	short-finned pilot whale	25	10	--
037	*Orcinus orca*	killer whale	0	1	--
046	*Physeter macrocephalus*	sperm whale	20	4	129
047	*Kogia breviceps*	pygmy sperm whale	0	3	--
049	*Ziphiid* whale	unidentified beaked whale	5	19	47*
051	*Mesoplodon* sp.	Mesoplodon beaked whale	2	5	--
059	*Mesoplodon densirostris*	Blainville's beaked whale	1	7	--
061	*Ziphius cavirostris*	Cuvier's beaked whale	2	9	--
065	*Indopacetus pacificus*	Longman's beaked whale	4	3	--

Cetacean Species			Number of Detections		
Code	Scientific Name	Common Name	Concurrent Visual & Acoustic	Visual Only	Acoustic Only
070	*Balaenoptera* sp.	unidentified rorqual	1	7	--
071	*Balaenoptera acutorostrata*	common minke whale	0	1	54
072	*Balaenoptera edeni*	Bryde's whale	0	2	--
074	*Balaenoptera physalus*	fin whale	1	1	--
075	*Balaenoptera musculus*	blue whale	0	2	--
076	*Megaptera novaeangliae*	humpback whale	0	6	--
077	----	unidentified dolphin	4	14	--
078	----	unidentified small whale	0	5	--
079	----	unidentified large whale	0	9	--
080	*Kogia* sp.	pygmy/dwarf sperm whale	3	2	--
096	----	unidentified cetacean	0	5	--
098	----	unidentified whale	0	3	--
099	*B. borealis/edeni*	sei/Bryde's whale	0	5	--
102	*Stenella longirostris*	Gray's spinner dolphin	0	3	--
177	----	unidentified small dolphin	9	11	--
277	----	unidentified medium dolphin	4	4	--
		TOTAL	197	159	--

* All acoustic detections of beaked whales were logged as '*Ziphiid* whale' during real-time monitoring.

Two-hundred twelve sonobuoys were deployed during the survey. Monitoring with sonobuoys took place during 91 nighttime CTD casts, utilizing 194 sonobuoys (Figure 4). Eighteen sonobuoys were deployed opportunistically during 11 baleen whale sightings identified by the visual observers as Bryde's whale (*B. edeni*), fin whale (*B. physalus*), humpback whale, unidentified sei (*B. borealis*) or Bryde's whale, or as unidentified rorqual (*Balaenoptera* sp.*)* or unidentified large whale (Appendix B).

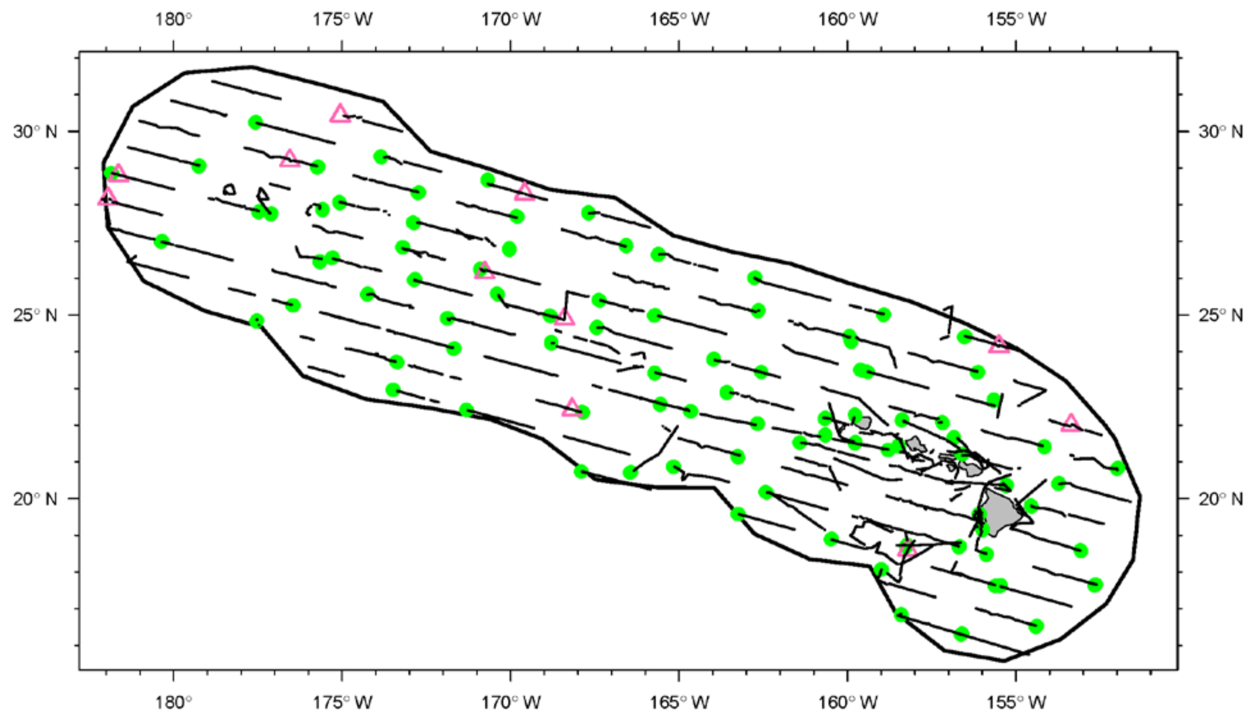


Figure 4. Sonobuoy deployments in the Hawai'i EEZ (black outline).

Nightly sonobuoy stations are indicated by green circles and opportunistic sonobuoy deployments are indicated by pink triangles. Black lines are visual survey effort.

Seabird Survey

A total of 58 seabird species were recorded, as well as several sightings that could not be identified to the species level. Within the Hawai'i EEZ, a total of 50 seabird species were identified in the 300 m strip transect survey (Table 5). The most numerically abundant seabirds within the Hawai'i EEZ were Wedge-tailed Shearwaters (*Puffinus pacificus*), Slender-billed Shearwaters (or Short-tailed Shearwaters, *Puffinus tenuirostris*), Sooty Terns (*Onychoprion fuscata*), and Bonin Petrels (*Pterodroma hypoleuca*). During the *Lasker*'s transit from San Diego to Honolulu, a total of 28 seabird species were identified in the strip transect survey (Table 6). Sooty Terns were the most abundant seabird species observed during the transit, followed by Buller's Shearwaters (*Puffinus bulleri*) and Leach's Storm-Petrels (*Oceanodroma leucorhoa*). Many species were represented by just a few records, including several sightings of shorebirds and passerines, though expectedly these were rare.

Sighting distribution seabird survey effort and daily density estimates (birds/100 km^2) for all seabird species recorded during the strip transect survey within the Hawai‘i EEZ is presented in Appendix C. Thirteen seabird species had a sighting density greater than 100 birds per 100 km^2 on at least one day of the survey: Wedge-tailed Shearwater, Slender-billed Shearwater, Sooty Tern, Bonin Petrel, Red-footed Booby (*Sula sula*), Black-winged Petrel (*Pterodroma nigripennis*), Bulwer's Petrel (*Bulweria bulwerii*), White Tern (*Gygis alba*), Great Frigatebird (*Fregata minor*), Black Noddy (*Anous minutus*), Brown Noddy (*Anous stolidus*), Hawaiian Petrel (*Pterodroma sandwichensis*), and Brown Booby (*Sula leucogaster*).

Throughout the project, 559 seabird feeding flocks were observed; 557 of those flocks were recorded within the Hawai‘i EEZ and 2 flocks were recorded during the *Lasker*’s transit from San Diego to Honolulu. Seabird flocks were most prevalent in the regions surveyed by the *Sette* (n=399), and less so for regions surveyed by *Lasker* (n=160) (Table 7).

Table 5. Number of seabirds recorded in the Hawai‘i EEZ, within the 300 m strip transect, in descending order of total number of individuals.

Code	Species Code	Scientific Name	Common Name	Encounters	Individuals
073	SHWW	*Puffinus pacificus*	Wedge-tailed Shearwater (light morph)	2619	5300
066	SHSB	*Puffinus tenuirostris*	Slender-billed (Short-tailed) Shearwater	166	2720
070	SHWD	*Puffinus pacificus*	Wedge-tailed Shearwater (dark morph)	687	2609
098	TESO	*Onychoprion fuscata*	Sooty Tern	717	2292
035	PEBO	*Pterodroma hypoleuca*	Bonin Petrel	1134	1673
037	PEBW	*Pterodroma nigripennis*	Black-winged Petrel	799	909
011	BORF	*Sula sula*	Red-footed Booby	521	894
036	PEBU	*Bulweria bulwerii*	Bulwer's Petrel	512	578
099	TEWH	*Gygis alba*	White Tern	405	538
031	NOBR	*Anous stolidus*	Brown Noddy	130	407
072	SHWT	*Puffinus pacificus*	Wedge-tailed Shearwater	7	345
016	FRGR	*Fregata minor*	Great Frigatebird	104	319
030	NOBL	*Anous minutus*	Black Noddy	94	301
040	PEHA	*Pterodroma sandwichensis*	Hawaiian Petrel	220	248
055	PEWN	*Pterodroma cervicalis*	White-necked Petrel	134	211
007	BOBR	*Sula leucogaster*	Brown Booby	142	175
067	SHSO	*Puffinus griseus*	Sooty Shearwater	108	168
042	PEJF	*Pterodroma externa*	Juan Fernandez Petrel	141	162
064	SHOR	----	shorebird	105	162
071	SHWI	*Puffinus pacificus*	Wedge-tailed Shearwater (intermediate morph)	119	152
093	TBRT	*Phaethon rubricauda*	Red-tailed Tropicbird	112	124
094	TBWT	*Phaethon lepturus*	White-tailed Tropicbird	111	121
002	ALBF	*Phoebastria nigripes*	Black-footed Albatross	99	103
059	SHCH	*Puffinus nativitatis*	Christmas Shearwater	86	101
008	BOMA	*Sula dactylatra/S. granti*	Masked/Nazca Booby	67	77

Code	Species Code	Scientific Name	Common Name	Encounters	Individuals
062	SHNE	*Puffinus (newelli) auricularis*	Newell's Shearwater	66	76
010	BOMY	*Sula dactylatra*	Masked Booby	58	63
056	PLPG	*Pluvialis fulva*	Pacific Golden Plover	45	56
097	TEGB	*Onychoprion lunata*	Gray-backed Tern	42	53
048	PEMO	*Pterodroma inexpectata*	Mottled Petrel	44	46
085	SPLW	*Oceanodroma leucorhoa*	White-rumped Leach's Storm-Petrel	37	40
043	PEJW	*Pterodroma externa/P. cervicalis*	Juan Fernandez/White-necked {etrel	24	38
017	FRIG	*Fregata* sp.	unidentified Frigatebird	15	34
069	SHSS	*Puffinus griseus/P. tenuirostris*	Sooty/Slender-billed Shearwater	16	32
029	NOBG	*Procelsterna cerulea*	Gray Noddy	19	29
004	ALLA	*Phoebastria immutabilis*	Laysan Albatross	28	28
038	PECO	*Pterodroma cookii*	Cook's Petrel	26	28
046	PEKI	*Pterodroma neglecta*	Kermadec Petrel (intermediate morph)	21	23
080	SPHA	*Oceanodroma castro*	Harcourt's (Band-rumped) Storm-Petrel	21	22
052	PEST	*Pterodroma longirostris*	Stejneger's Petrel	14	17
074	SKSP	*Stercorarius maccormicki*	South Polar Skua	12	13
060	SHFF	*Puffinus carneipes*	Flesh-footed Shearwater	12	12
026	JAPO	*Stercorarius pomarinus*	Pomarine Jaeger	10	11
013	COOK	*Pterodroma* sp.	unidentified *Cookilaria*	9	10
025	JAPA	*Stercorarius parasiticus*	Parasitic Jaeger	10	10
039	PECP	*Pterodroma cooki/P. pycrofti*	Cook's/Pycroft's Petrel	9	9
089	SPWR	----	White-rumped Storm-Petrel	6	9
087	SPTR	*Oceanodroma tristrami*	Tristram's Storm-Petrel	8	8
024	JALT	*Stercorarius longicaudus*	Long-tailed Jaeger	8	8
041	PEHE	*Pterodroma heraldica (arminjoniana)*	Herald Petrel	7	7
044	PEKD	*Pterodroma neglecta*	Kermadec Petrel (dark morph)	6	6
047	PEKL	*Pterodroma neglecta*	Kermadec Petrel (light morph)	5	5

Code	Species Code	Scientific Name	Common Name	Encounters	Individuals
063	SHNZ	*Puffinus bulleri*	Buller's (New Zealand) Shearwater	5	5
065	SHPF	*Puffinus creatopus*	Pink-footed Shearwater	4	4
058	PTSP	*Pterodroma* sp.	unidentified *Pterodroma*	2	3
095	TEAR	*Sterna paradisaea*	Arctic Tern	1	3
078	SPBR	*Hydrobates pelagicus*	European (British) Storm-Petrel	2	2
051	PEPY	*Pterodroma pycrofti*	Pycroft's Petrel	2	2
034	PASS	----	Passerines	2	2
012	BUSP	*Bulweria* sp.	unidentified *Bulweria*	1	1
018	FRLE	*Fregata ariel*	Lesser Frigatebird	1	1
019	FUND	*Fulmarus glacialis*	Northern Fulmar (dark morph)	1	1
021	GULB	*Larus fuscus*	Lesser Black-backed Gull	1	1
088	SPWI	*Oceanites oceanicus*	Wilson's Storm-Petrel	1	1
083	SPLH	*Oceanodroma leucorhoa/O. castro*	Leach's/Harcourt's Storm-Petrel	1	1
086	SPSP	*Oceanodroma* sp.	unidentified Storm-Petrel	1	1
053	PESW	*Pterodroma longirostris/P. leucoptera*	Stejneger's/White-winged Petrel	1	1
045	PEKH	*Pterodroma neglecta/P. heraldica*	Kermadec/Herald Petrel	1	1
054	PETA	*Pterodroma rostrata*	Tahiti Petrel	1	1
068	SHSP	*Puffinus* sp.	unidentified Shearwater	1	1
061	SHMT	*Puffinus* sp.	Manx-type Shearwater	1	1
023	JAEG	*Stercorarius* sp.	unidentified Jaeger	1	1
075	SKUA	*Stercorarius* sp.	unidentified Skua	1	1
009	BOMO	*Sula granti*	Nazca Booby	1	1
079	SPDR	----	dark-rumped Storm-Petrel	1	1
			TOTAL	9951	21419

Table 6. Number of seabirds observed during the *Lasker*'s transit from San Diego to Honolulu, within the 300 m strip transect, in descending order of total number of individuals.

Code	Species Code	Scientific Name	Common Name	Encounters	Individuals
098	TESO	*Onychoprion fuscata*	Sooty Tern	3	121
063	SHNZ	*Puffinus bulleri*	Buller's (New Zealand) Shearwater	26	34
085	SPLW	*Oceanodroma leucorhoa*	white-rumped Leach's Storm-Petrel	23	26
086	SPSP	*Oceanodroma* sp.	unidentified Storm-Petrel	2	16
093	TBRT	*Phaethon rubricauda*	Red-tailed Tropicbird	14	16
038	PECO	*Pterodroma cookii*	Cook's Petrel	13	14
073	SHWW	*Puffinus pacificus*	Wedge-tailed Shearwater (light morph)	3	12
042	PEJF	*Pterodroma externa*	Juan Fernandez Petrel	9	9
094	TBWT	*Phaethon lepturus*	White-tailed Tropicbird	5	6
081	SPLD	*Oceanodroma leucorhoa*	dark-rumped Leach's Storm-Petrel	5	5
040	PEHA	*Pterodroma sandwichensis*	Hawaiian Petrel	5	5
067	SHSO	*Puffinus griseus*	Sooty Shearwater	5	5
031	NOBR	*Anous stolidus*	Brown Noddy	1	4
084	SPLI	*Oceanodroma leucorhoa*	intermediate-rumped Leach's Storm-Petrel	4	4
002	ALBF	*Phoebastria nigripes*	Black-footed Albatross	3	3
043	PEJW	*Pterodroma externa/P. cervicalis*	Juan Fernandez/White-necked Petrel	3	3
024	JALT	*Stercorarius longicaudus*	Long-tailed Jaeger	3	3
049	PEMU	*Pterodroma ultima*	Murphy's Petrel	1	2
099	TEWH	*Gygis alba*	White Tern	2	2
076	SPAS	*Oceanodroma homochroa*	Ashy Storm-Petrel	2	2
082	SPLE	*Oceanodroma leucorhoa*	Leach's Storm-Petrel	2	2
055	PEWN	*Pterodroma cervicalis*	White-necked Petrel	2	2
046	PEKI	*Pterodroma neglecta*	Kermadec Petrel (intermediate morph)	2	2
023	JAEG	*Stercorarius* sp.	unidentified Jaeger	2	2
011	BORF	*Sula sula*	Red-footed Booby	2	2
003	ALCD	*Alcidae* sp.	unidentified Alcid	1	1

Code	Species Code	Scientific Name	Common Name	Encounters	Individuals
096	TEBL	*Chlidonias niger*	Black Tern	1	1
022	GUWE	*Larus occidentalis*	Western Gull	1	1
077	SPBL	*Oceanodroma melania*	Black Storm-Petrel	1	1
092	TBRB	*Phaethon aethereus*	Red-billed Tropicbird	1	1
050	PEPH	*Pterodroma alba*	Phoenix Petrel	1	1
039	PECP	*Pterodroma cooki/P. pycrofti*	Cook's/Pycroft's Petrel	1	1
047	PEKL	*Pterodroma neglecta*	Kermadec Petrel (light morph)	1	1
070	SHWD	*Puffinus pacificus*	Wedge-tailed Shearwater (dark morph)	1	1
074	SKSP	*Stercorarius maccormicki*	South Polar Skua	1	1
026	JAPO	*Stercorarius pomarinus*	Pomarine Jaeger	1	1
007	BOBR	*Sula leucogaster*	Brown Booby	1	1
032	NPSS	----	unidentified bird (non-marine and non-passerine)	1	1
			TOTAL	155	315

Table 7. Number of seabird feeding flocks recorded in the Hawai‘i EEZ during strip transect surveys conducted aboard the *Sette* and the *Lasker*.

Active feeding flocks were recorded out to 1-reticle (~5 km) on either side of the vessel.

Ship	Leg 1	Leg 2	Leg 3	Leg 4	TOTAL
Sette	160	123	116	-----	399
Lasker	13	70	52	23	158

Ecosystem Sampling

A total of 243 CTD casts were conducted during HICEAS 2017 (Figure 5).

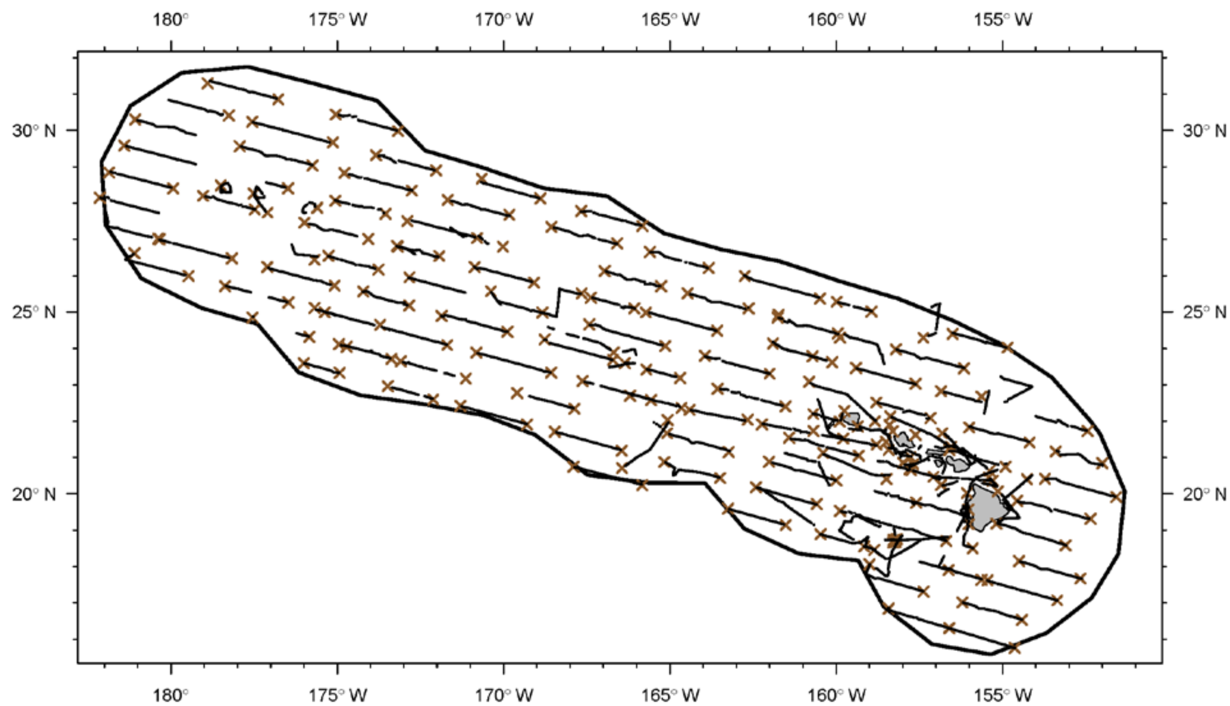


Figure 5. CTD station locations within the Hawai‘i EEZ (black outline).

The location of CTD casts are marked with a brown “X” and typically mark the start and end of a survey day’s visual effort (black lines).

Active acoustic sampling with the Simrad EK60 echosounder occurred continuously, day and night, except when secured during specific cetacean passive acoustic detections. These data may provide a better understanding of cetacean habitat within the Hawaiian Archipelago.

Marine turtles were sighted on 3 occasions by the cetacean or seabird observers; one loggerhead sea turtle (*Caretta caretta*) during the transit from California, one green sea turtle (*Chelonia mydas*), and an unidentified hard shell marine turtle (Appendix D).

One Hawaiian monk seal (*Monachus schauinslandi*) was sighted at sea by the cetacean observers (Appendix D).

Autonomous Drifting Acoustic Recorders

Nineteen DASBRs were deployed during HICEAS 2017 (Appendix I). Thirteen DASBRs were recovered, and six were lost. Five were lost due to equipment and transmitter failure, and one DASBR was retrieved with a severed line and missing the acoustic recorder. Of the 13 recovered units, acoustic data were collected on 251 days and over 6,354 km of drifting track (Figure 6), primarily within the MHI focal area. DASBR data will be processed for occurrence of a variety of vocal cetacean species.

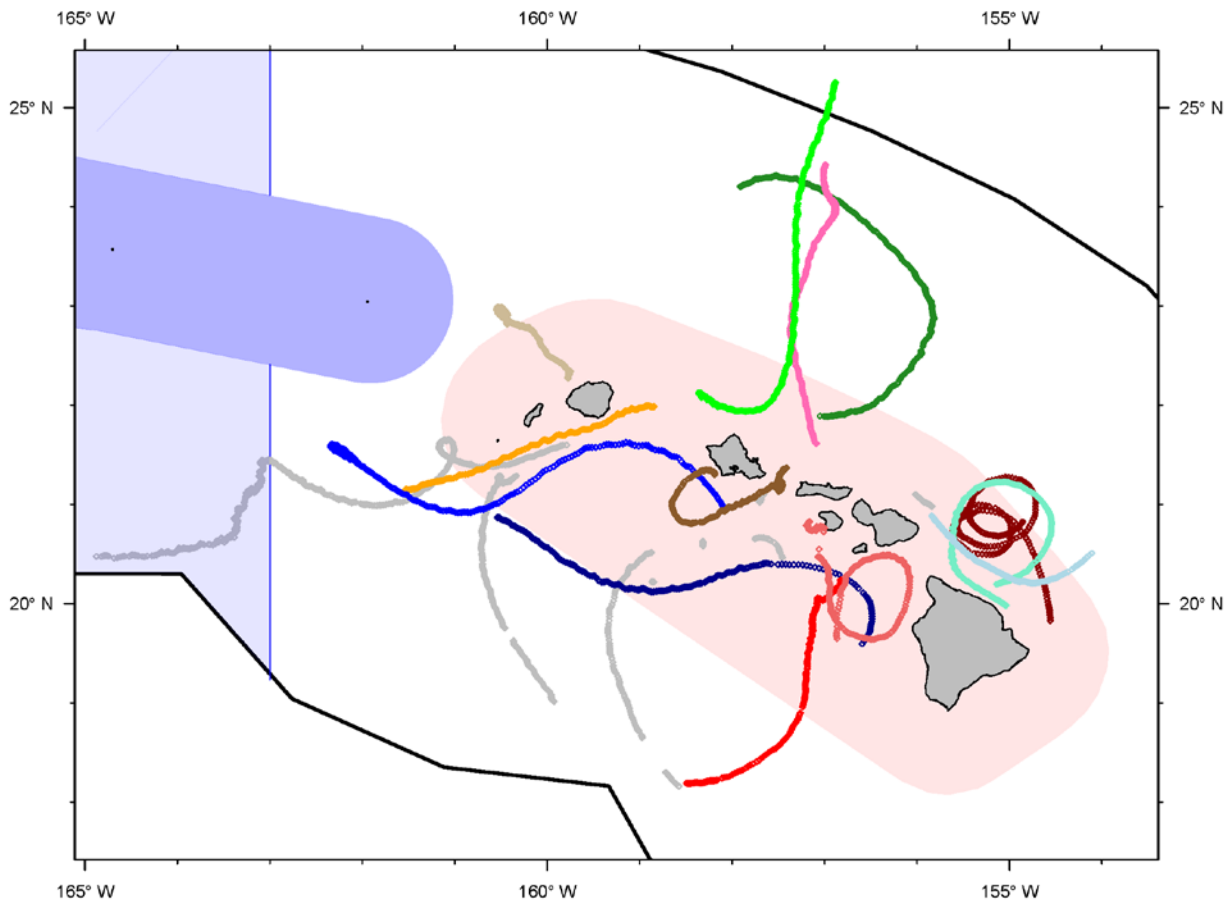


Figure 6. Tracklines of 19 DASBRs that were deployed in the MHI focal area (red shading) of the Hawaiʻi EEZ (black outline).

DASBR tracks in color each represent the recording period for 13 retrieved units. Gray tracks represent received Iridium transmissions from the DASBRs that were lost. Survey strata are defined in Figure 1.

Acknowledgements

The PacMAPPS partners – BOEM (Interagency Agreement (IAA) M17PG00024 and M17PG00025), U.S. Navy Pacific Fleet Environmental Readiness Division (IAA NMFS-PIC-07-006) and Chief of Naval Operations N45 (IAA NEC-16-011-01BP) – provided partial funding for all shipboard visual and passive acoustic survey operations, including collection of cetacean photographs and biopsy samples. Additional funding for HICEAS 2017 project survey operations was provided by PIFSC, the NMFS Take-Reduction Program, and by the NMFS National Seabird Program. Satellite tagging and DASBR deployments during HICEAS were funded by PIFSC. Ship time aboard *Sette* and *Lasker* was provided by PIFSC and SWFSC, respectively. The Chief Scientists for HICEAS 2017 were Erin Oleson and Jeff Moore and the Survey Coordinators were Kym Yano and Annette Henry. Many thanks to the HICEAS 2017 Cruise Leaders (Erin Oleson, Amanda Bradford, Marie Hill, Jeff Moore, Eric Archer, Jim Carretta, and Karin Forney) for keeping HICEAS on-track and running smoothly while at sea. Many observers, acousticians, visiting scientists, and the officers and crew of the *Sette* and *Lasker* made HICEAS possible. Many thanks to Shannon Rankin, Yvonne Barkley, and Erik Norris for their assistance prior to the start of the survey with planning, preparing, and maintaining passive acoustic equipment, to Al Jackson for his assistance with the QA/QC of the data collected within WinCruz, and to Jay Barlow for partnering with us to design and implement the DASBR survey. Significant appreciation is also extended to PIFSC administrative and Science Operations Division staff (including Julie Whitaker, Martha Kawai, Susan Kamei, Nori Shoji, Hoku Johnson, and Amanda Dillon) for ensuring HICEAS success through their assistance with funding agreements, contracts, permits, outreach and media, and ship coordination. Sonobuoys were provided by the U.S. Navy Living Marine Resources Program. Marine mammals were approached and sampled under NMFS MMPA-ESA take permit 20311. Encounters of non-target species (monk seals and marine turtles) were also covered under NMFS MMPA-ESA take permit 20311. All seabird research was conducted under U.S. Fish and Wildlife Service Migratory Bird permit 033305-0. Cetacean, seabird, and ecosystem survey data were collected within the PMNM under permit PMNM-2017-17.

Literature Cited

Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.K. Deakos, A.D. Ligon, G.S. Schorr, J. Barlow, and S.D. Mahaffy. 2008. False killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands: Long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24:591-612.

Ballance, L.T. 2007. Understanding seabirds at sea: why and how? Marine Ornithology 35:127-135.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22:446–464.

Barlow, J., S. Rankin, E. Zele, and J. Appler. 2004. Marine mammal data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) conducted aboard the NOAA Ships *McArthur* and *David Starr Jordan*, July-December 2002. U.S. Department of Commerce, NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-362, 39 pp.

Barlow, J. and E. Griffiths. 2017. Precision and bias in estimating detection distances for beaked whale echolocation clicks using a two-element vertical hydrophone array. The Journal of the Acoustical Society of America 141: 4388-4397.

Baumann-Pickering, S., M.A. Roch, R.L. Brownell, A.E. Simonis, M.A. McDonald, A. Solsona-Berga, E.M. Oleson, S.M. Wiggins, J.A. Hildebrand. 2014. Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific. PLoS ONE 9(1): e86072. doi:10.1371/journal.pone.0086072.

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2014. Accounting for subgroup structure in line-transect abundance estimates of false killer whales (*Pseudorca crassidens*) in Hawaiian waters. PloS One 9:e90464.

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142.

Gillespie, D., J. Gordon, R. McHugh, D. McLaren, D.K. Mellinger, P. Redmond, A. Thode, P. Trinder, and X.-Y. Deng. 2008. PAMGUARD: Semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. Proceedings of the Institute of Acoustics 30:1–9.

Griffiths, E.T. and J. Barlow. 2015. Equipment performance report for the Drifting Acoustic Spar Buoy Recorder (DASBR). U.S. Department of Commerce, NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-543. doi: 10.7289/V5/TM-SWFSC-543.

Griffiths, E.T. and J. Barlow. 2016. Cetacean acoustic detections from free-floating vertical hydrophone arrays in the southern California Current. The Journal of the Acoustical Society of America 140:EL399-EL404.

Haver, S.M., J. Gedamke, L.T. Hatch, R.P. Dziak, S. Van Parijs, M.F. McKenna, J. Barlow, C. Berchok, E. DiDonato, B. Hanson, J. Haxel, M. Holt, D. Lipski, H. Matsumoto, C. Meinig, D.K. Mellinger, S.E. Moore, E.M. Oleson, M.S. Soldevilla, and H. Klick. 2018. Monitoring long-term soundscape trends in U.S. waters: The NOAA/NPS Ocean Noise Reference Station Network. Marine Policy 90: 6-13. doi: 10.1016/j.marpol. 2018.01.023.

Heinemann, D. 1981. A range finder for pelagic bird censusing. The Journal of Wildlife Management 45: 489-493.

Keating, J.L. and J. Barlow. 2013. Summary of PAMGUARD beaked whale click detectors and classifiers used during the 2012 Southern California Behavioral Response Study. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-517, 17 pp.

Kinsey, D., P. Olson, and T. Gerrodette. 2000. Marine mammal data collection procedures on research ship line-transect surveys by the Southwest Fisheries Science Center. U.S. Department of Commerce, NOAA Administrative Report LJ-00-07C, 32 pp.

Johnston, D.W., M. McDonald, J.J. Polovina, R. Domokos, S.M. Wiggins, and J.A. Hildebrand. 2008. Temporal patterns in the acoustic signals of beaked whales at Cross Seamount. Biology Letters 4: 208-211.

Miller, B.S., S. Wotherspoon, S. Rankin, S. Calderan, R. Leaper, and J.L. Keating. 2018. Estimating drift of directional sonobuoys from acoustic bearings. The Journal of the Acoustical Society of America 143:EL25-EL30.

Rankin, S., J. Barlow, Y. Barkley, and R. Valtierra. 2013. A guide to constructing hydrophone arrays for passive acoustic data collection during NMFS shipboard cetacean surveys. U.S. Department of Commerce, NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-511, 33 pp.

Appendices

Appendix A: Project Schedule

Table A1. Departure and arrival dates for each project leg.

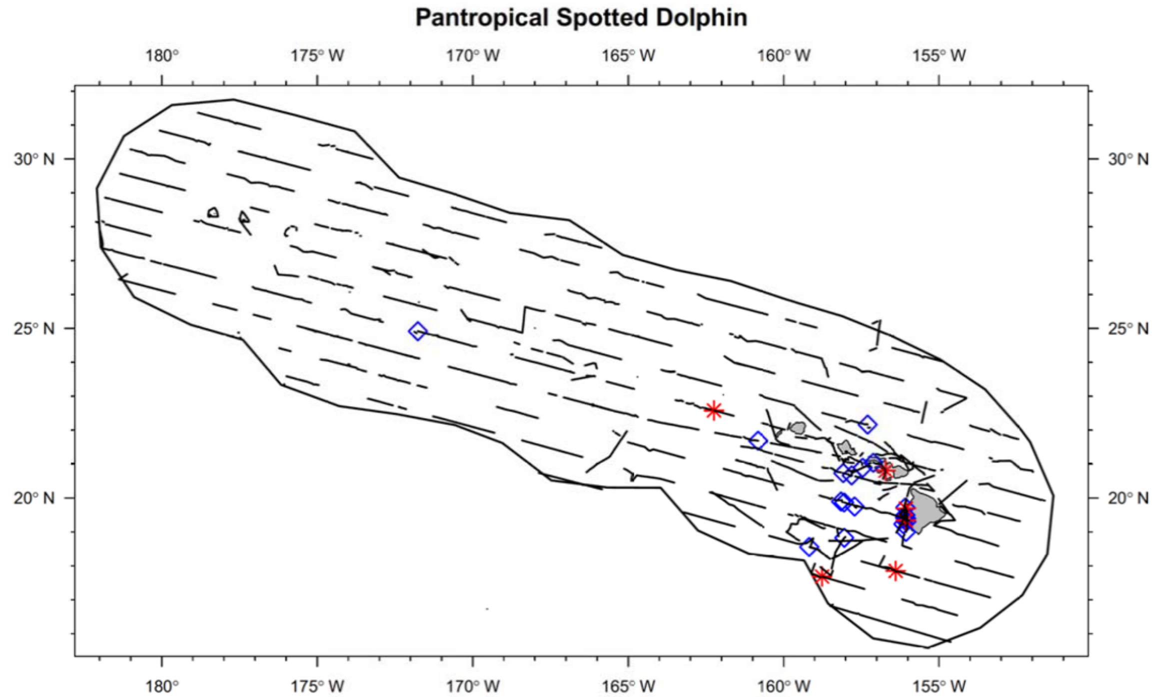
Ship, Leg Number	Ship-Leg Abbreviation	Depart Date	Arrive Date
Oscar Elton Sette, Leg 1	S1	6 July 2017	2 August 2017
Oscar Elton Sette, Leg 2	S2	8 August 2017	5 September 2017
Reuben Lasker, Leg 1	L1	17 August 2017*	5 September 2017
Oscar Elton Sette, Leg 3	S3	11 September 2017	10 October 2017
Reuben Lasker, Leg 2	L2	11 September 2017	10 October 2017
Reuben Lasker, Leg 3	L3	16 October 2017	9 November 2017
Reuben Lasker, Leg 4	L4	15 November 2017	1 December 2017

*All in-ports were in Honolulu, except *Lasker* Leg 1 that departed from San Diego.

Appendix B: Cetacean Distribution Maps

Sightings and Acoustic Detections of Delphinids (Figure B1-Figure B6)

Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. All sightings are shown, independent of visual effort type (black lines). Acoustic detections of delphinid groups that did not have associated visual species identification are classified at this time as unidentified dolphin and are shown in Figure B16. The project's study area, the Hawai'i EEZ, is marked by the black outline.



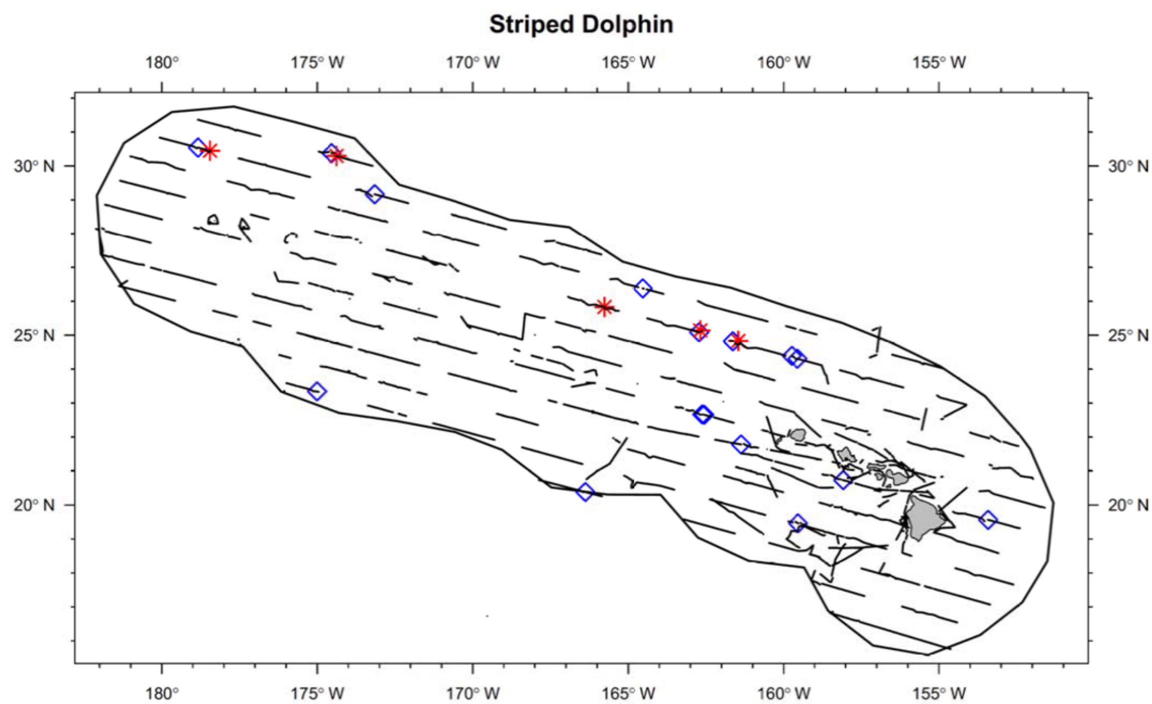
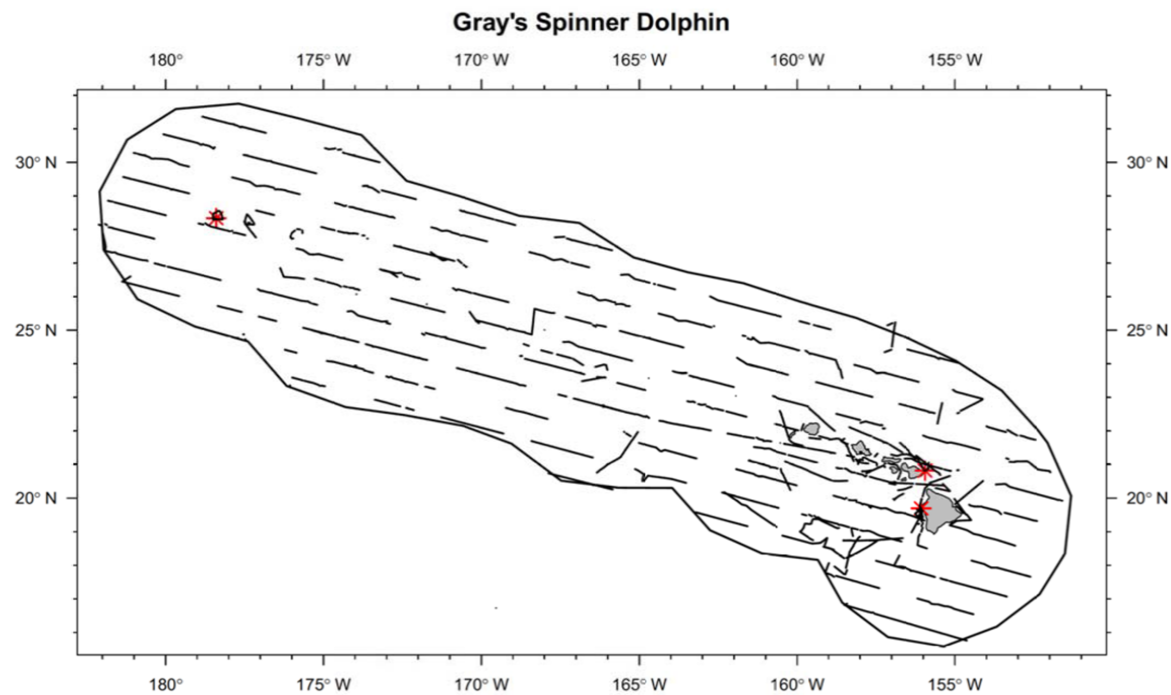


Figure B1. Sightings and acoustic detections of pantropical spotted and striped dolphins.



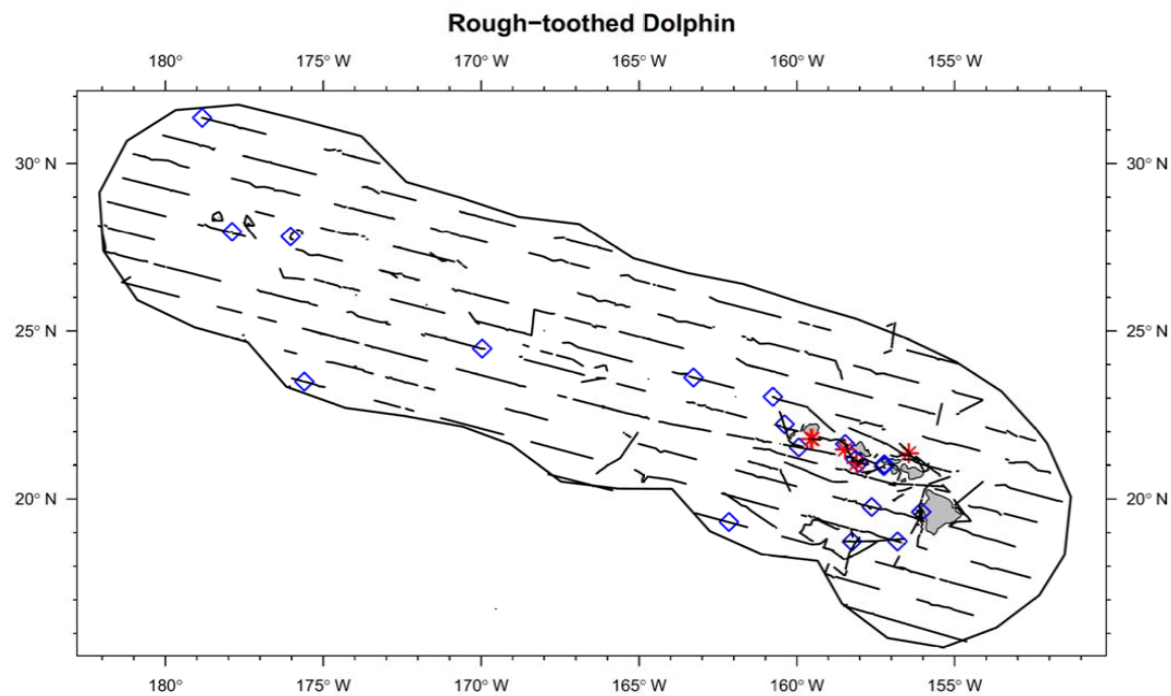
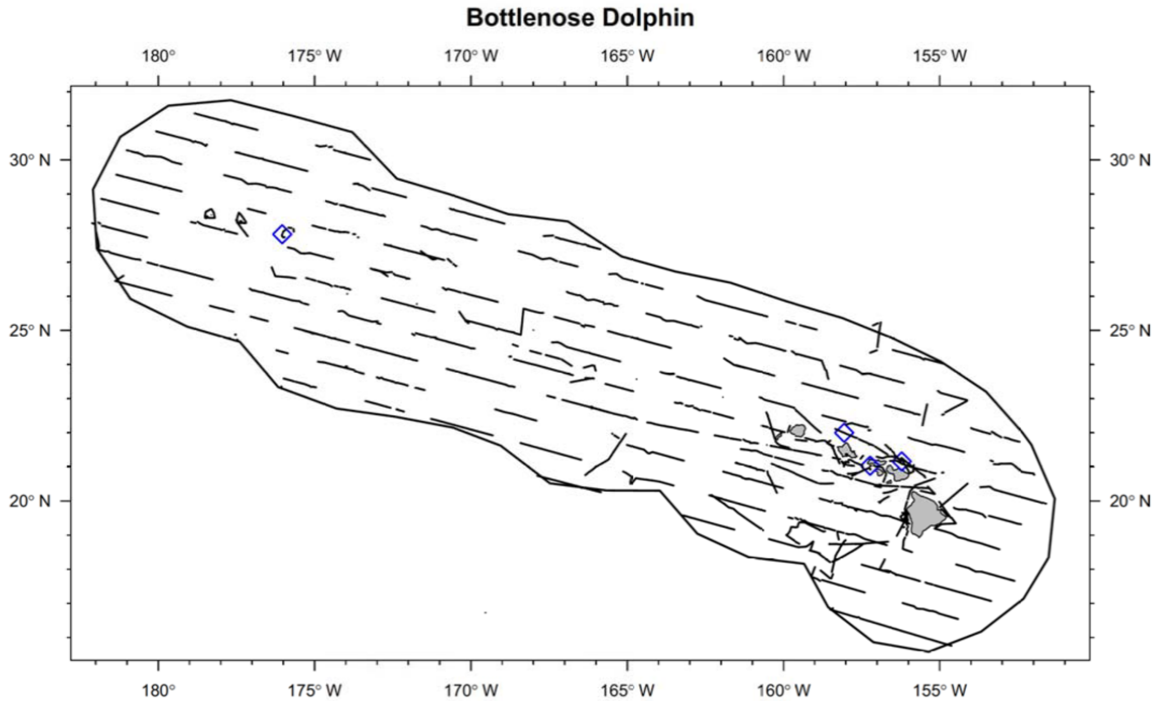


Figure B2. Sightings and acoustic detections of Gray's spinner and rough-toothed dolphins.



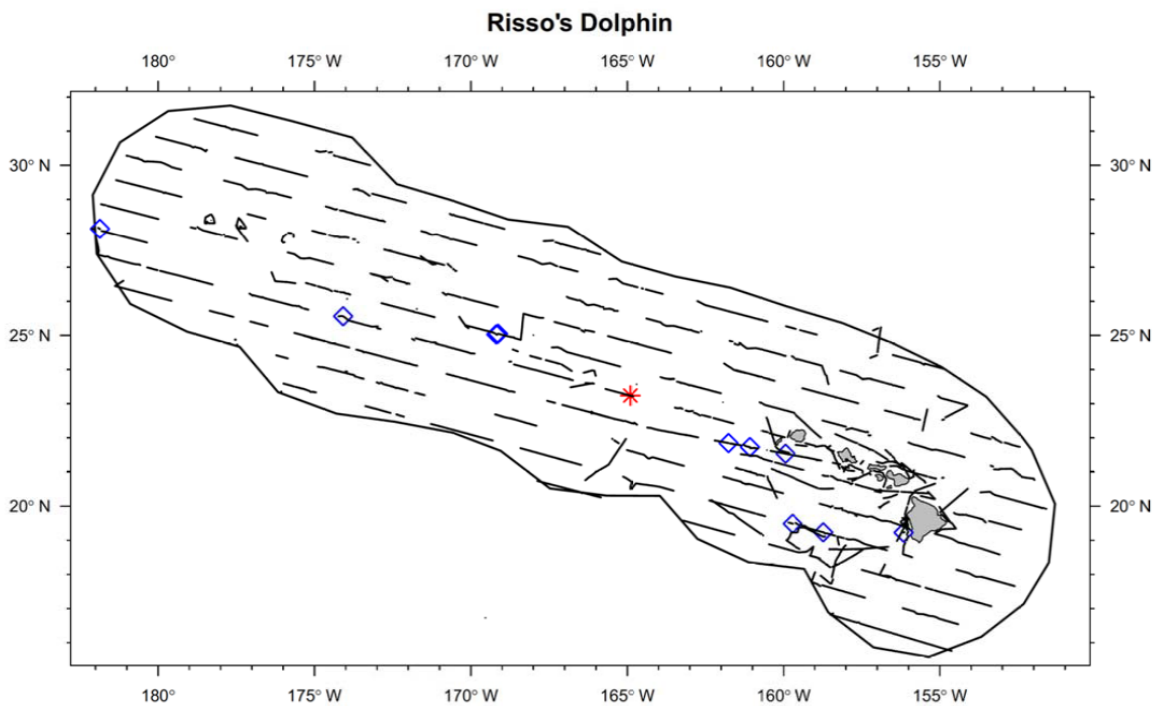
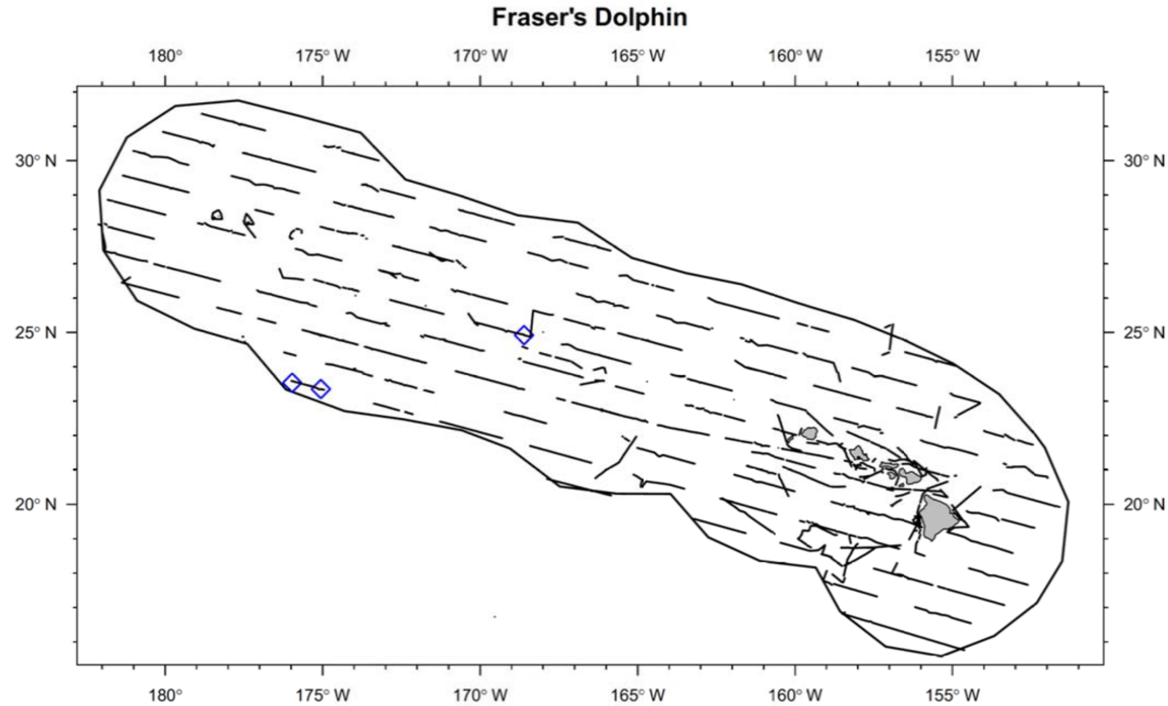


Figure B3. Sightings and acoustic detections of bottlenose and Risso's dolphins.



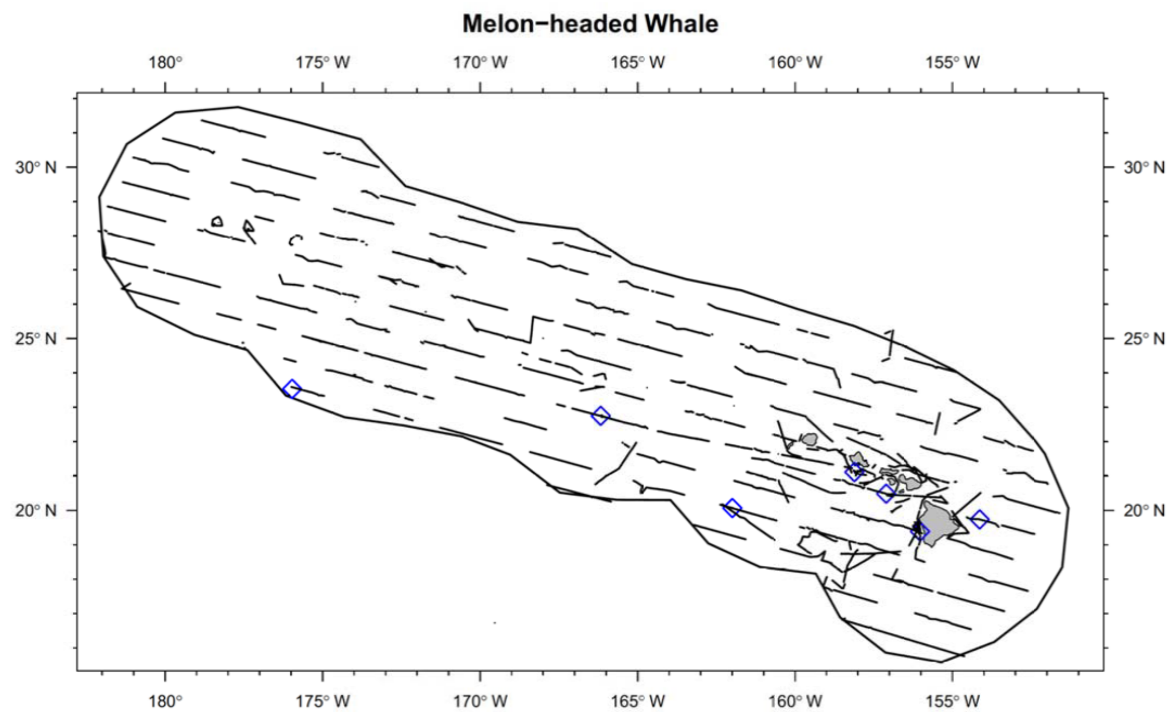
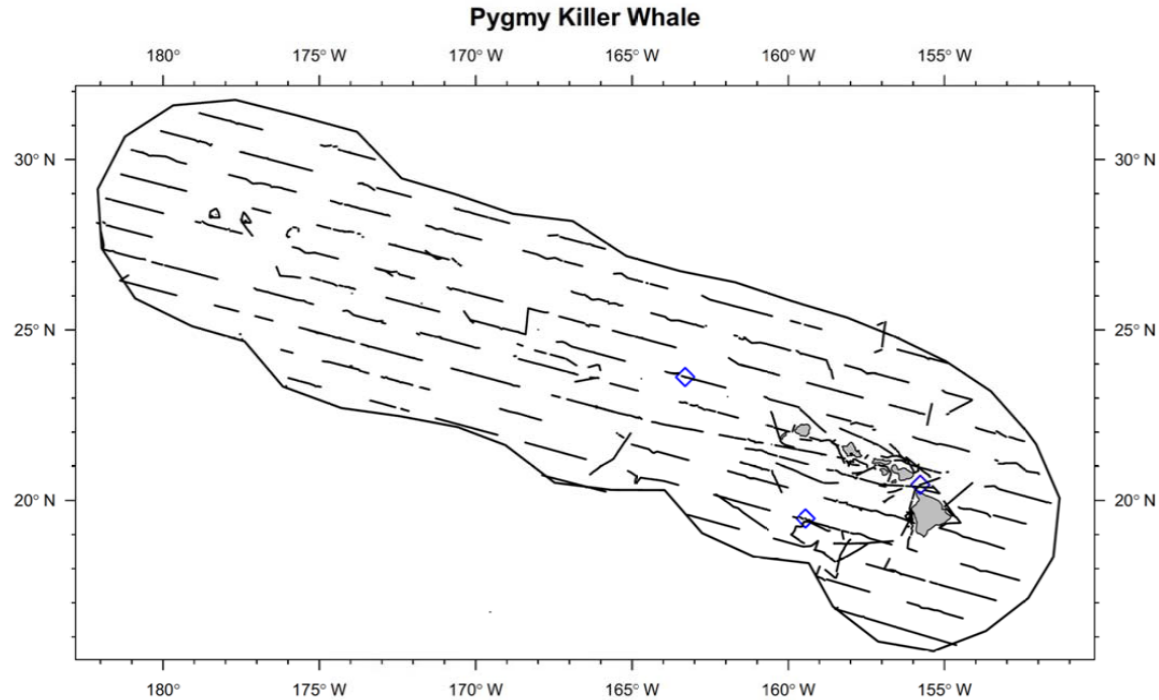


Figure B4. Sightings and acoustic detections of Fraser's dolphins and melon-headed whales.



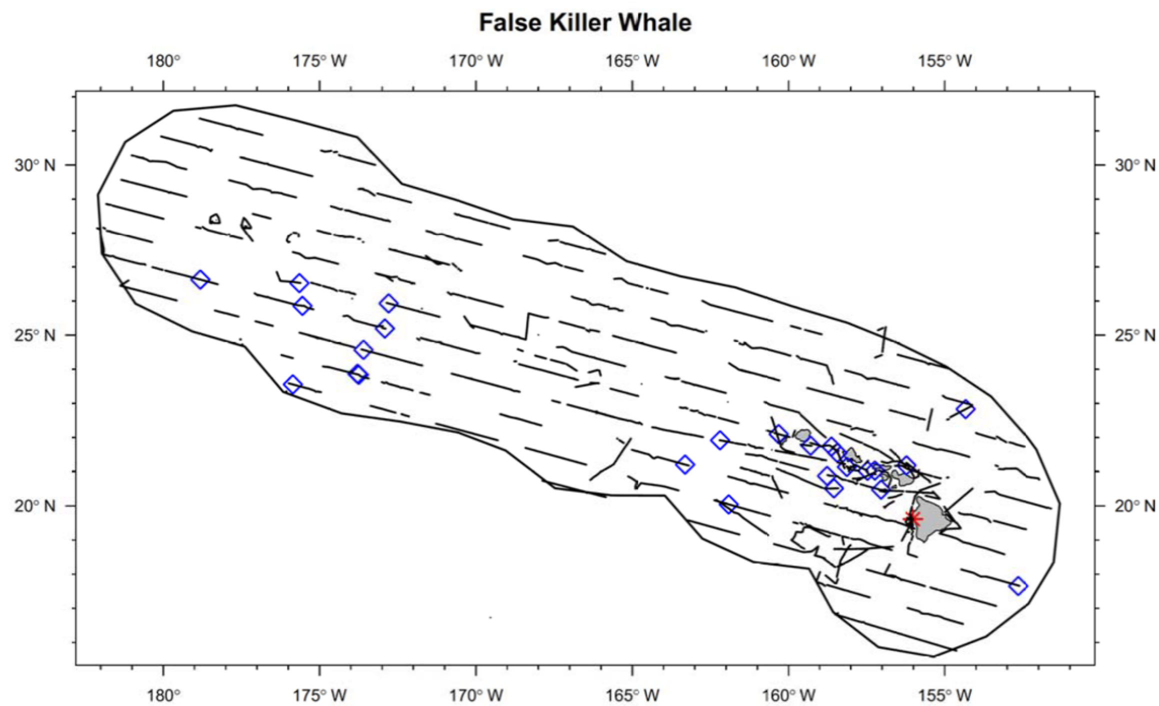
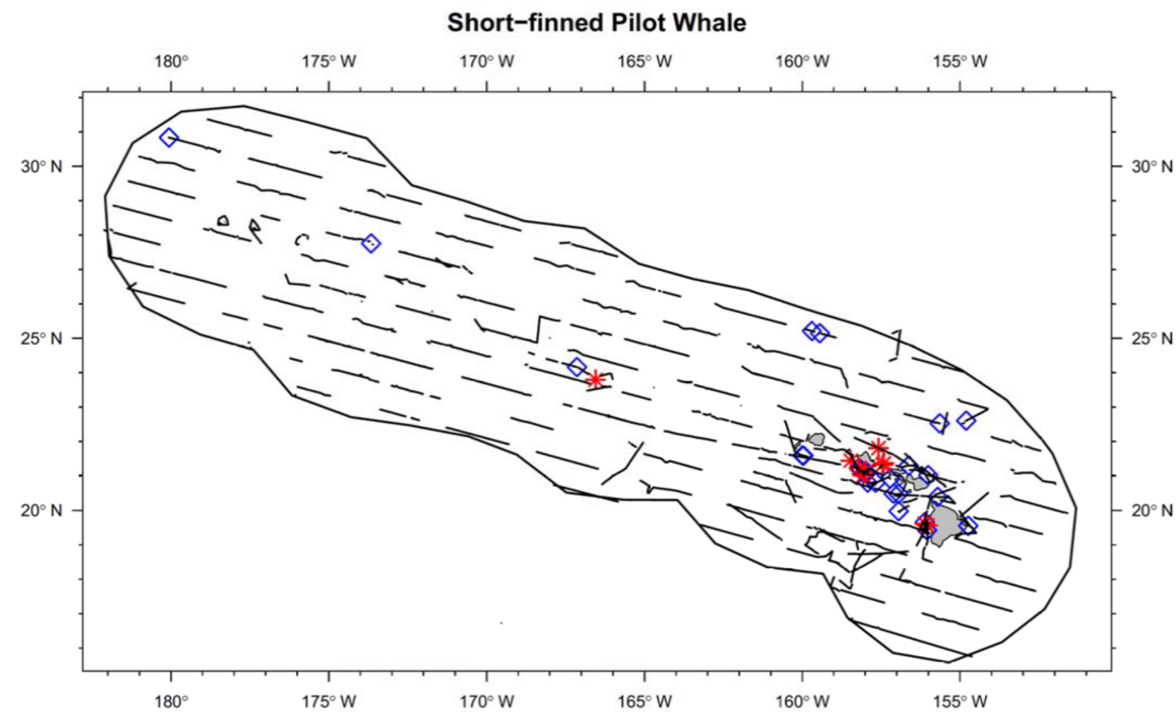


Figure B5. Sightings and acoustic detections of pygmy killer and false killer whales.



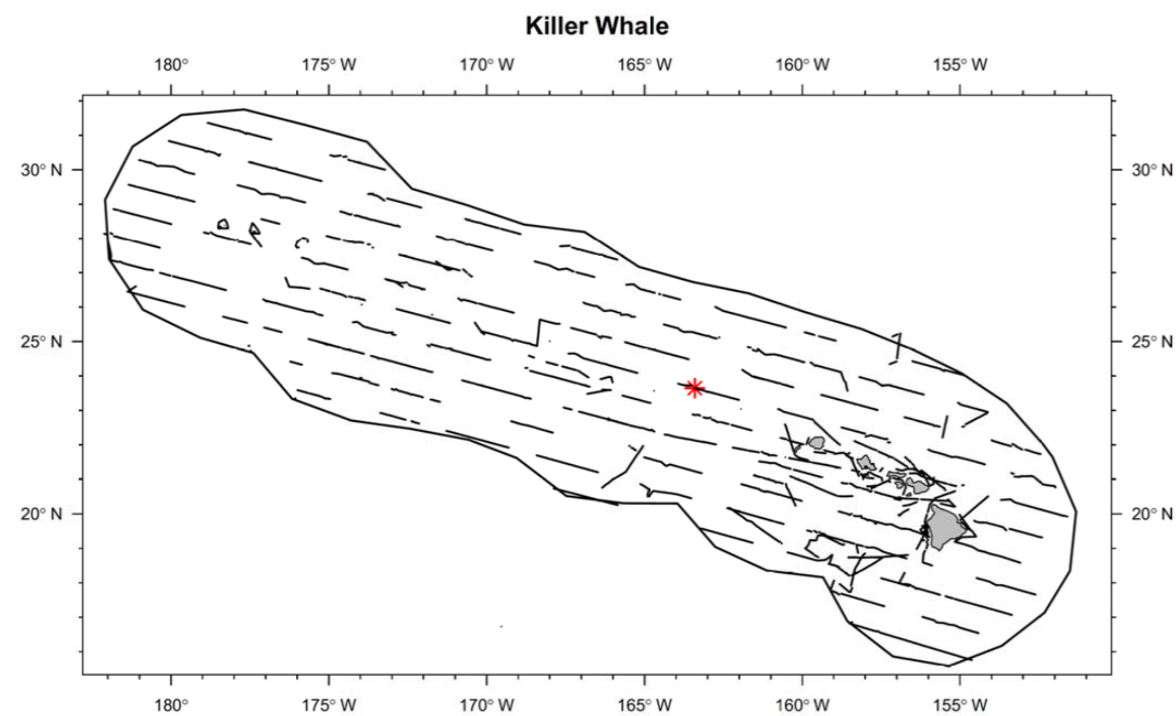
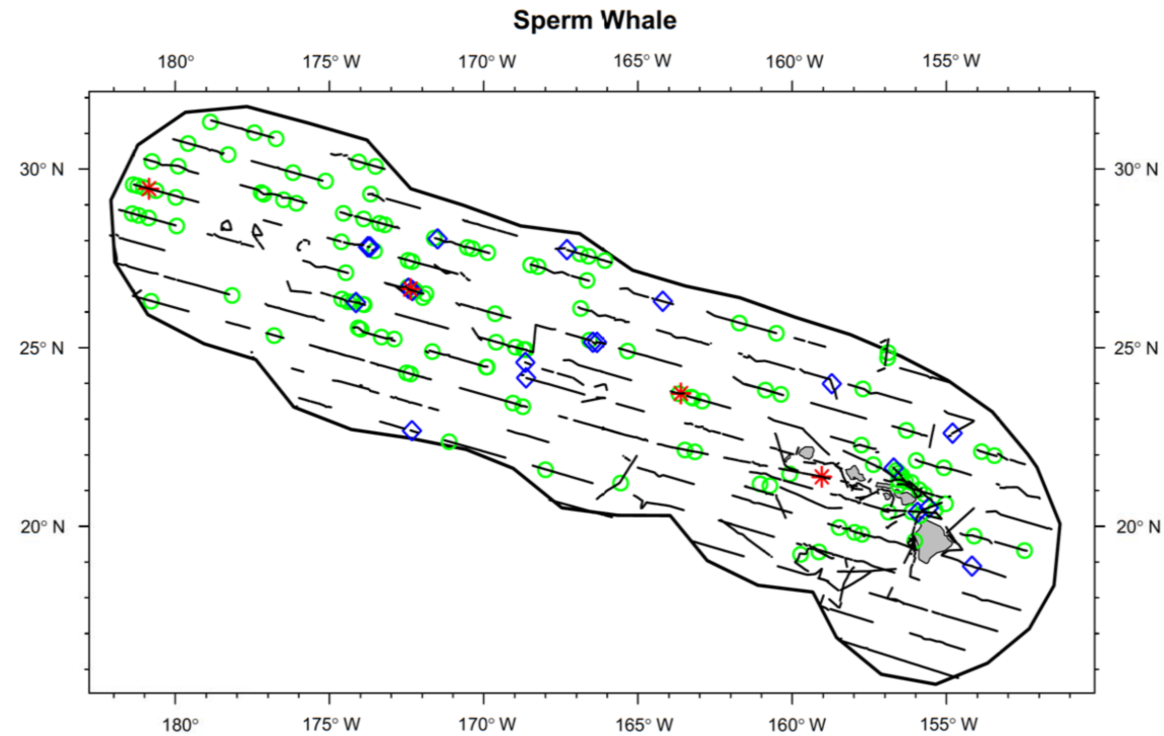


Figure B6. Sightings and acoustic detections of short-finned pilot and killer whales.

Sightings and Acoustic Detections of Sperm and Beaked Whales (Figure B7-Figure B10)

Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. All sightings are shown, independent of visual effort type (black lines). Acoustic detections without concurrent sightings are shown as green circles (sperm whales and unidentified beaked whales only). All acoustic detections of beaked whales without concurrent sightings are noted as an unidentified beaked whale. The project's study area, the Hawai‘i EEZ, is marked by the black outline.



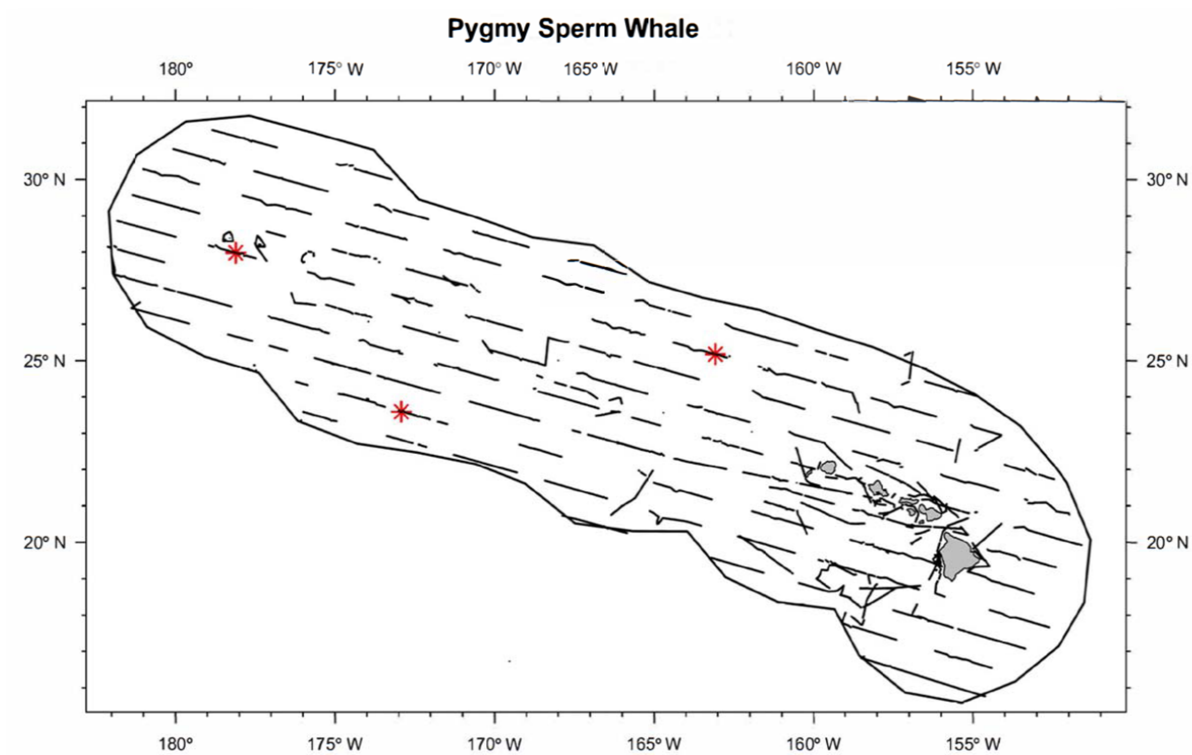
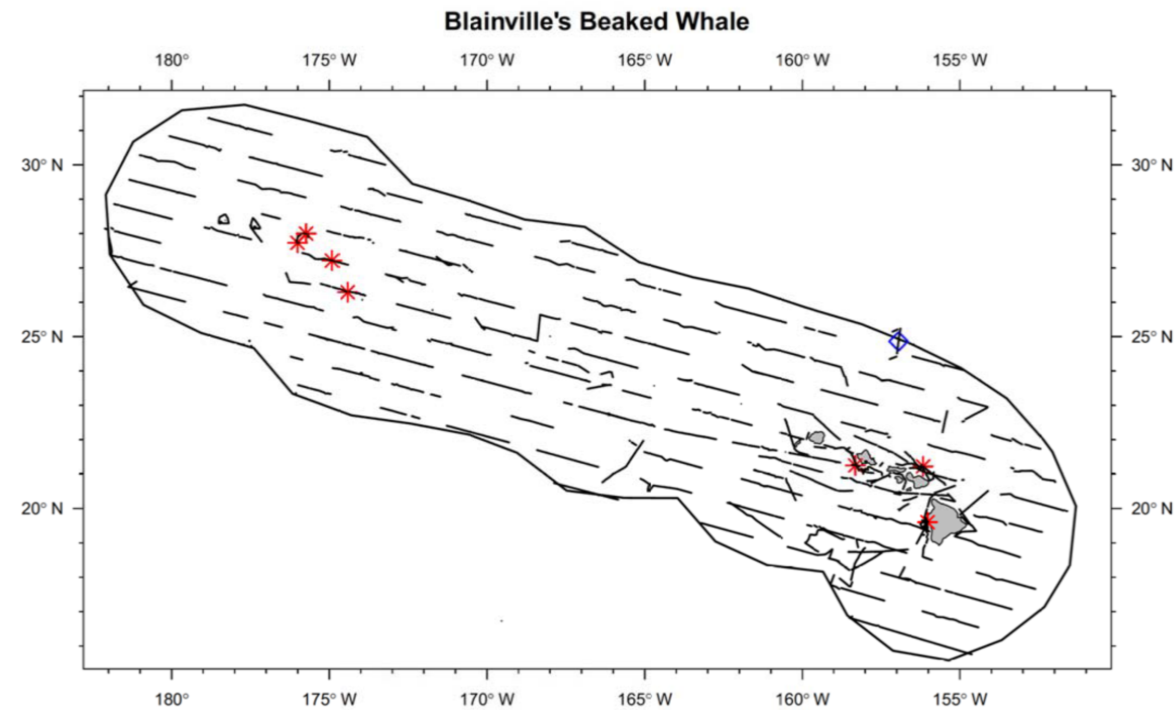


Figure B7. Sightings and acoustic detections of sperm and pygmy sperm whales.



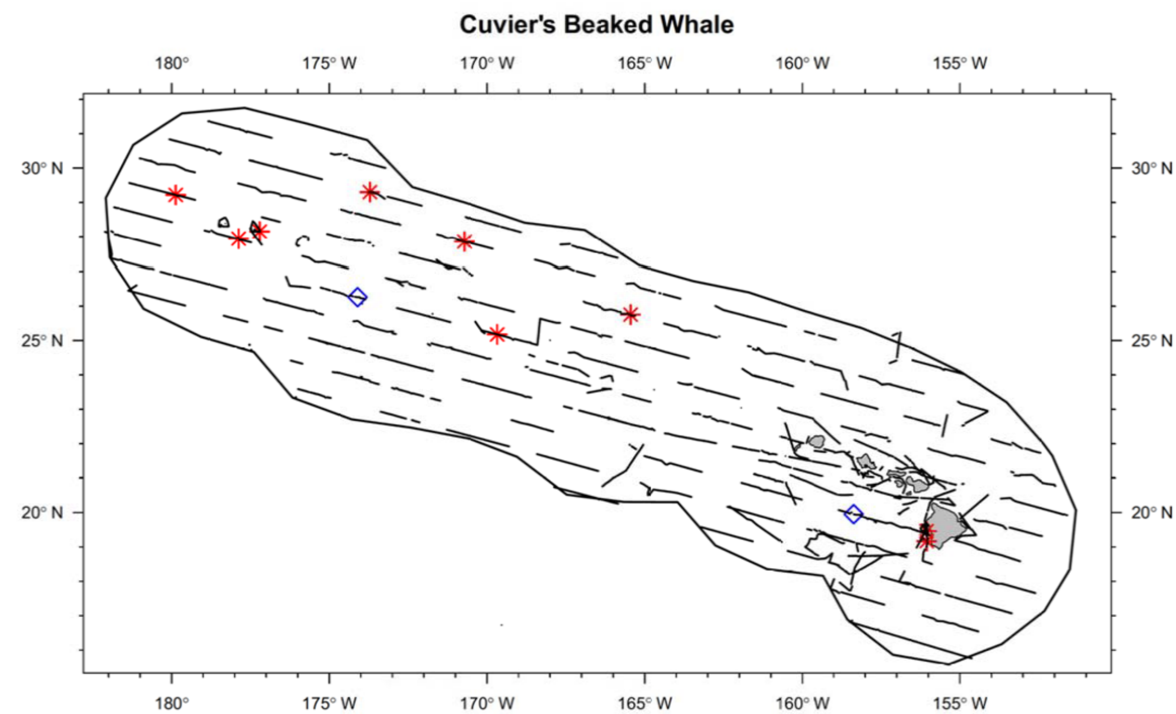
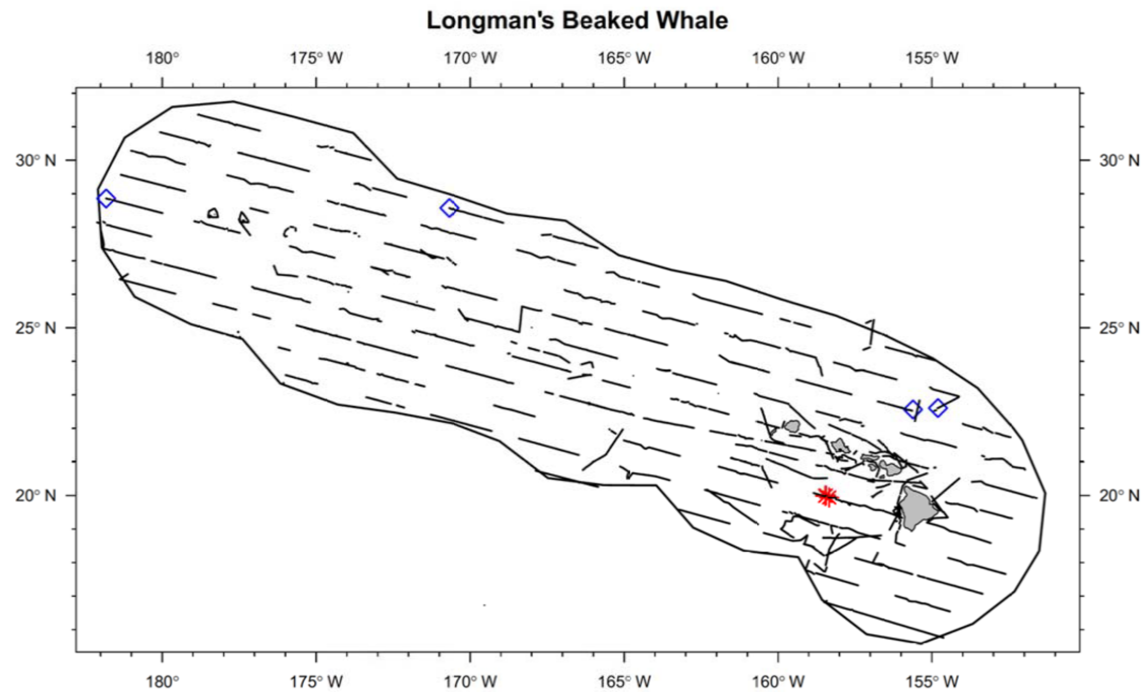


Figure B8. Sightings and acoustic detections of Blainville's and Cuvier's beaked whales.



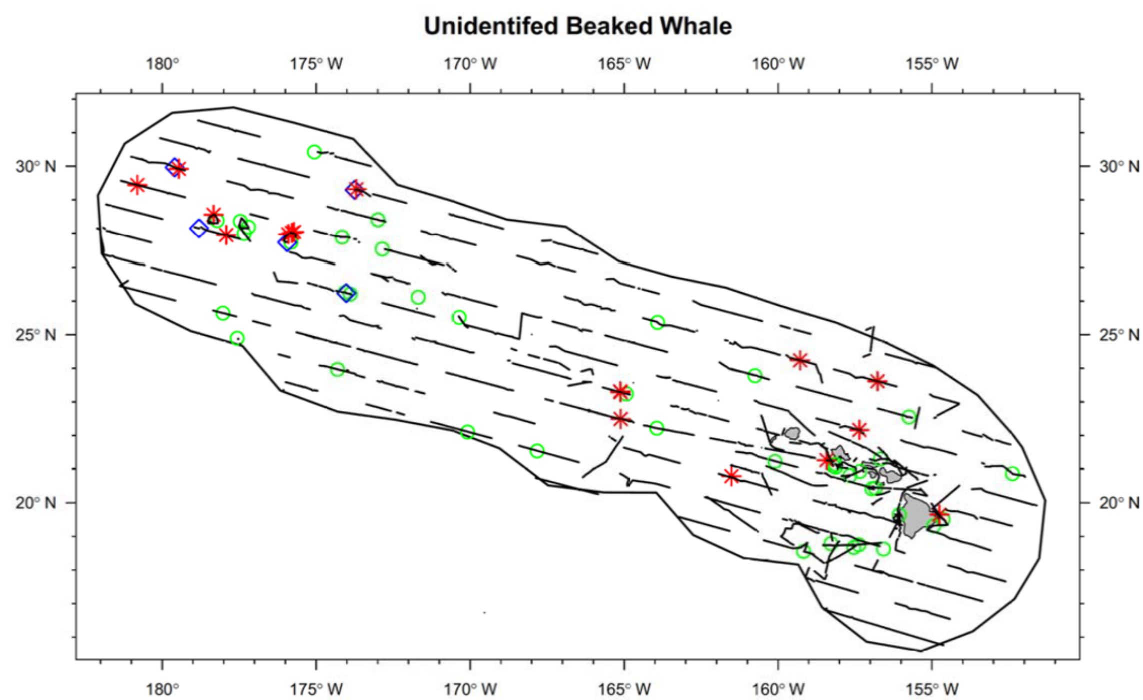
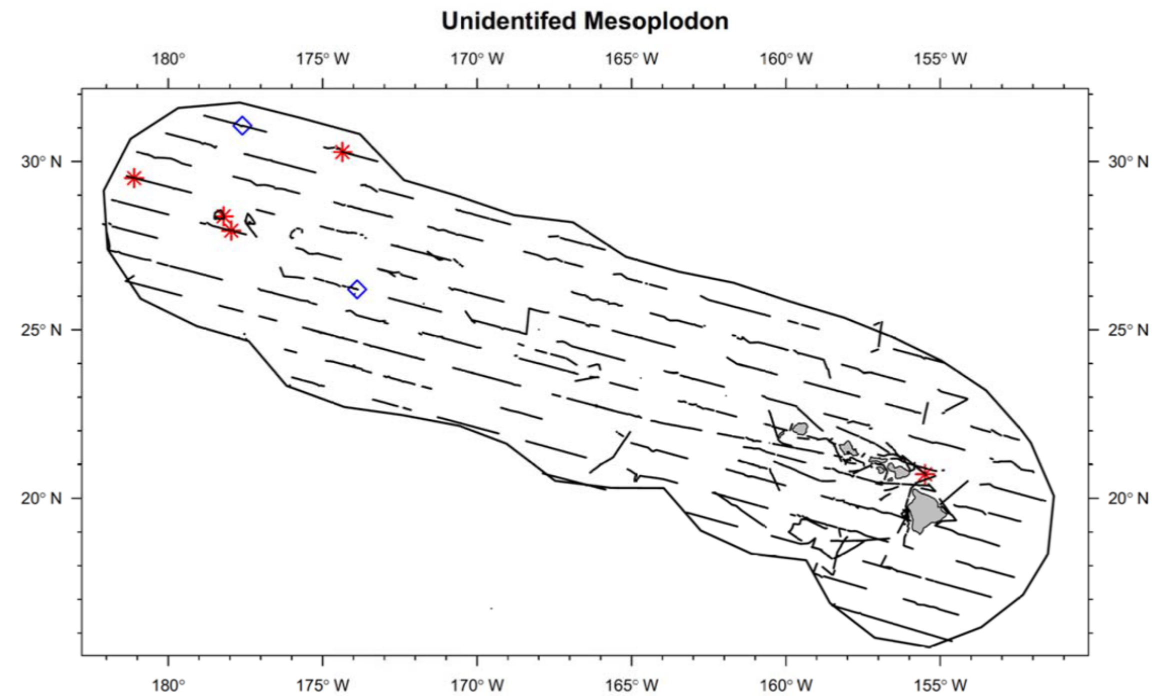


Figure B9. Sightings and acoustic detections of Longman's beaked whales and unidentified beaked whales.



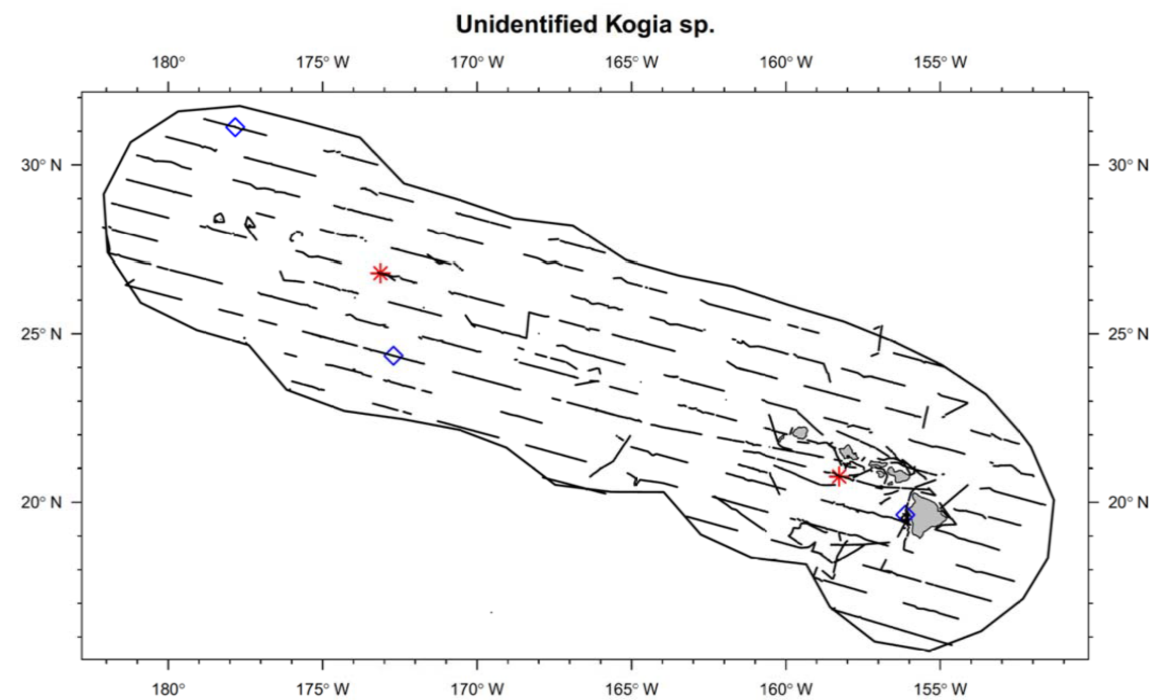
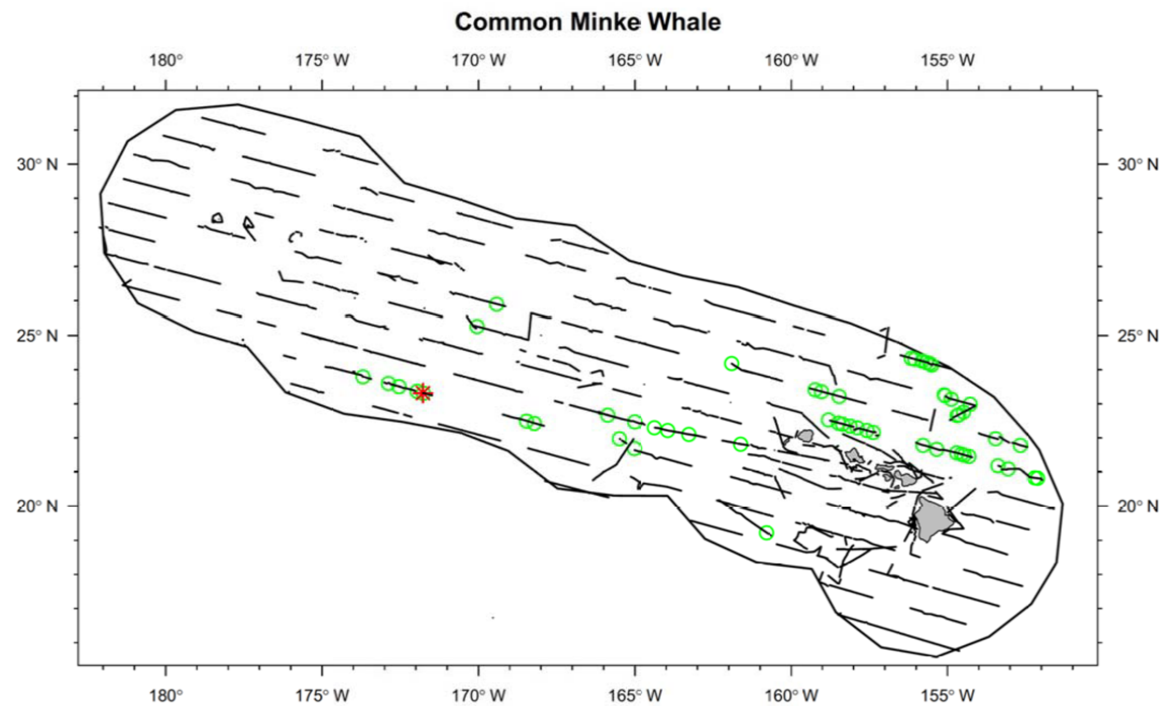


Figure B10. Sightings and acoustic detections of unidentified *Mesoplodon* sp. and unidentified *Kogia* sp. whales.

Sightings and Acoustic Detections of Baleen Whales (Figure B11-Figure B13)

Due to the design of the towed hydrophone array, baleen whale calls cannot be detected with the exception of common minke whale boings. Concurrent sightings and acoustic detections on sonobuoys for all other species are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks (note that a sonobuoy was not deployed at every baleen whale sighting). All sightings are shown, independent of visual effort type (black lines). Acoustic detections without concurrent sightings are shown as green circles (common minke whales only) and were detected with the towed hydrophone array. There were no concurrent visual and acoustic detections of common minke whales. The project's study area, the Hawai'i EEZ, is marked by the black outline.



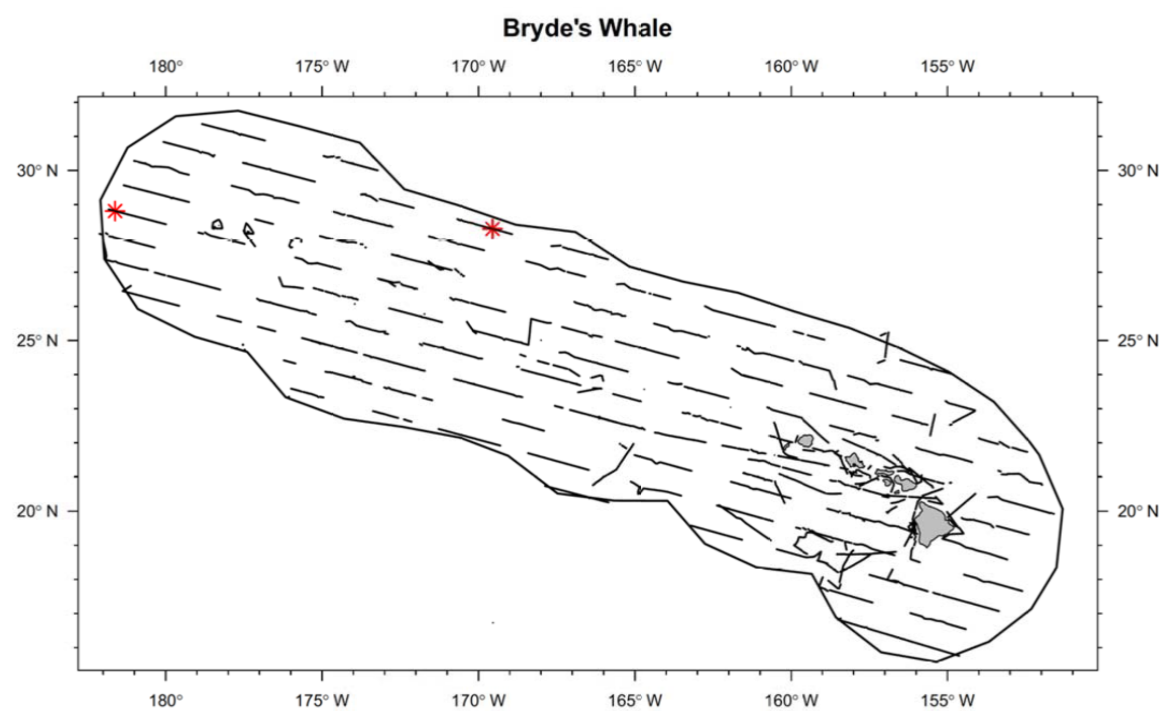
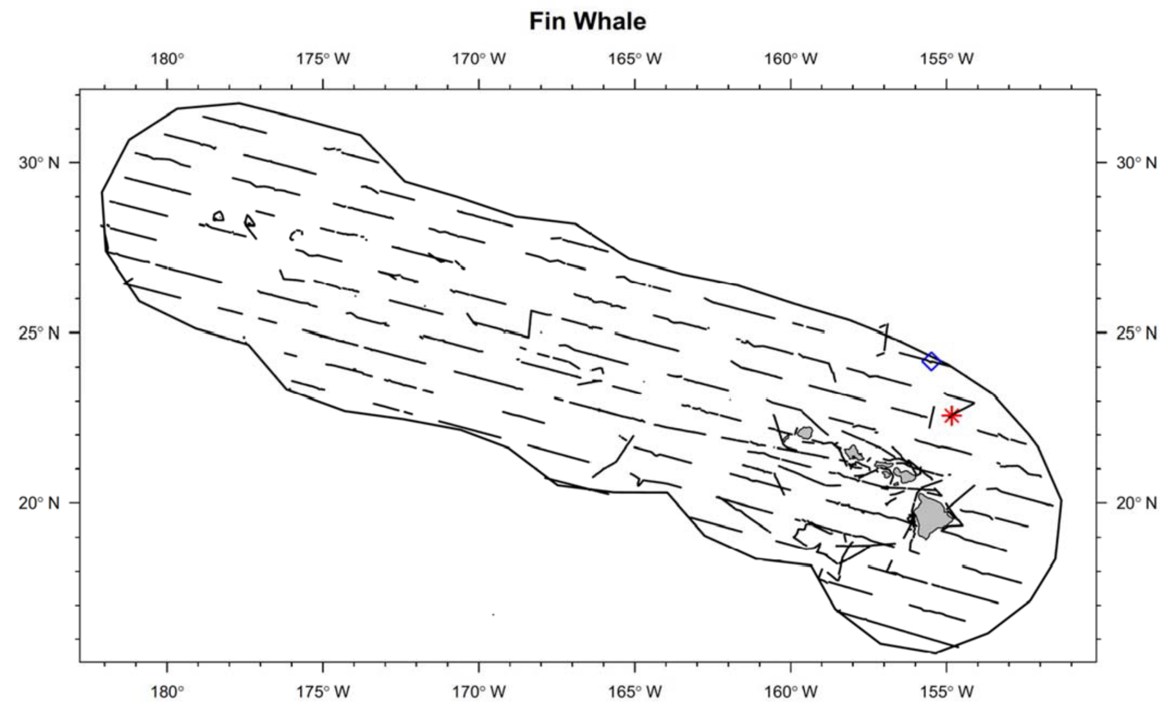


Figure B11. Sightings and acoustic detections of common minke and Bryde's whales.



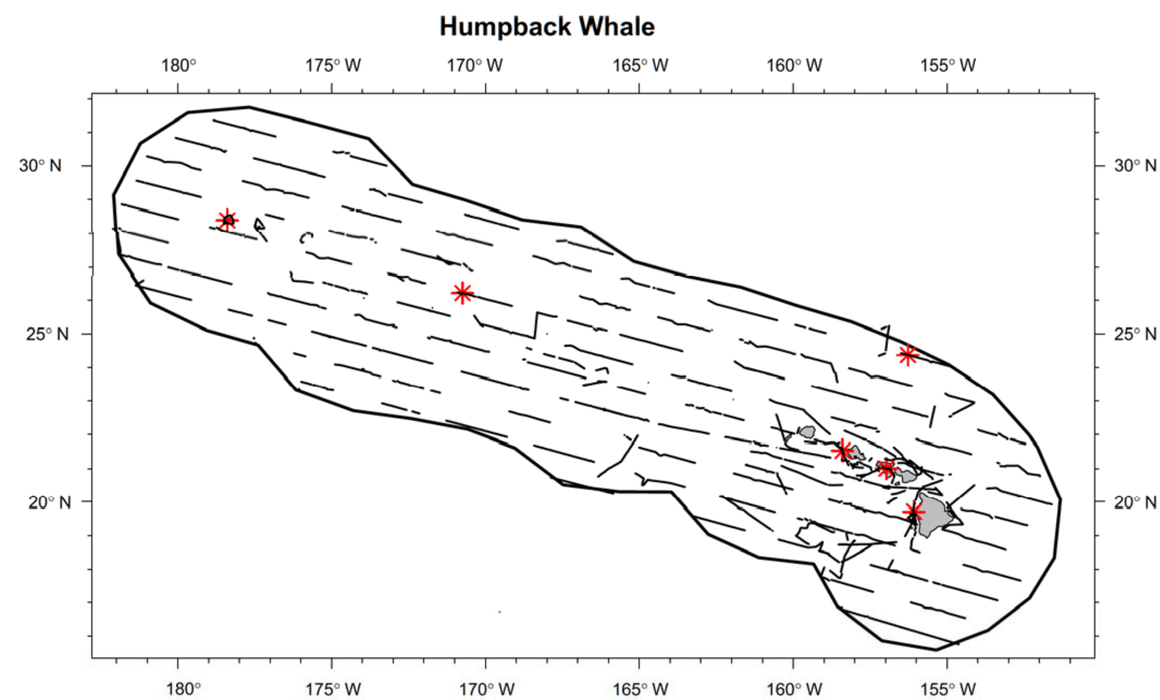
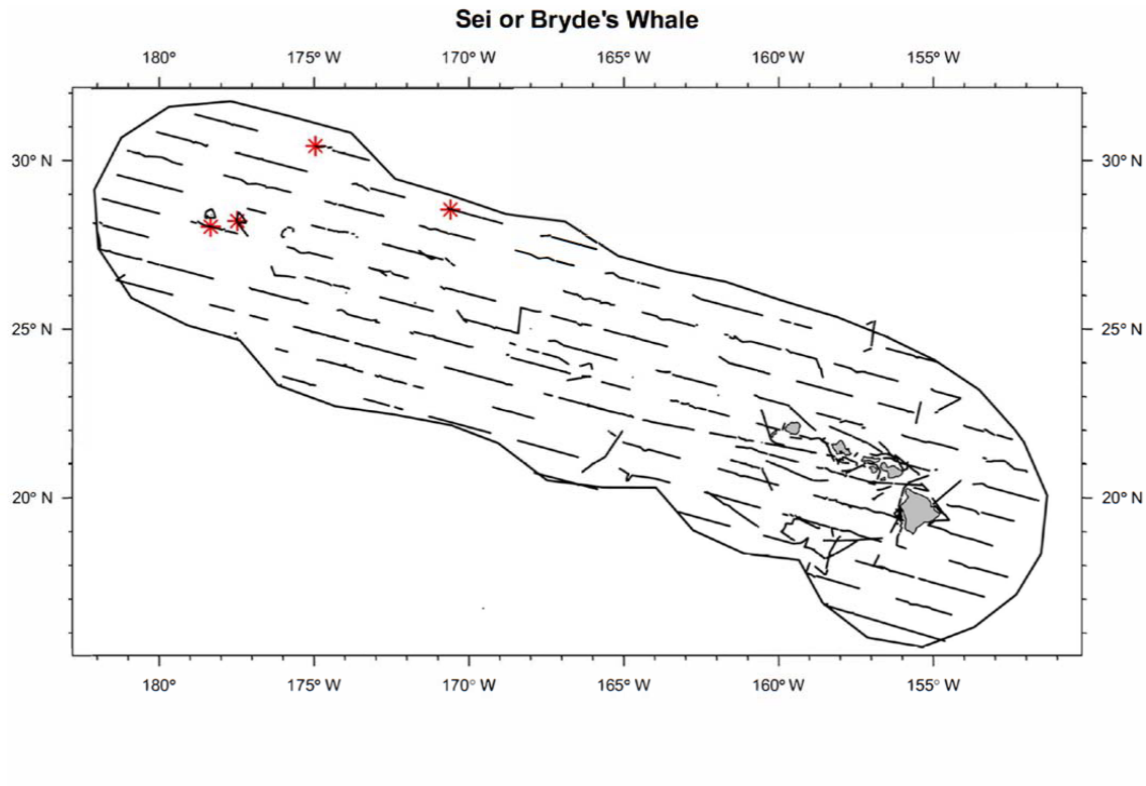


Figure B12. Sightings and acoustic detections of fin and humpback whales.



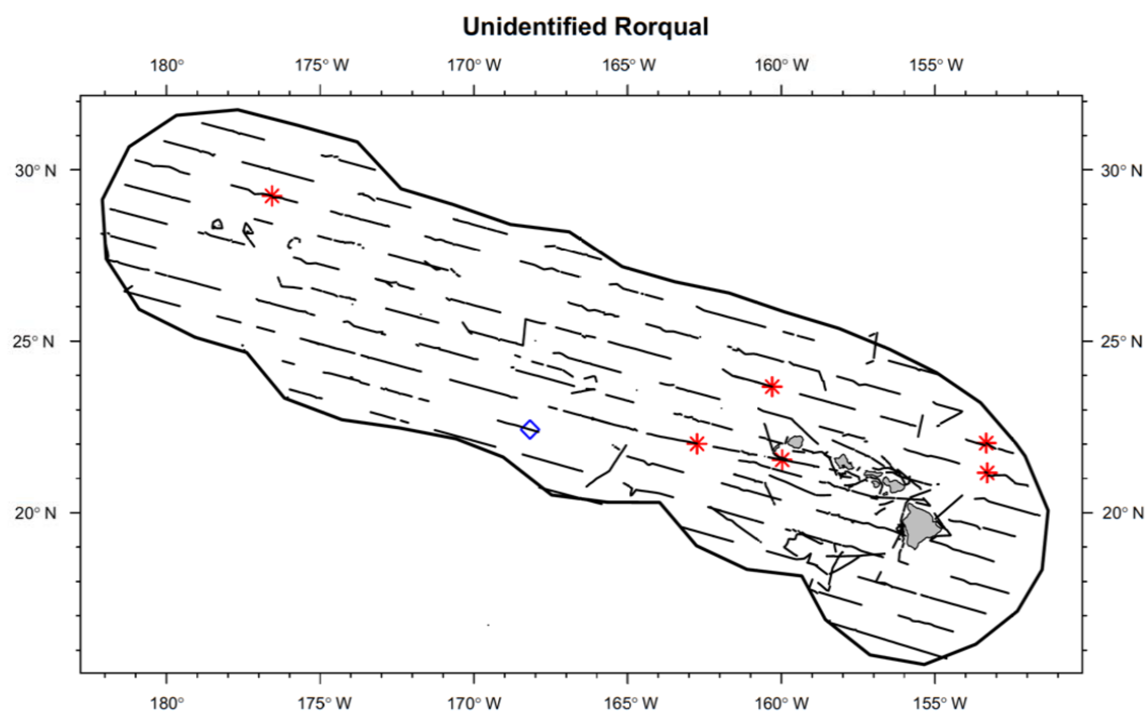
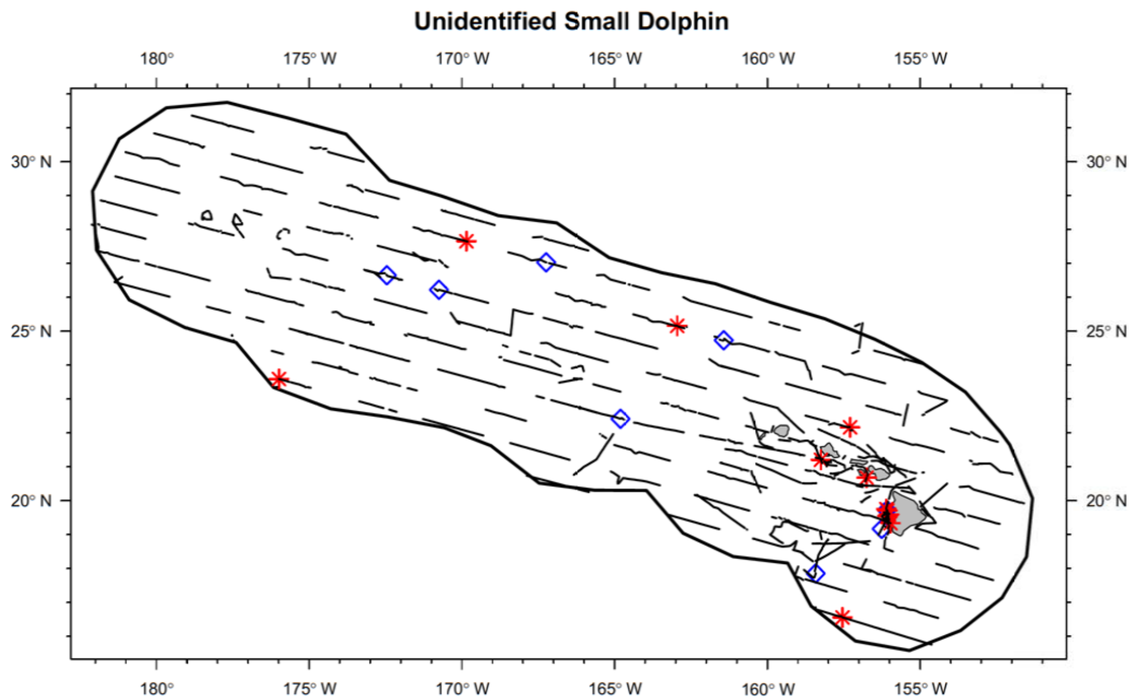


Figure B13. Sightings and acoustic detections of sei/Bryde's and unidentified rorqual whales.

Sightings of Unidentified Species (Figure B14-Figure B17)

Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. All sightings are shown, independent of visual effort type (black lines). Acoustic detections of delphinid groups that did not have associated visual sighting are shown in Figure B16. Due to the design of the towed hydrophone array, low-frequency signals commonly produced by large whales would not be detected. Sonobuoys were generally not deployed on unidentified whales. The project’s study area, the Hawai‘i EEZ, is marked by the black outline.



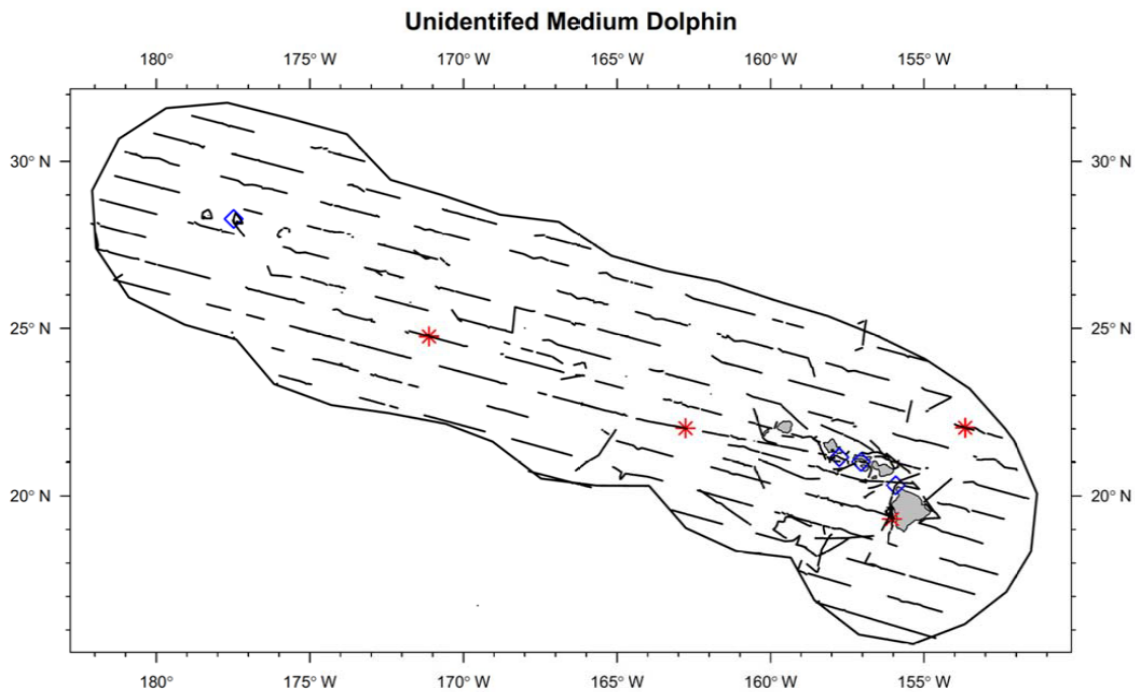
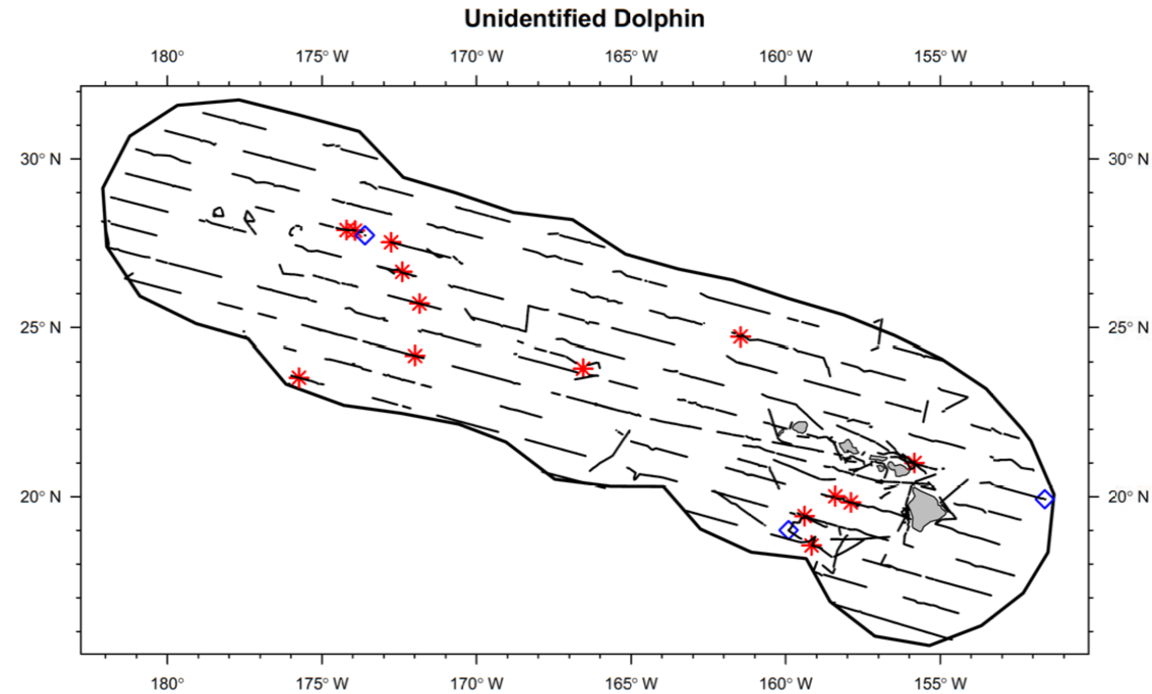


Figure B14. Sightings and acoustic detections of unidentified small and unidentified medium dolphins.



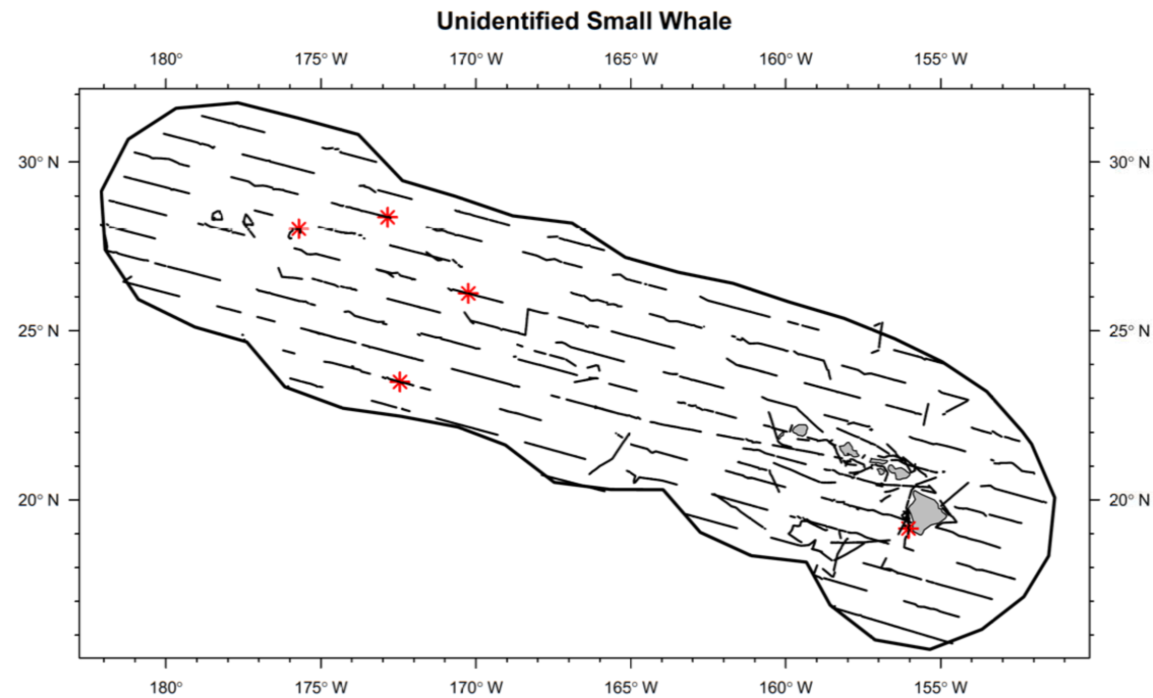
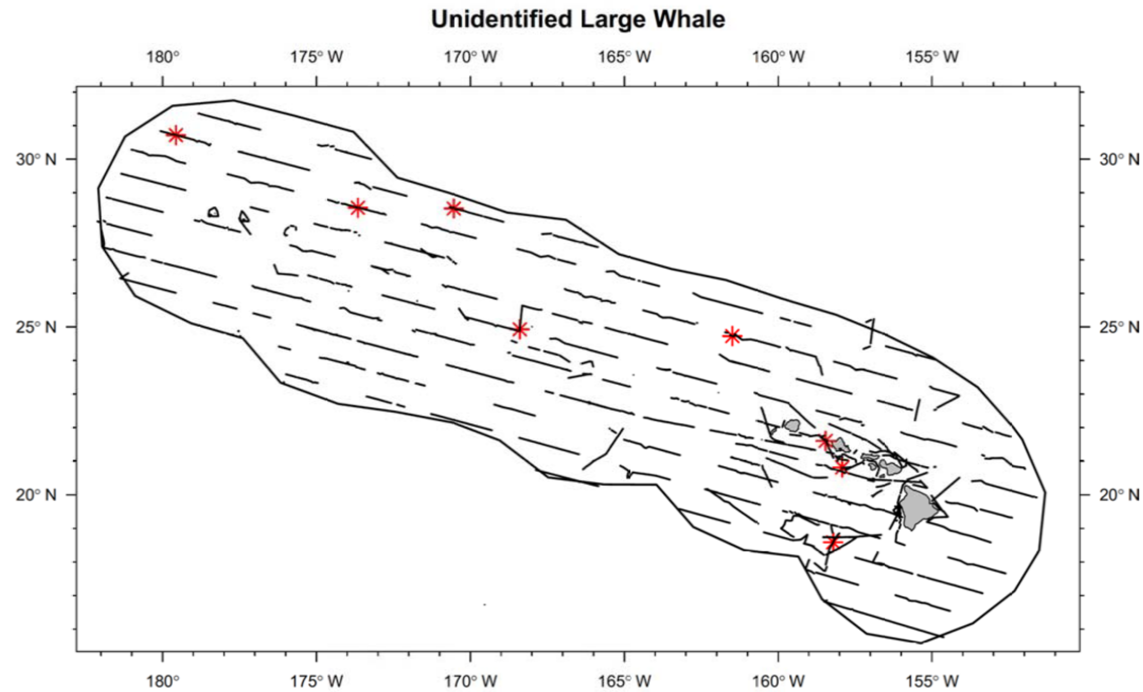


Figure B15. Sightings and acoustic detections of unidentified dolphins and unidentified small whales.



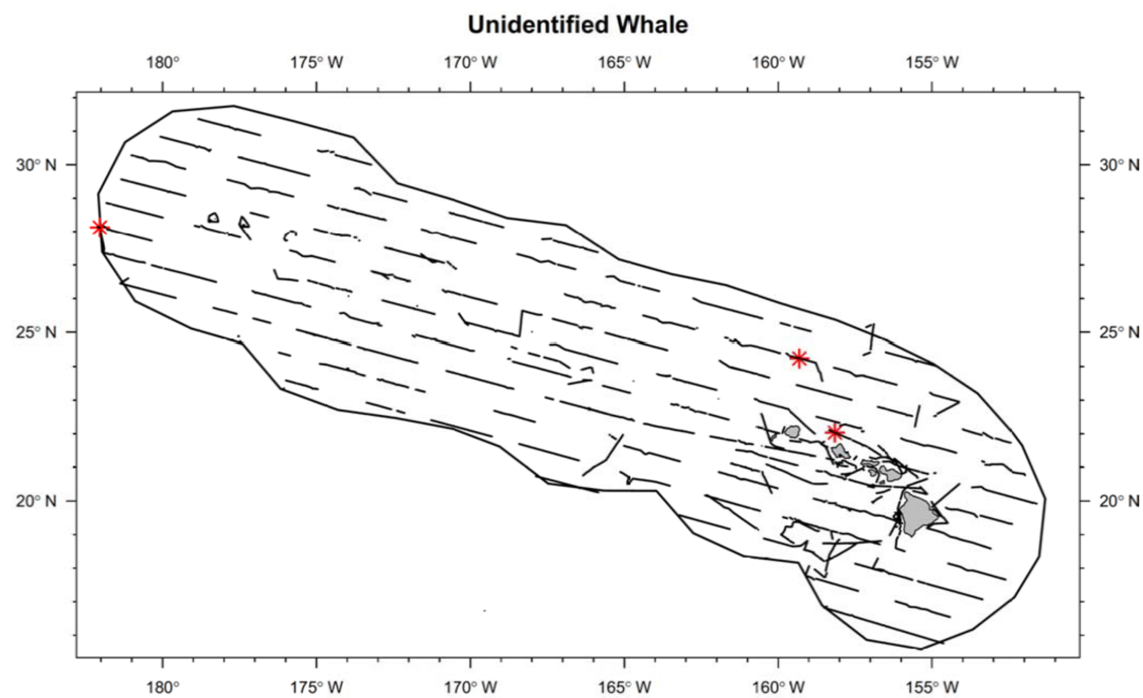


Figure B16. Sightings of unidentified large whales and unidentified whales.

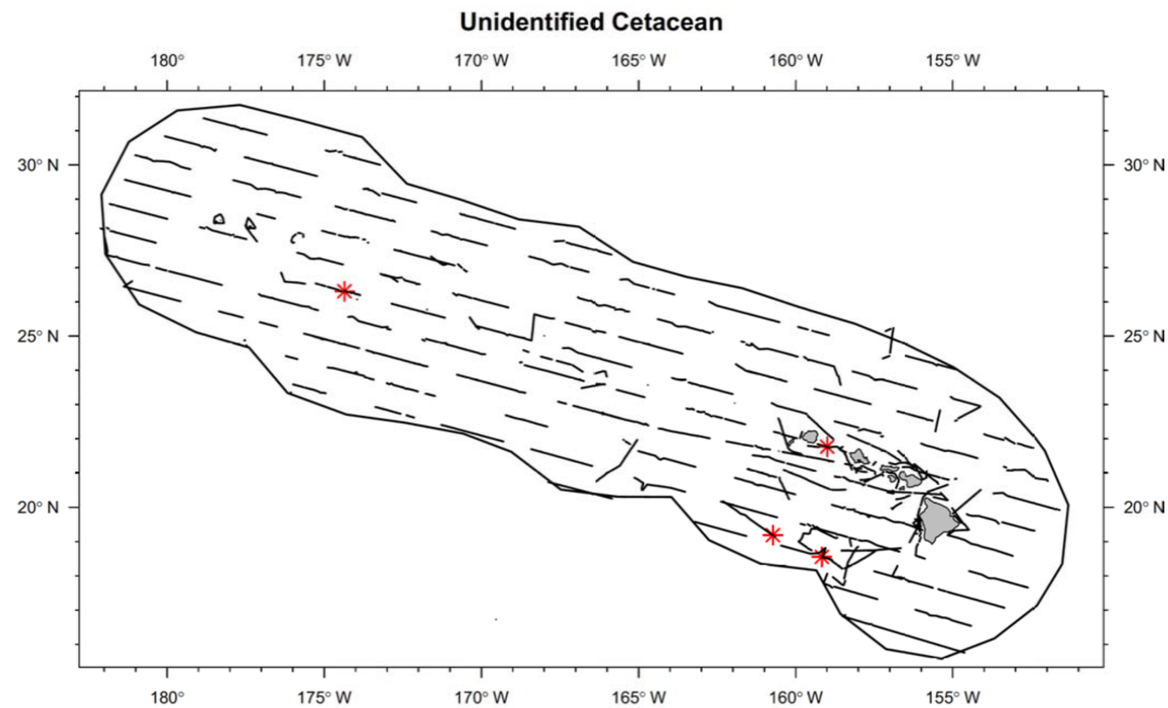


Figure B17. Sightings of unidentified cetaceans.

Sightings during the Transit from San Diego to the Hawai'i EEZ Study Area (Figure B18)

Nineteen (19) cetacean sightings were made from the *Lasker* Leg 1 during the transit from San Diego to Honolulu. All sightings are shown, independent of visual effort type (black lines). The project's study area, the Hawai'i EEZ, is not shown on this map as it is beyond the western range of this map.

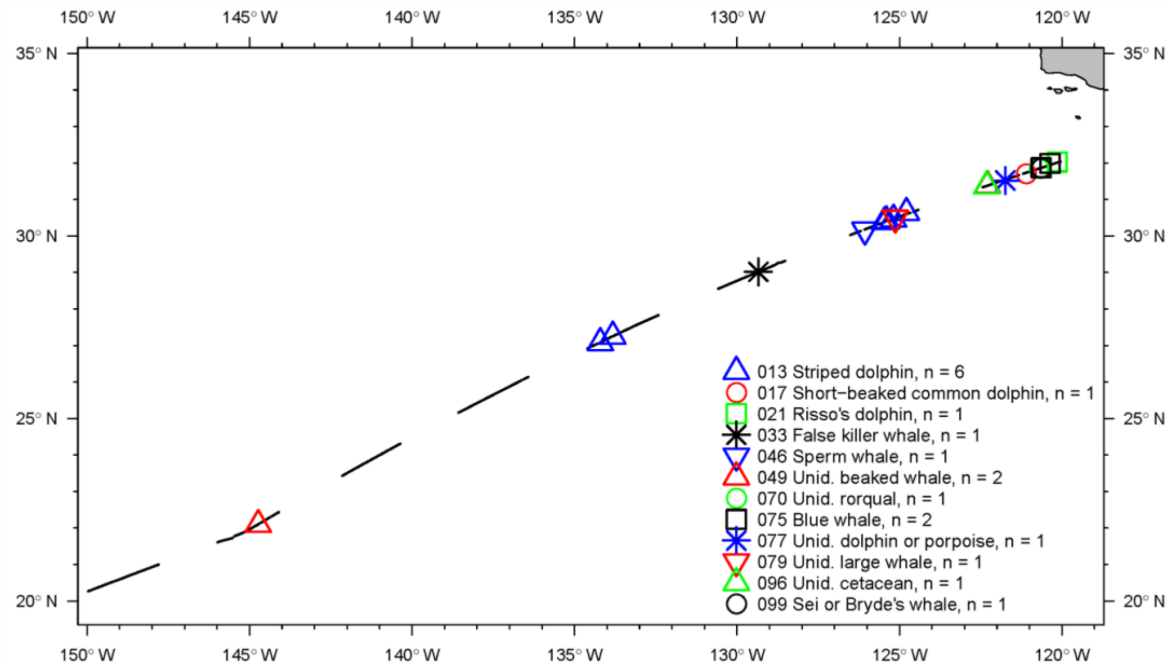


Figure B18. Cetacean sightings outside of the Hawai'i EEZ study area.

Appendix C: Seabird Distribution and Density Maps

Distribution and Density Maps for Procellariiformes (Figure C1-Figure C13)

Distribution and density (birds/100 km^2) for Procellariiform seabird species recorded during the 300 m strip transect survey. On-effort periods are indicated by gray lines; seabird densities are presented in terms of three categories: 1-50 birds/100 km^2, 51-100 birds/100 km^2, and > 100 birds/100 km^2.

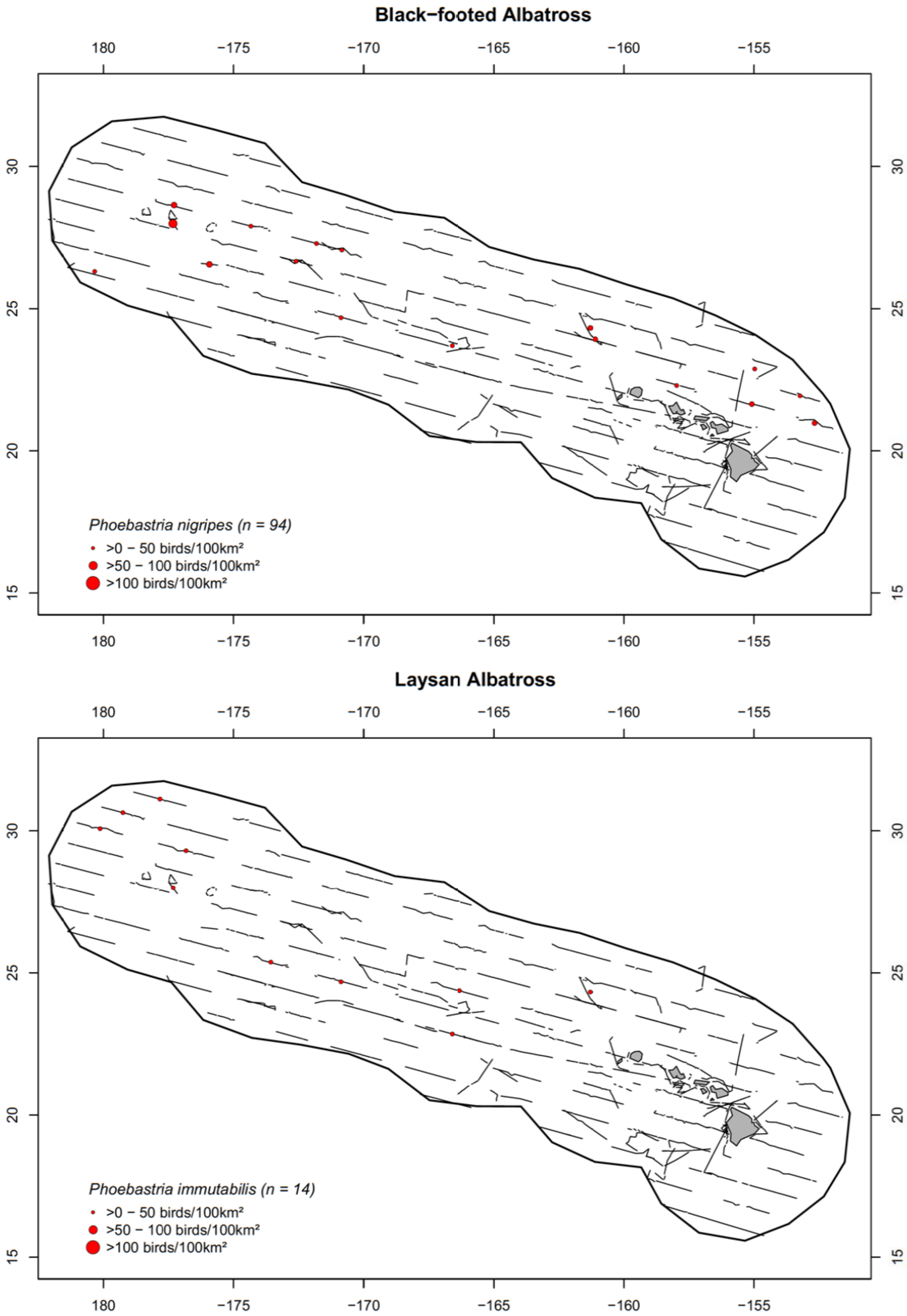


Figure C1. Distribution and density (birds/100 km^2) for Black-footed and Laysan Albatrosses.

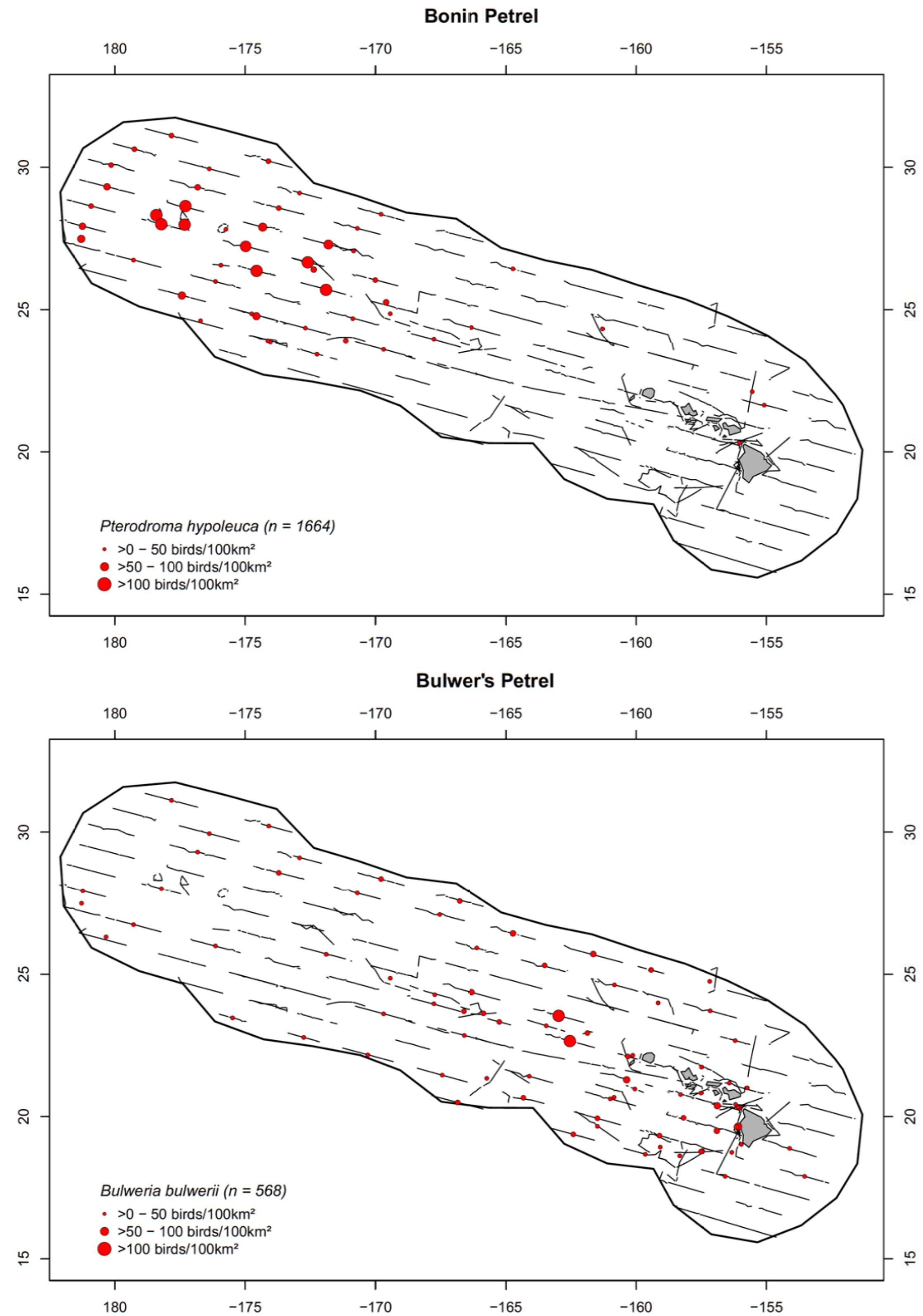
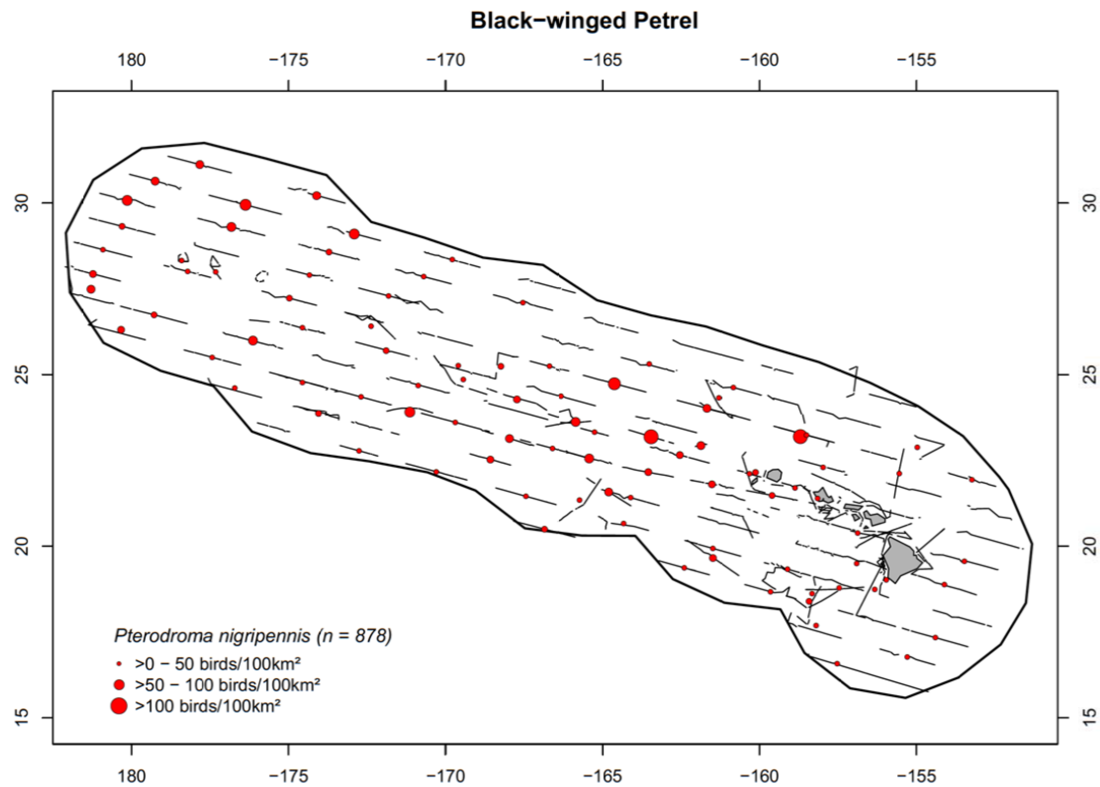


Figure C2. Distribution and density (birds/100 km^2) for Bonin and Bulwer's Petrels.



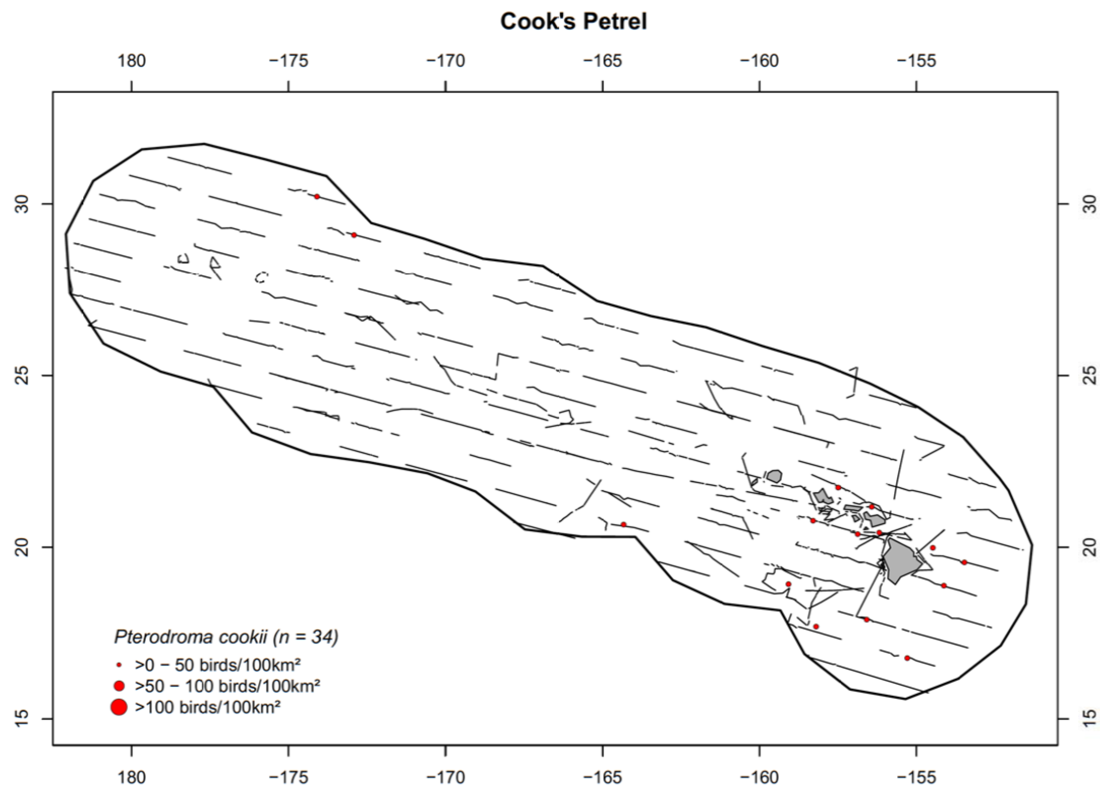
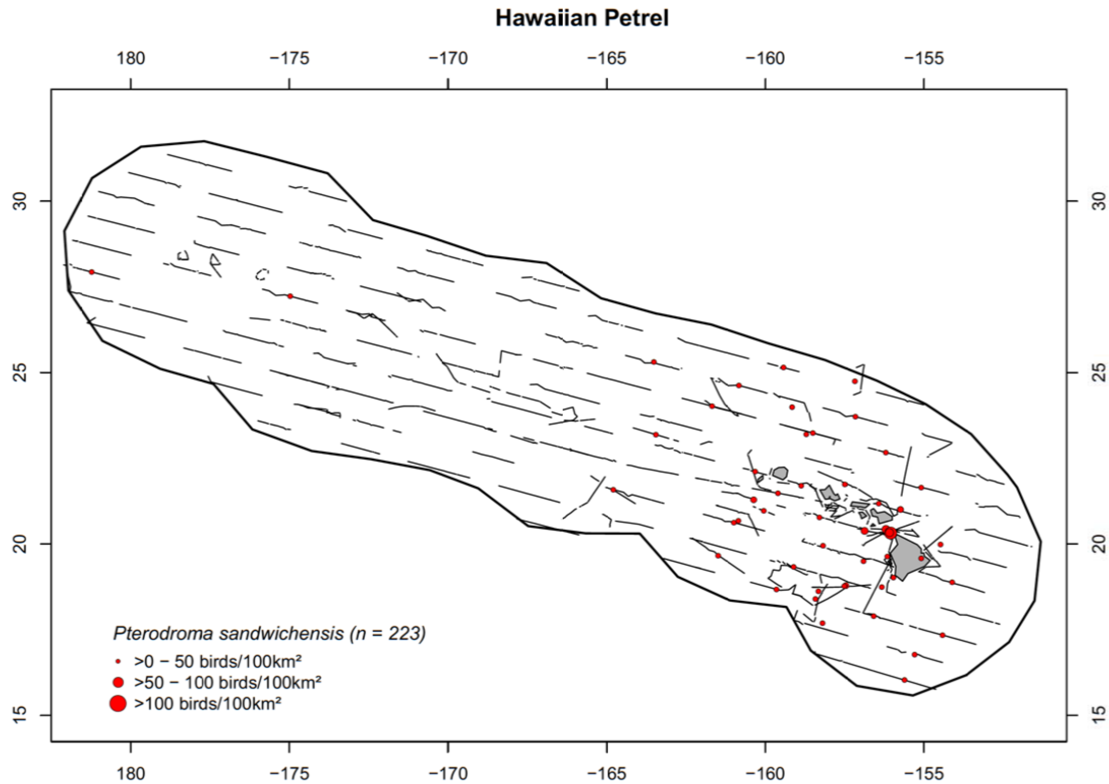


Figure C3. Distribution and density (birds/100 km^2) for Black-winged and Cook's Petrels.



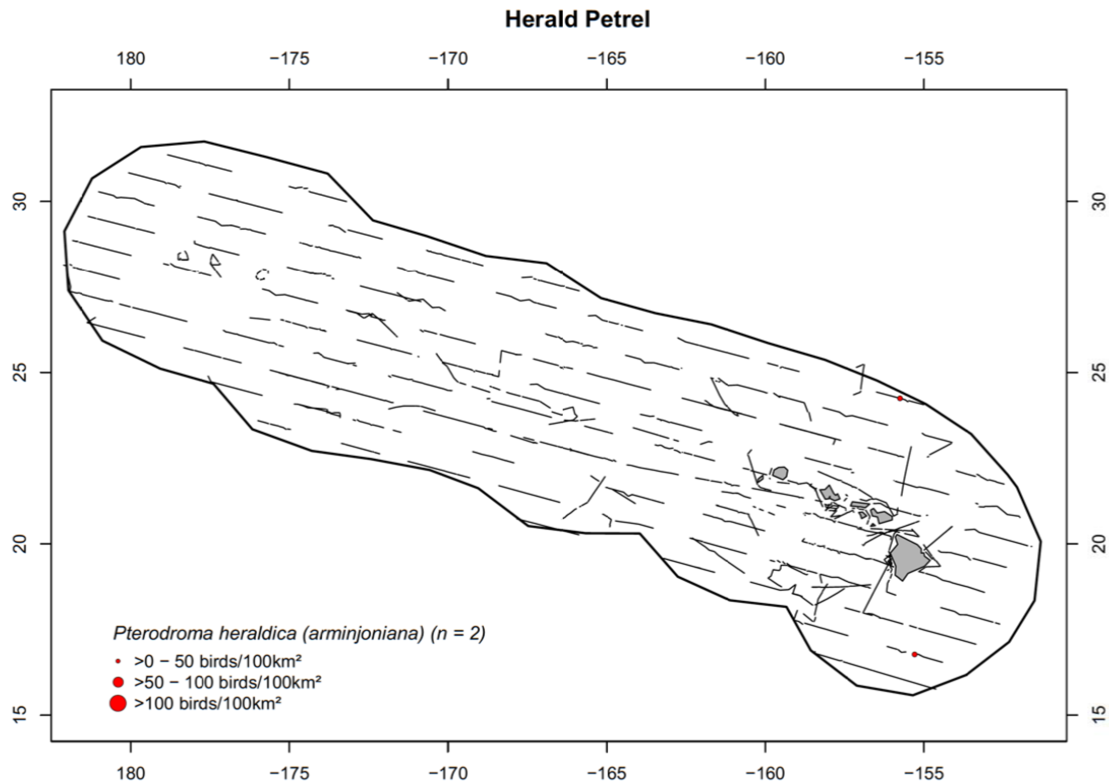


Figure C4. Distribution and density (birds/100 km^2) for Hawaiian and Herald Petrels.

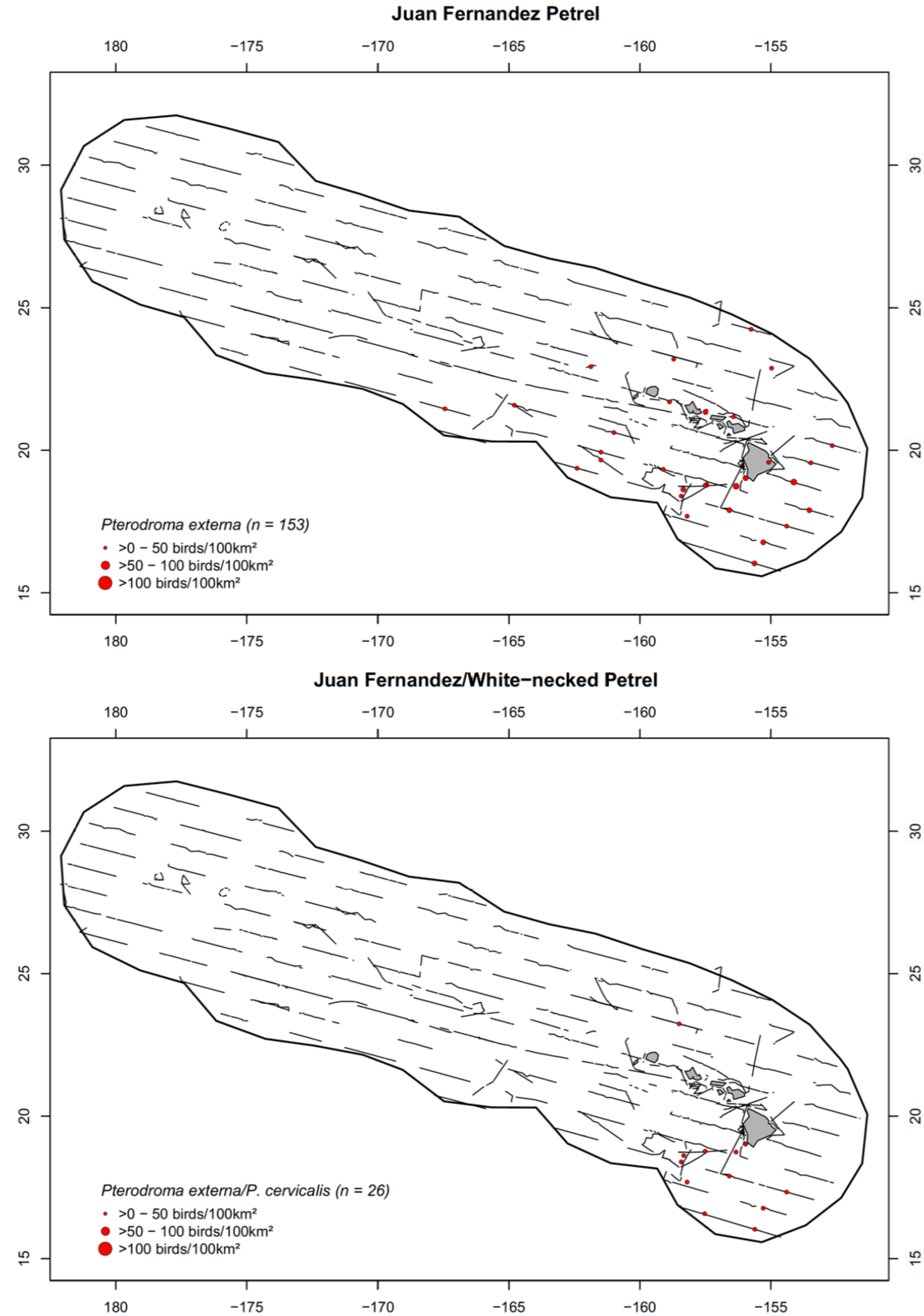
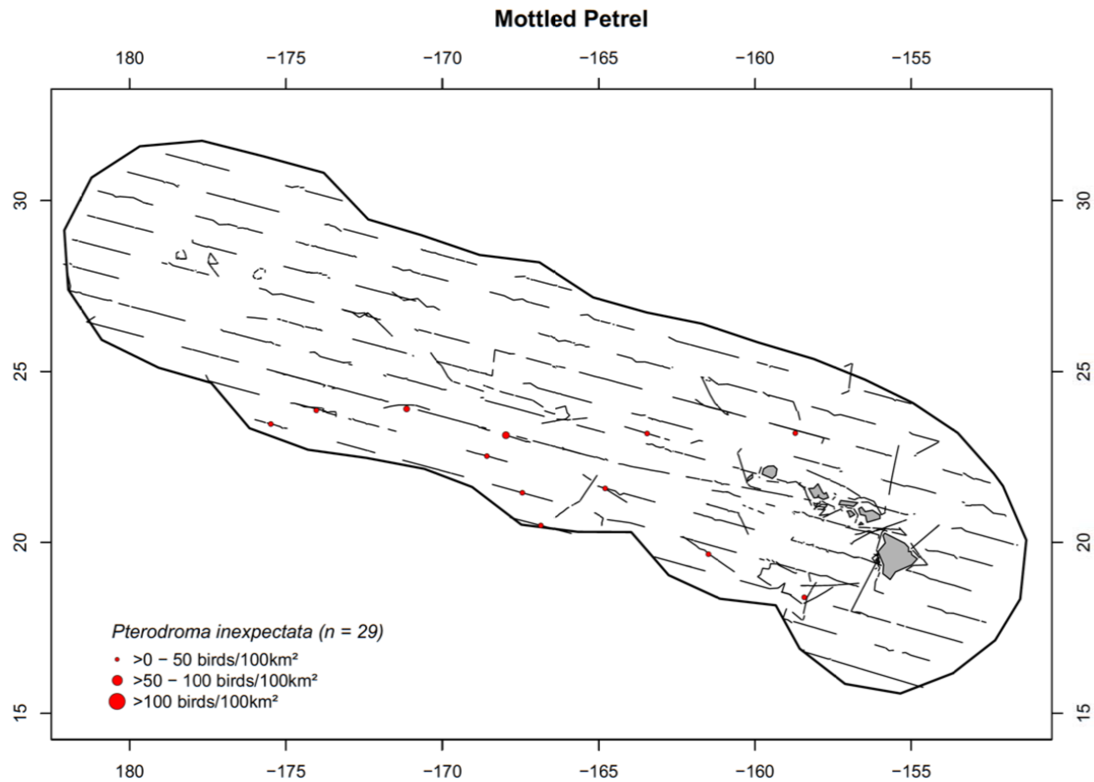


Figure C5. Distribution and density (birds/100 km²) for Juan Fernandez and Juan Fernandez/White-necked Petrels.



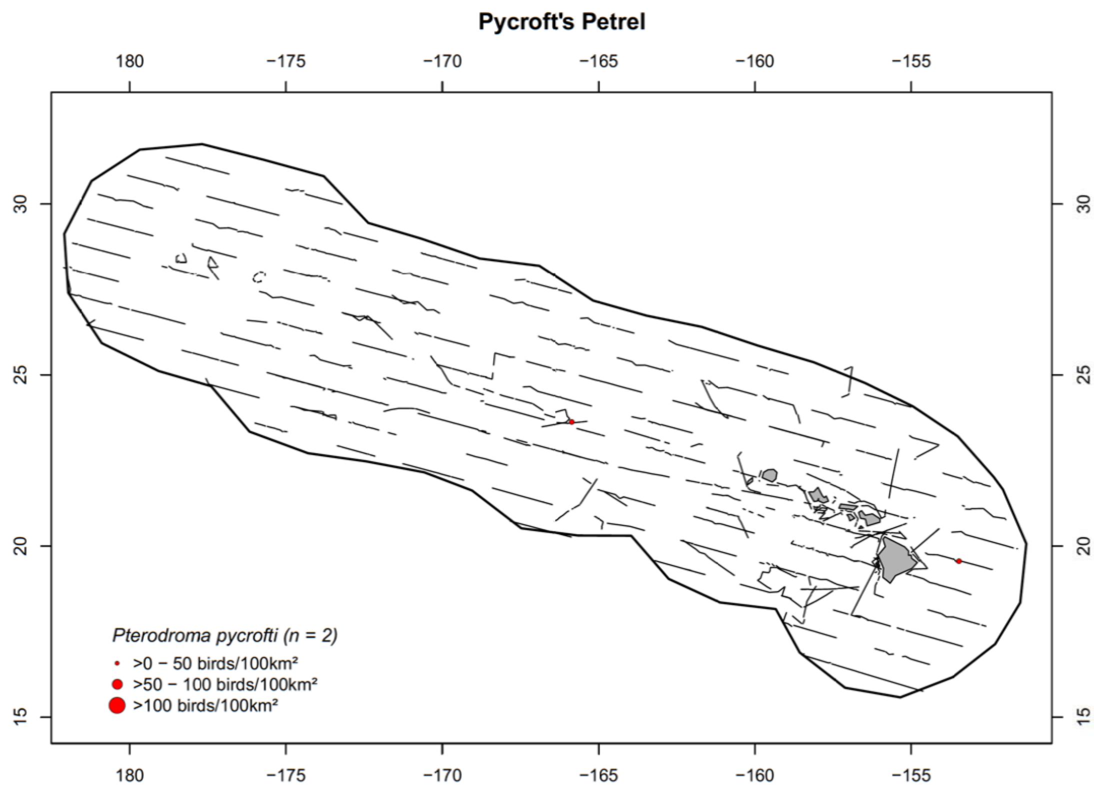
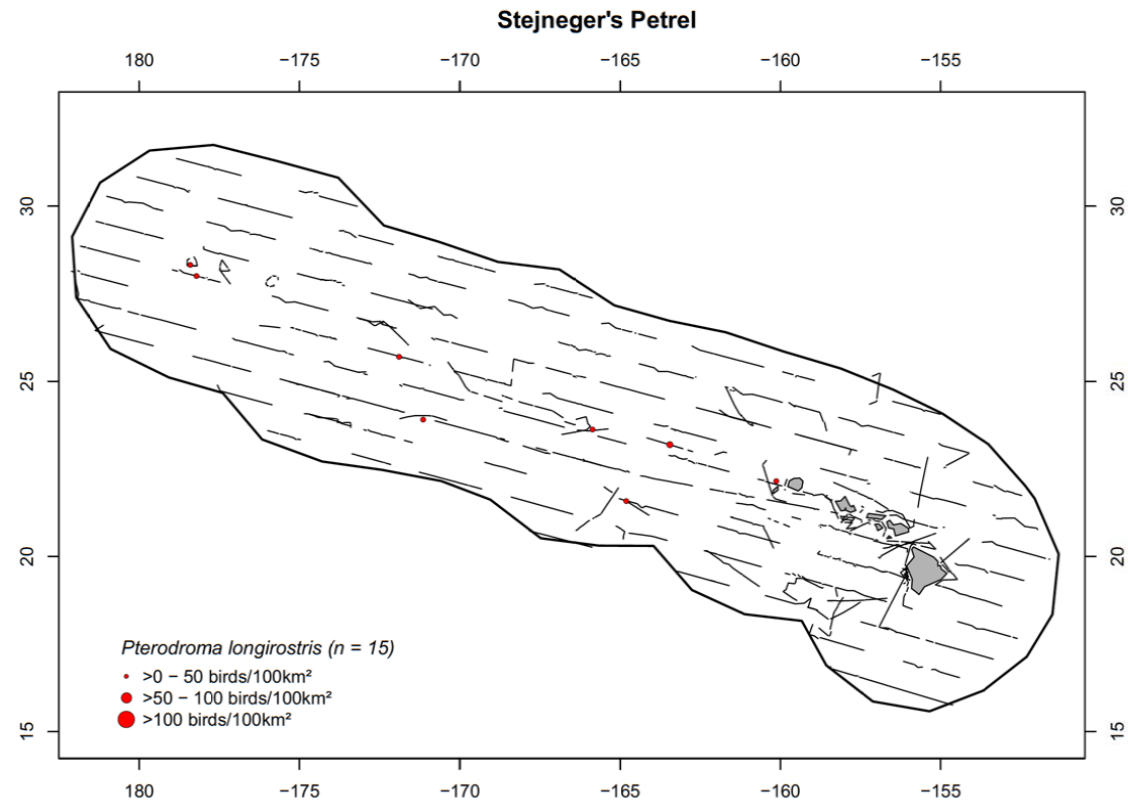


Figure C6. Distribution and density (birds/100 km^2) for Mottled and Pycroft's Petrels.



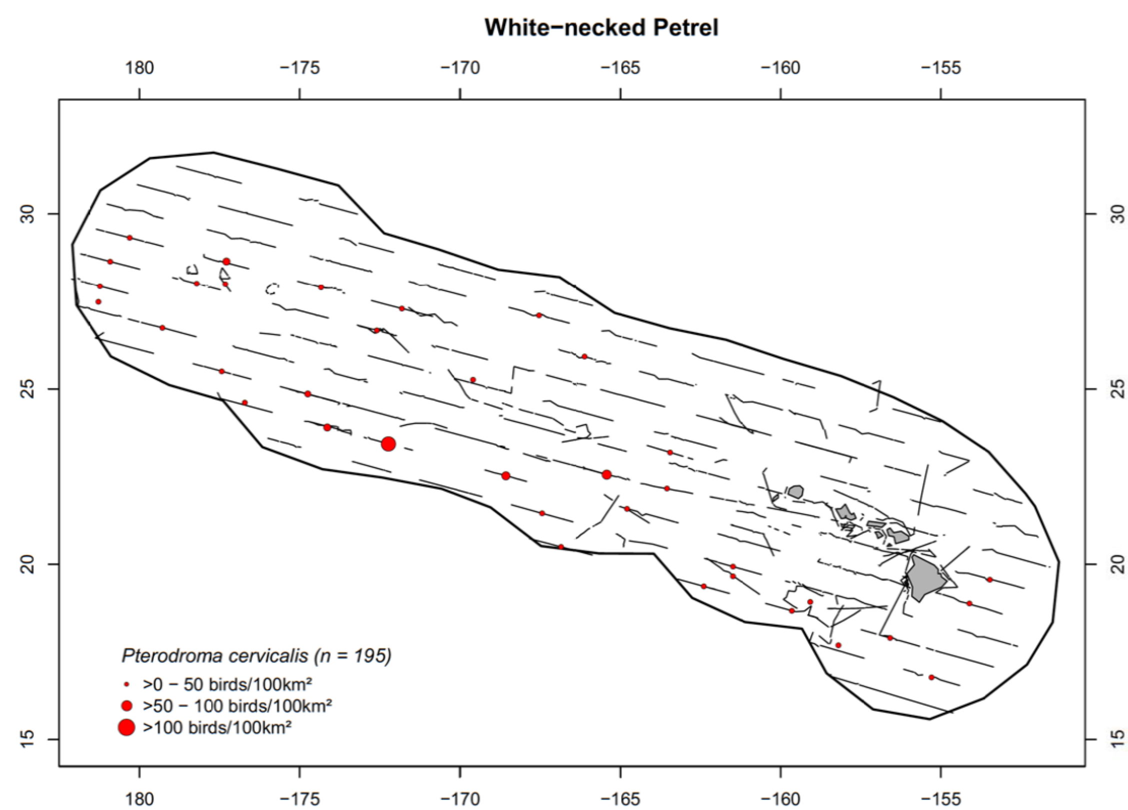
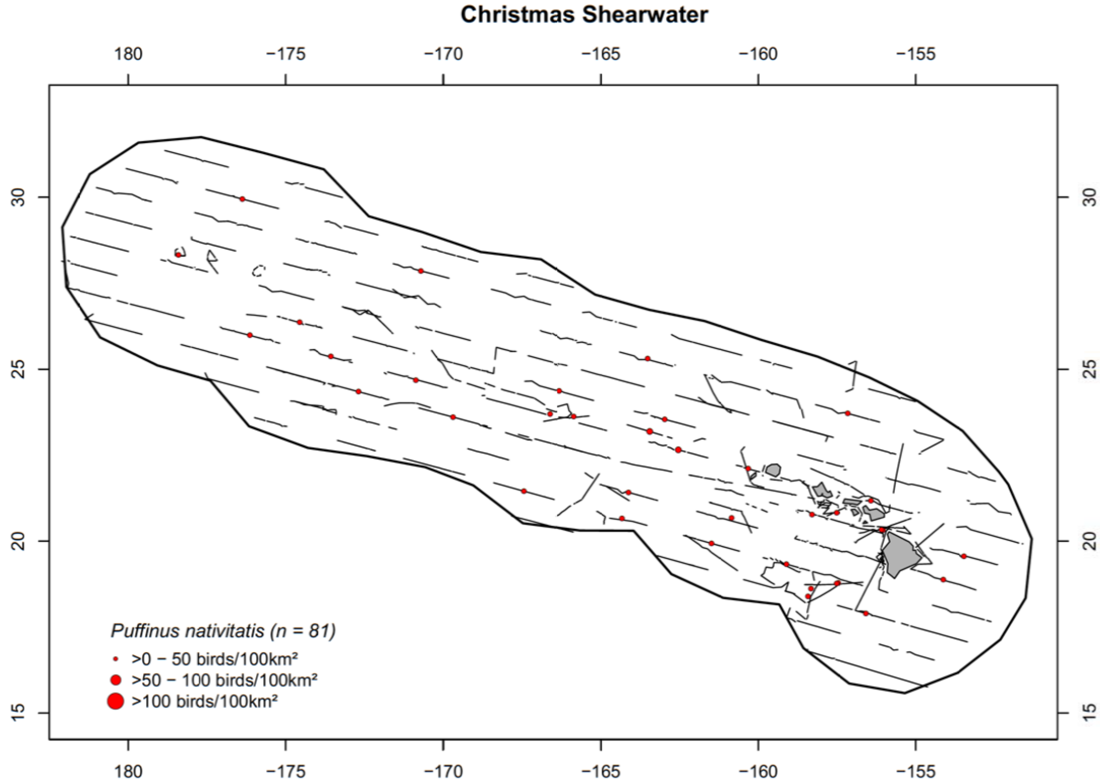


Figure C7. Distribution and density (birds/100 km^2) for Stejneger's and White-necked Petrels.



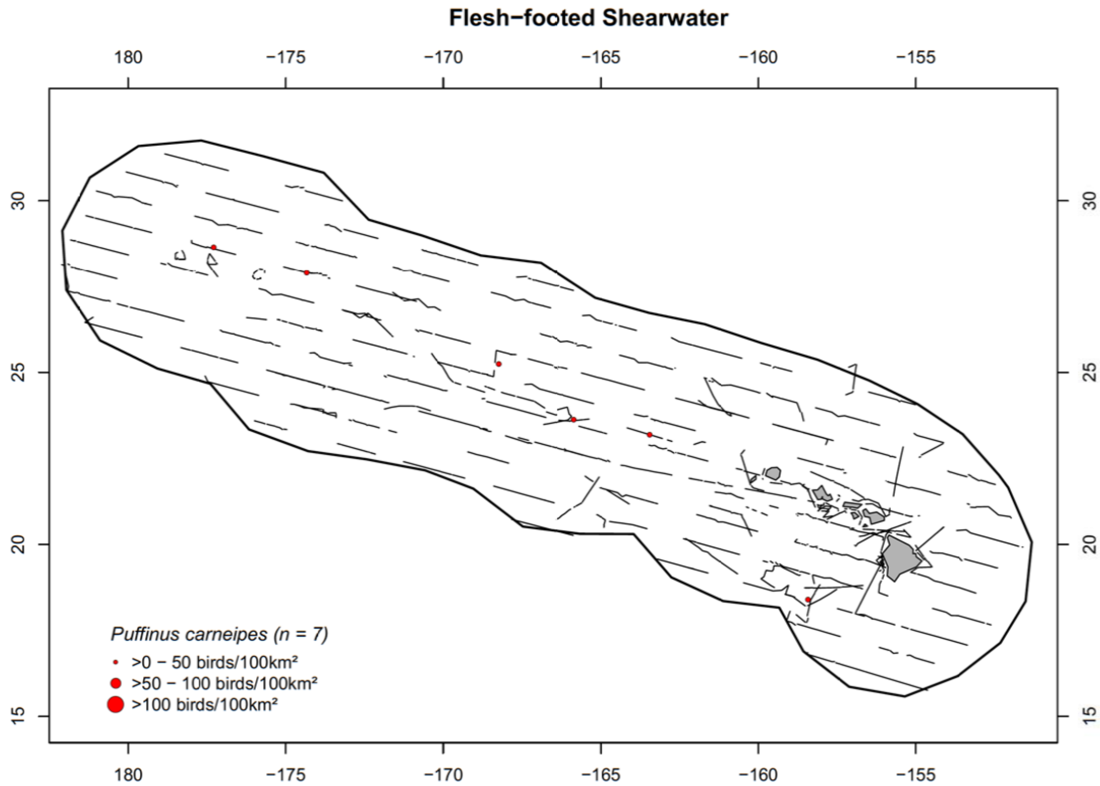
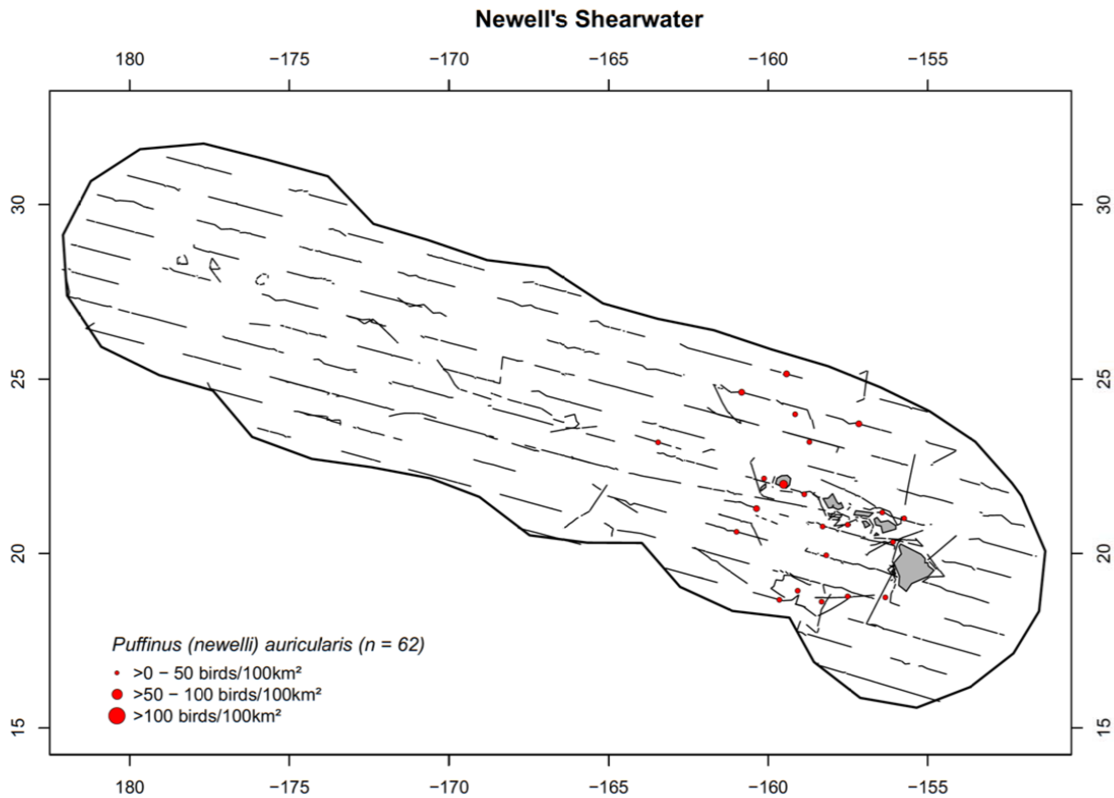


Figure C8. Distribution and density (birds/100 km^2) for Christmas and Flesh-footed Shearwaters.



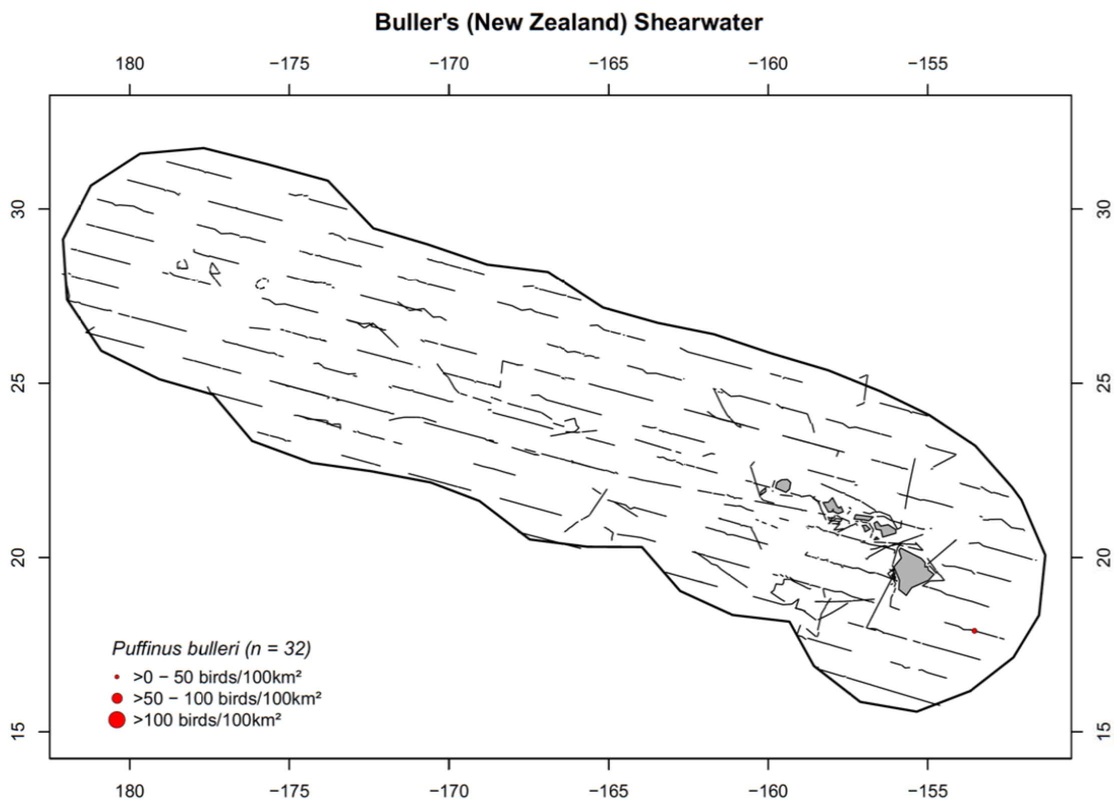
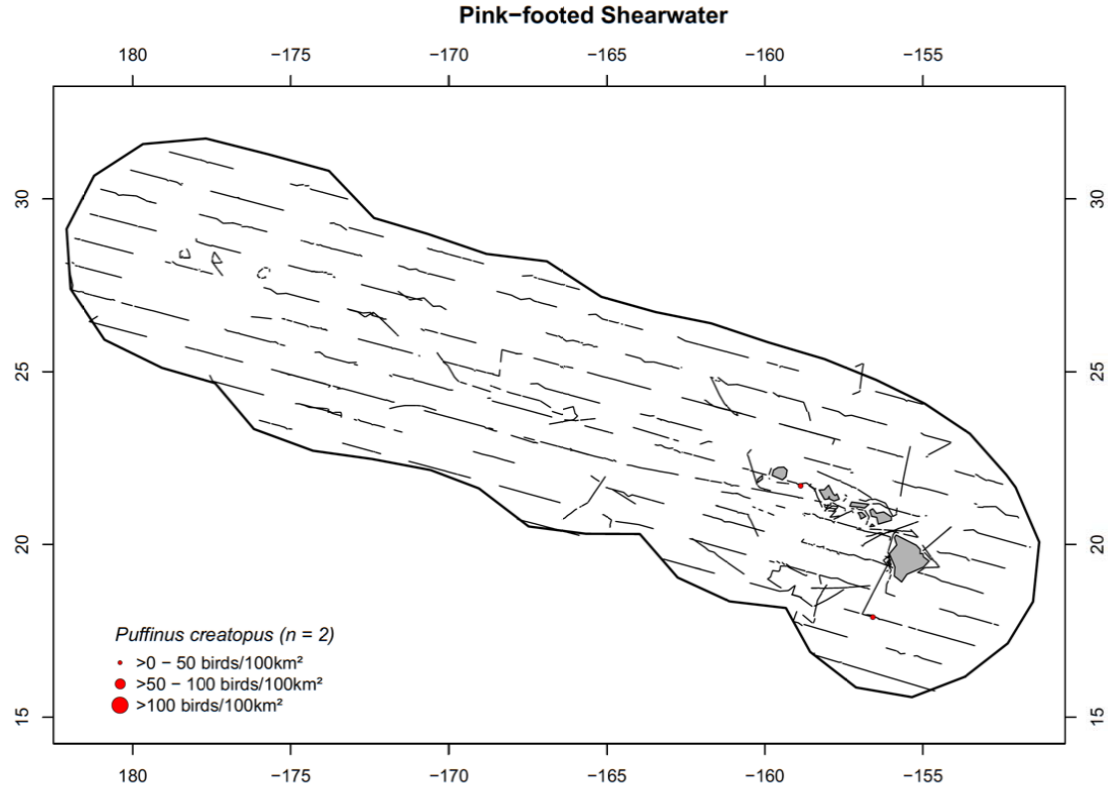


Figure C9. Distribution and density (birds/100 km^2) for Newell’s and Buller’s (New Zealand) Shearwaters.



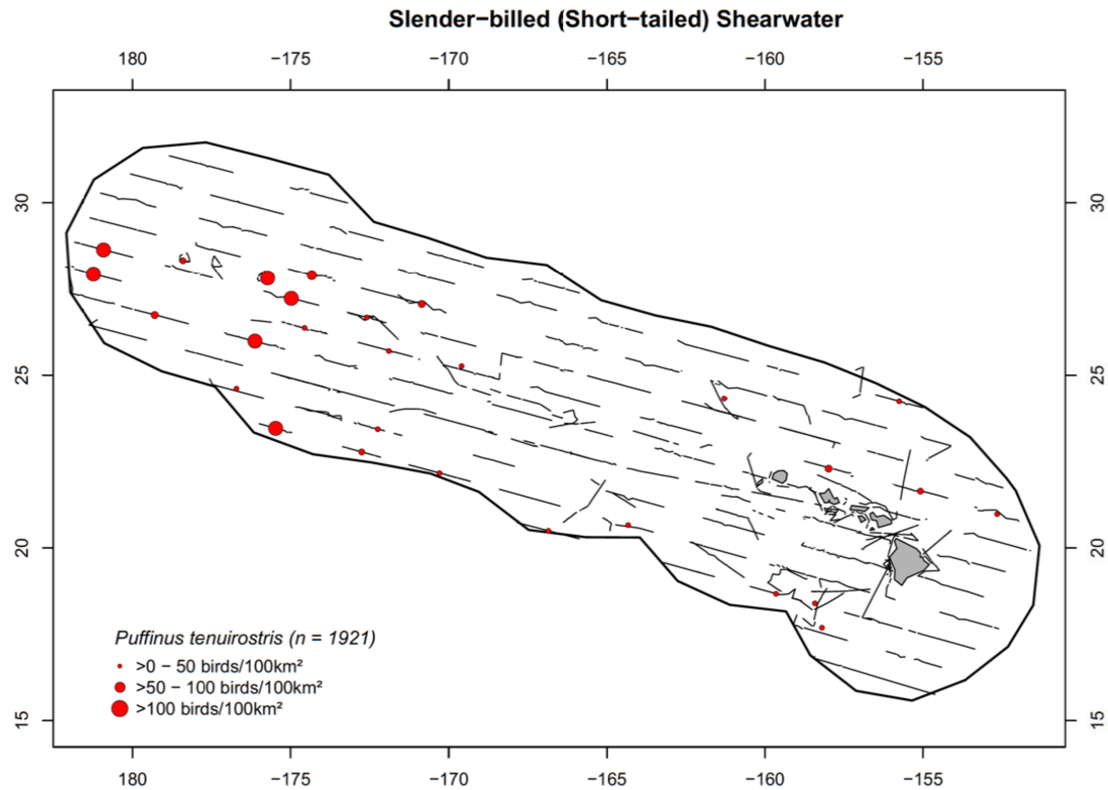


Figure C10. Distribution and density (birds/100 km^2) for Pink-footed and Slender-billed (Short-tailed) Shearwaters.

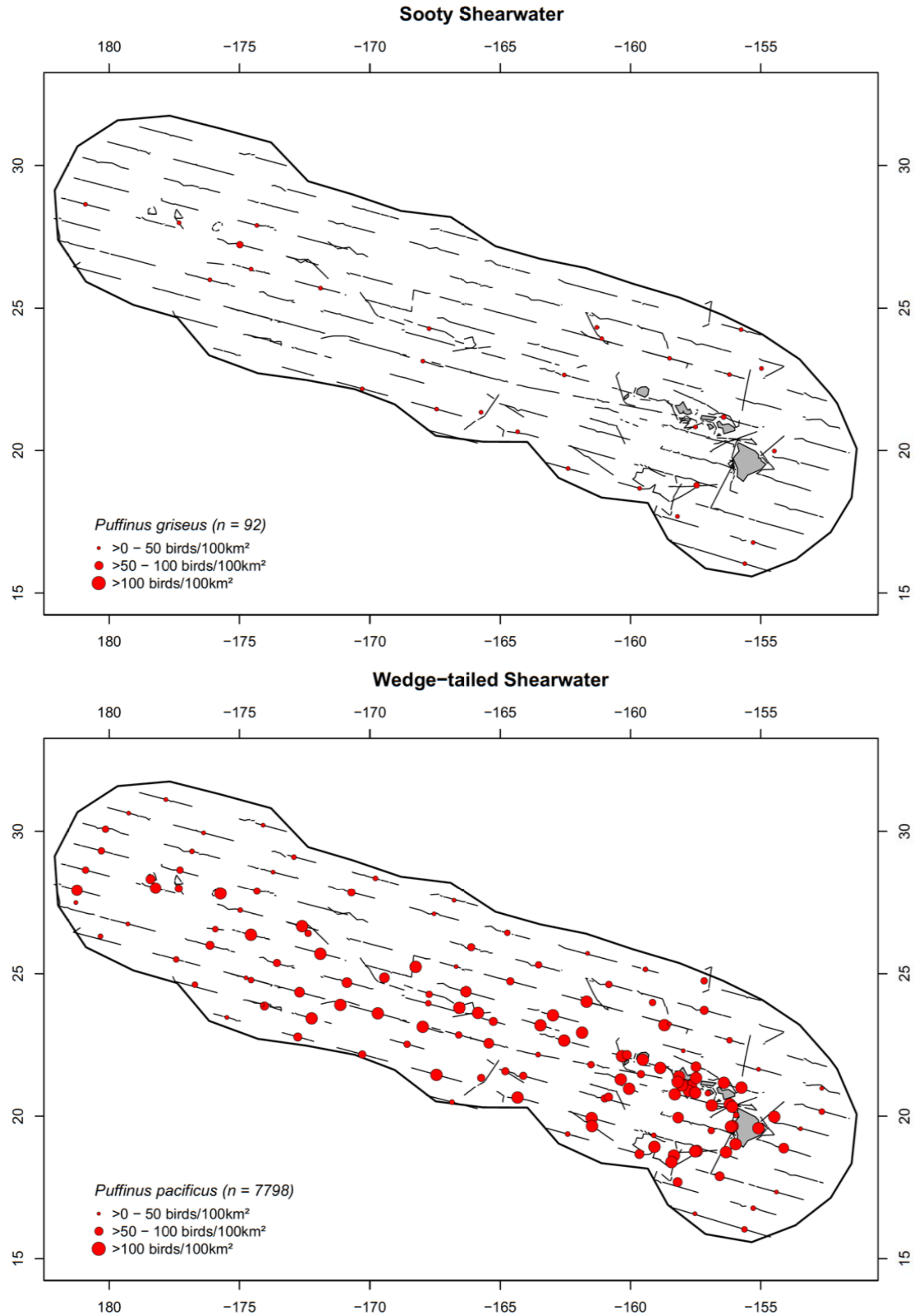
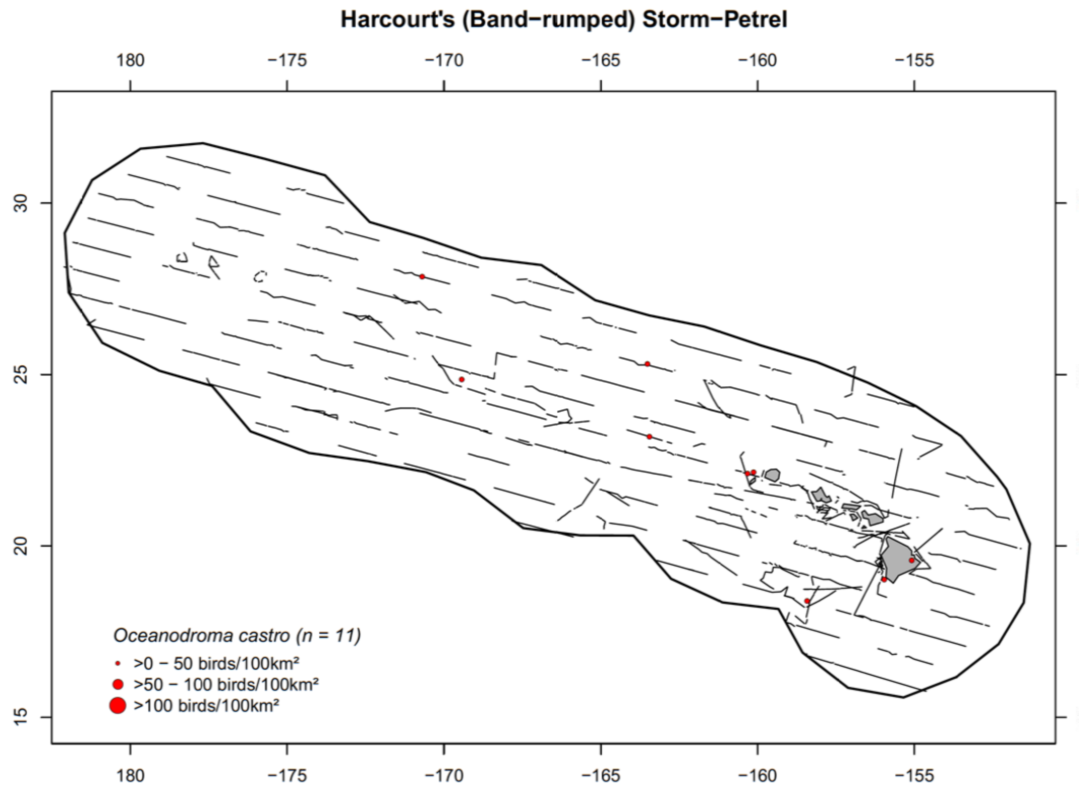


Figure C11. Distribution and density (birds/100 km^2) for Sooty and Wedge-tailed Shearwaters.



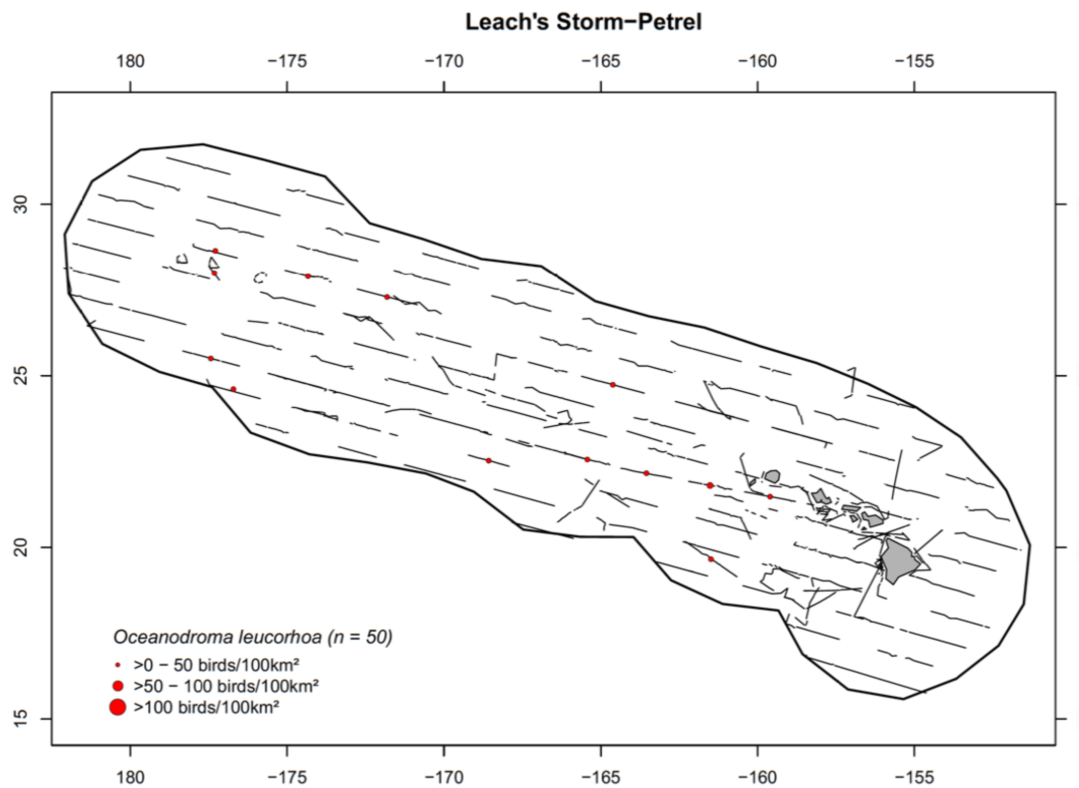


Figure C12. Distribution and density (birds/100 km^2) for Harcourt's (Band-rumped) and Leach's Storm-Petrels.

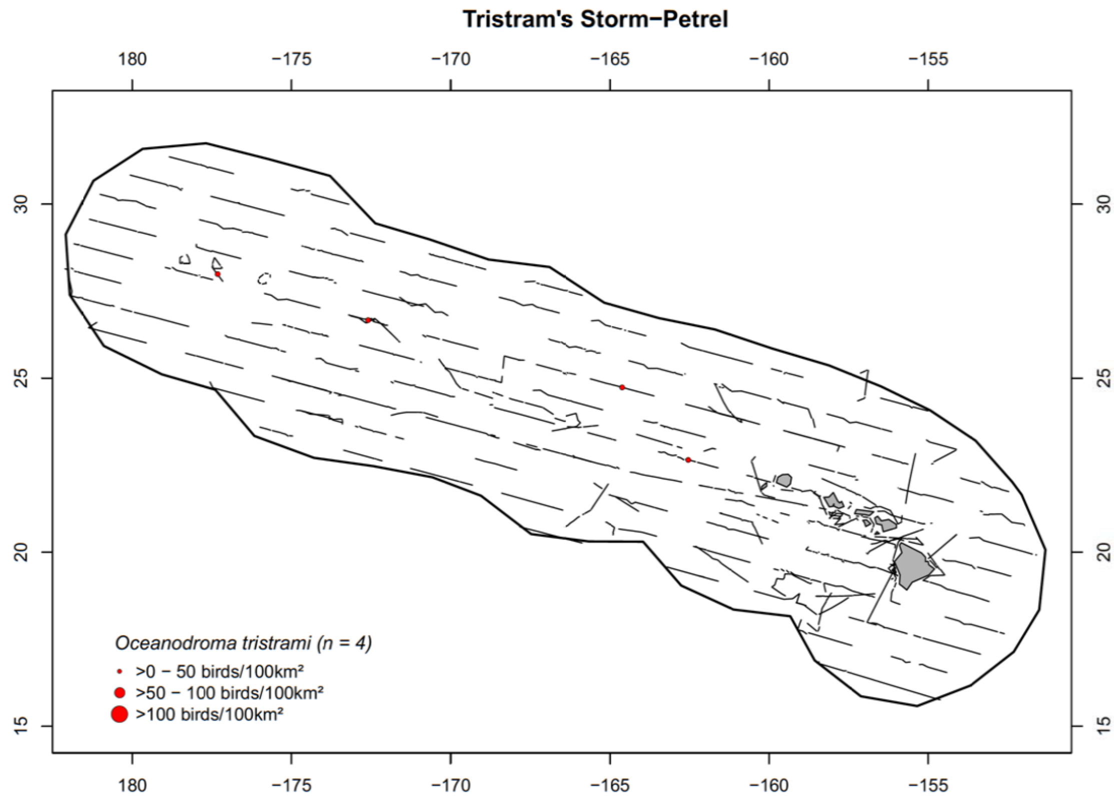


Figure C13. Distribution and density (birds/100 km^2) for Tristram's Storm-Petrels.

Distribution and Density Maps for Phaethontiformes (Figure C14)

Distribution and density (birds/100 km^2) for Phaethontiform seabird species recorded during the 300 m strip transect survey. On-effort periods are indicated by gray lines; seabird densities are presented in terms of three categories: 1-50 birds/100 km^2, 51-100 birds/100 km^2, and > 100 birds/100 km^2.

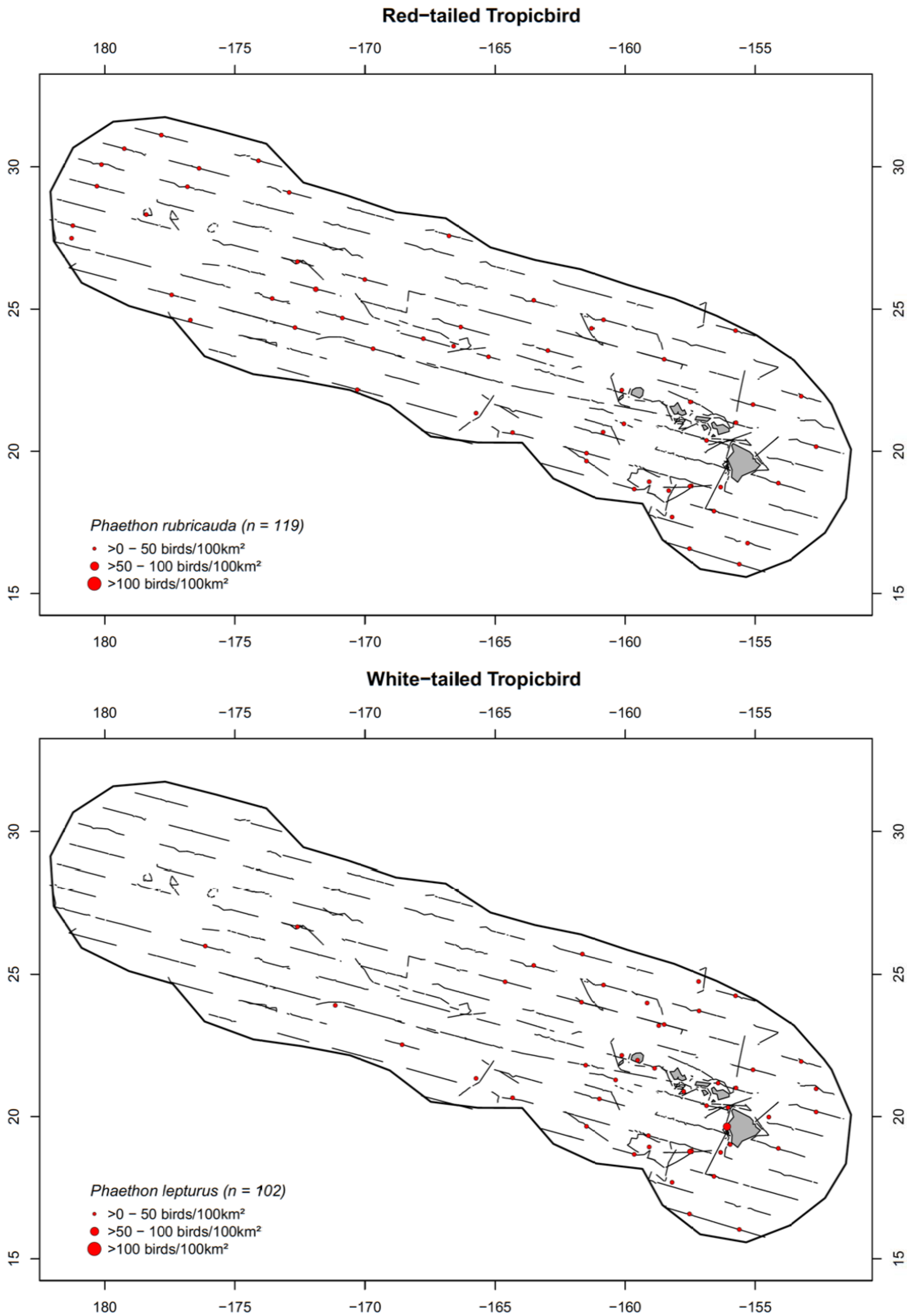
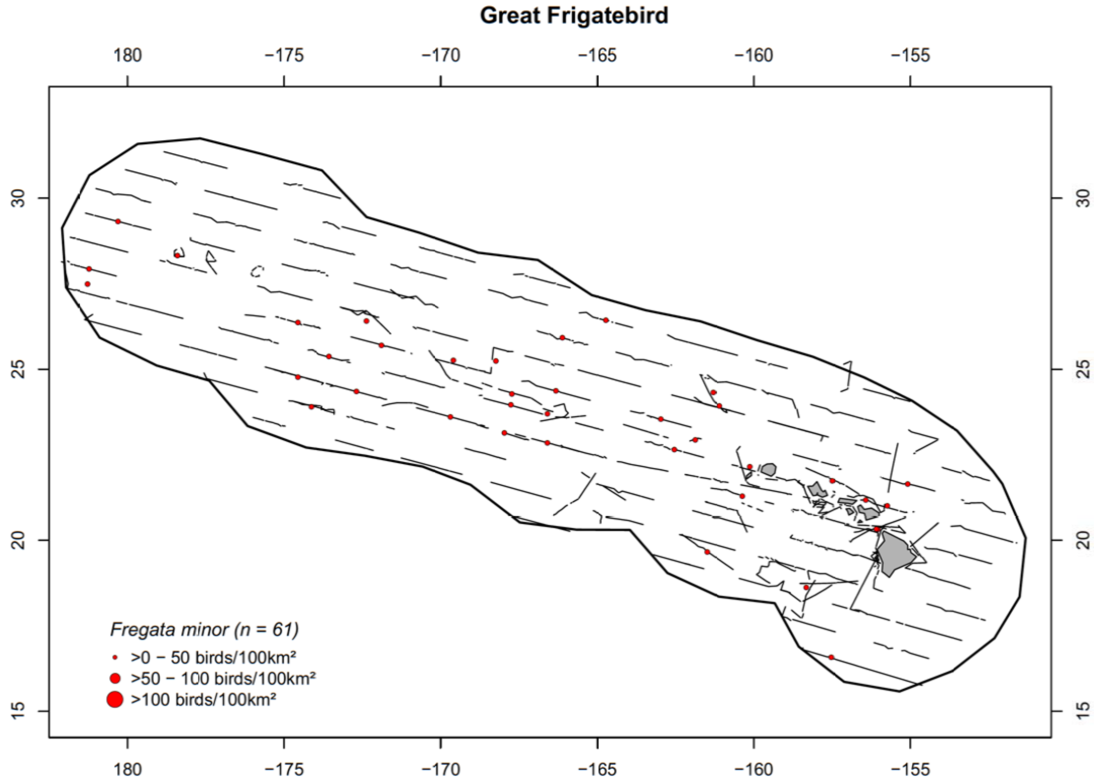


Figure C14. Distribution and density (birds/100 km^2) for Red-tailed and White-tailed Tropicbirds.

Distribution and Density Maps for Suliformes (Figure C15-C16)

Distribution and density (birds/100 km^2) for Suliform seabird species recorded during the 300 m strip transect survey. On-effort periods are indicated by gray lines; seabird densities are presented in terms of three categories: 1-50 birds/100 km^2, 51-100 birds/100 km^2, and > 100 birds/100 km^2.



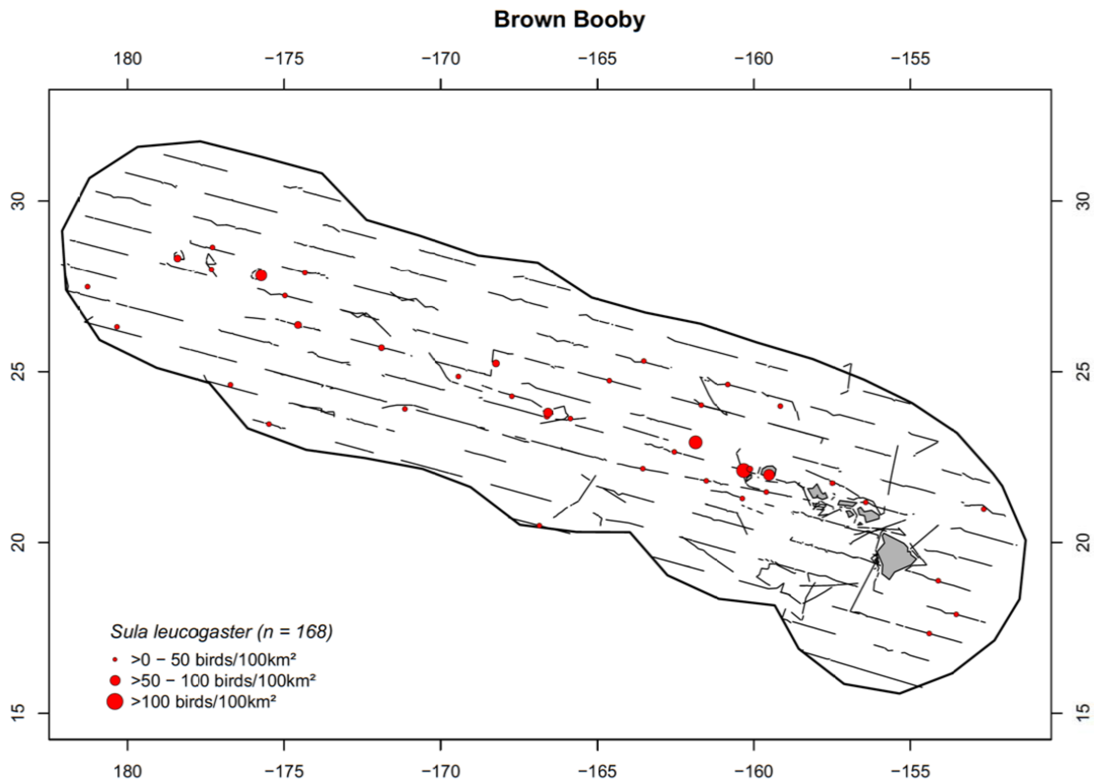
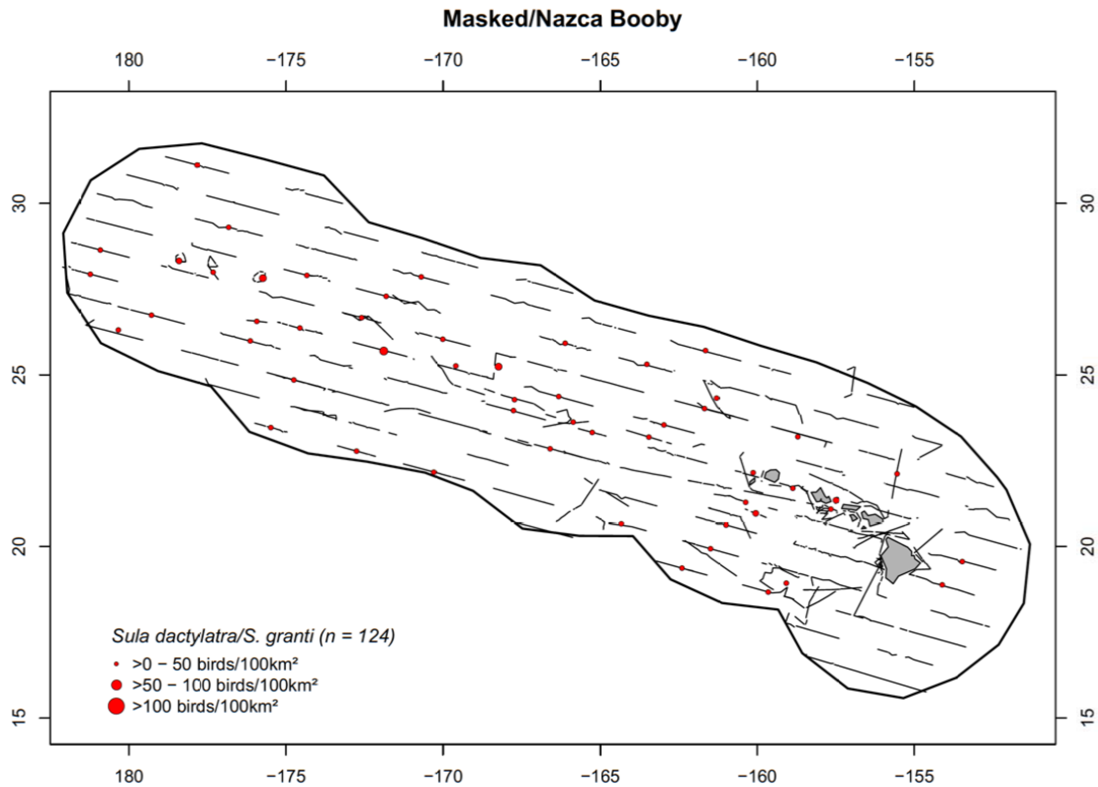


Figure C15. Distribution and density (birds/100 km^2) for Great Frigatebirds and Brown Boobies.



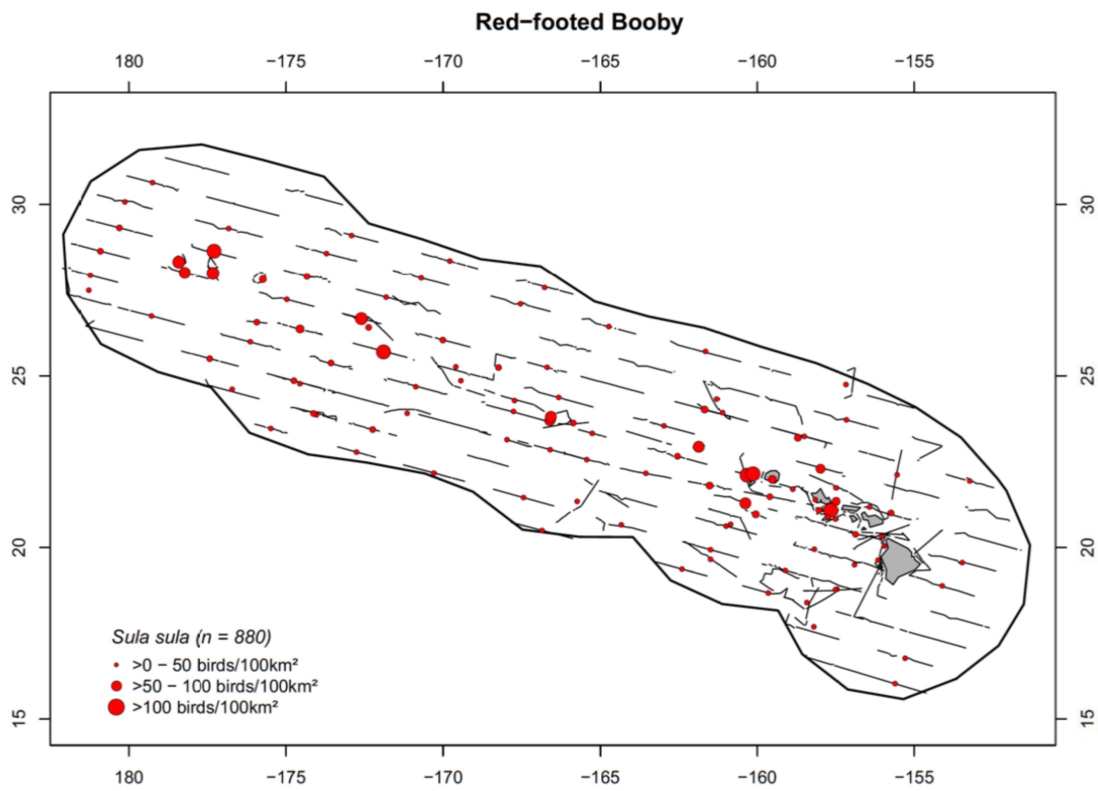
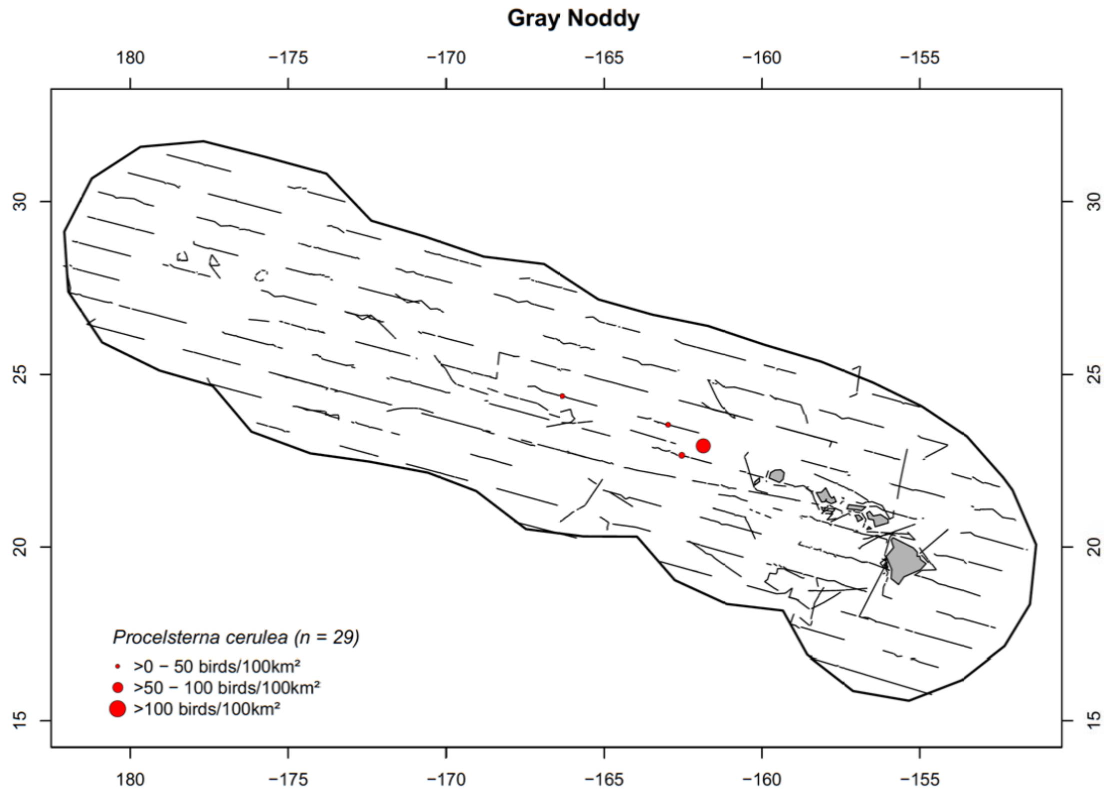


Figure C2. Distribution and density (birds/100 km^2) for Masked/Nazca and Red-footed Boobies.

Distribution and Density Maps for Charadriiformes (Figure C17-C21)

Distribution and density (birds/100 km^2) for Charadriiform seabird species recorded during the 300 m strip transect survey. On-effort periods are indicated by gray lines; seabird densities are presented in terms of three categories: 1-50 birds/100 km^2, 51-100 birds/100 km^2, and > 100 birds/100 km^2.



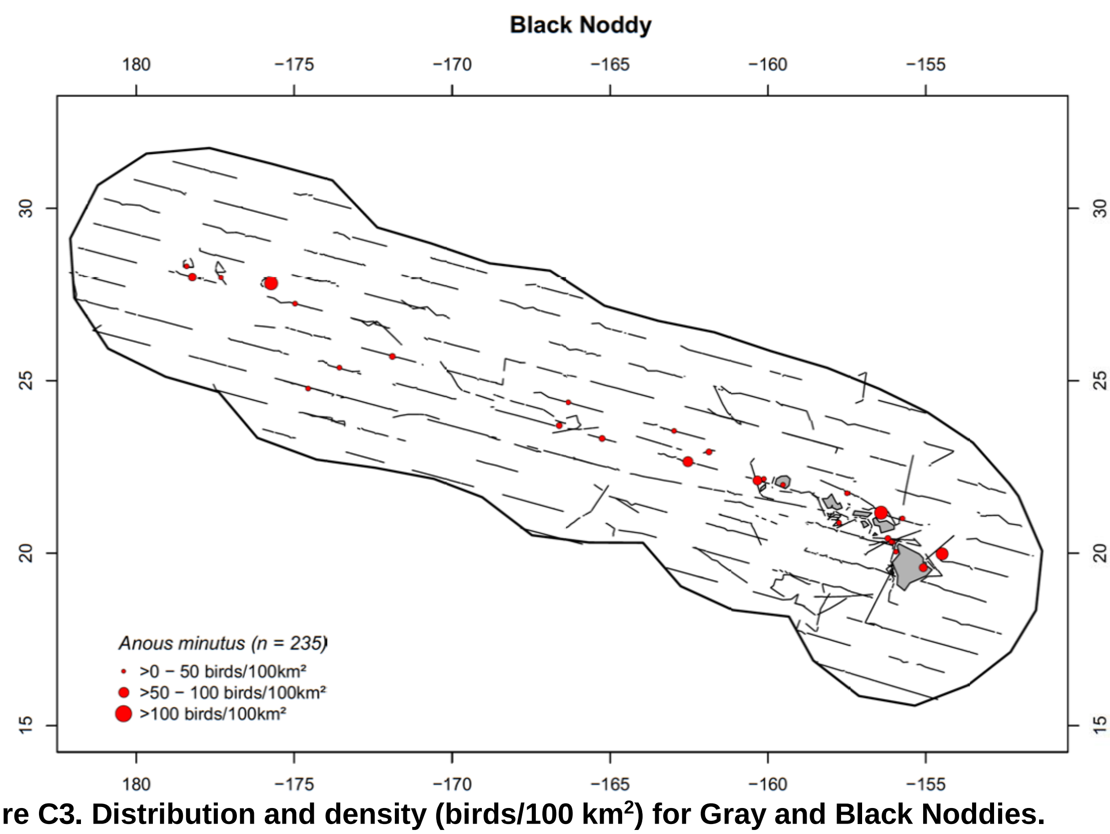
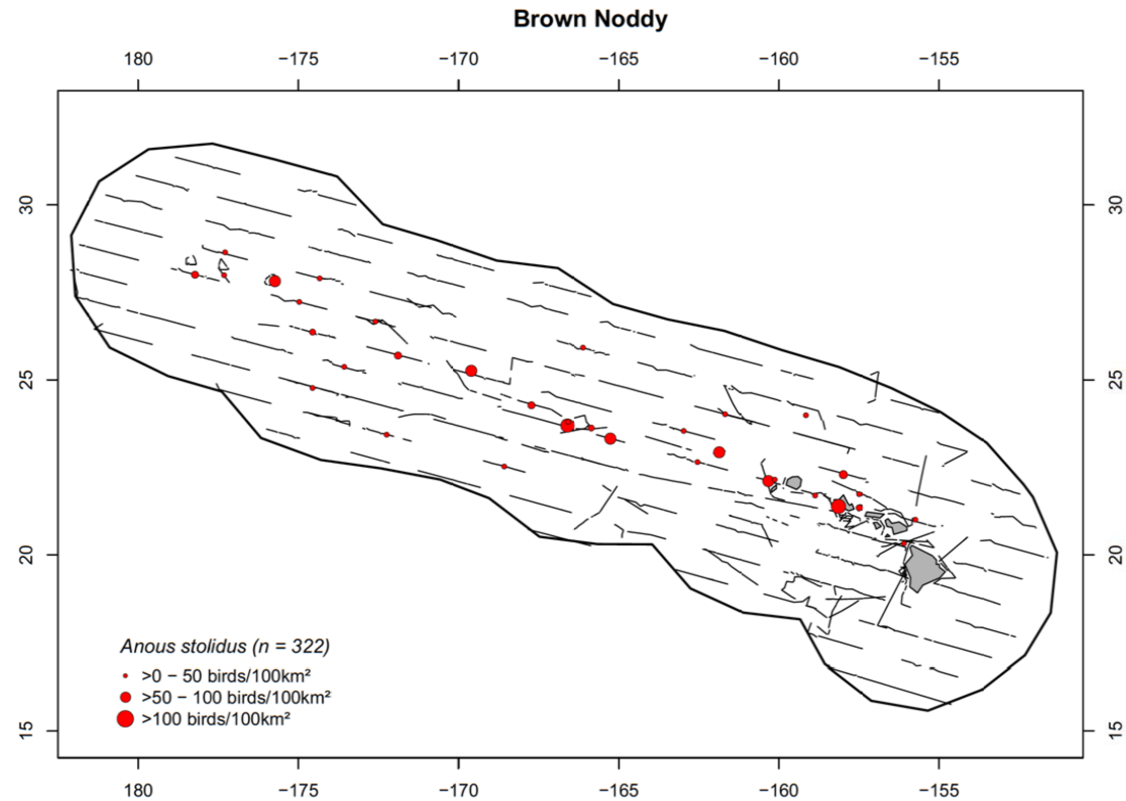


Figure C3. Distribution and density (birds/100 km²) for Gray and Black Noddies.



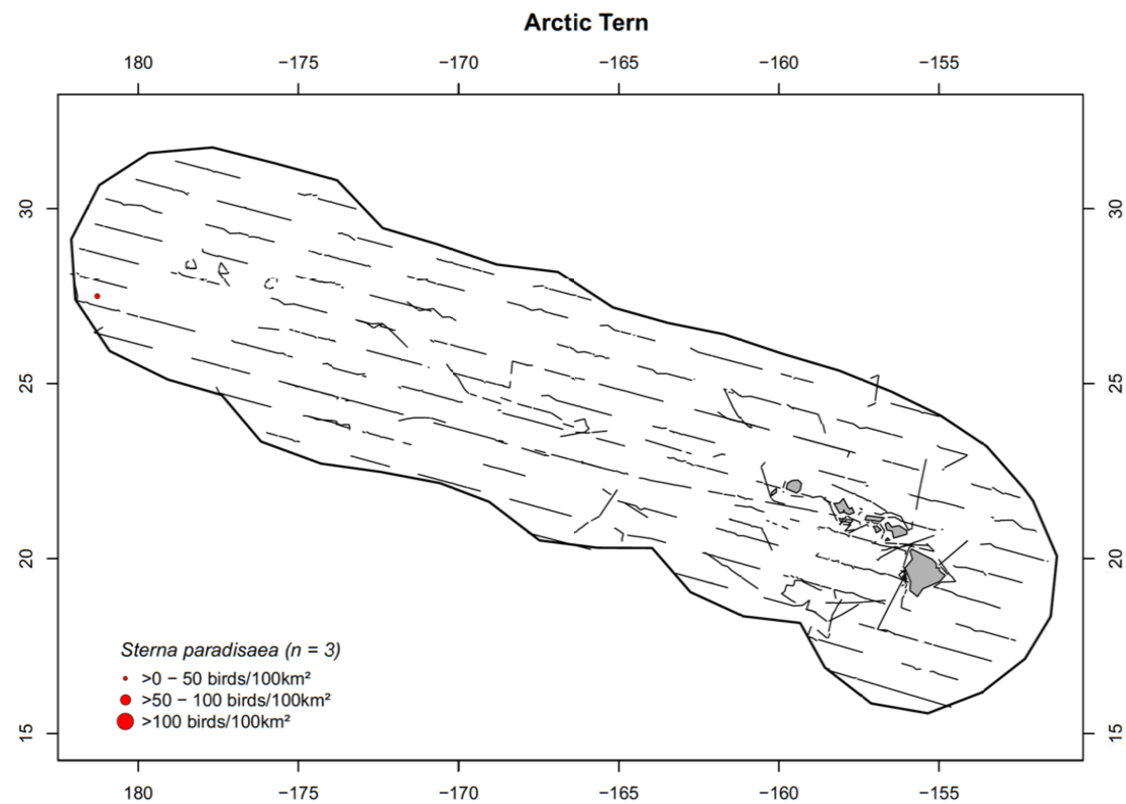


Figure C4. Distribution and density (birds/100 km^2) for Brown Noddies and Arctic Terns.

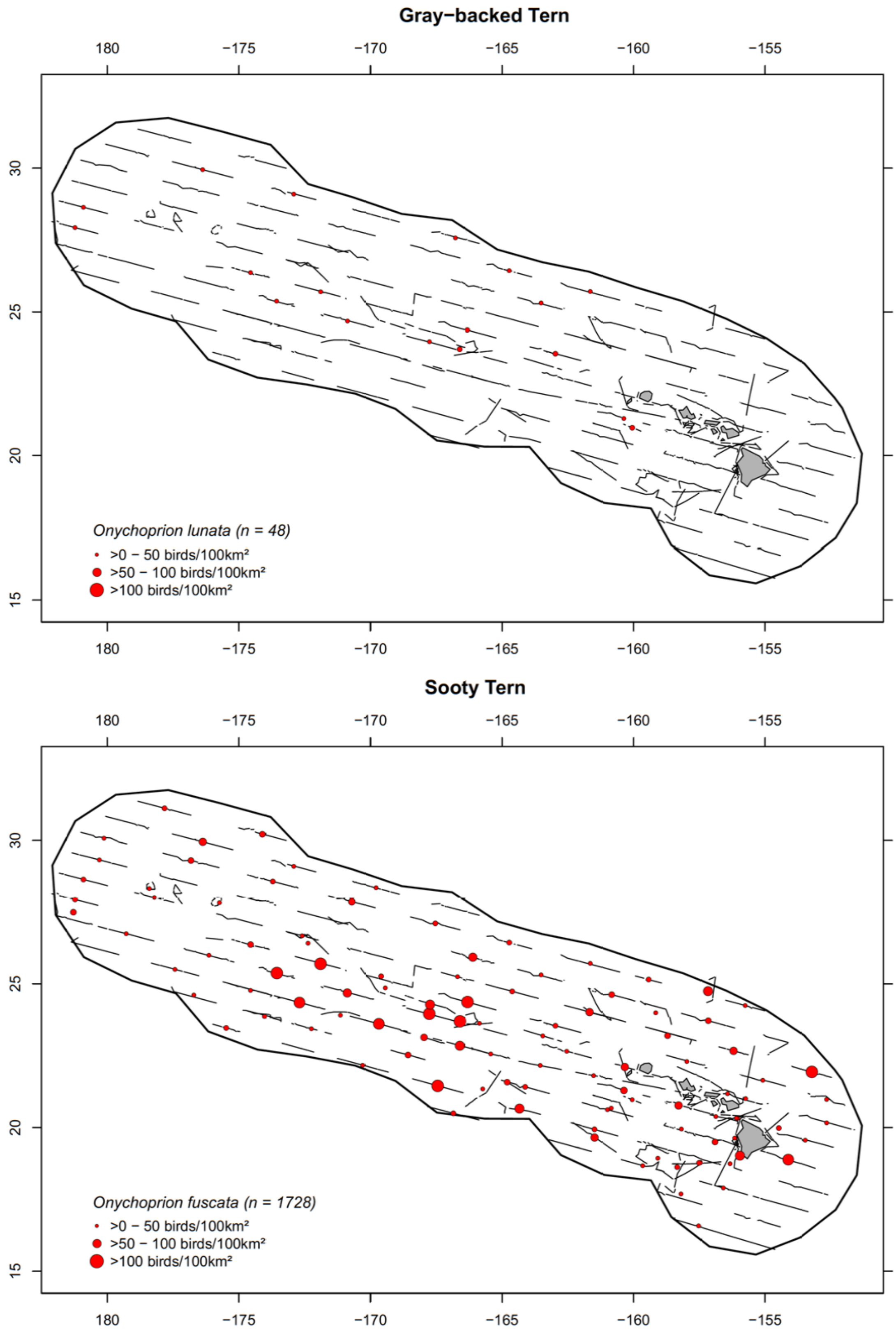
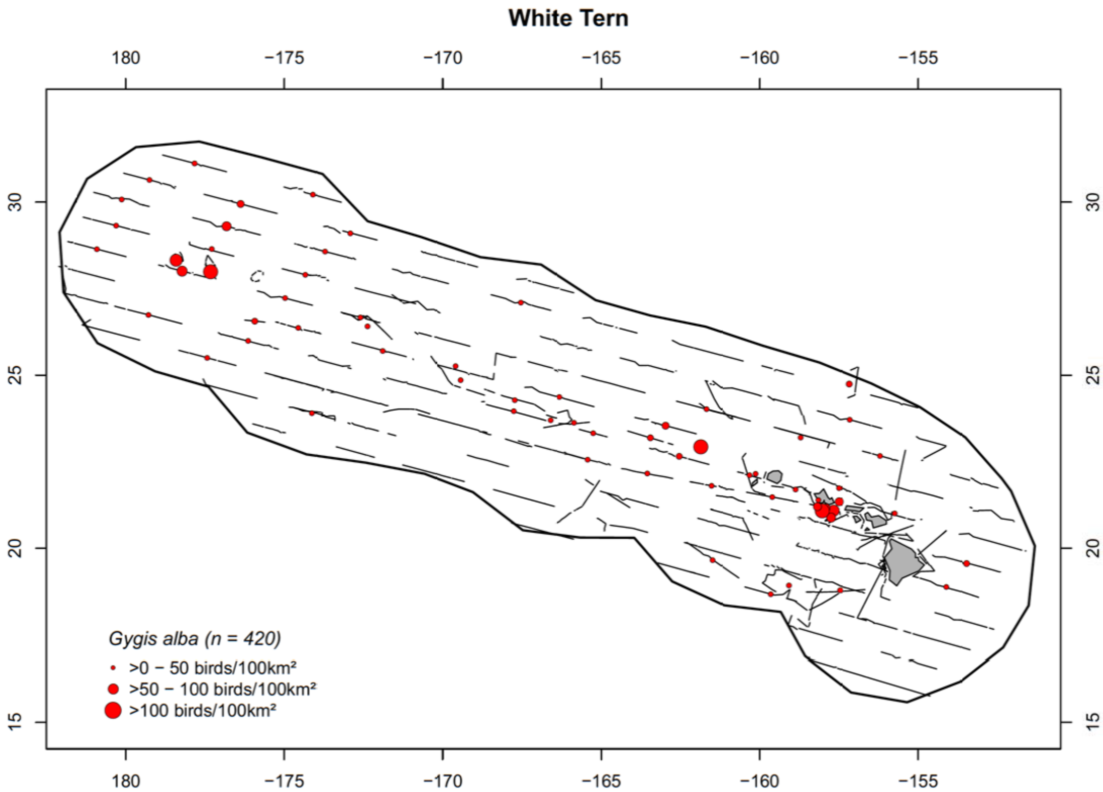


Figure C19. Distribution and density (birds/100 km^2) for Gray-backed and Sooty Terns.



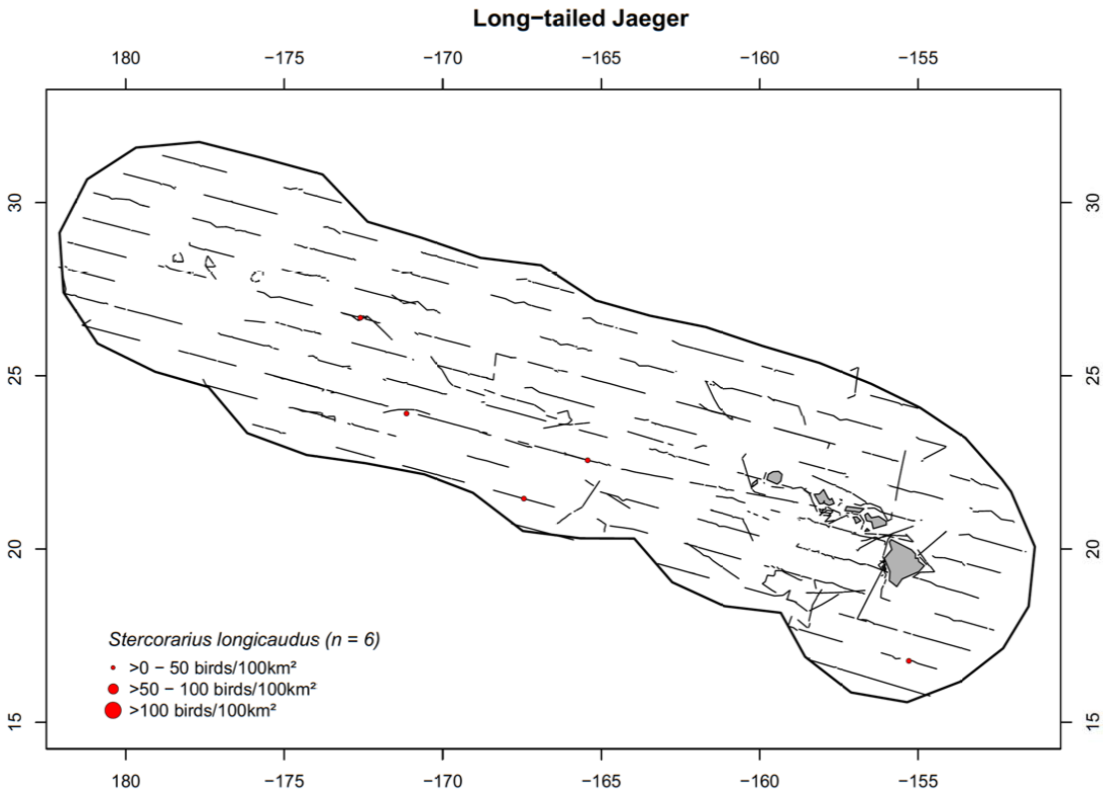
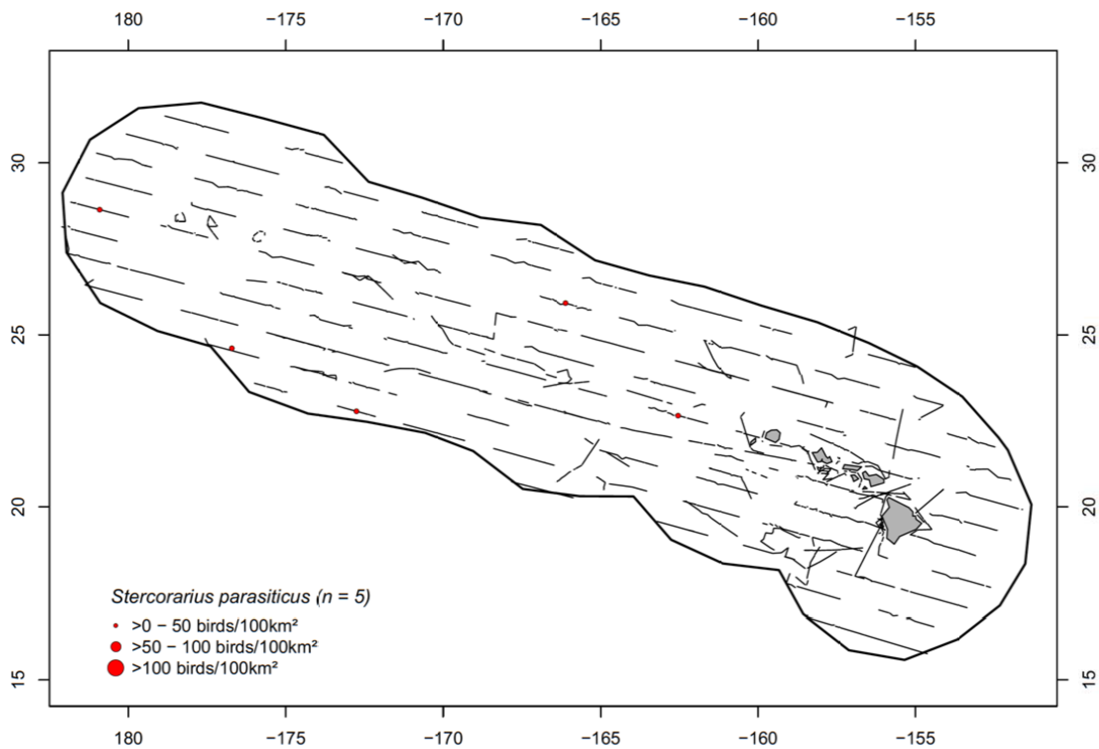


Figure C20. Distribution and density (birds/100 km^2) for White Terns and Long-tailed Jaegers.

Parasitic Jaeger



Pomarine Jaeger

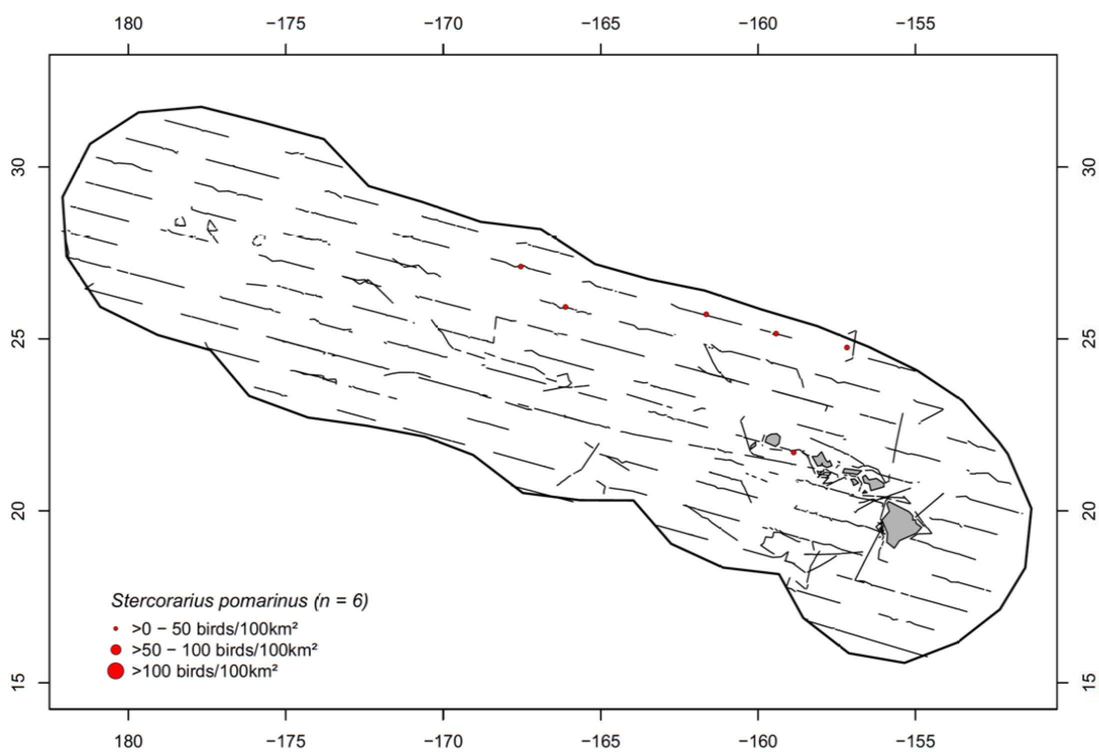


Figure C21. Distribution and density (birds/100 km^2) for Parasitic and Pomarine Jaegers.

Appendix D: Maps of Other Species Sightings

Sightings of Other Species (Figures D1-D2)

Sightings of three marine turtles and one Hawaiian monk seal during visual effort (black lines). The Loggerhead sea turtle was sighted during the *Lasker* Leg 1 transit from San Diego to Honolulu (Figure D1.A). The remaining two marine turtles and the Hawaiian monk seal sightings were within in the Hawaiʻi EEZ (Figure D1.B and Figure D2).

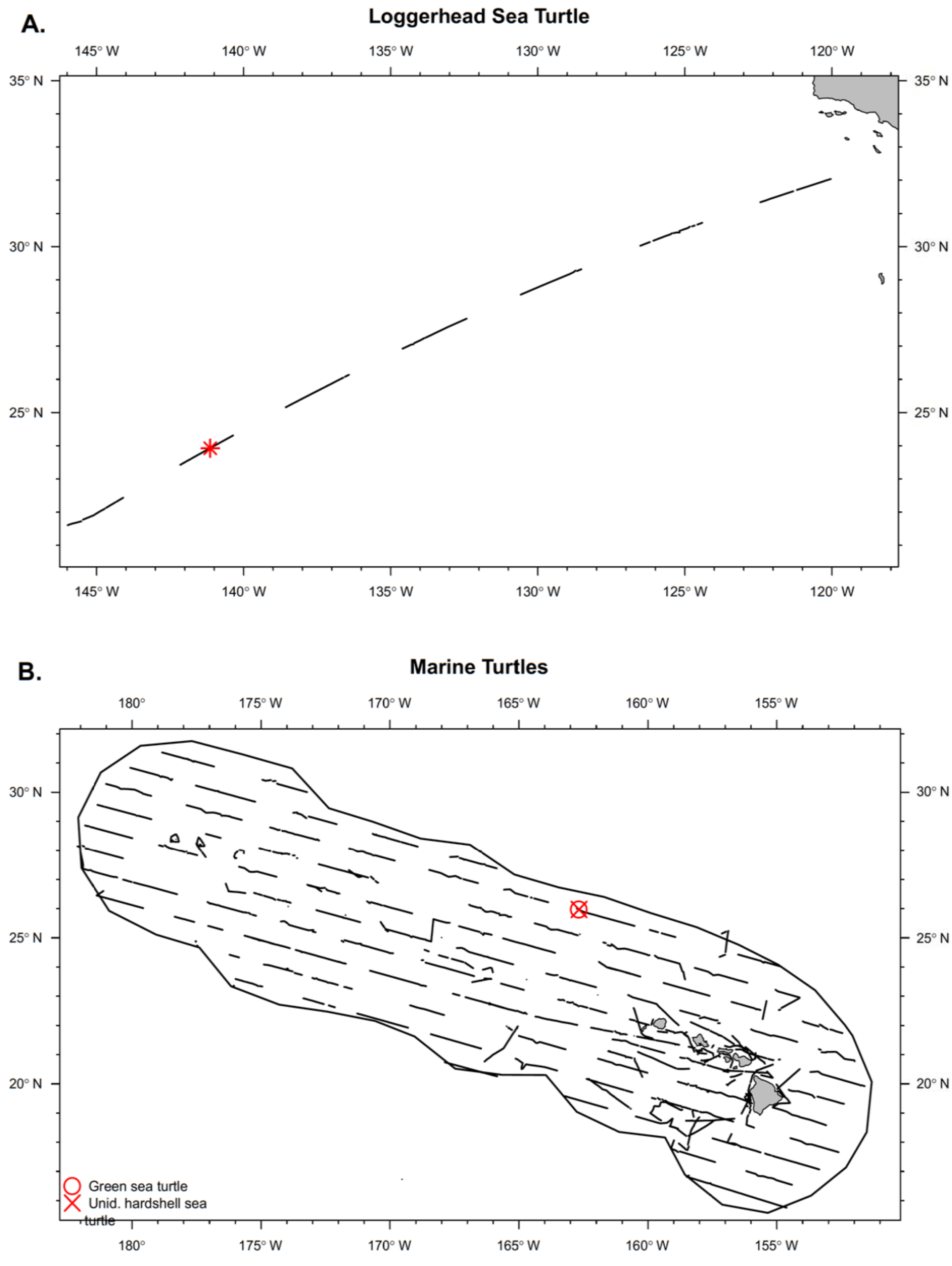


Figure D1. Sightings of marine turtles.

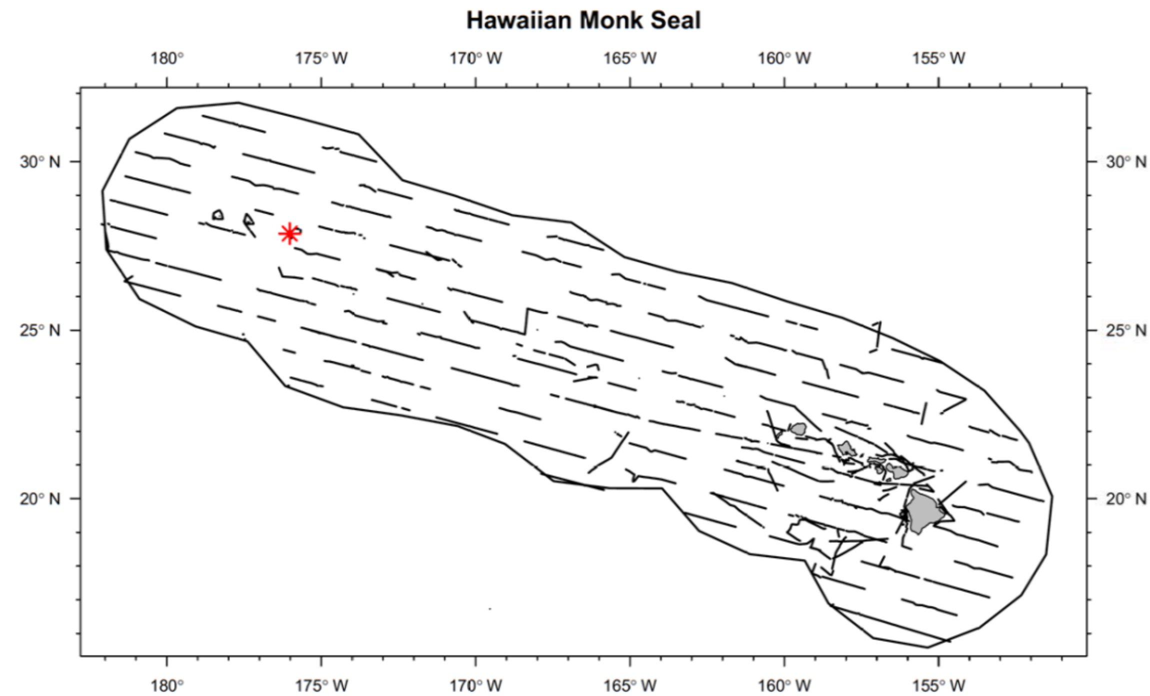


Figure D2. Sighting of a Hawaiian monk seal.

Appendix E: Data Collected by Visual Observers

Cetacean Survey Effort and Sighting Information Collected in WinCruz

- Cruise Number – a 4-digit number unique to each of the 2 vessels used and this survey
- Local Date – YYMMDD (year, month, day)
- Local Time - HHMMSS (hour, minute, second)
- Position – latitude and longitude in decimal degrees; western longitudes were recorded as negative numbers
- Survey Mode – passing, closing
- Effort Type – standard, non-standard, fine scale, off
- Beaufort Sea State
- Swell Height
- Swell Direction
- Wind Speed
- Wind Direction – relative to the ship's bow, with the bow being 000
- Precipitation – none, fog, rain, both, haze
- Sun Angle – vertical, horizontal
- Ship's Course
- Visibility Distance (nmi)
- Observer Positions – left observer, recorder, right observer, or independent observer
- Observer Code - specific to each marine mammal observer
- Event Code – a letter or symbol identifying the reason for entering the current line of data (e.g., automatic position update, begin transect, on-effort sighting, end transect, off-effort sighting, comment)
- Sighting Number – a unique sighting number generated by WinCruz
- Species Number - a 3-digit code unique to each species or lowest possible taxonomic category when species is unknown
- Sighting Cue – bird, splash, marine mammal, ship, blow
- Sighting Method – eye, handheld 7x power binoculars, mounted 25x power binoculars, other
- Bearing – to sighting from the ship's bow
- Reticle – to sighting using binoculars
- Association – with other cetaceans (mixed-species) or birds
- Comments

Pinnipeds and marine turtles sighted by the observer team were also recorded.

Survey Effort, Strip Transect, and Flock Information Collected in SeeBird

- Cruise Number – a 4-digit number unique to each of the 2 vessels used and this survey
- Date – YYMMDD (year, month, day), in both local and Greenwich
- Time – HHMMSS (hour, minute, second) in both local and Greenwich
- Position – latitude and longitude in decimal degrees; western longitudes were recorded as negative numbers
- Beaufort Sea State
- Wind Speed
- Wind Direction – relative to the ship's bow, with the bow being 000
- Ship's Course
- Observation Condition – a 1-digit number that combined all environmental conditions that affected an observer's ability to detect seabirds (e.g., glare, wind velocity and direction, swell height and direction) into a single value that represented the taxon-specific strip width for any given transect
- Observation Side
- Observer Code – specific to each seabird observer
- Event Code – a 1-digit number identifying the reason for entering the current line of data (e.g., automatic position update, begin transect, on-effort sighting, end transect, cumulative total, off-effort sighting, comment)
- Species Code – a 4-letter code unique to each species, and in many cases, color morphs and larger taxonomic groupings
- Species Number – a 4-number "code" unique to each species, and in many cases, color morphs and larger taxonomic groupings
- Distance – the radial distance to the sighting
- Association – with any other birds, mammals/fish, objects
- Behavior – sitting, following the ship, feeding, kleptoparasitism, unknown, directional flight, non-directional fight
- Flight Direction – for birds in directional flight
- Age
- Sex
- Comments

Pinnipeds and marine turtles that entered the quadrant being surveyed were also recorded.

Appendix F: Cetacean Sighting Codes when Species is Unknown

177 – Unidentified small dolphin
A cetacean <12 ft in length that is likely of the genus *Delphinus*, *Lagenodelphis*, or *Stenella*.

277 – Unidentified medium dolphin
A cetacean <12 ft in length that is likely of the genus *Feresa*, *Grampus*, *Peponocephala*, *Steno*, or *Tursiops*.

377 – Unidentified large dolphin
A cetacean <12 ft in length that is likely of the genus *Pseudorca*, *Orcinus*, or *Globicephala*.

077 – Unidentified dolphin
A cetacean <12 ft in length that cannot be placed in one of the three unidentified dolphin size categories. An animal that cannot be positively identified but is thought to be a dolphin is coded 077 although it may exceed 12 ft in length.

051 – Unidentified *Mesoplodon*
Mesoplodon sp. not positively identified to species.

049 – Unidentified beaked whale
A beaked whale (*Ziphiidae*) not positively identified to a more specific category.

080 – Unidentified *Kogia*
Kogia sp. not positively identified as either dwarf or pygmy sperm whale. If suspected to be *Kogia* but unsure, then use code 078 (unidentified small whale).

078 – Unidentified small whale
A cetacean 12-30 ft in length not positively identified to a more specific category.

099 – Rorqual identified as a sei or Bryde’s whale
A rorqual that is clearly either a sei or Bryde’s whale, but the head was not seen to confirm.

070 – Unidentified rorqual
A large whale >30 ft in length with tall columnar spouts, two-part blows, or distinctive falcate dorsal fin located in the latter third of the body (*Balaenoptera* sp.). An animal that cannot be positively identified but is thought to be a minke whale may be coded as 070 although it does not exceed 30 ft in length.

079 – Unidentified large whale
A cetacean >30 ft in length not positively identified to a more specific category.

098 – Unidentified whale
A cetacean >12 ft in length not positively identified to a more specific category.

096 – Unidentified cetacean
A cetacean that cannot be placed in a more specific category.

Appendix G: False Killer Whale Protocol

False Killer Whale Protocol for Visual Observers

OVERVIEW

False killer whales, *Pseudorca crassidens* (PC), usually travel in multiple subgroups of a few individuals that are part of a larger group of tens of individuals. Previous studies of PC have found that 1) subgroups are the best unit of detection for line-transect analysis, and 2) visual-only searches tend to miss a large proportion of subgroups that can be acoustically detected. Therefore, a two-phase PC protocol was developed to combine visual and acoustic detection methods so that more precise subgroup and group size estimates can be made, while adhering to line-transect assumptions.

***PHASE 1**. On-effort trackline passing mode*

Remain on current trackline so visual observers can get accurate subgroup distances and bearings (for line-transect analysis) and passing mode estimates of subgroup size.

***PHASE 2.** Off-effort acoustic-directed passing mode*

Pass through the center of the overall group so visual observers can get size estimates for as many subgroups as possible and a sense of overall group size and behavior.

ALL PERSONNEL

The following provides general information and key points relevant to all personnel. Please see individual protocols for responsibilities of the cruise leader, visual observers, and acoustics team members.

PHASE 1: Phase 1 is initiated when a possible PC detection is made within 3 nmi of the trackline while the visual observers are on-effort, regardless of how the animals were detected. During this phase, the ship should continue along the trackline at 10 kt with both the visual and acoustics teams independently localizing and naming subgroups. Visual and acoustic detections of other species should be noted as usual, but the ship should not turn. The only circumstance where a turn might be warranted is if the visual team sights possible PC and, following consultation with acoustics, a brief turn would aid in PC identification. As soon as such a sighting has been established as PC or not, the ship should immediately return to the trackline at a 20° angle and continue the passing mode detection of PC subgroups. Continue Phase 1 until there are no additional visual or acoustic detections ahead of the beam of the ship and, based on characteristics of the group (behavior, dispersion of subgroups), it is judged by the visual and acoustics teams that all animals are past the beam. Phase 2 should be initiated as soon as possible after Phase 1 is complete to maximize the likelihood of relocating the animals.

PHASE 2: Once the cruise leader initiates Phase 2, the ship should slow to a speed of 5-6 kt, and the acoustics team should direct the ship toward what appears to be the center of the overall group to maximize subgroup detections. Note that a new acoustics-led naming system should be initiated, and that the Phase 2 subgroup detections do not need to be linked to those from Phase 1. Continue Phase 2 until there are no additional visual or acoustic detections ahead of the beam of the ship or the cruise leader determines that operations should change or end.

CRUISE LEADER

Your overall responsibility is to coordinate the PC protocol, which will require active direction, guidance, and decision-making on the flying bridge.

ACTIONS

1. Go to the flying bridge to monitor operations once notified by the visual team of a possible PC sighting within 3 nmi. If first alerted by acoustics of possible PC (at any distance), wait at the acoustics team station until the visual team makes a Phase 1 sighting or until the animals from the acoustic detection are past the beam.
2. Call the off-effort visual observers to the flying bridge and assign them to positions once a PC sighting has been made by the on-effort visual observers during Phase 1 or, if no Phase 1 sightings were made, when you initiate Phase 2.
3. Serve as the flying bridge communicator and/or runner or assign an off-effort visual observer to cover one or both positions.
    - *Communicator*: responsible for radio communications with acoustics and for ensuring that the primary and backup visual observers are adequately communicating.
    - *Runner*: writes down the subgroup information on a white-board (time, observer, subgroup letter, bearing, and distance) and supplemental data form (observer, subgroup letter, closest distance, size, and response), and ensuring that necessary information is relayed to the center observer and communicator.
    - Note that PIFSC cruise leaders have gravitated toward serving in both roles, but this approach is not necessary.
4. Make decisions regarding PC detections beyond 3 nmi, ending Phase 2 early, and post-protocol operations.

DECISIONS

- If a PC detection is made beyond 3 nmi of the trackline, convene with the team(s) who made the detection. Once it is established that all subgroups are past the beam (i.e., there is no chance of initiating Phase 1), either:
    a. Bypass the detection,
    b. Initiate an unpaired Phase 2 of the PC protocol, or
    c. Approach the group for photo/biopsy sampling from ship or small boat.
- After 30 min of Phase 2, evaluate if the acoustics team has been able to localize and differentiate subgroups and if the visual observers have been able to detect and estimate the size of subgroups (i.e., *Is Phase 2 working?*):
    a. If not, end Phase 2.
    b. If yes, continue Phase 2 until there are no detections ahead of the beam or for 30 min more, when success of Phase 2 will be reevaluated.
- Once both phases of the protocol are completed, convene with the visual team and either:
    a. Approach the group for photo/biopsy sampling from ship or small boat, or
    b. Resume on-effort survey.

ON-EFFORT (PRIMARY) VISUAL OBSERVER – PHASE 1

Your overall responsibility is to search for and record data on subgroups while maintaining your normal observer roles and rotation. Delays to the rotation may be needed during active periods.

1. Immediately notify the cruise leader and acoustics team of a possible or confirmed PC sighting at any distance from the trackline. A sighting within 3 nmi will prompt the cruise leader to summon the off-effort observers to the flying bridge for Phase 1 operations.
2. *Big-eye observers*: search for subgroups ahead of the ship. Once a new subgroup is detected, hand it off to the off-effort backup observers for tracking and subgroup size estimation and resume general searching ahead of the ship for new subgroups as soon as possible. If the primary observer had an adequate look at a given subgroup, discreetly give the Runner a Best/High/Low estimate and closest observed distance from the subgroup.
3. *Center observer*: use the subgroup functionality in WinCruz to record and map subgroups, which should be named alphabetically with each new subgroup assigned a new, consecutive letter (i.e., A, B, C, D, etc.).
   - If it is uncertain whether a visual sighting is an existing or new subgroup, assign a new letter.
   - If the subgroup is later determined to be an existing subgroup, note this in the WinCruz record (e.g., with the comment "Subgroup C=F").
   - Although the characteristics of each subgroup (bearing, distance, size) at its initial detection are most important for subsequent analyses, the joining of subgroups and other behavioral observations should also be noted (e.g., "Now Subgroup C=C+D").
4. Share each new visual subgroup detection and letter designation with the acoustics team as soon as possible. Resightings of subgroups should also be recorded in WinCruz and relayed to the acoustics team.

OFF-EFFORT (BACKUP) VISUAL OBSERVER – PHASE 1

Your overall responsibility is to search for and estimate the size of subgroups that have been detected by the primary visual observers. You may serve as the Communicator and/or Runner.

1. When paged, report to the flying bridge in support of subgroup localization and size estimation. The cruise leader will assign you to a position, which you should maintain throughout the protocol. However, if enough time passes and it would not be disruptive, you can rotate into your next on-effort shift.
2. Search for subgroups using the aft big-eyes until the primary observer passes you one or more subgroups for tracking and size estimation. As you are tracking these subgroups, relay resightings to the center observer and the acoustics team.
3. Track each subgroup until it passes the beam. At that time, give the Runner a Best/High/Low estimate and closest observed distance from the subgroup.
4. If you sight a subgroup not seen by the primary observer, do <u>not</u> communicate the sighting to the primary observer. Wait until the subgroup passes the beam and then announce the detection so it can be relayed to acoustics and recorded on the supplemental data form.

ALL VISUAL OBSERVERS – PHASE 2

Your overall responsibility is to search for and estimate the size of subgroups that have been detected by the acoustics team.

5. Once the cruise leader initiates Phase 2, the center observer should go off-effort in WinCruz. All observers (primary and backup) should attempt to locate each acoustically-detected subgroup and estimate subgroup sizes. You will not be in on-effort search mode but should search specifically for acoustically-detected subgroups.
6. As the acoustics team relays acoustically-detected subgroup information (i.e., estimated location and subgroup name SA, SB, SC, SD, etc.), at least one observer will be assigned to visually scan that area in an attempt to locate the subgroup and obtain subgroup size estimates.
    - If there are fewer acoustically-detected subgroups than observers at a given time, observers not focused on a subgroup should scan for other subgroups.
    - If there are more acoustically-detected subgroups than observers at a given time, first priority should go to subgroups closer to the transect line or at greater bearing angles (if the distance is unknown).
7. Once a subgroup is sighted, relay the bearing and distance to the acoustics team, who must decide if the subgroup is a match to one of their subgroups or a new one that has not yet been acoustically detected.
    - The center observer should input the subgroup name provided by the acoustics team into WinCruz, noting if a "new" subgroup is subsequently determined to be an existing subgroup.
    - Remain with the sighted subgroup while reporting resighting locations until either acoustics confirms a match with an acoustic detection or the subgroup passes the beam of the ship.
    - At that time, give the Runner a Best/High/Low estimate and closest observed distance from the subgroup. Note that in most cases, subgroup size estimates will be made by only one observer.
8. Although acoustics will be directing the ship, the visual team may make turn suggestions to acoustics to improve the approach distance for subgroup size estimation. The acoustics team will determine when and how such recommended course changes will be made.
9. Up to two personnel (one port, one starboard) can also take identification photographs if a subgroup(s) is in close enough proximity to the ship. Photo-identification efforts at this time should be restricted to the flying bridge and should stop when additional subgroups are acoustically detected.
10. Upon conclusion of the PC protocol, observers who were able to get a good sense of total group size (i.e., accounting for all subgroups) are encouraged to record a Best/High/Low estimate in their green book. Subgroup size estimates will be recorded on a supplemental data form and do not need to be included in the green book.

False Killer Whale Protocol for Passive Acoustics

OVERVIEW

False killer whales, *Pseudorca crassidens* (PC), usually travel in multiple subgroups of a few individuals that are part of a larger group of tens of individuals. Previous studies of false killer whales have found that visual-only searches tend to miss a large proportion of subgroups that can be acoustically detected. Therefore, a two-phase PC Protocol was developed to combine visual and acoustics methods, allowing more precise subgroup and group size estimates to be made.

PASSIVE ACOUSTICS – PHASE 1

Your goal is to detect and localize all false killer whale whistles and clicks, organize those detections into subgroups, and track those subgroups for pairing against visual sightings.

1. Immediate notify Cruise Leader of false killer whale detections that are within or near 3 nmi of the trackline. Very distant groups should still be tracked, but the PC protocol will not begin until subgroups are within 3 nmi.
2. Using the telephone, call the ship's bridge and let them know that we are in the PC protocol and that they should not make any unscheduled turns or change speed. Do not communicate with the visual team.
3. Using the timing, signal type, and bearing angle information from the PAMGUARD detector output for both clicks and whistles, create a subgroup IDs starting with AA.
4. Continue to monitor incoming signals and assign new subgroups until there are no more detections ahead of the beam of the ship. The visual team may call in subgroup sightings. To the extent feasible, pair up visual sighting locations with acoustic detections locations and link visual subgroup sightings in the Acoustics notes**.**
5. Continue for 0.5 nmi past the last acoustic detection, and then notify the Cruise Leader that the Acoustic Phase 1 is complete.

PASSIVE ACOUSTICS -- PHASE 2

During Phase 2, Acoustics attempts to direct the ship through the subgroups as efficiently (i.e., without lots of extra turning) as possible. You may request that the ship reduce its speed if helpful for localizing subgroups. Use the collection of Phase 1 detections, as well as information from the visual team (viewing conditions, etc.) to decide how to reposition the ship to begin Phase 2.

Clear the map of Phase 1 detections to eliminate confusion, as it is not necessary to match Phase 1 and Phase 2 detections. When new subgroups are localized:

6. As the PAMGUARD detectors provide new information on detected clicks and whistles, create subgroups and assign IDs sequentially starting with SA (i.e., SA, SB, SC, etc.)
7. Relay the subgroup ID and location to the visual team. Continue to provide position updates until they sight the subgroup or until it passes the beam of the ship (>90^{o}).
8. If the visuals team sights a subgroup that does not match an acoustics subgroup, assign it the next subgroup ID.
9. Keep track of which subgroups are sighted by the visual team.

Appendix H: Sperm Whale Protocol

Sperm Whale Protocol for Visual Observers

OVERVIEW

Sperm whale groups can be spread over several miles and commonly contain smaller subgroups (also called clusters) of 1-10 tightly associated individuals. Within a group, these subgroups commonly exhibit asynchronous dive behavior, with each cluster diving for 20-60 min followed by an 8-12 min surface period. Given the asynchrony and long durations of these dives, the standard line-transect group size estimation approach results in underestimating sperm whale group size. Thus, extended group counts are needed.

Sperm whale group counts during Pacific Islands Fisheries Science Center surveys have typically lasted 60 min. However, comparisons of 60-min and 90-min sperm whale counts from Southwest Fisheries Science Center surveys have suggested that 60-min counts may still lead to underestimates of group size. Given that sperm whales are one of the most frequently sighted species during ship surveys in Hawaiian waters, 90-min counts for all sightings might impede trackline progress. However, to assess if 60-min counts are underestimating sperm whale group size during HICEAS 2017, a sample of 90-min counts will be made for comparison.

Specifically, a 90-min count will be made for the first sperm whale detection of the day regardless of detection source (visual or acoustics team), as long as the detection is within 3 nmi of the trackline.

VISUAL OBSERVER

The following points outline the steps visual observer should take for visual or acoustic sperm whale detections within 3 nmi of the trackline.

1. Once a visual sighting of sperm whales (or likely sperm whales) is made and entered into WinCruz, inform acoustics and the ship's bridge following standard protocols. Ask acoustics to confirm that a localization of any subgroup has been made.
    - If so, go off-effort and close on group for group size estimation.
    - If not, continue on-effort in passing mode until acoustics has a localization or the visual sighting is past the beam and then close on group.
    - If acoustics can confirm that the sighting is of a single male, forego group size estimation and remain on trackline unless instructed otherwise by cruise leader.
2. For acoustic detections that were not sighted, the acoustics team will notify the visual team of the detection when all animals are past the beam. Unless the detection is of a single male, group size estimation of the detection should be initiated.
3. Once closing has begun, call the next on-effort observer to the flying bridge, while scanning 360° for all visible subgroups. See Count Details section below.
    - After 10 min, the initial three on-effort observers should record independent Best/High/Low group size estimates in their green book.
    - After an additional 60 min (and again at 90 min, if first detection of the day), all four observers should record independent Best/High/Low group size estimates in their green book.

4. Off-effort sperm whale detections should be treated like off-effort detections of other species (i.e., the sperm whale protocol is not required).
5. When filling out the sighting form on the iPad, note that the supplemental sighting portion of the form contains a few fields that are different than for other species.
   - There will be a field for the number of males in the group.
   - Observers will enter calf and neonate estimates as numbers, not percentages.
   - Although not required, if you have a good sense of the number of subadults in the group, record the estimate in the comments section.
6. Once the 60/90-min count is complete, consult with the cruise leader and initiate photo/biopsy sampling as advised. The remaining two observers should be prepared to help with either photo/biopsy sampling or with finding animals for the ship or small boat.

COUNT DETAILS

- While group size estimates are made independently, observers can talk freely about the size of individual subgroups since a given observer may not see all subgroups.
- Observers can make notes about subgroup sizes in their green book to aid in estimating total group size at the end of the count.
- Brief the next on-effort observer joining the count on the number and size of subgroups sighted in the first 10-min estimate.
- Each new sighted subgroup should be entered into WinCruz as an object (Ctrl+F2) with the subgroup letter designation (e.g., A, B, C, D, etc.) in the "ID Label" field.
  - o Subgroups can be entered as resights, but keep in mind that the map will connect these resights to the initial sighting, which may become confusing if many subgroups are present.
  - o Alternatively, the subgroup function in WinCruz used for false killer whales can be used for tracking and recording sperm whales, noting that this functionality works best if initiated at the beginning of the sighting (i.e., in the initial F2 window).
  - o If a subgroup surfaces during the 60/90-min count that cannot readily be linked to a subgroup that surfaced previously, assign it a new subgroup letter, but the center observer should record a comment that it may be the same as a previous subgroup (e.g., Subgroup I is possibly Subgroup B).
  - o Use external clues to link subgroups that were previously sighted (e.g., resight location, subgroup size, presence of calves or distinctive individuals, dive time) to avoid double-counting subgroups.
- After an observer sees a subgroup dive, inform the other observers of the subgroup letter, size, and age composition so they can make a note in their green book. If the center observer made a comment that the subgroup was possibly seen previously, this information should be relayed again for all observers to note.
- Use the WinCruz map to maintain a good position of the ship to sight subgroups once they surface after diving. If the ship is traveling slowly or holding a position, check the box to hold the course on the WinCruz map to prevent it from losing a useful orientation. It is best to do this before the map begins to struggle.

Note that communication is open between the visual and acoustics team during the count. Acoustics can call up subgroup detections that the visual team may not have seen and can notify observers of subgroups that have stopped vocalizing and may be coming to the surface.

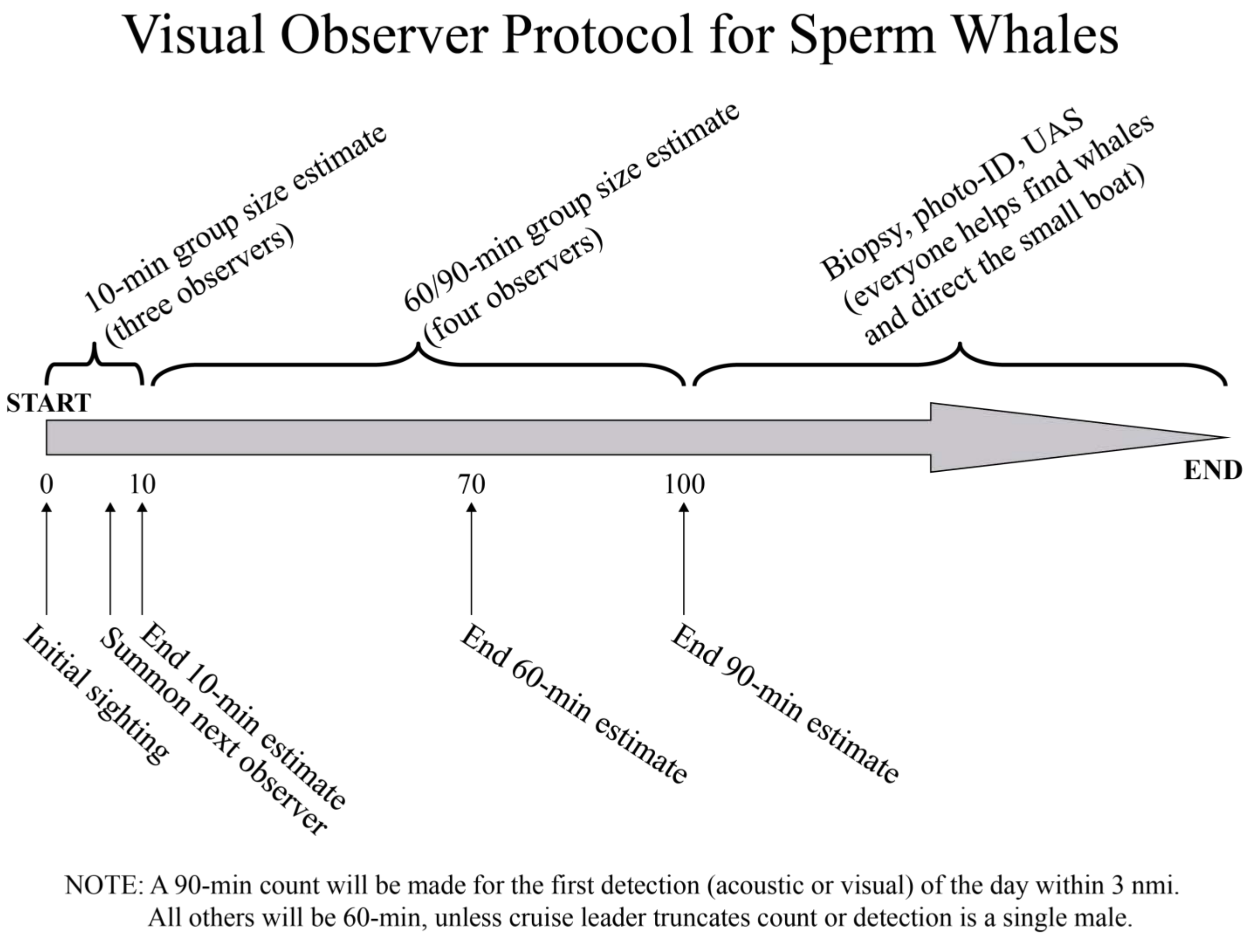


Figure H1. Sperm Whale Protocol diagram for visual observers.

Sperm Whale Protocol for Passive Acoustics

To use acoustic detections for population estimation, it is critical that the sperm whale protocol be followed for ALL acoustic detections of sperm whales that occur while the visual team is 'on-effort'. There are three types of detection scenarios: the initial detection may be made by the visual team ahead of the beam (detection angle <90°); the initial detection may be made by the acoustics team ahead of the beam; or the detection may be made by the acoustics team behind the beam (detection angle >90°). Below are more details that pertain to each scenario.

VISUAL TEAM Sights Animals <90°

When the visual team sights sperm whales ahead of the beam, they ask the acoustics team if the animals have been detected and localized. If the acoustics team has localized the group, the visual team will start the sperm whale group size protocol. The ship will remain on the trackline until the acoustic team has localized the group or until the group passes the beam of the ship.

Once initiated, the sperm whale protocol can last anywhere from 10 to 90 min. During their sperm whale group size protocol, the visual team has direction of the ship. This means that they can turn the ship and change the speed at any time. At this point, communication between the visual and acoustics teams is open and the acoustics team will assist the visual team in tracking animals.

ACOUSTICS TEAM Detects Animals <90°

When the acoustics team has a detection ahead of the beam of the ship, they will localize ALL animals, but NOT communicate with visual team about the detection. Communication is not allowed at this point because the visual team can potentially detect the animals until they pass the beam of the ship (90°). If the visual team sights the animals before they pass the beam, then proceed as above (see VISUAL TEAM Sights Animals <90°).

ACOUSTICS TEAM Detects Animals >90°

If the acoustics team either makes the initial detection of a sperm whale group that is behind the beam, or if a group initially heard ahead of the beam is tracked past the beam without detection by the visual team, then the acoustics team may divert from the trackline to close on this group and initiate the sperm whale group size protocol. The acoustics team must be certain that ALL animals have passed the beam (90°) and they are within 3 nmi (perpendicular to trackline). In this situation, the acoustics team contacts the visual team (communications are now open) and starts an Acoustic Chase. During an Acoustics Chase, directions to the ship's bridge come from Acoustics. Once the animals are sighted, Visuals takes direction of the ship, and Acoustics continues to assist in tracking animals.

If animals were ALL past the beam but not within 3 nmi, then no one is contacted, and the ship continues along the trackline.

Appendix I: Data Collected during DASBR Deployment and Retrieval

Table I1. Deployment and recording details for the 19 deployed DASBR units.

DASBR Station (Deploy ID)	Deployment			Retrieval			Data Recorded	
	Latitude	Longitude	Date/Time	Latitude	Longitude	Date/Time	End Time	Duration (h:m:s)
DS0	21.2946	-160.3270	07/07/2017 12:26:09	--	--	--	--	--
DS1	20.5159	-158.8730	07/08/2017 15:46:19	--	--	--	--	--
DS2	20.6522	-157.7652	07/09/2017 04:18:27	--	--	--	--	--
DS3	19.5565	-156.6238	07/12/2017 12:23:02	20.8682	-160.5414	07/29/2017 14:27:30	07/29/2017 14:27:30	410:04:28
DS4	19.8190	-154.5582	07/14/2017 20:58:37	20.8289	-154.8551	08/01/2017 07:11:59	08/01/2017 07:11:59	418:13:22
DS5	20.9780	-155.8352	07/15/2017 09:38:55	--	--	--	--	--
DS6	21.8919	-157.0669	07/15/2017 23:24:30	23.8549	-158.6454	08/11/2017 08:52:17	08/07/2017 03:57:50	532:33:20
DS7	21.9896	-158.8317	07/17/2017 05:35:23	21.1300	-161.5539	07/29/2017 07:39:22	07/29/2017 07:39:22	290:03:59
DS8	20.9672	-158.0958	08/08/2017 19:37:09	21.988	-165.0272	09/24/2017 07:22:25	08/30/2017 14:04:02	522:26:53
DS9	20.2385	-156.8205	08/09/2017 06:02:03	18.1894	-158.4958	09/01/2017 12:48:19	09/01/2017 12:48:19	558:46:16
DS10	20.1983	-155.1452	08/09/2017 16:34:15	19.9828	-155.0373	08/27/2017 07:06:08	08/27/2017 07:06:08	422:31:53
DS11	21.6073	-157.0838	08/10/2017 09:07:01	24.427	-156.9911	08/30/2017 16:21:18	08/30/2017 16:21:18	487:14:17
DS12	22.1228	-158.3717	08/10/2017 21:27:09	25.2553	-156.8827	08/30/2017 08:21:25	08/30/2017 08:21:25	466:54:16

DASBR Station (Deploy ID)	**Deployment**			**Retrieval**			**Data Recorded**	
	Latitude	Longitude	Date/Time	Latitude	Longitude	Date/Time	End Time	Duration (h:m:s)
DS13	21.5981	-159.7898	08/11/2017 20:40:00	20.5102	-164.897	09/23/2017 15:25:47	--	--
DS14	20.8857	-155.8408	09/02/2017 07:22:17	20.5294	-154.0864	09/13/2017 07:19:32	09/13/2017 07:19:32	263:57:15
DS15	20.8258	-157.1627	09/03/2017 16:07:42	17.7283	-158.4665	10/08/2017 10:00:11	09/26/2017 14:44:17	550:36:35
DS16	21.1100	-157.6463	09/11/2017 14:44:42	--	--	--	--	--
DS17	21.3709	-157.4106	09/11/2017 17:39:20	21.1139	-157.9478	10/09/2017 07:12:14	10/04/2017 20:28:42	554:49:22
DS18	22.2738	-159.7721	09/12/2017 19:13:10	22.6207	-160.5555	10/07/2017 08:29:36	10/05/2017 06:24:30	539:11:20

Appendix J: Science Personnel

Table J1. NOAA Ships *Oscar Elton Sette* and *Reuben Lasker* science personnel.

PIFSC (Pacific Islands Fisheries Science Center, NOAA); OAI (Ocean Associates, Inc.); JIMAR (Joint Institute for Marine and Atmospheric Research, University of Hawai‘i at Manoā); NOAA TAS (NOAA Teacher at Sea); DU (Duke Univeristy); SEFSC (Southeast Fisheries Science Center, NOAA); BOEM (Bureau of Ocean Energy Management); SWFSC (Southwest Fisheries Science Center, NOAA); UCSD (University of California, San Diego); OSU (Oregon State University); AFSC (Alaska Fisheries Science Center, NOAA)

Science Role	Name	Affiliation	Leg Sailed (Alternate Role, if applicable)
Cruise Leader	Erin Oleson	PIFSC	S1
Cruise Leader	Amanda Bradford	PIFSC	S1 (Visiting Scientist), S2
Cruise Leader	Marie Hill	JIMAR	L1 (Visiting Scientist), S3
Cruise Leader	Jeff Moore	SWFSC	L1
Cruise Leader	Eric Archer	SWFSC	L2
Cruise Leader	Jim Carretta	SWFSC	L3
Cruise Leader	Karin Forney	SWFSC	L4
Senior Mammal Observer	Paula Olson	OAI	S1, S2, S3, L3
Senior Mammal Observer	Ernesto Vazquez	OAI	S1
Senior Mammal Observer	Andrea Bendlin	OAI	S1 (Mammal Observer), S2, S3, L3
Senior Mammal Observer	Juan Carlos Salinas	OAI	L1, L2, L4
Senior Mammal Observer	Suzanne Yin	OAI	L1, L2, L4
Mammal Observer	Allan Ligon	Contractor	S1, S2, S3, L3
Mammal Observer	Adam Ü	OAI	S1, S2, S3
Mammal Observer	Amy Van Cise	OAI	S1, S2
Mammal Observer	Greg Sanders	BOEM	S3
Mammal Observer	Carrie Sinclair	SEFSC	S3
Mammal Observer	Bernardo Alps	OAI	L1, L2, L3, L4
Mammal Observer	Heather Colley	OAI	L1, L2, L3, L4
Mammal Observer	Mark Cotter	OAI	L1, L2, L3, L4
Mammal Observer	Jim Gilpatrick	SWFSC	L1, L2
Mammal Observer	Charlotte Boyd	AFSC	L4

Science Role	Name	Affiliation	Leg Sailed (Alternate Role, if applicable)
Seabird Observer	Dawn Breese	OAI	S1, S2, S3
Seabird Observer	Christopher Hoefer	OAI	S1, S2, S3
Seabird Observer	Andy Bankert	OAI	L1, L2, L3, L4
Seabird Observer	Michael Force	OAI	L1, L2, L3, L4
Lead Acoustician	Jennifer Keating	JIMAR	S1, S2, S3, L4 (Acoustician)
Lead Acoustician	Shannon Coates	OAI	S1 (Acoustician), L1, L2, L3, L4
Acoustician	Erik Norris	JIMAR	S1, S2, S3
Acoustician	Rory Driskell	PIFSC	S2 (Mammal Observer), S3, L3
Acoustician	Ali Bayless	JIMAR	S2
Acoustician	Megan Slack	OAI	L1
Acoustician	Jenny Trickey	UCSD	L1
Acoustician	Arial Brewer	OAI	L2
Acoustician	Taiki Sakai	OAI	L2
Acoustician	Anne Simonis	OAI	L3
Acoustician	Jessica Crance	AFSC	L4
Visiting Scientist	Staci DeSchryver	NOAA TAS	S1
Visiting Scientist	Kym Yano	JIMAR	S1
Visiting Scientist	Joseph Fader	DU	S2
Visiting Scientist	Ann Allen	PIFSC	S3
Visiting Scientist	Seth Sykora-Bodie	DU	L1
Visiting Scientist	Brittany Hancock-Hanser	SWFSC	L2
Visiting Scientist	Lauren Jacobsen	OSU	L3
Visiting Scientist	Elizabeth Hetherington	UCSD	L4
Visiting Scientist	Michael Richlen	HDR, Inc.	L4