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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Pacific Islands Fisheries Science Center
NOAA Technical Memorandum NMFS-PIFSC-111

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Ocean Energy Management
OCS Study BOEM 2020-049

https://doi.org/10.25923/ehfg-dp78
November 2020

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NOAA Technical Memorandum NMFS-PIFSC-111
November 2020

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National Marine Fisheries Service
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U.S. Department of the Interior
Bureau of Ocean Energy Management
OCS Study BOEM 2020-049

Recommended citation

Yano KM, Oleson EM, McCullough JLK, Hill MC, and Henry AE. 2020. Cetacean and seabird data collected during the Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January–March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

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, Hawaii 96818

Or online at

https://repository.library.noaa.gov/

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

The content of this report, in part, fulfills the requirements of Interagency Agreements between the Bureau of Ocean Energy Management and the National Marine Fisheries Service (BOEM Agreement Number M17PG00024; NOAA Agreement Number NMFS-PIC-17-005) and between the U.S. Navy and the National Marine Fisheries Service (Navy Agreement Numbers N0002518GTC032-06 and N0007018MP4C587-01; NOAA Agreement Number NMFS-NEC-16-011-06 and NMFS-PIC-18-005).

Cover: Photo of rough-toothed dolphins (*Steno bredanensis*) and humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Photo courtesy of NOAA Fisheries/Andrea Bendlin.

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Project Overview

The Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (referred to as "Winter HICEAS") of 2020 was a ship-board survey for cetaceans and seabirds within offshore waters surrounding the main Hawaiian Islands (MHI). This project used many of the same methods as the previous HICEAS projects which occurred in 2002 (Barlow 2006), 2010 (Bradford et al. 2017), and 2017 (Yano et al. 2018).

The Winter HICEAS 2020 project represents the third 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), and the U.S. Navy. 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. The previous PacMAPPS surveys include the 2017 HICEAS and 2018 California Current Ecosystem Survey. The HICEAS project was a collaborative effort between the Pacific Islands and the Southwest Fisheries Science Centers (PIFSC and SWFSC) and surveyed the U.S. waters surrounding the northwestern and main Hawaiian Islands from July through December 2017, whereas the 2018 California Current Ecosystem Survey, led by the SWFSC, surveyed waters offshore from the U.S. West Coast from June through December 2018 (Henry et al. 2020).

Winter HICEAS 2020 sailed aboard the NOAA Ship *Oscar Elton Sette* (hereafter referred to as the *Sette*) for 51 days-at-sea. The project was conducted during 2 survey "legs"; Leg 1 sailed on 18 January to 12 February and Leg 2 sailed on 17 February to 12 March.

Survey Objectives

The primary goals of Winter HICEAS 2020 were to collect data required to estimate the abundance and distribution, examine the population structure, and understand the habitat of cetaceans around the main Hawaiian Islands during the winter months (January–March). There were 5 major research components to the project:

- 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 Winter HICEAS 2020 study area was delineated as a convex hull around a 100-nmi (185.2-km) radius of the MHI, truncated to the northwest at the easternmost edge of the Papahānaumokuākea Marine National Monument (PMNM; Figure 1). The study area includes the known ranges of several island-associated populations of cetaceans, and additional transect lines in this region were intended to provide finer-scale data on the abundance and distribution of those populations. Nearshore survey strata were defined by the farthest offshore extent of the

overlaid insular stock ranges for spinner and bottlenose dolphins around Kaua‘i and Ni‘ihau; for spinner (*Stenella longirostris*), pantropical spotted (*Stenella attenuata*), and bottlenose (*Tursiops truncatus*) dolphins around O‘ahu and the 4-Islands area (Maui, Lāna‘i, Moloka‘i, and Kaho‘olawe; also referred to as Maui Nui); and by spinner, bottlenose, and Kohala resident melon-headed whales (*Peponocephala electra*) around Hawai‘i Island. The insular stock ranges of MHI insular false killer whales (*Pseudorca crassidens*) and Hawai‘i Island pantropical spotted dolphins are fully within the broader MHI study area.

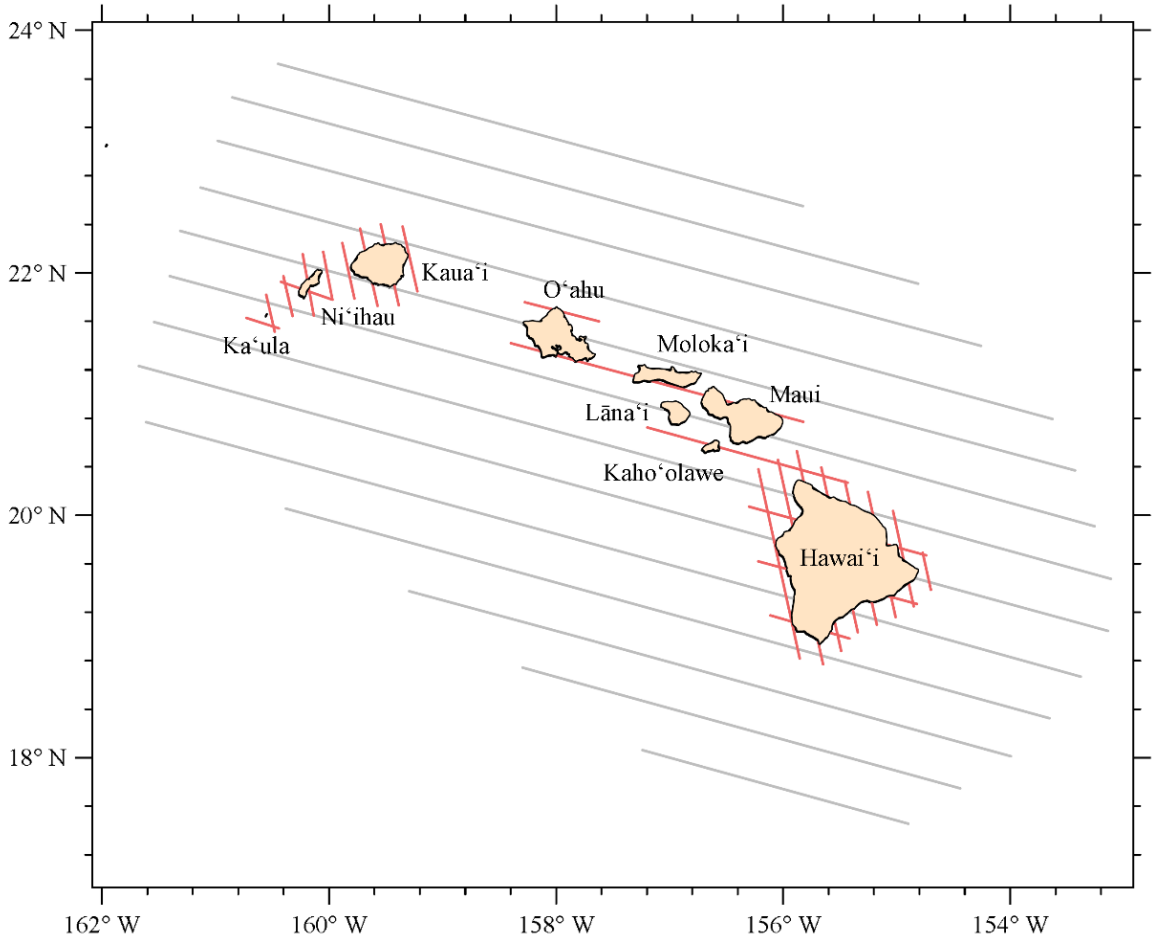

Figure 1. Winter HICEAS 2020 study area.

The parallel transect lines (gray) formed the basis for the line-transect standard survey effort. The inshore transect lines (red) were used for fine-scale effort.

Equipment and Methods

Winter HICEAS 2020 consisted of visual surveys of cetaceans and seabirds with simultaneous passive acoustic monitoring during daylight hours and oceanographic sampling 1 hour before sunrise and 1 hour after sunset.

Cetacean Survey Operations

Ship-based visual and passive acoustic survey effort for cetaceans generally occurred along parallel transect lines (or tracklines), which were spaced 46 km apart and traversed the study area from WNW to ESE (Figure 1). The full span of an individual transect line was generally divided among 2 or more survey days (see Results and Discussion, Visual Effort). Survey effort 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. Near-island fine-scale survey included an additional WNW-ESE transect line spaced between the standard tracklines for all nearshore areas, as well as NNW-SSE lines spaced 18.5 km apart around Kauaʻi, Niʻihau, and Kaʻula and around Hawaiʻi Island (Figure 1). Several nearshore lines could be surveyed within a single survey day.

Visual Observations

The cetacean visual survey methods used during Winter HICEAS 2020 were developed by the SWFSC and have been used for the last 3 decades, including HICEAS 2002, 2010, and 2017 (Barlow 2006; Bradford et al. 2017; Yano et al. 2018). 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 the *Sette* (approximately 15 m above the sea surface) during daylight hours (sunrise to sunset). The observer team rotated through 3 on-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° or less. 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, including periods of heavy precipitation, swell greater than 13 ft (4.0 m) or greater than 10 ft (3.0 m) with a short wave period, or 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 logbooks. Estimates of group size were not discussed among observers at any time. Note that group-size estimation protocols varied for three species: false killer whales, sperm whales (*Physeter macrocephalus*), and humpback whales (*Megaptera novaeangliae*) (see Species-Specific Protocols). Following group-size estimation, some groups were pursued for additional data collection, including photo-identification or biopsy sampling from the ship's bow. Although a small boat launched from the ship has been used during prior surveys to collect photographs or tissue samples for some species, such operations were not feasible during the project due to limitations with the ship's crane that restricted launches to Beaufort 0–2 and swell height of 5 ft (1.5 m) or less.

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 for the MHI study area (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 ports, between transects, or while circumnavigating islands. Fine-scale effort occurred while surveying along inshore transect lines (Figure 1). 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, swell height greater than 13 ft (4.0 m), 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.

Visual Survey Data

Data collection by the visual observers follows the same procedures as described in detail in Yano et al. (2018) so it is only briefly summarized here. Search effort, environmental conditions, and cetacean sightings were recorded using the software WinCruz, which also logged the time, latitude, and longitude for each event via connection to the ship's global positioning system (GPS). 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 by the center observer at each observer rotation or when effort was resumed following a sighting. The bearing and binocular reticle for each sighting were used by WinCruz to calculate the perpendicular distance of the sighting location from the trackline.

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 a variety of data fields allowing cross-reference to the WinCruz record as well as descriptions of the encounter, group composition and behavior, photo details (if collected), and information required for reporting under applicable permits. A linked biopsy sampling form collected details about each biopsy attempt and provided a sample number for use during sample archiving.

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 & Biopsy Sampling

Digital single-lens reflex (SLR) cameras with telephoto zoom lenses (100–400 mm and 70–200 mm) were used for taking photographs from the ship to aid in species identification, individual identification, and health and injury assessment.

Biopsy samples were collected 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 in a dewar of liquid nitrogen. At the end of the project, half of each sample was stored in a −80°C freezer at the PIFSC for archiving and the other half of each sample was stored in a −80°C freezer at the SWFSC for tissue archiving and processing.

Passive Acoustic Operations

Towed Hydrophone Array

Data collection by the acoustics team generally followed the same procedures as described in detail in Yano et al. (2018) so will be briefly summarized here. A towed hydrophone array was deployed approximately 300 m behind the ship from sunrise to sunset during each day of survey. The array system was comprised of a modular towed array (Rankin et al. 2013), SailDAQ soundcard, laptop computers, and PAMGuard software version 2.01.3 (Gillespie et al. 2008). The towed array contained an inline and an end array with a total of six HTI-96-min hydrophones and custom-built preamplifiers with combined average measured sensitivity of –144dB ± 5dB re: 1V/µPa from 2–100 kHz and approximately linear roll-off to –156dB ± 2 dB re 1V/ µPa at 150 kHz. The hydrophones had strong high-pass filters at 1600 Hz to reduce low-frequency flow noise and ship noise, reducing sensitivity by 10 dB at 1000 Hz. The inline and end arrays also contained a Honeywell depth sensor, with depth recorded every second with a voltage MicroDAQ (max voltage ± 2V). The SailDAQ sampled all 6 channels simultaneously at 500 kHz sample rate and applied 0–12 dB of gain to the incoming signal from each hydrophone. 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. 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.

Acoustics Effort

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.

The occurrence of humpback whale song and minke whale (*Balaenoptera acutorostrata*) boings were noted at 30-min intervals. During each period the number of calling whales was evaluated by the acousticians and recorded as zero, one, or two-plus animals for each species.

Sonobuoys

Directional Fixing and Ranging (DIFAR) type 53F and 53G sonobuoys were deployed daily at 08:00 and 15:00, as well as during sightings of baleen whales. Daily monitoring assessed the presence/absence of seasonal baleen whales in the region. Sonobuoys deployed during baleen whale sightings occurred when the ship approached the group within 1 nmi and generally when the visual observers had identified the group to species. The VHF signal from the sonobuoy was received at the ship using an omni-directional VHF antenna cabled into a WinRadio set to the VHF frequency specified for an individual sonobuoy. 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 v. 2.01.02-J. Only the low-frequency portion (0–3000 Hz) of the signal was monitored in real-time.

Species-specific Protocols

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. Data collection protocols for humpback whales were also modified due to the large number of sightings and inability to maintain forward progress on the trackline if closing on each sighting. These data collection protocols are summarized as follows, with each protocol included in its entirety as an appendix to this report.

False Killer Whales

PIFSC has used a specific data collection protocol for false killer whales since 2011. The protocol is intended to align our assessment of false killer whale encounter rate with the tendency of this species to associate in small coordinated subgroups often spread over tens of miles. Individual subgroups are recorded as separate visual detections using the subgroup functionality within WinCruz. Following detailed analysis of false killer whale subgroup size estimates collected during the two protocol phases (Bradford et al. 2020), PIFSC modified the protocol prior to winter HICEAS, such that Phase 2 is conditioned on data collection during Phase 1. If subgroup size estimates were collected during Phase 1 of the protocol, then Phase 2 can be skipped. All other elements of the false killer whale protocol remain the same.

In brief, Phase 1 focused on the detection of false killer whale subgroups and 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 beyond the beam of the ship. 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. During Phase 2, the ship was directed to go back through the center of the group so that observers could determine sizes for as many subgroups as possible. Recent examination of subgroup sizes collected during Phase 1 and Phase 2 from 2011 to 2017 PIFSC ship-board surveys indicates that these subgroup sizes are similar and that there is no bias in subgroup sizes reported during the passing mode in Phase 1 (Bradford et al. 2020). For this reason, if subgroup size estimates were collected during Phase 1 of a given sighting, Phase 2 was skipped.

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

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 the acoustics team detected more than one animal within 3 nmi (5.6 km) an extended group-size count was initiated after all animals passed the beam. In addition, for acoustic-only detections of a single sperm whale a minimum of a 20° turn was conducted to resolve left/right ambiguity for post-processing analyses.

From the time of the sighting, or when alerted to the acoustic detection, the observer team recorded overall group size estimates at 3 intervals. The on-effort visual team independently recorded their group-size estimates after 10 min, at which time the fourth observer joined the team. After 60 min of observation with the 4-person team, observers independently recorded overall group size again. During this period, the team openly discussed the location, behavior, composition, and size of individual subgroups, and used that information to track individual subgroups through dive cycles. Finally, for the first sperm whale group sighting of each day, the observer team continued observation for another 30 min to record individual 90-min overall group size estimates. 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; Yano et al. 2018), 90-min counts were not conducted for all sperm whale sightings during WHICEAS 2020 to ensure daily trackline progress. The collection of 60- and 90-min counts may be used to assess bias in group size estimates that may arise given long dive cycles for this species.

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

Humpback Whales

The waters surrounding the MHI are a known breeding grounds for humpback whales during the fall and winter months (November–March). In anticipation of large numbers of humpback whale sightings during this survey, a protocol was created to provide guidance on surveying high density areas of humpbacks. In short, if the visual observers could identify a sighting as humpback whale, the group size was estimated by the observer that made the sighting without changing the ship's speed or direction and while remaining on-effort. In rare cases, humpback whale groups were approached for photographs and tissue sample collection.

For more detailed information on the Humpback Whale Protocol, see Appendix E.

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. Radial distance from the ship to individual birds entering the quadrant was estimated using a range-calibrating device based on Heinemann (1981).

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 predetermined 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 sunset each day. Two seabird observers worked in rotating 2-h shifts, with 1 observer on-effort at any one time throughout the day. 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 *Sette*'s flying bridge and entered using the software SeeBird. The software recorded date, time, and location of seabird sightings (and feeding flocks, see below) from the ship's scientific computer system. Species identification, radial distance from the ship, flight direction, and behavior were entered manually by the seabird observer during the sighting. Environmental data (e.g., wind speed and direction) and factors affecting visibility were manually entered when conditions changed or a new observer started a watch.

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 were 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 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. An additional CTD cast was conducted at Cross Seamount (see Ancillary Projects).

Autonomous Drifting Acoustic Recorders

The Drifting Acoustic Spar Buoy Recorders (DASBRs) used during this survey were redesigned in 2018 by the PIFSC Science Operations Division's Advanced Tech program. The buoy included a polyvinyl chloride (PVC) spar surface buoy housing an NAL Research Iridium transmitter. The 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. Each DASBR included an array of 2 hydrophones, separated by 10 m vertical distance, forming a short vertical array at ~150 m depth. The acoustic data were logged on an Ocean Instruments SoundTrap ST4300-HF recorder. The SoundTrap acoustic data were duty cycled, recording 2 of every 5 min, and were sampled at a rate of 288 kHz.

Tri-axial accelerometer and depth data were also logged through the 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 have several unique capabilities not available in the other acoustic systems and were used to listen for cetaceans throughout the MHI. The DASBR hydrophones were at deeper depths than those of the towed hydrophone array and were not subject to ship and flow noise while freely drifting, which allowed them to monitor signals at lower frequencies. DASBRs recorded across a broad frequency range, which enabled the detection of most cetacean species, from baleen whales to dolphins. DASBRs could more intensively survey an area after the ship

left and could detect animals that may have avoided passing ships. The primary use for DASBRs was to augment cetacean encounter rates, primarily for deep-diving beaked whales and *Kogia* species, which are infrequently encountered during shipboard 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.

DASBRs were deployed from the ship at randomly chosen locations around the MHI and allowed to drift for 2–11 days before retrieval.

Ancillary Projects

Several ancillary projects were conducted during this survey. 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 the High-Frequency Acoustic Recording Packages (HARPs) near Kona, Hawai‘i within the Pacific Islands Passive Acoustic Network; (2) recovery and deployment of the Ocean Noise Reference Station (NRS04) north of O‘ahu (see Haver et al. 2018); and (3) 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

Marine mammal surveys were conducted during all daylight hours on each day of the survey that weather and sea conditions permitted. During 51 days-at-sea, the *Sette* surveyed approximately 5,200 km of on-effort trackline across all effort categories over 45 on-effort survey days (Figure 2, Table 1). Survey effort within nearshore strata around each island area was incomplete due to poor weather and prioritizing effort along broad-scale transect lines.

There were 326 cetacean sightings that included 54 groups of dolphins and whales that could not be identified to species (Table 2, Appendix A). The most frequently sighted species during the project were humpback whales (164 sightings), sperm whales (14 sightings), and pantropical spotted dolphins (12 sightings). Weather and sea conditions likely contributed to the high number of sightings of "unidentified" species; observers sighted 22 groups of "unidentified whales," 15 groups of "unidentified rorquals," and 23 groups of "unidentified dolphins."

Approximately 5,000 photos were collected for individual or species identification. Thirteen biopsy samples were collected from 7 cetacean species (Table 3). No satellite telemetry tags were deployed during the project.

There were 15 mixed-species sightings (Table 4). The most common mixed-species sightings were bottlenose dolphins with humpback whales (4 sightings), melon-headed whales with Fraser's dolphins (*Lagenodelphis hosei*, 3 sightings), and rough-toothed dolphins (*Steno bredanensis*) with pantropical spotted dolphins (3 sightings).

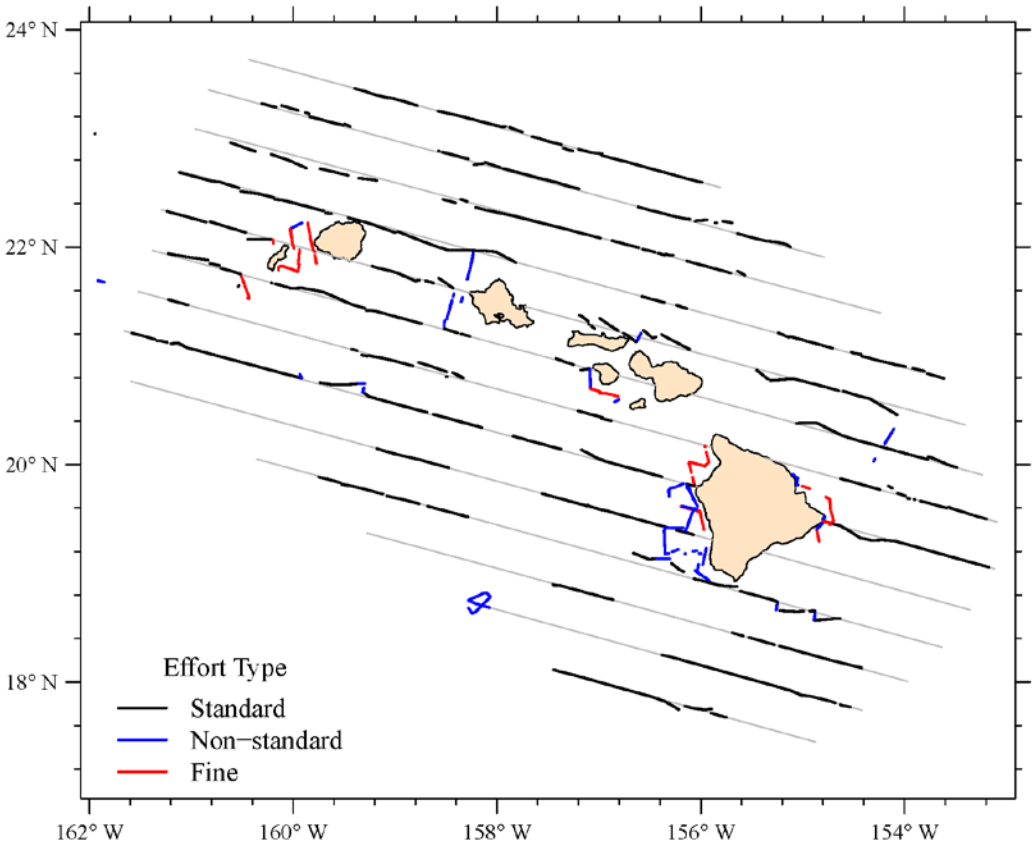

Figure 2. Daytime sighting effort for Winter HICEAS 2020.

The sighting effort (standard in black, non-standard in blue, and fine-scale in red) overlays predetermined tracklines (gray). 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. Fine-scale effort occurred along nearshore transect lines (Figure 1).

Table 1. Summary of survey effort (km) by Beaufort sea state.

Beaufort Sea State	Standard Effort (km)	Non-standard Effort (km)	Fine-scale Effort (km)	TOTAL
1	74.5	10.0	0.0	84.4
2	182.0	63.9	20.9	266.8
3	311.1	92.2	36.6	440.0
4	1247.6	94.1	109.2	1451.0
5	1815.9	97.3	50.2	1963.4
6	810.5	136.1	92.5	1030.1
TOTAL	4441.6	493.6	309.5	5244.7

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 each counted once.

Code	Scientific name	Common name	Standard	Non-standard	Fine-scale	Off	Total groups
002	*Stenella attenuata*	pantropical spotted dolphin	5	4	2	1	12
013	*Stenella coeruleoalba*	striped dolphin	3	2	1	1	7
015	*Steno bredanensis*	rough-toothed dolphin	4	2	1	0	7
018	*Tursiops truncatus*	bottlenose dolphin	4	0	1	4	9
021	*Grampus griseus*	Risso's dolphin	4	1	0	0	5
026	*Lagenodelphis hosei*	Fraser's dolphin	2	1	0	0	3
031	*Peponocephala electra*	melon-headed whale	3	2	1	0	6
032	*Feresa attenuata*	pygmy killer whale	3	0	0	0	3
033	*Pseudorca crassidens*	false killer whale	3	1	0	0	4
036	*Globicephala macrorhynchus*	short-finned pilot whale	5	0	1	0	6
046	*Physeter macrocephalus*	sperm whale	10	0	2	2	14
048	*Kogia sima*	dwarf sperm whale	1	0	0	0	1
049	*Ziphiid* whale	unidentified beaked whale	4	0	0	0	4
051	*Mesoplodon* sp.	Mesoplodon beaked whale	2	0	0	1	3
059	*Mesoplodon densirostris*	Blainville's beaked whale	0	0	1	1	2
065	*Indopacetus pacificus*	Longman's beaked whale	1	0	0	0	1
070	*Balaenoptera* sp.	unidentified rorqual	4	2	7	2	15
071	*Balaenoptera acutorostrata*	minke whale	1	0	0	0	1
073	*Balaenoptera borealis*	sei whale	3	0	1	1	5
074	*Balaenoptera physalus*	fin whale	1	0	0	0	1
076	*Megaptera novaeangliae*	humpback whale	85	16	49	13	163
077	----	unidentified dolphin	5	1	1	2	9
078	----	unidentified small whale	2	0	0	0	2
079	----	unidentified large whale	7	0	2	7	16

Code	Scientific name	Common name	Standard	Non-standard	Fine-scale	Off	Total groups
096	----	unidentified cetacean	1	0	0	0	1
098	----	unidentified whale	3	0	0	1	4
099	*Balaenoptera borealis/edeni*	sei/Bryde's whale	4	1	0	1	6
102	*Stenella longirostris longirostris*	Gray's spinner dolphin	1	0	0	0	1
177	*Delphinus/Lagenodelphis/Stenella*	unidentified small dolphin	4	2	0	3	9
199	*Balaenoptera physalus/borealis/edeni*	fin/sei/Bryde's whale	1	0	0	0	1
277	*Feresa/Grampus/Peponocephala/ Steno/Tursiops*	unidentified medium dolphin	1	1	2	0	4
377	*Pseudorca/Orcinus/Globicephala*	unidentified large dolphin	1	0	0	0	1
		TOTAL	178	36	72	40	326

Table 3. Biopsy samples collected during Winter HICEAS 2020.

The biopsy samples are listed in descending order of total samples.

Scientific Name	Common Name	Biopsy Samples
Steno bredanensis	rough-toothed dolphin	3
Tursiops truncatus	bottlenose dolphin	3
Peponocephala electra	melon-headed whale	2
Stenella longirostris longirostris	Gray's spinner dolphin	2
Feresa attenuata	pygmy killer whale	1
Physeter macrocephalus	sperm whale	1
Megaptera novaeangliae	humpback whale	1
	TOTAL	13

Table 4. Cetacean sightings with multiple species encountered during Winter HICEAS 2020.

Sighting	Species 1	Species 2	Species 3
2	bottlenose dolphin	pantropical spotted dolphin	----
53	bottlenose dolphin	humpback whale	----
58	bottlenose dolphin	humpback whale	----
94	rough-toothed dolphin	pantropical spotted dolphin	----
118	bottlenose dolphin	humpback whale	----
146	rough-toothed dolphin	humpback whale	pygmy killer whale
174	melon-headed whale	Fraser's dolphin	----
183	unidentified dolphin	humpback whale	----
202	melon-headed whale	Fraser's dolphin	----
205	bottlenose dolphin	humpback whale	----
208	rough-toothed dolphin	short-finned pilot whale	sei/Bryde's whale
272	rough-toothed dolphin	pantropical spotted dolphin	----
254	melon-headed whale	humpback whale	----
302	rough-toothed dolphin	short-finned pilot whale	----
308	melon-headed whale	Fraser's dolphin	----

Passive Acoustics

Towed array surveys were conducted during daylight hours on each day of the survey that weather and sea conditions permitted. During Winter HICEAS 2020, there were 273 acoustic detections of separate cetacean groups during daytime monitoring of the towed hydrophone array. Of the 273 towed array detections, 86 were linked to visually sighted groups (Table 2,

Figure 3). In several instances, more than one species was detected during a single encounter, resulting in 286 species detections (Table 4). Paired visual sighting and acoustic detection data provided visual confirmation of species identification of detected sounds for 17 cetacean species (Table 5).

Acoustic species identification was not conducted in real-time for any detection without an accompanied visual observation, with a few exceptions (beaked whales, Risso's dolphins (*Grampus griseus*), sperm whales, and *Kogia* sp.). Clicks produced by sperm whales and Risso's dolphins are well described and were readily identifiable by the acoustics team, so were identified to species in real-time. Species-specific upswept clicks commonly produced by beaked whale species were also identified in real-time and were assigned a species classification. Acoustic-only detections of possible false killer whales and short-finned pilot whales (*Globicephala macrorhynchus*) were classified as unidentified large dolphin (species identification code 377). This decision was based on peak frequencies of echolocation clicks between 15 and 25 kHz accompanied with low frequency whistles (4–10 kHz) (Baumann-Pickering et al. 2015; Murray et al. 1998).

Humpback whale song was monitored during all daytime towed-array effort. During the monitored effort, song from lone singers was detected 26% of the time and that from two or more singers was detected 38% of the time (Figure 4). Minke whale "boings" were also monitored during all daytime effort. Boings were detected during nearly all (94%) 30-min periods. Boings from lone whales were detected 13% of the time and those from two or more whales were detected 81% of the time (Figure 5).

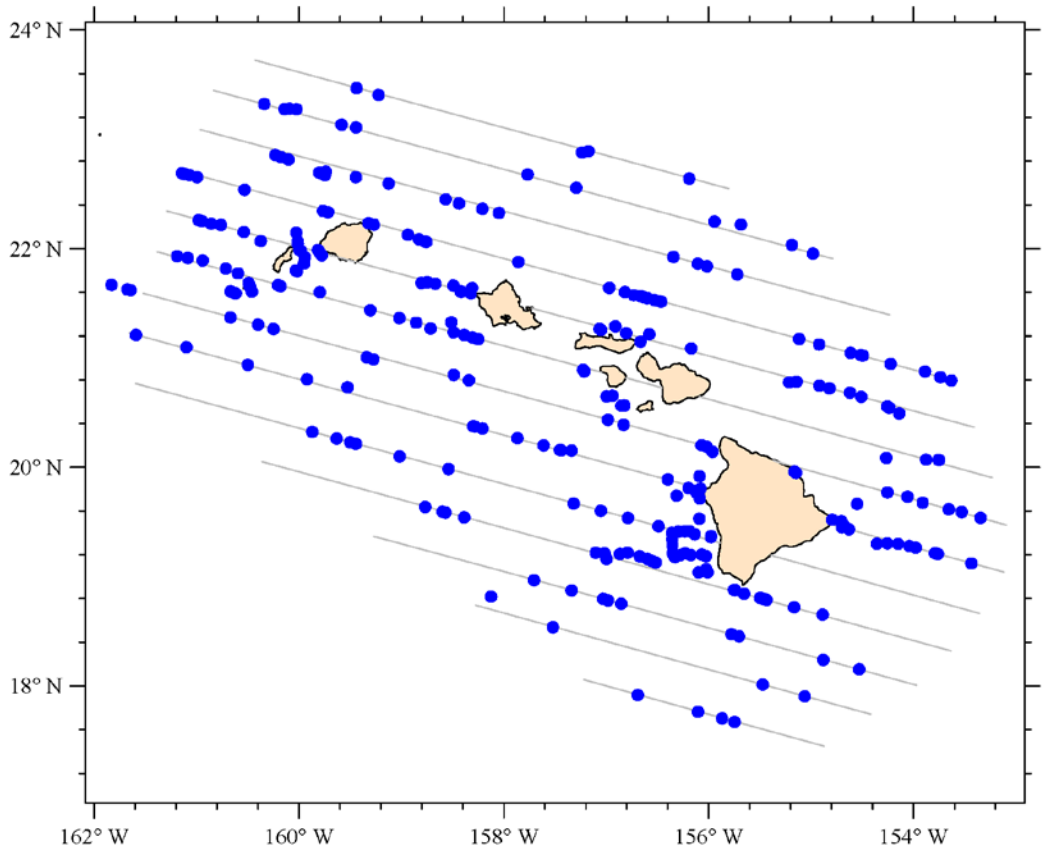

Figure 3. Locations of acoustic detections of cetaceans by the towed array.

Acoustic detections of cetaceans shown in blue and the predetermined tracklines shown in gray.

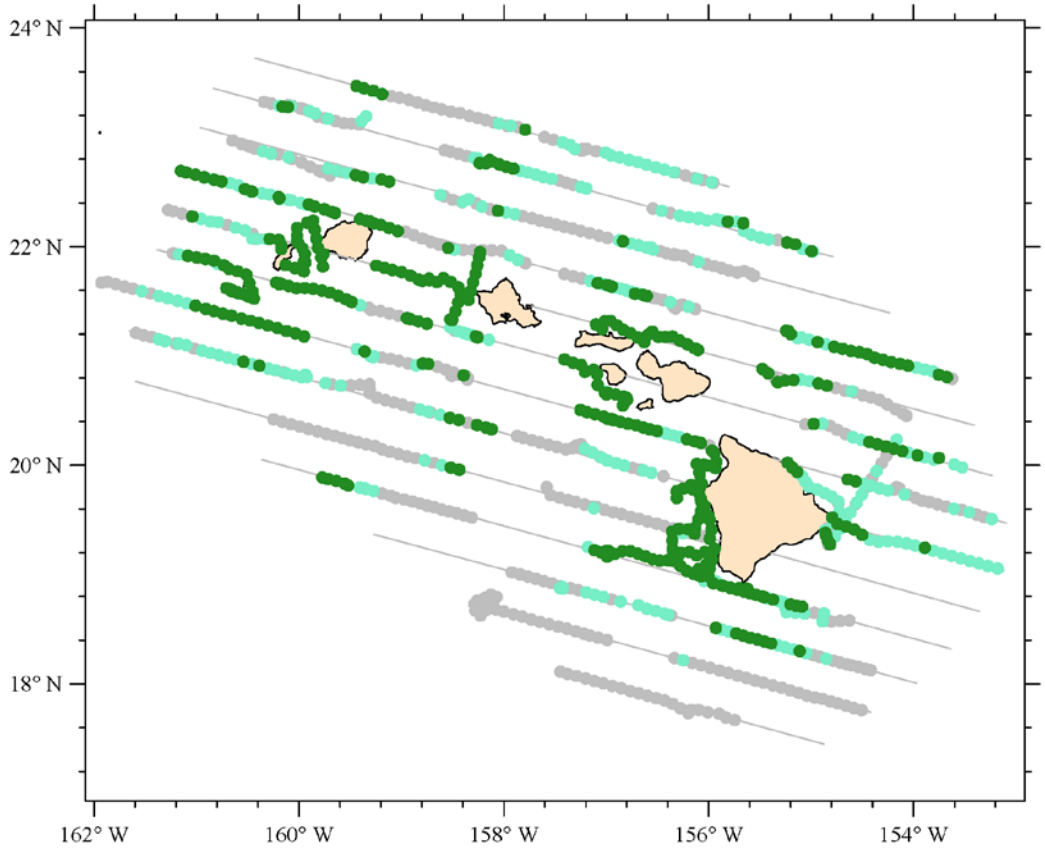

Figure 4. Locations of humpback whale detections by the towed array.

The predetermined tracklines are marked in gray. The circle color indicates the number of humpback whales heard on the array (gray = 0; light green = 1 individual; dark green = 2 or more individuals).

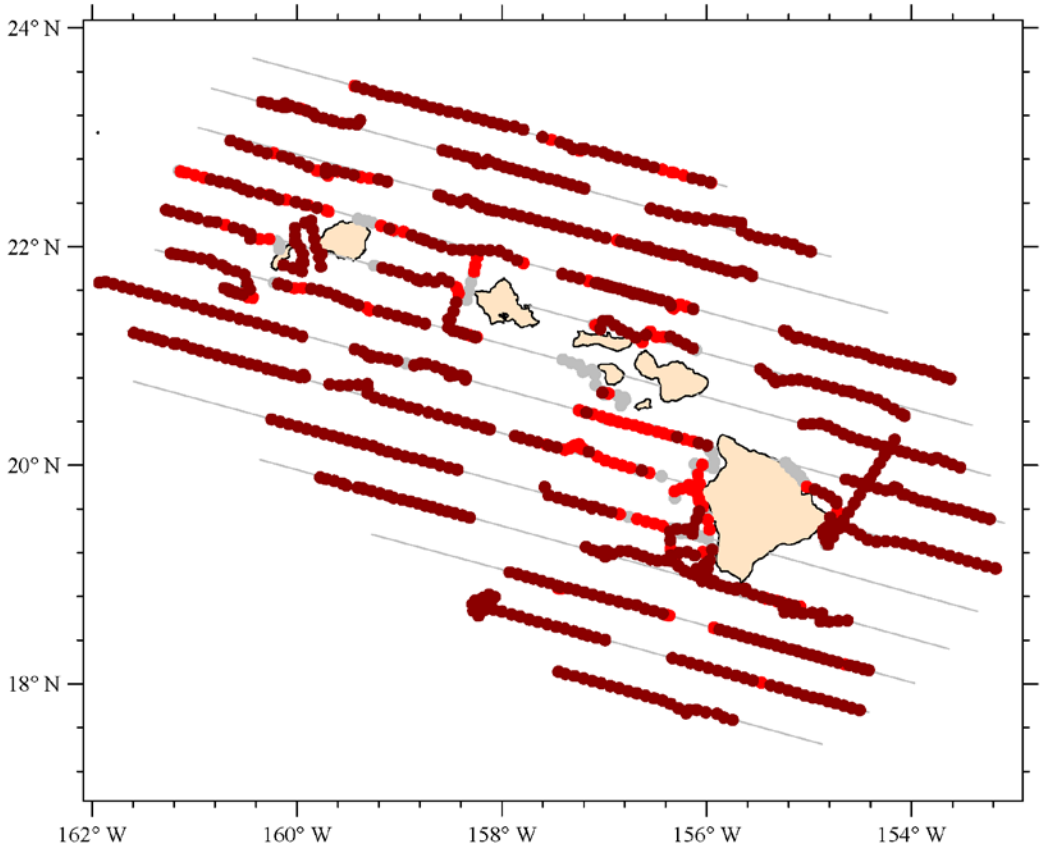

Figure 5. Locations of minke whale detections by the towed array.

The predetermined tracklines are marked in gray. The circle color indicates the number of minke whales heard on the array (gray = 0; red = 1 individual; dark red = 2 or more individuals).

Table 5. Comparison of cetacean species sighted and acoustically detected during daylight hours.

CETACEAN SPECIES			NUMBER OF DETECTIONS		
Code	**Scientific Name**	**Common Name**	**Concurrent Visual & Acoustic**	**Visual Only**	**Acoustic Only**
002	*Stenella attenuata*	pantropical spotted dolphin	12	0	--
013	*Stenella coeruleoalba*	striped dolphin	8	0	--
015	*Steno bredanensis*	rough-toothed dolphin	7	0	--
018	*Tursiops truncatus*	bottlenose dolphin	4	5	--
021	*Grampus griseus*	Risso's dolphin	5	0	2
026	*Lagenodelphis hosei*	Fraser's dolphin	3	0	--
031	*Peponocephala electra*	melon-headed whale	6	0	--
032	*Feresa attenuata*	pygmy killer whale	2	1	--
033	*Pseudorca crassidens*	false killer whale	4	0	--
036	*Globicephala macrorhynchus*	short-finned pilot whale	6	0	--
046	*Physeter macrocephalus*	sperm whale	14	0	98
048	*Kogia sima*	dwarf sperm whale	0	1	--
049	*Ziphiid* whale	unidentified beaked whale	0	4	0
051	*Mesoplodon* sp.	Mesoplodon beaked whale	0	2	0
059	*Mesoplodon densirostris*	Blainville's beaked whale	2*	1	5
061	*Ziphius cavirostris*	Cuvier's beaked whale	0	0	4
065	*Indopacetus pacificus*	Longman's beaked whale	1	0	3
070	*Balaenoptera* sp.	unidentified rorqual	0	15	--
071	*Balaenoptera acutorostrata*	minke whale	--	1	+
073	*Balaenoptera borealis*	sei whale	0	5	--
074	*Balaenoptera physalus*	fin whale	0	1	--
076	*Megaptera novaeangliae*	humpback whale	--	164	+
077	----	unidentified dolphin	5	4	74
078	----	unidentified small whale	0	2	--
079	----	unidentified large whale	0	16	--
080	*Kogia* sp.	pygmy/dwarf sperm whale	0	0	1

CETACEAN SPECIES			NUMBER OF DETECTIONS		
Code	**Scientific Name**	**Common Name**	**Concurrent Visual & Acoustic**	**Visual Only**	**Acoustic Only**
096	----	unidentified cetacean	0	1	--
098	----	unidentified whale	0	4	--
099	*Balaenoptera borealis/edeni*	sei/Bryde's whale	0	6	--
102	*Stenella longirostris longirostris*	Gray's spinner dolphin	1	0	--
177	*Delphinus/Lagenodelphis/Stenella*	unidentified small dolphin	4	5	--
199	*Balaenoptera physalus/ borealis/edeni*	fin/sei/Bryde's whale	0	1	--
277	*Feresa/Grampus/Peponocephala/ Steno/Tursiops*	unidentified medium dolphin	2	2	--
377	*Pseudorca/Orcinus/Globicephala*	unidentified large dolphin	0	1	13^
		TOTAL	86	242	200

Notes:

*Visual sighting s44 was originally species code 051, but acoustic identification confirmed species code 059.
+Acoustic detection of humpback and minke whales was noted at 30-min intervals so cannot be compared to specific sighting events.
^Acoustic detection of unidentified large dolphin likely to be determined as false killer whale or short-finned pilot whale.

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 5, but not the total number of group sightings listed in Table 2.

Eighty-five functioning and 7 dead-on-deployment sonobuoys were deployed to monitor baleen whales (Figure 6; dead-on-deployment sonobuoys are not shown). Sounds from large whales were detected on 97% of sonobuoys (Figure 6). Detected species included sperm whale, minke whale, sei whale (*Balaenoptera borealis*), fin whale (*Balaenoptera physalus*), blue whale (*Balaenoptera musculus*), and humpback whale.

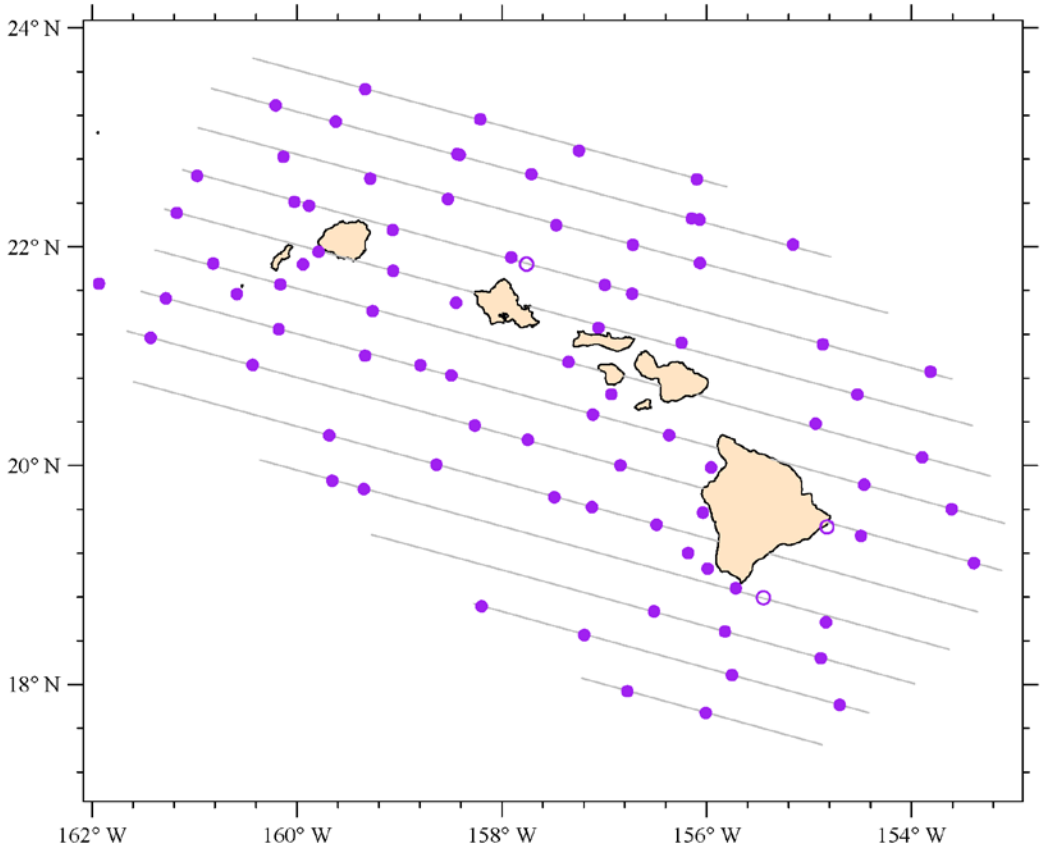

Figure 6. Locations of sonobuoys deployed for monitoring baleen whales.

A total of 92 sonobuoys were deployed during this survey, including 7 sonobuoys that were dead on deployment (not shown). Sonobuoys with acoustic detections (filled circle) and without acoustic detections (open circle) are shown in purple. The predetermined tracklines are marked in gray.

Seabird Survey

The seabird observers counted 3,563 individuals in 1,470 seabird detections comprising 41 species (plus 12 additional taxa) on-effort (Table 6). All but one bird were marine species, the exception being an unidentified songbird, most likely a Eurasian Skylark.

Three species, all common breeders in the state, dominate Hawaiian waters during the winter and together contributed 50% of the detections and 60% of the total birds seen (Table 6): Sooty Tern (290 detections, 34% relative abundance), Red-footed Booby (282 detections, 12% relative abundance), and Wedge-tailed Shearwater (165 detections, 15% relative abundance). These three

species also formed the nucleus of mixed-species feeding flocks, an important component of their foraging strategy. Ninety-eight feeding flocks were detected, and complete counts were obtained for some of them. The majority were too distant to properly quantify.

The strip-transect seabird data collected on Winter HICEAS 2020 documented changes in seabird distribution and abundance as the season progressed from late winter to early spring. Northbound boreal migrants were apparent in mid-February and slowly increased throughout the rest of the month and into March. Boreal breeding species such as Red Phalarope (fairly scarce in Hawai‘i) is a good example: rare in January, then sightings occurred almost daily by late February/early March. A single Long-tailed Jaeger detection in early March, consisting of two adults, was undoubtedly northbound migrants. Austral breeding species display a similar pattern. The first Sooty Shearwater and Mottled Petrel were seen in early to mid-March, all rapidly flying north-northwesterly, but none prior to that. Local breeders such as Gray-backed Tern and Hawaiian Petrel were scarce until late February, and Newell's Shearwater were hardly detected at all with only 5 individuals seen during the entire project.

Several species uncommon in Hawai‘i were seen on this survey and include Glaucous-winged Gull, Phoenix Petrel, and Herald Petrel. Unfortunately, photographic documentation is unavailable for any of these. Phoenix Petrel remains hypothetical in the state with no confirmed sightings. Phoenix and Herald Petrels breed widely across the central south-tropical Pacific Ocean; Glaucous-winged Gull is a rare but annual winter visitor to the state. Of interest was an adult Nazca Booby photographed one morning associating with the ship. This species is a rare visitor from the eastern Pacific Ocean. Another highlight was a single Flesh-footed Shearwater, rare in the state at any season.

Table 6. Seabird sightings during Winter HICEAS 2020.

Scientific Name	Common Name	Number of Birds
Arenaria interpres	Ruddy Turnstone	1
Phalaropus fulicarius	Red Phalarope	40
Stercorarius pomarinus	Pomarine Jaeger	7
Stercorarius parasiticus	Parasitic Jaeger	4
Stercorarius longicaudus	Long-tailed Jaeger	2
Larus glaucescens	Glaucous-winged Gull	1
Anous stolidus	Brown Noddy	249
Anous minutus	Black Noddy	113
Anous ceruleus	Blue-gray Noddy	4
Gygis alba	White Tern	98
Onychoprion fuscatus	Sooty Tern	1,216
Onychoprion lunatus	Gray-backed Tern	9
Phaethon lepturus	White-tailed Tropicbird	61
Phaethon rubricauda	Red-tailed Tropicbird	21
Phaethon sp.	Unidentified tropicbird	2
Phoebastria sp.	Unidentified albatross	1

Scientific Name	Common Name	Number of Birds
Phoebastria immutabilis	Laysan Albatross	45
Phoebastria nigripes	Black-footed Albatross	107
Oceanodroma leucorhoa	Leach's Storm-Petrel	43
Oceanodroma leucorhoa/ socorrensis/cheimomnestes	Leach's/Townsend's/ Ainley's Storm-Petrel	3
Oceanodroma castro	Band-rumped Storm-Petrel	12
Oceanodroma leucorhoa/castro	Leach's/Band-rumped Storm-Petrel	5
Oceanodroma tristrami	Tristram's Storm-Petrel	1
Hydrobatidae/Oceanitidae sp.	"White-rumped" storm-petrel	1
Hydrobatidae/Oceanitidae sp.	Unidentified storm-petrel	3
Pterodroma neglecta	Kermadec Petrel	27
Pterodroma heraldica	Herald Petrel	2
Pterodroma ultima	Murphy's Petrel	1
Pterodroma inexpectata	Mottled Petrel	4
Pterodroma externa	Juan Fernandez Petrel	7
Pterodroma sandwichensis	Hawaiian Petrel	37
Pterodroma cervicalis	White-necked Petrel	12
Pterodroma externa/cervicalis	Juan Fernandez/White-necked Petrel	9
Pterodroma hypoleuca	Bonin Petrel	3
Pterodroma cookii	Cook's Petrel	1
Pterodroma longirostris	Stejneger's Petrel	1
Pterodroma sp.	Unidentified Cookilaria	2
Pterodroma alba	Phoenix Petrel	1
Pterodroma sp.	Unidentified *Pterodroma*	3
Bulweria bulwerii	Bulwer' Petrel	6
Ardenna carneipes	Flesh-footed Shearwater	1
Ardenna pacifica	Wedge-tailed Shearwater	516
Ardenna grisea	Sooty Shearwater	7
Puffinus nativitatis	Christmas Shearwater	217
Puffinus newelli	Newell's Shearwater	5
Puffinus sp.	Manx-type Shearwater	1
Fregata minor	Great Frigatebird	18
Fregata sp.	Unidentified frigatebird	2
Sula dactylatra	Masked Booby	117
Sula granti	Nazca Booby	1
Sula leucogaster	Brown Booby	92
Sula sula	Red-footed Booby	420
----	Unidentified passerine	1
	TOTAL	3,563

Ecosystem Sampling

A total of 57 CTD casts were conducted during the project (Figure 7).

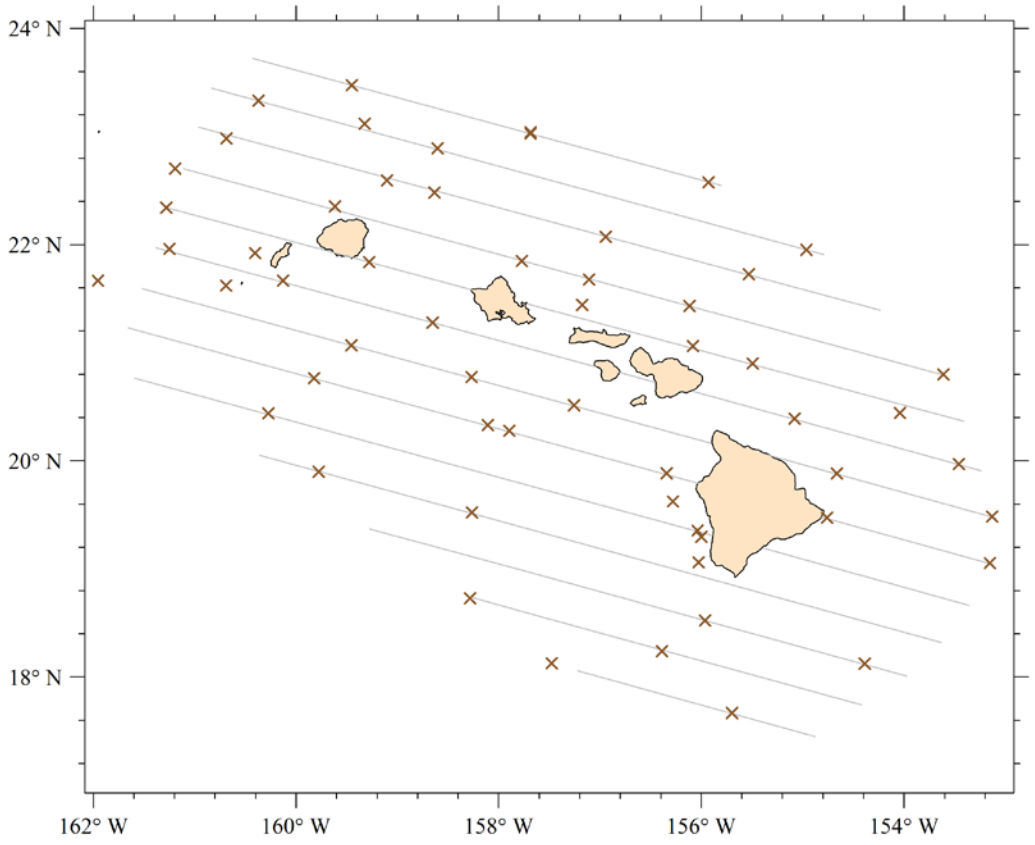

Figure 7. CTD station locations conducted during Winter HICEAS 2020.

The locations of CTD casts are represented by brown “X”s. The predetermined tracklines are marked in gray.

Autonomous Drifting Acoustic Recorders

Fourteen DASBRs were deployed during Winter HICEAS 2020. Thirteen DASBRs were recovered, and one was lost due to equipment and transmitter failure. DASBR drift tracks are shown in Figure 8 and deployment and recovery details are provided in Appendix F. In addition, a three-hydrophone model was tested, which was designed to improve the detection of narrow-band high-frequency echolocation clicks.

DASBR acoustic data have not yet been analyzed for cetacean occurrence.

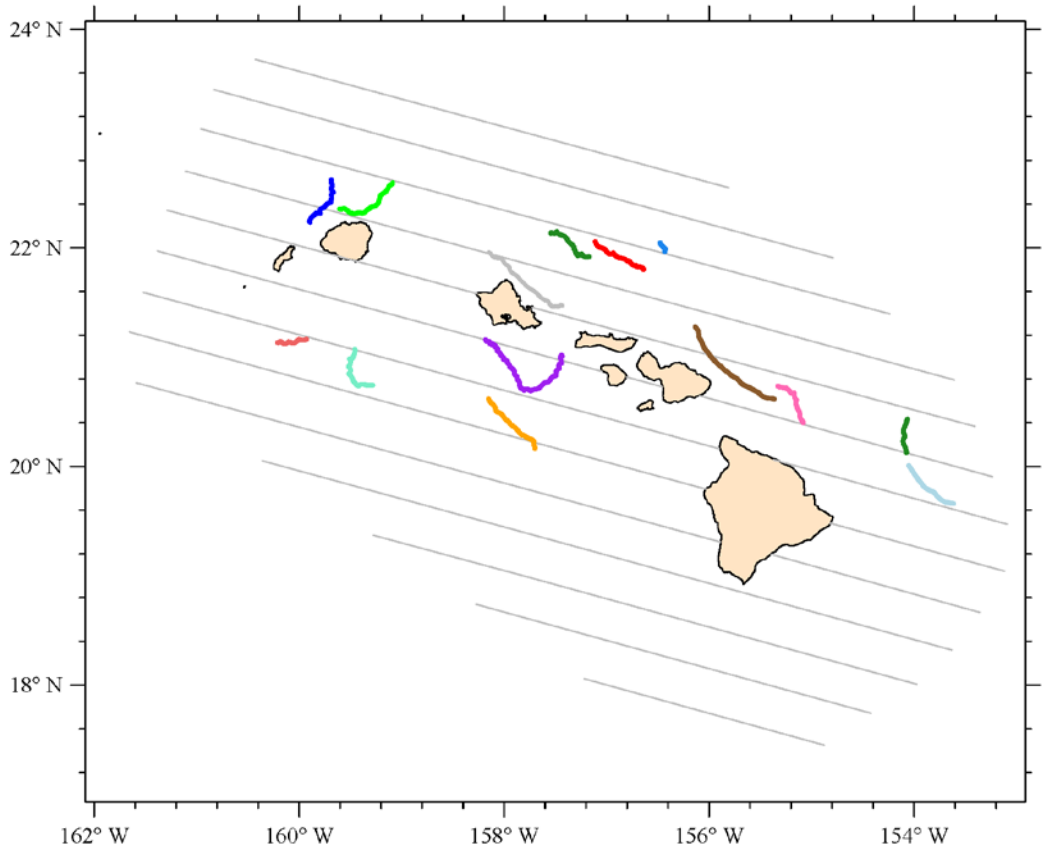

Figure 8. Drift tracks of the 14 Drifting Acoustic Spar Buoy Recorders (DASBRs) deployed during Winter HICEAS 2020.

DASBR tracks in color each represent the recording period for 13 retrieved units. The gray track represents received Iridium transmissions from the DASBR that was lost. The predetermined tracklines are marked in gray.

Acknowledgements

The PacMAPPS partners—BOEM (Interagency Agreement (IAA) M17PG00024/NMFS-PIC-17-005), U.S. Navy Pacific Fleet Environmental Readiness Division (IAA N0007018MP4C587-01/NMFS-PIC-18-005) and Chief of Naval Operations N45 (IAA N0002518GTC032-06/NMFS-NEC-16-011-06)—provided partial funding for all shipboard visual and passive acoustic survey operations, including collection of cetacean photographs and biopsy samples. Additional funding for project survey operations was provided by PIFSC and the NMFS Take-Reduction Program. All DASBR deployments during Winter HICEAS 2020 were funded by PIFSC. Ship time aboard *Sette* was provided by PIFSC. The Chief Scientist was Erin Oleson, the Cruise Leaders were Erin Oleson (Leg 1) and Marie Hill (Leg 2), and the Survey Coordinator was Kym Yano. Many observers, acousticians, visiting scientists, and the officers and crew of the *Sette* made the survey possible and a success. Many thanks to Sam Woodman for his development and assistance with the CruzPlot mapping program. Significant appreciation is also extended to PIFSC administrative and Science Operations Division staff (including Julie Whitaker, Leslie Kiriakos, Kyle Koyanagi, Sujuan Situ, Tanya Ochoa, and Nori Shoji) for ensuring Winter HICEAS 2020 success through their assistance with funding agreements, contracts, permits, and ship coordination. Sonobuoys were provided by the U.S. Navy Living Marine Resources Program. Cetaceans were approached and sampled 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 Papahānaumokuākea Marine National Monument under permit PMNM-2020-01.

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Appendix A: Cetacean Distribution Maps

Sightings and Acoustic Detections of Delphinids (Figure A1–Figure A6)

Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. Acoustic detections without a concurrent visual sighting are shown as green circles. All sightings are shown, independent of visual effort type (black lines). Acoustic detections of delphinid groups (except Risso's dolphins) that did not have associated visual species confirmation are classified at this time as unidentified dolphin and are shown in Figure A16.

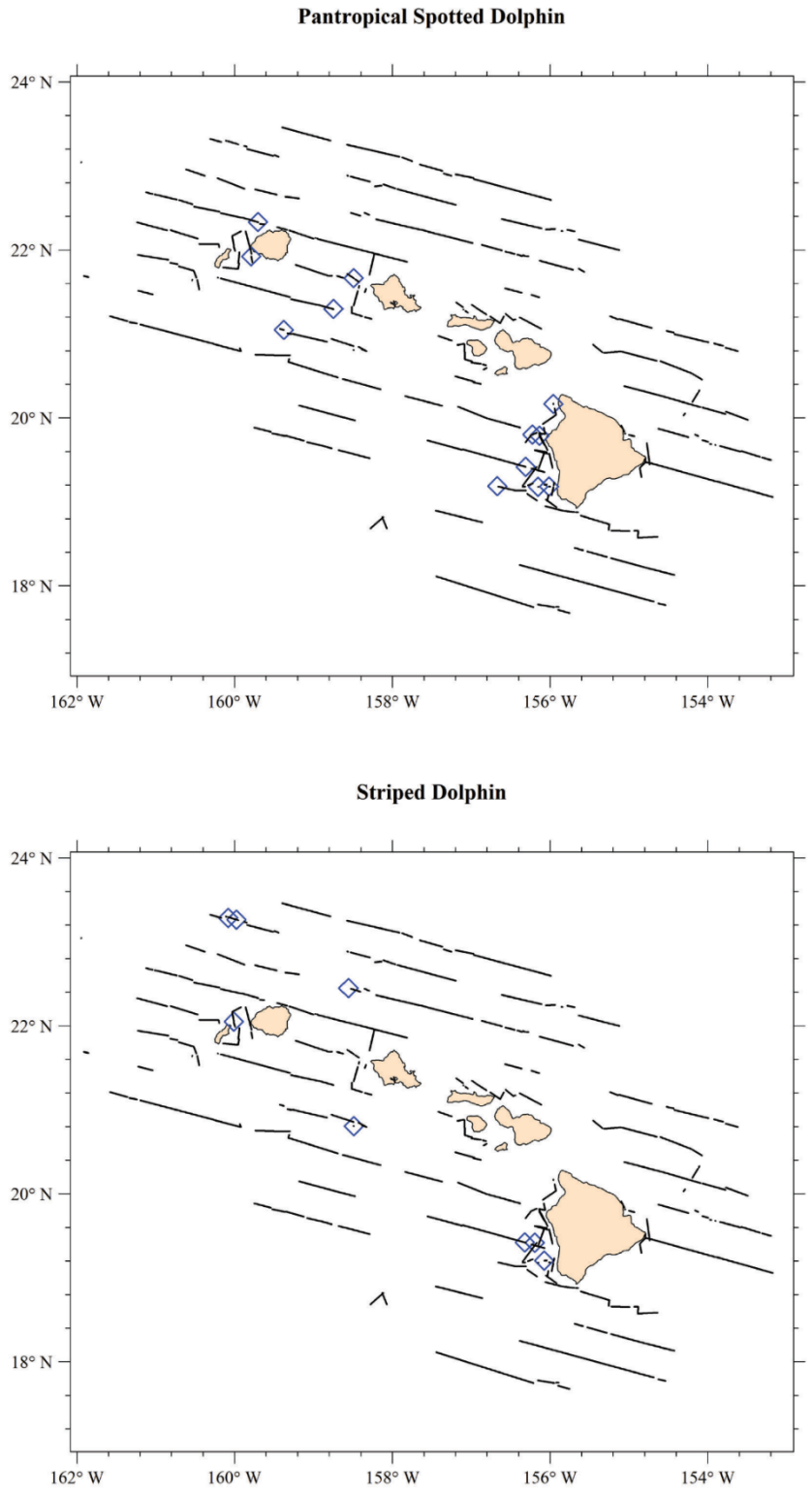

Figure A1. Sightings and acoustic detections of pantropical spotted and striped dolphins.

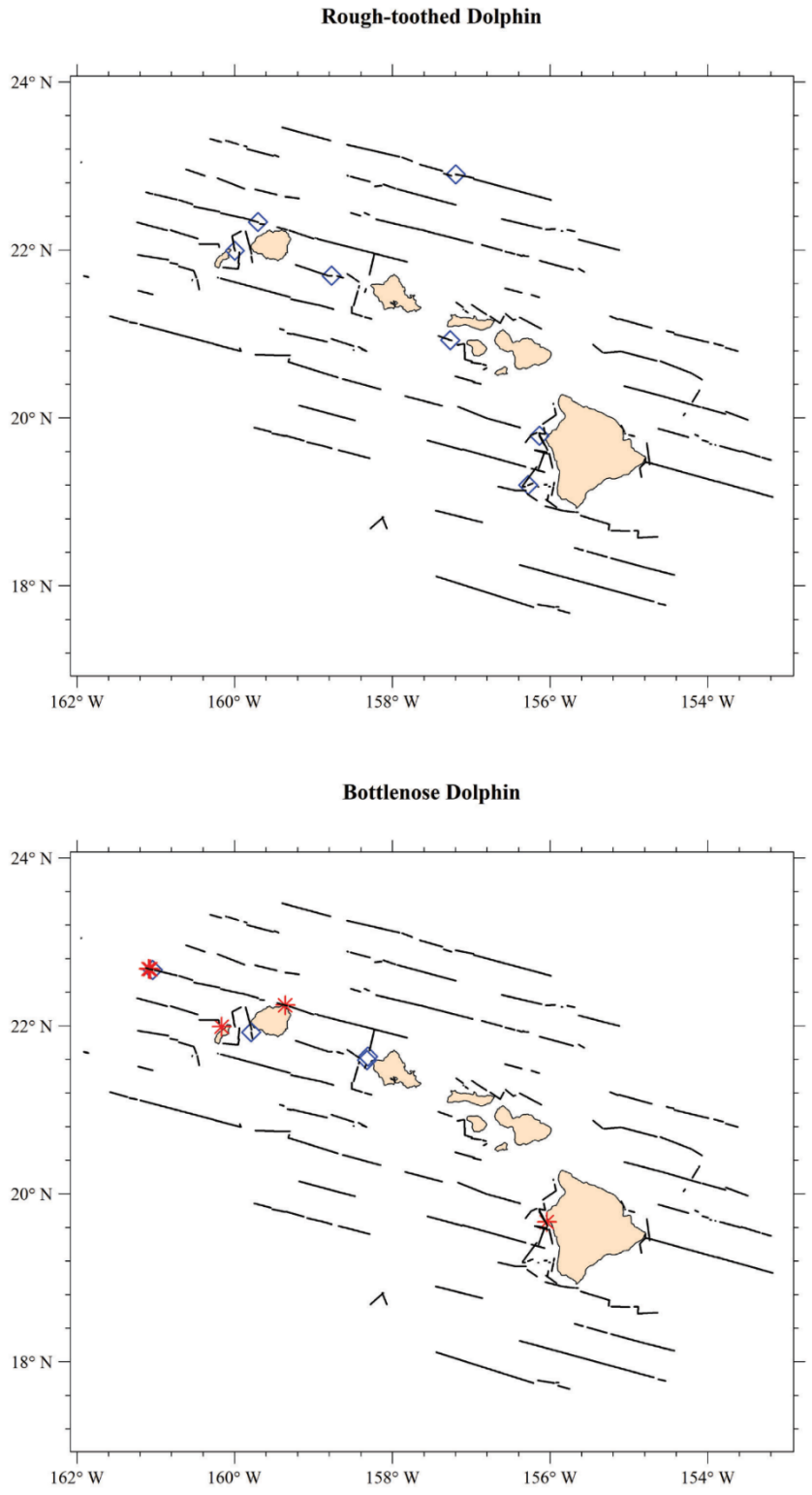

Figure A2. Sightings and acoustic detections of rough-toothed and bottlenose dolphins.

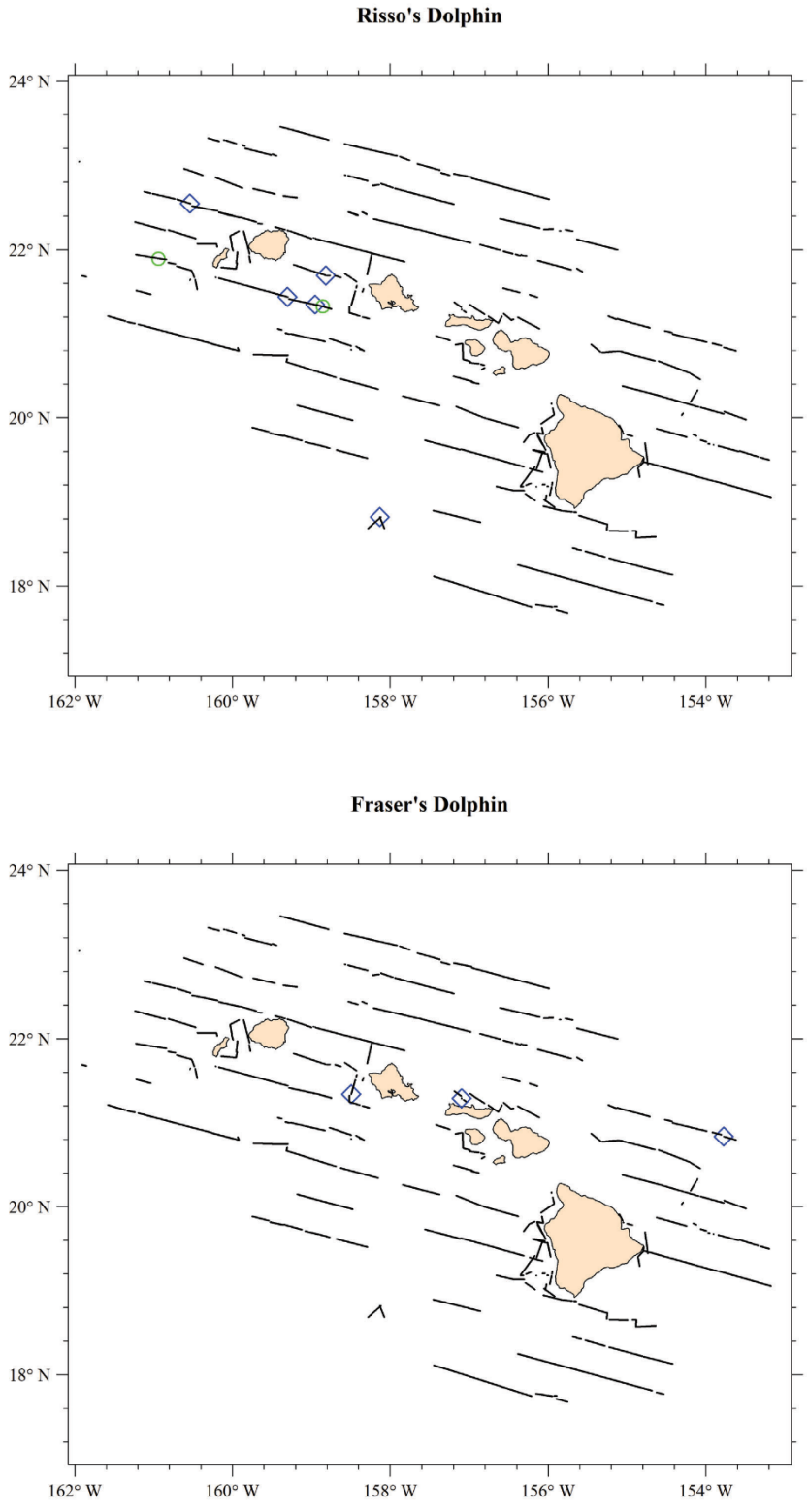

Figure A3. Sightings and acoustic detections of Risso's and Fraser's dolphins.

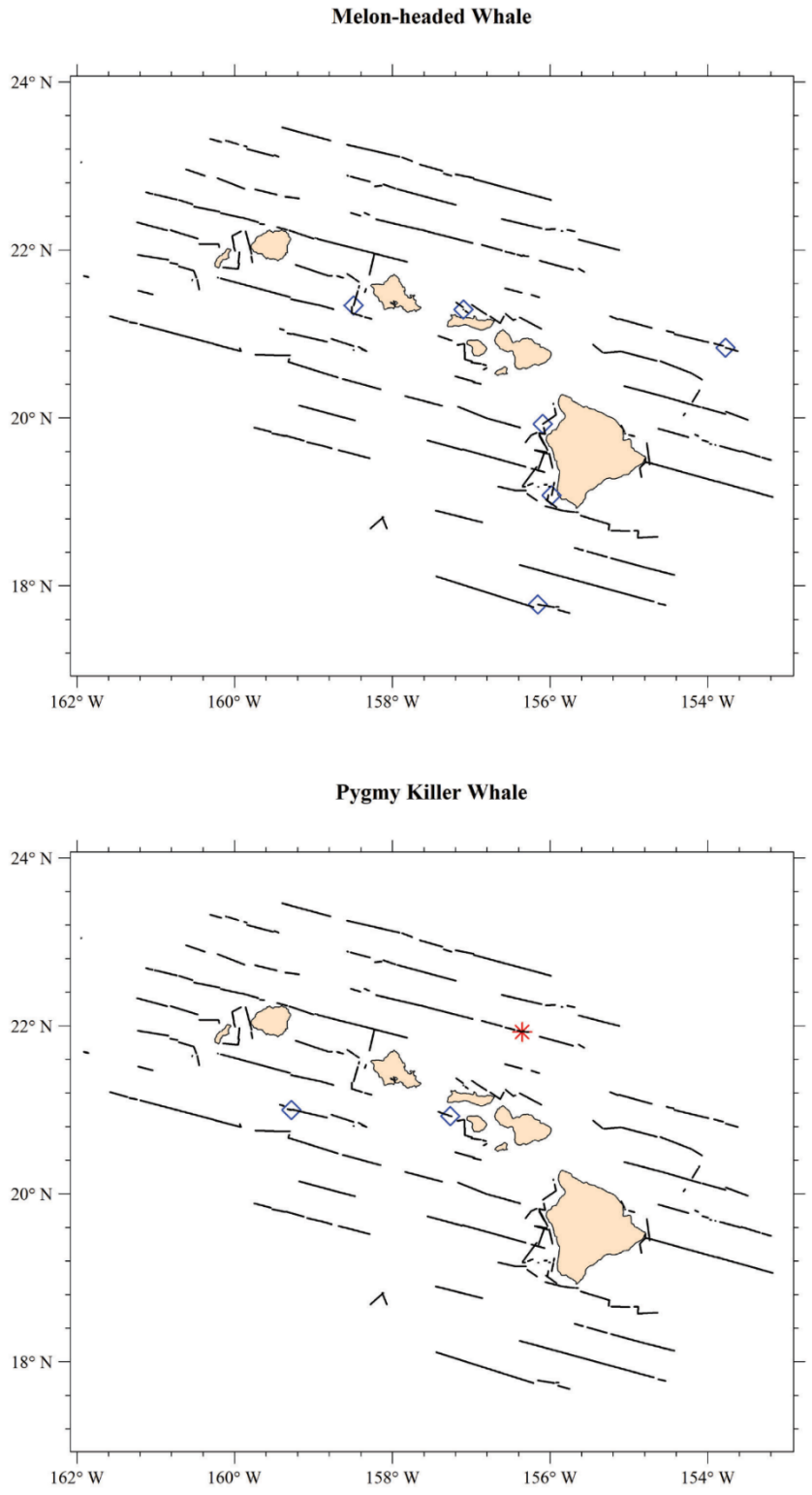

Figure A4. Sightings and acoustic detections of melon-headed and pygmy killer whales.

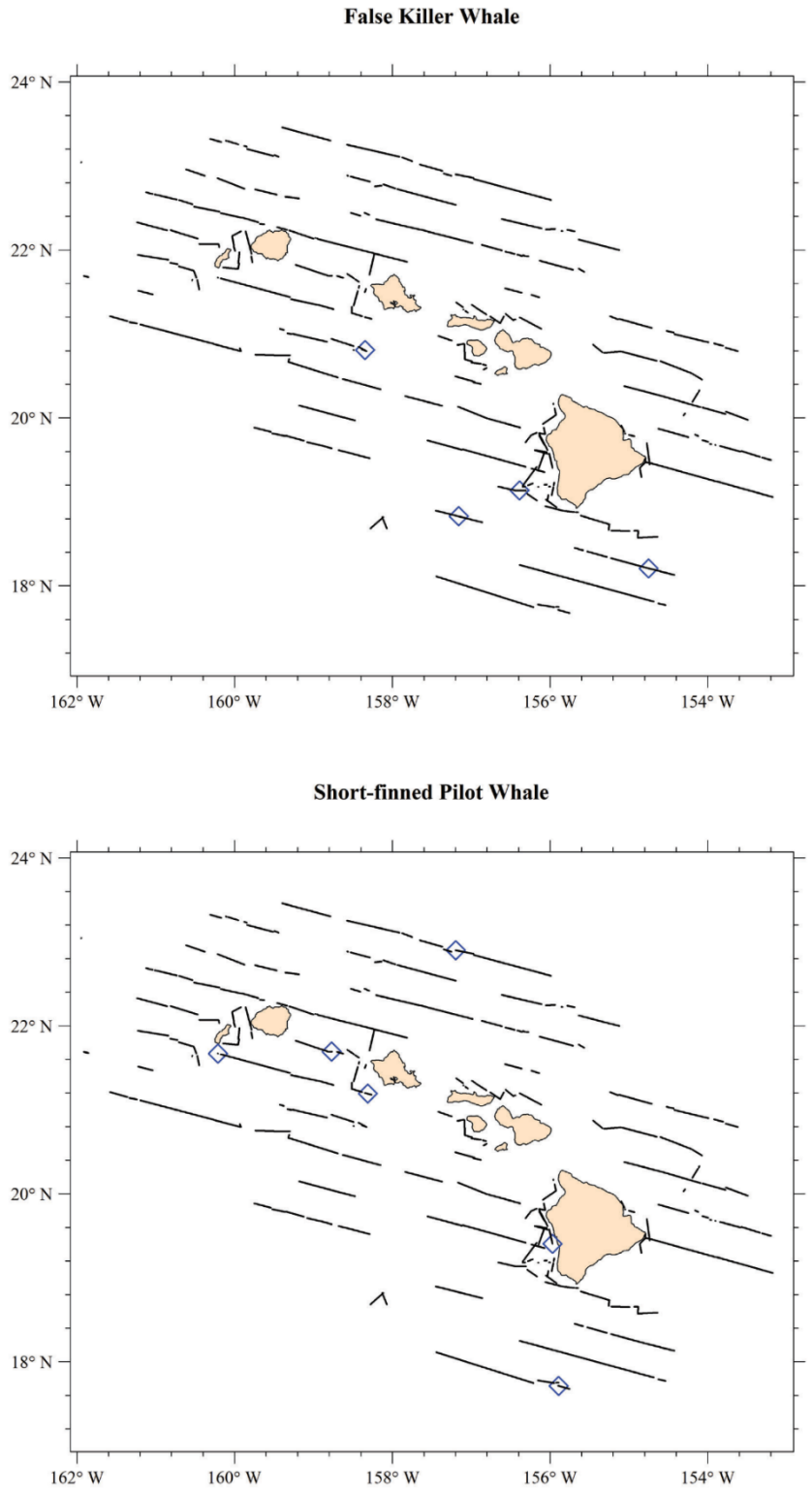

Figure A5. Sightings and acoustic detections of false killer and short-finned pilot whales.

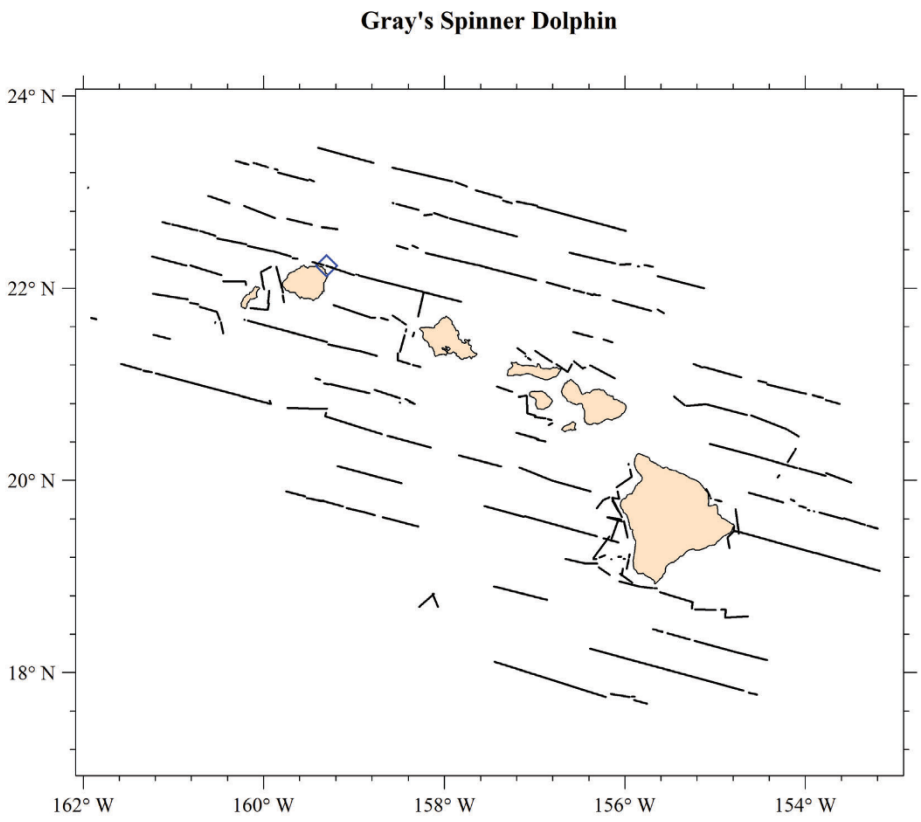

Figure A6. Sightings and acoustic detections of Gray's spinner dolphins.

Sightings and Acoustic Detections of Sperm and Beaked Whales (Figure A7–Figure A10)

Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. Acoustic detections without a concurrent visual sighting are shown as green circles. All sightings are shown, independent of visual effort type (black lines).

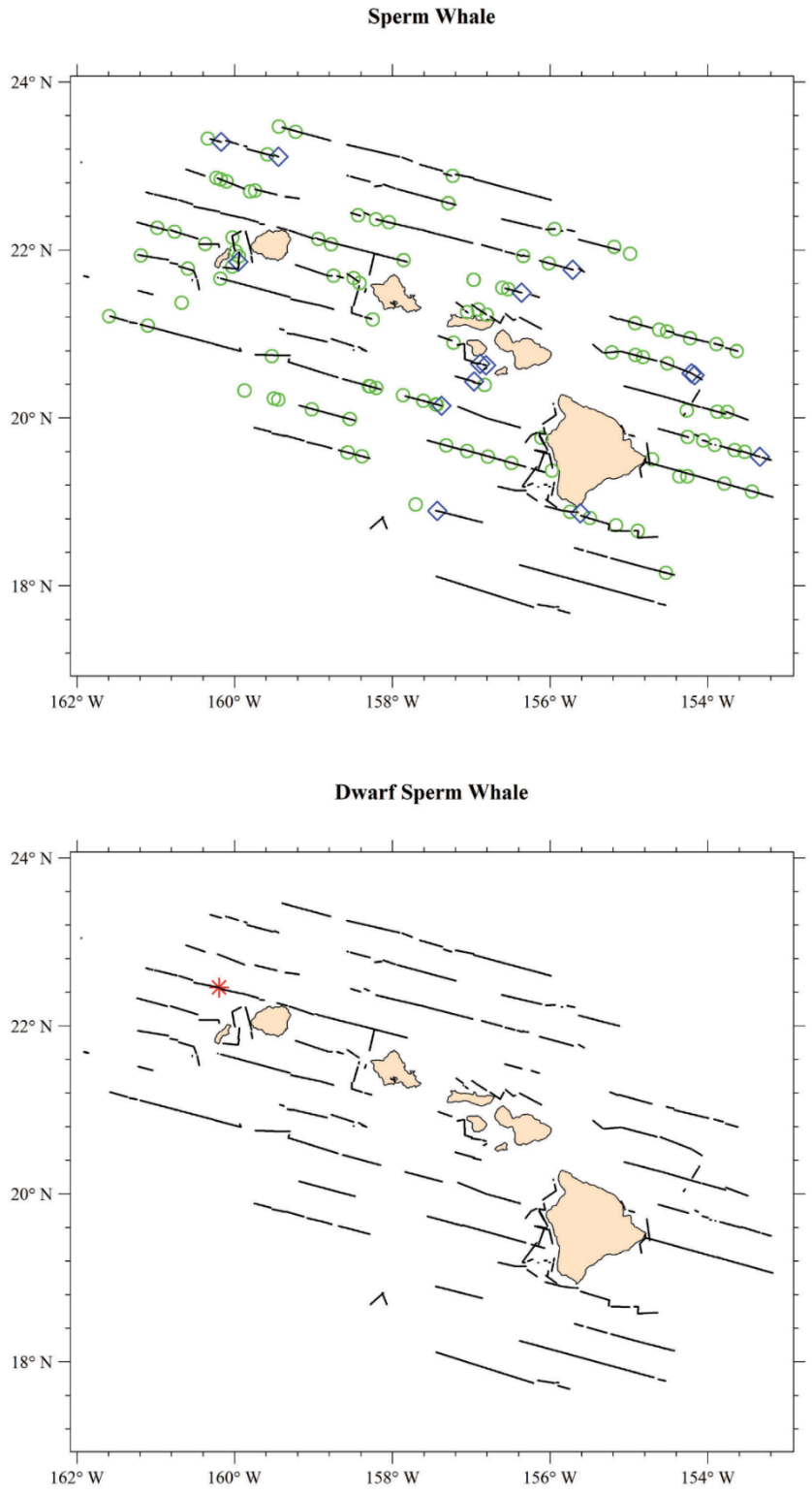

Figure A7. Sightings and acoustic detections of sperm and dwarf sperm whales.

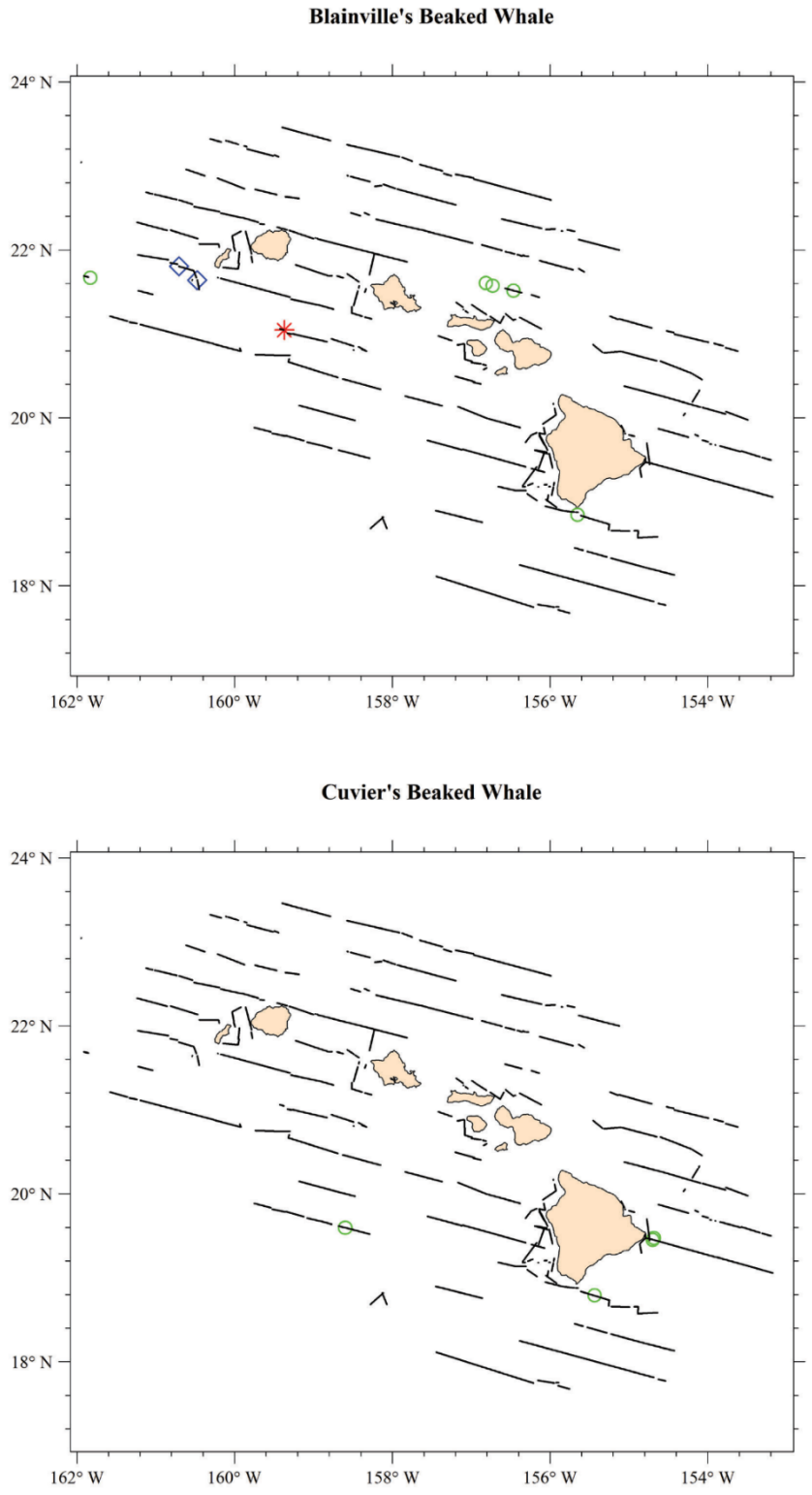

Figure A8. Sightings and acoustic detections of Blainville's and Cuvier's beaked whales.

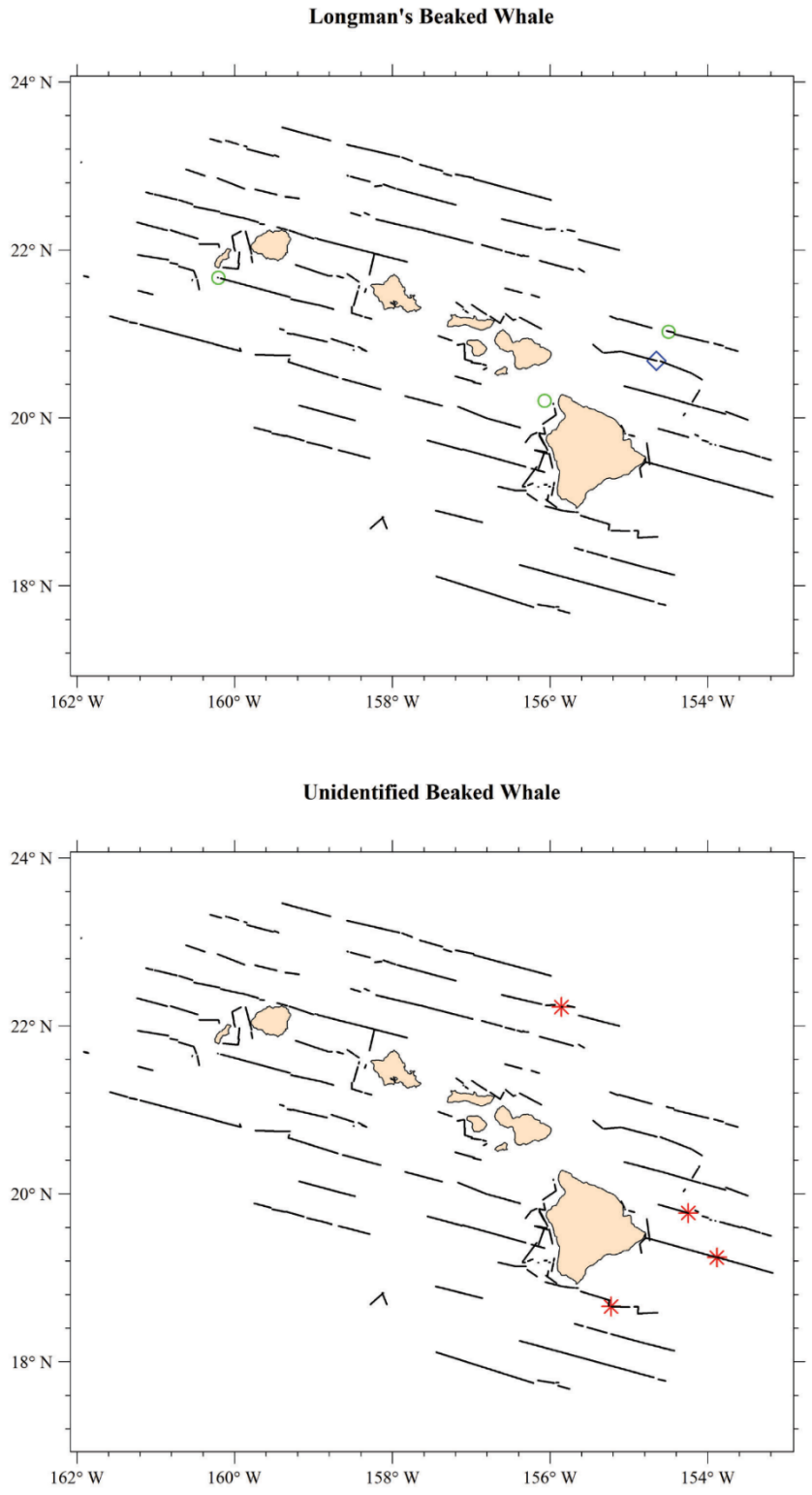

Figure A9. Sightings and acoustic detections of Longman's and unidentified beaked whales.

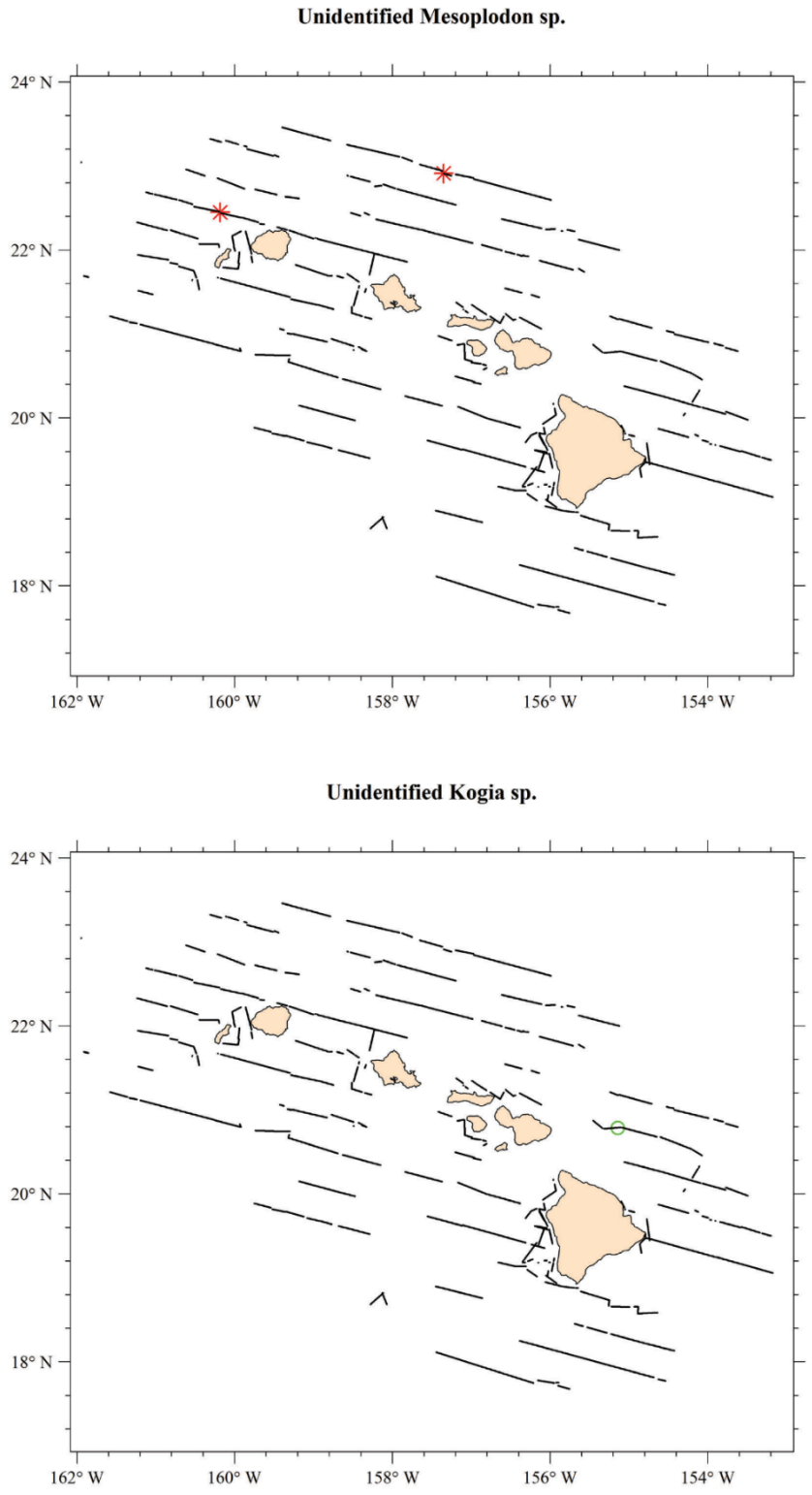

Figure A10. Sightings and acoustic detections of unidentified *Mesoplodon* sp. and unidentified *Kogia* sp.

Sightings and Acoustic Detections of Baleen Whales (Figure A11–Figure A14)

Due to the design of the towed hydrophone array, baleen whale calls cannot be detected with the exception of humpback whale song and minke whale boings. Acoustic detections of humpback and minke whales are shown in Figure 4 and Figure 5, respectively, and not shown in Appendix A. 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).

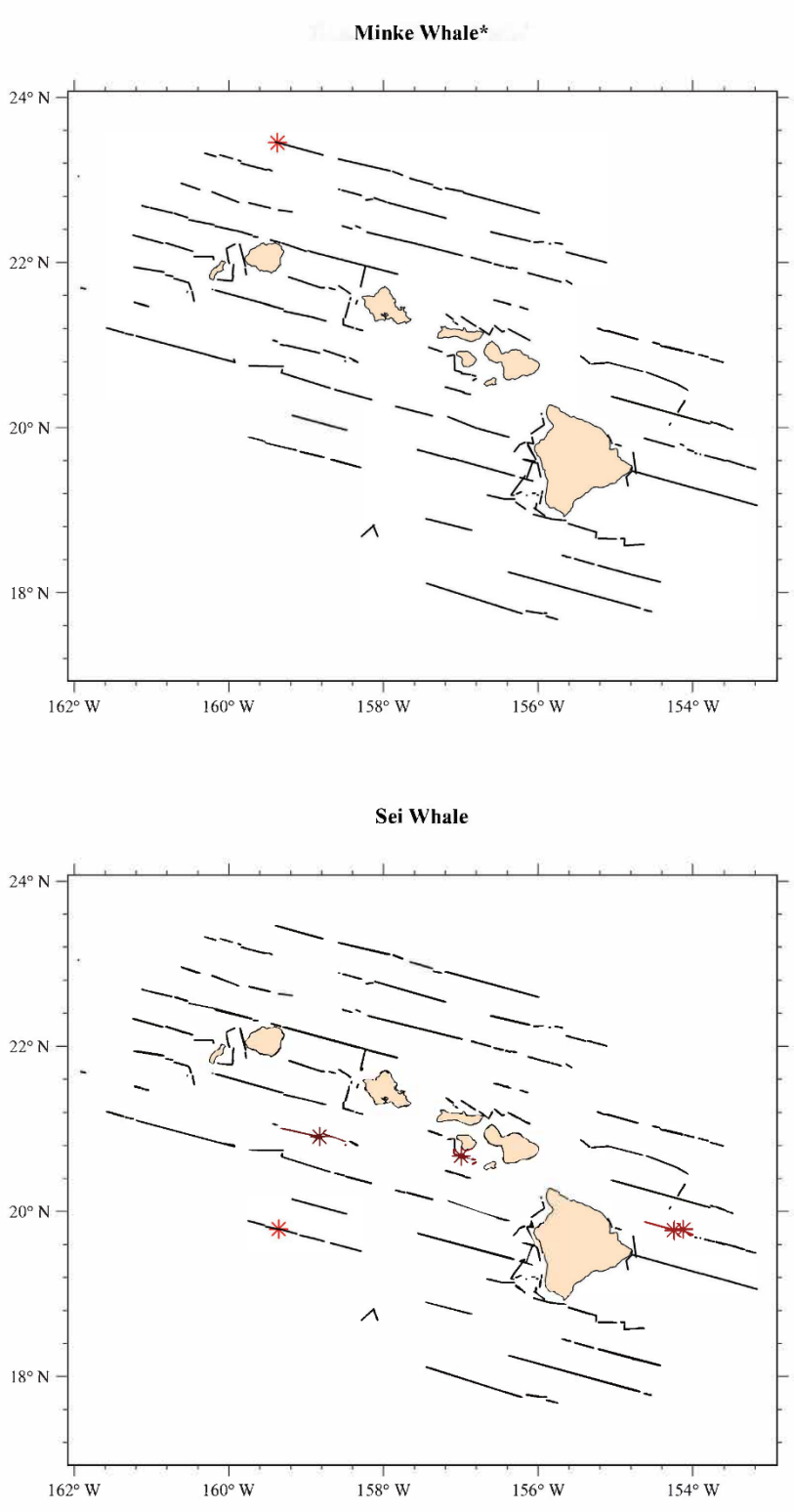

Figure A11. Sightings and acoustic detections of minke and sei whales.

*Acoustic detections of minke whales are not shown, see Figure 5.

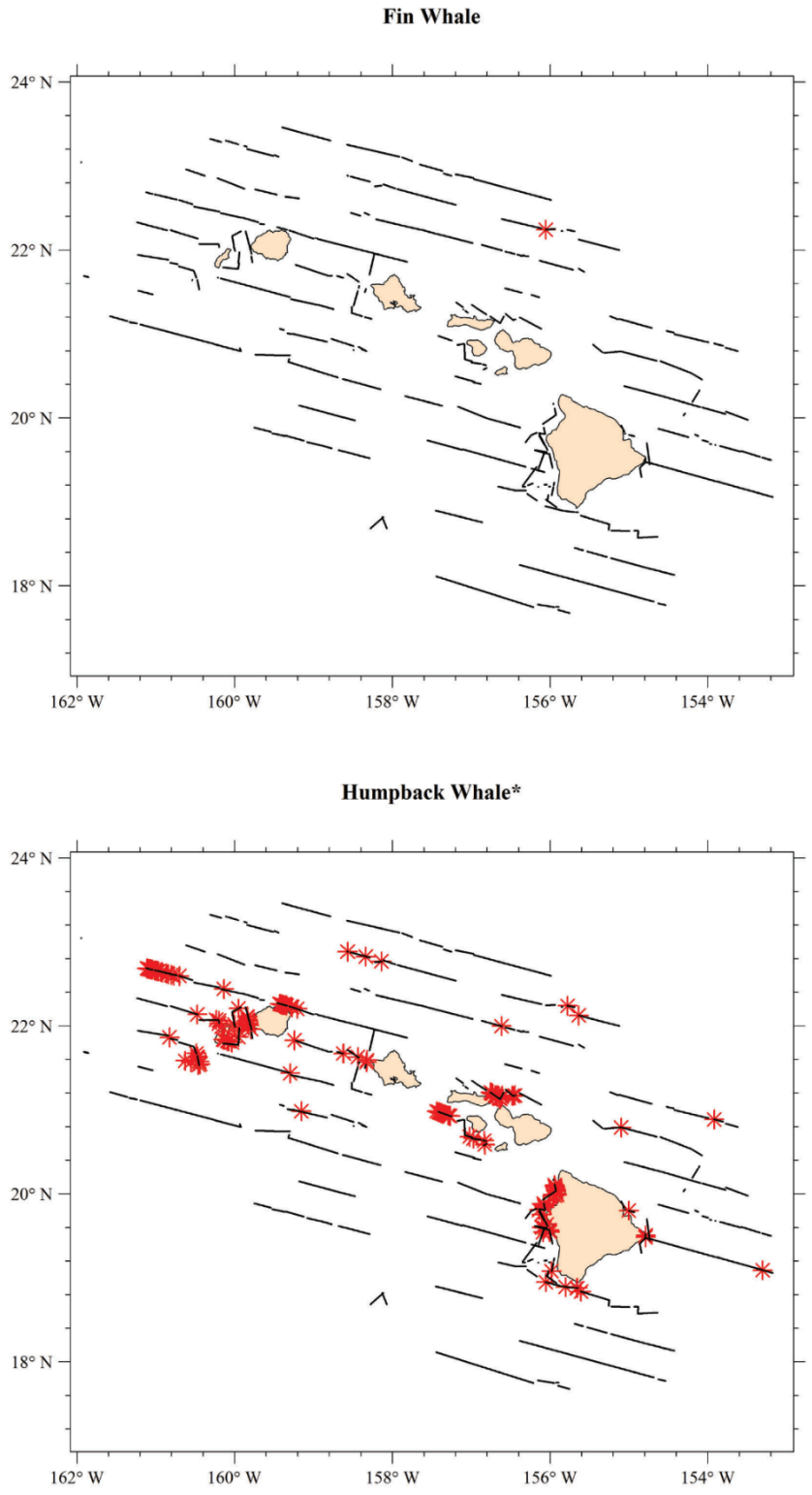

Figure A12. Sightings and acoustic detections of fin and humpback whales.

*Acoustic detections of humpback whales are not shown, see Figure 4.

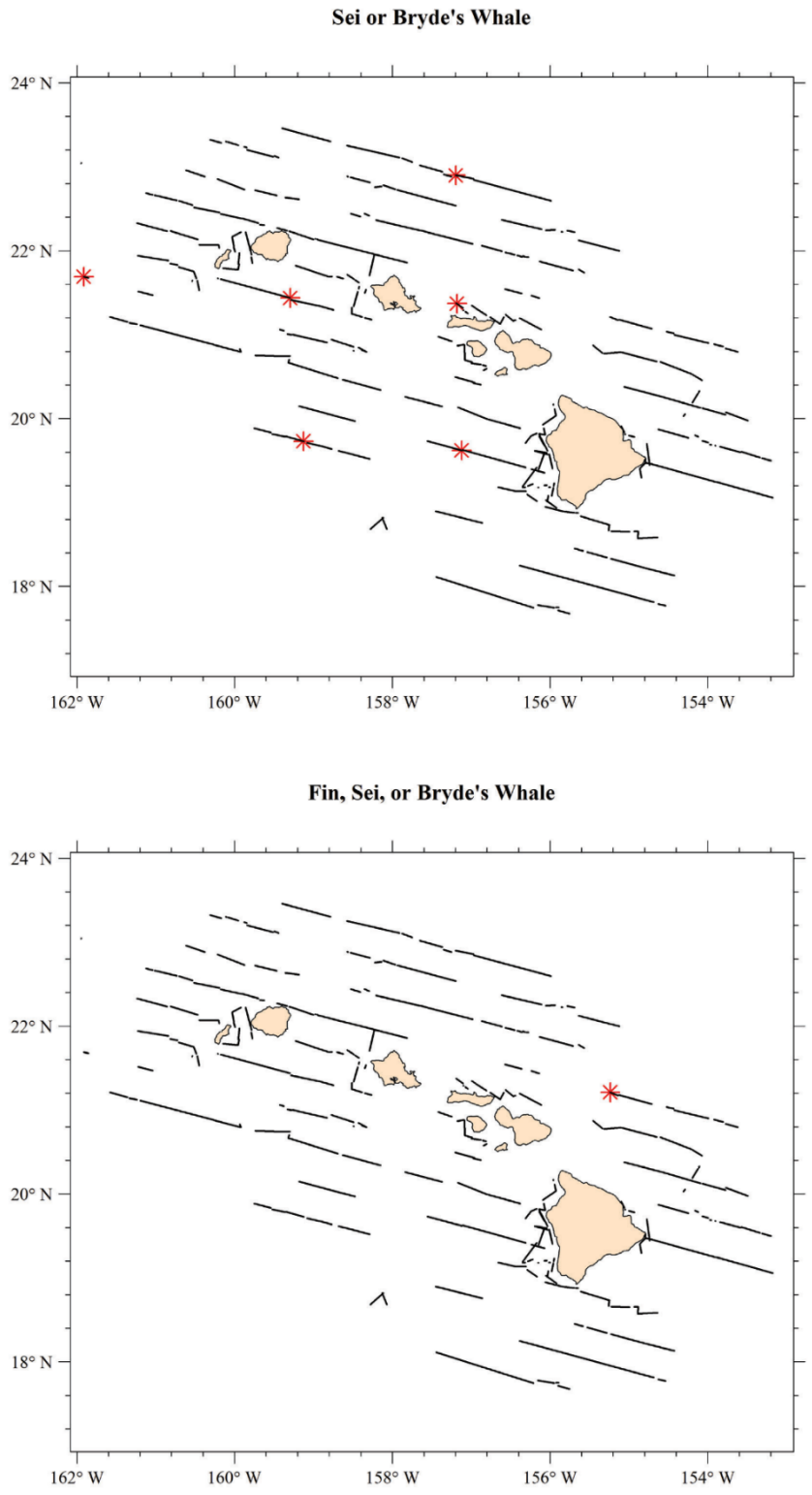

Figure A13. Sightings and acoustic detections of unidentified rorqual (sei or Bryde's) and unidentified rorqual (fin, sei, or Bryde's) whales.

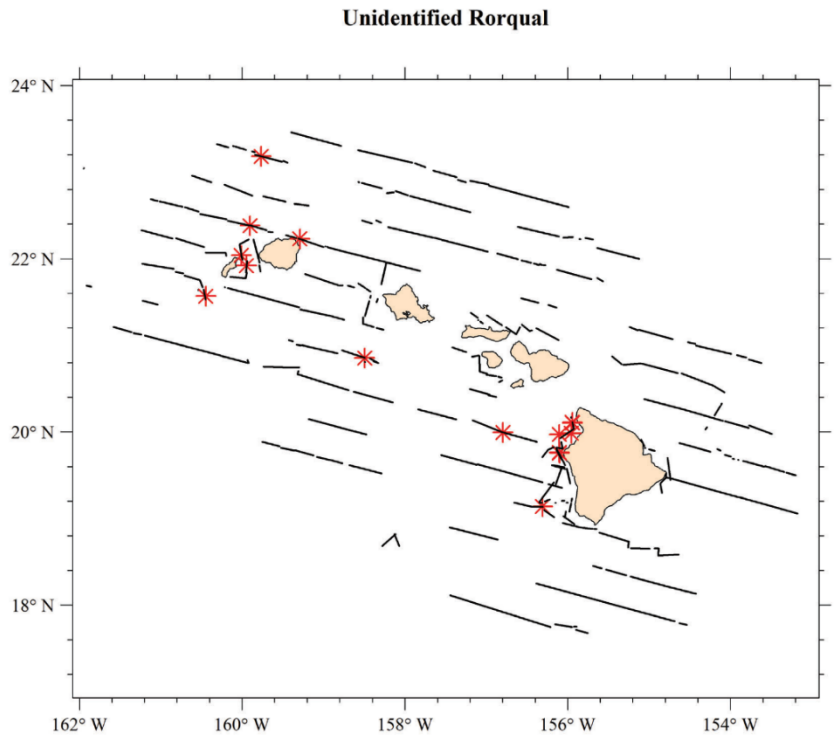

Figure A14. Sightings and acoustic detections of unidentified rorqual whales.

Sightings and Acoustic Detections of Unidentified Species (Figure A15–Figure A18)

Due to the design of the towed hydrophone array, low-frequency signals commonly produced by large whales would not be detected except for humpback and minke whales. Concurrent sightings and acoustic detections are shown as blue diamonds. Sightings without concurrent acoustic detection are shown as red asterisks. Acoustic detections without a concurrent visual sighting are shown as green circles. All sightings are shown, independent of visual effort type (black lines). Acoustic-only detections of possible false killer whales and short-finned pilot whales were classified as unidentified large dolphins and all other unknown delphinid detections remained as unidentified dolphins due to the acoustic feature overlap between small and medium unidentified dolphins. Sonobuoys were generally not deployed on unidentified whales.

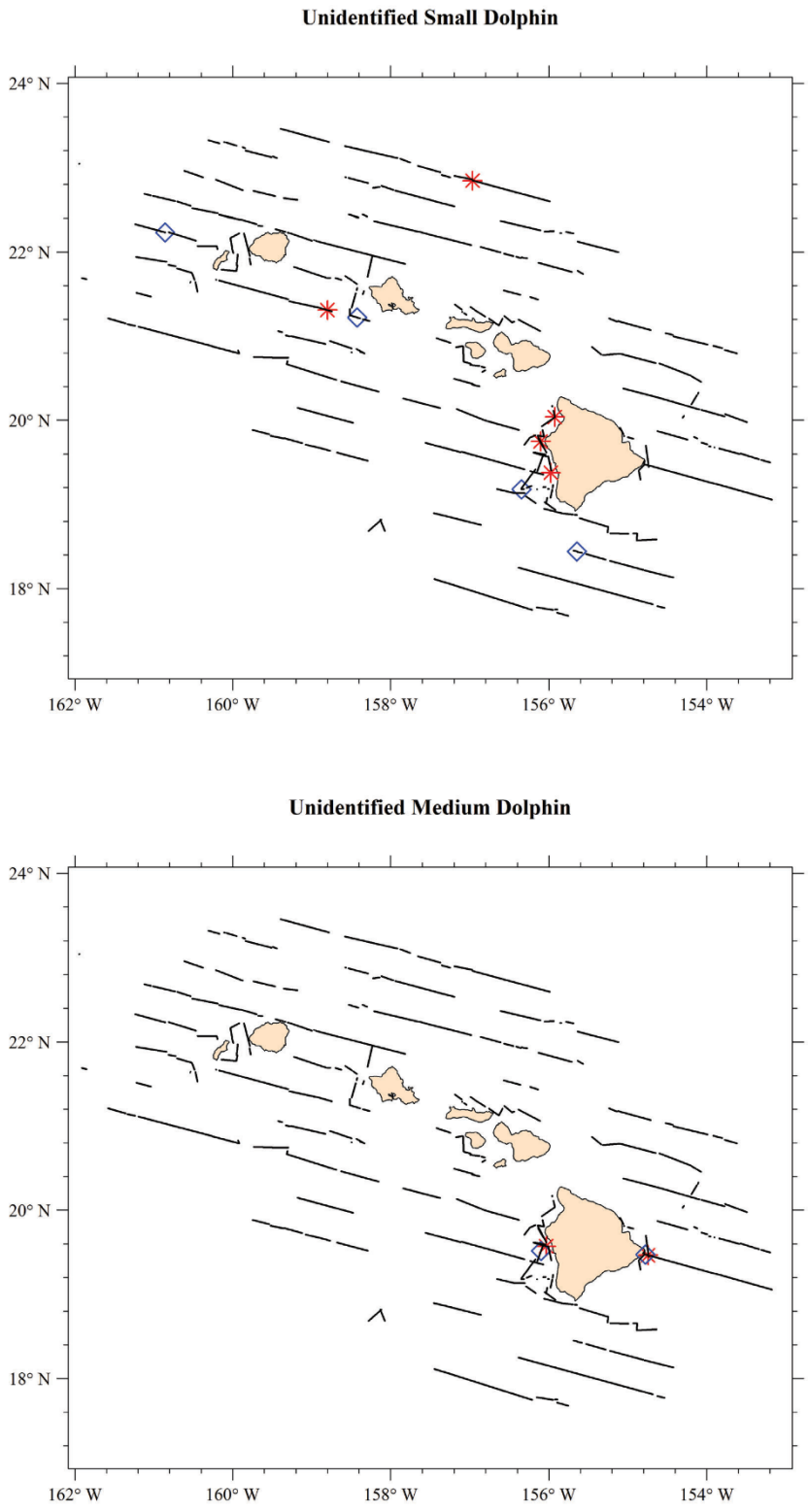

Figure A15. Sightings and acoustic detections of unidentified small and medium dolphins.

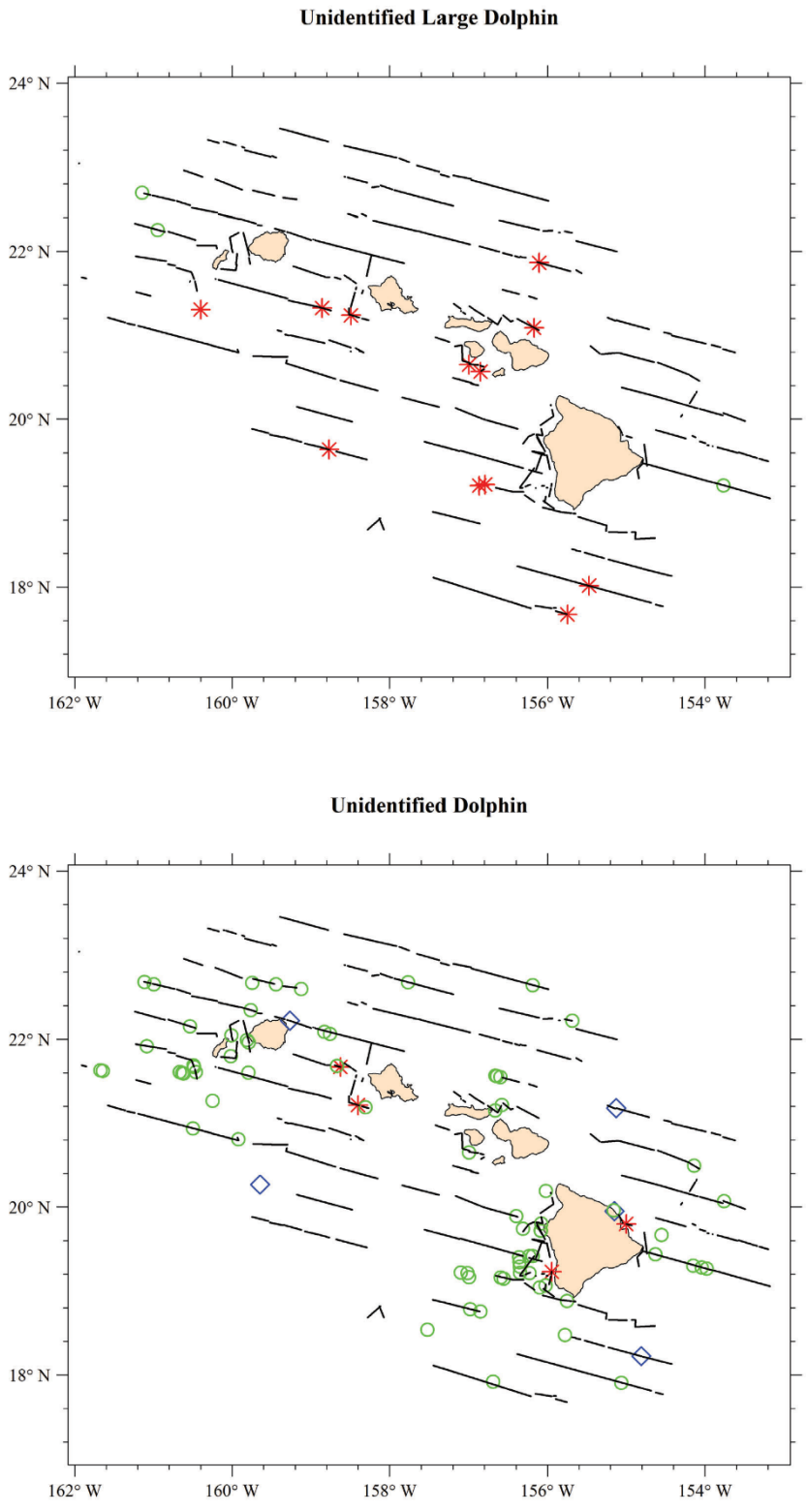

Figure A16. Sightings and acoustic detections of unidentified large dolphins and unidentified dolphins.

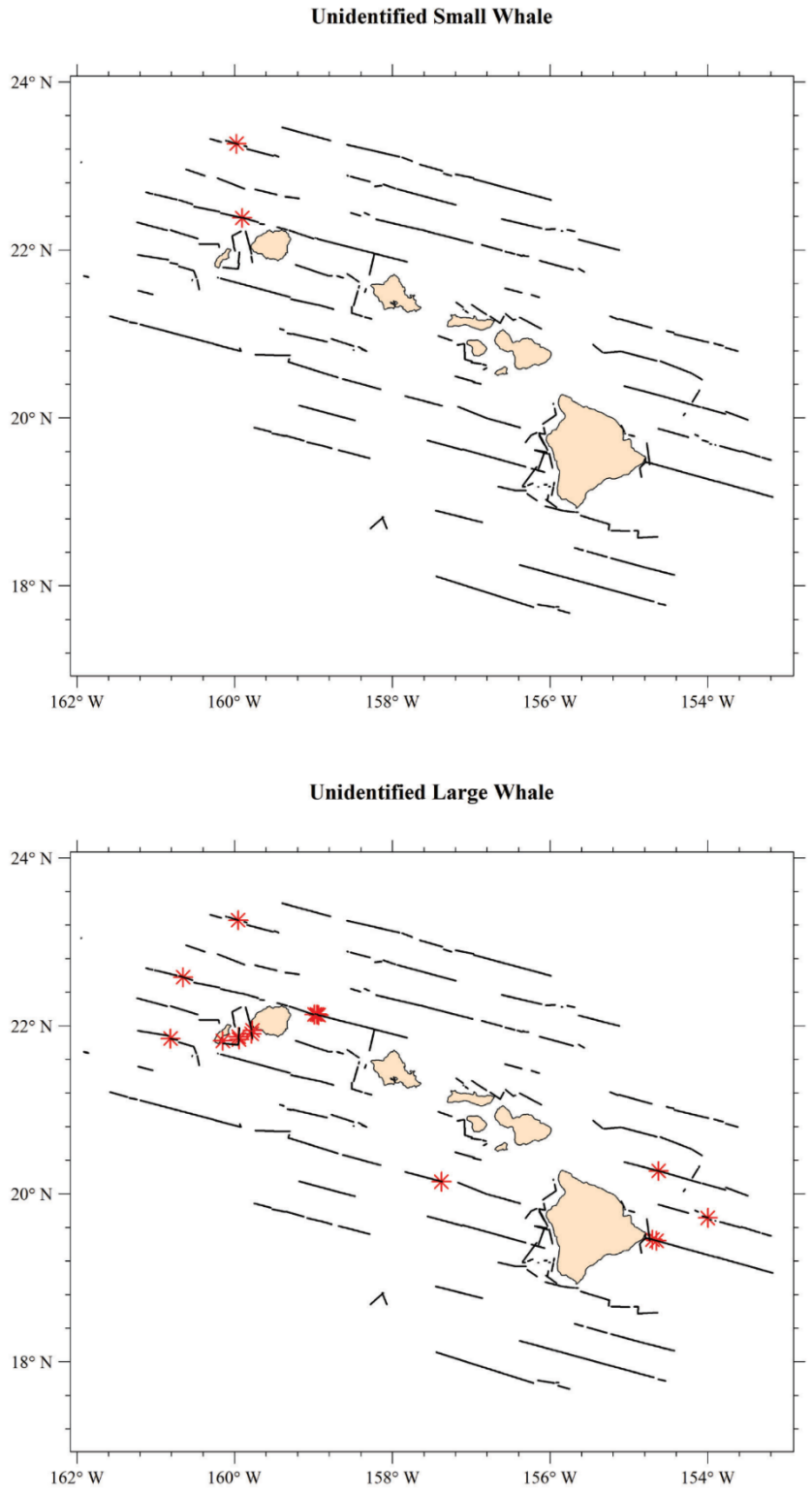

Figure A17. Sightings and acoustic detections of unidentified small and large whales.

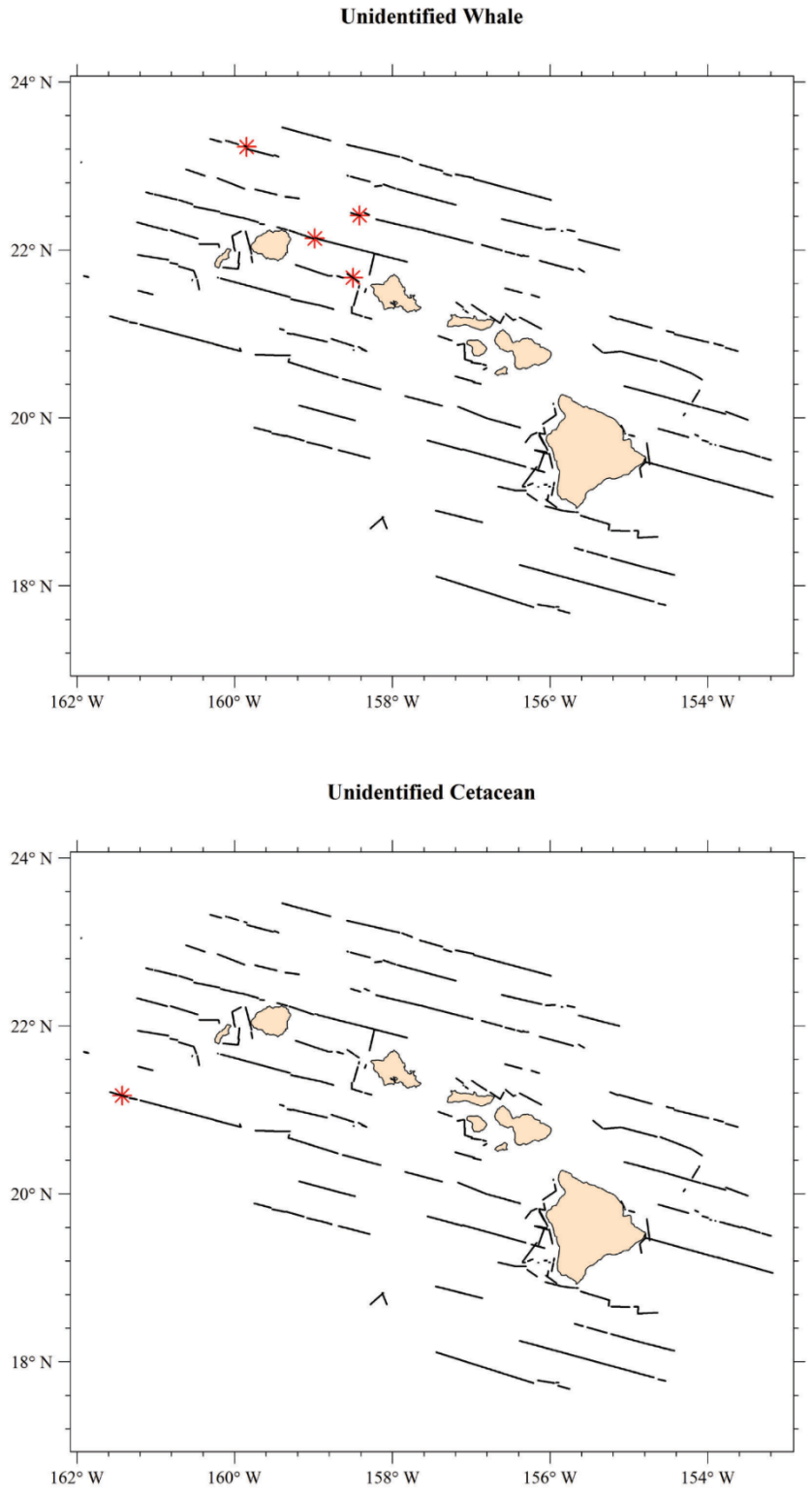

Figure A18. Sightings and acoustic detections of unidentified whale and unidentified cetaceans.

Appendix B: 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.

199 Rorqual identified as a sei, Bryde's, or fin whale
A rorqual that is either a sei, Bryde's, or fin 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 C: 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 acoustic 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, 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. IF the visual team is notified they are in Phase 1 (by Acoustics or the Bridge) prior to detection, they should indicate that in WinCruz with a Comment.

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. If the visual team is notified they are in Phase 1 prior to visual sighting (i.e., by bridge or acoustics), ensure a WinCruz comment is entered regarding the sighting bias.
5. Make real-time decisions, see next.

REAL-TIME DECISIONS

- If the visual team made a species ID and adequate subgroup estimates, then skip Phase 2.
- 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 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, letter designation, and GPS location/time information with the acoustics team as soon as possible. Re-sightings 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 re-sightings 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, while also noting visually-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 subgroup's sighting information (GPS location/time from WinCruz map) 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 into WinCruz the subgroup name provided by the acoustics team, noting if a "new" subgroup is subsequently determined to be an existing subgroup.
    - Remain with the sighted subgroup while reporting re-sighting 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.

Revised January 2020

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. Immediately notify Cruise Leader of false killer whale detections that occur 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 located 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 it is 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°).
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.

Revised January 2020

Appendix D: Sperm Whale Protocol

Sperm Whale Protocol for Visual Observers

OVERVIEW

Sperm whales 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 asynchronicity 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 clusters will be documented using the sub-group functionality within WinCruz.

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, 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 acoustic team), as long as the detection occurs 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 Bridge following standard protocols. Ask acoustics to confirm that a localization of any subgroup has been made.
    a. If so, go off-effort and close on group for group size estimation.
    b. If not, continue on-effort in passing mode until acoustics has a localization, or the visual sighting is past the beam, then close on group.
    c. 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. If the detection is a single animal, the visual team will go off-effort while the Acoustics team directs the ship to turn in order to resolve the left/right ambiguity. If the detection is of a group of animals, the acoustic team will initiate an Acoustics Chase to help the visual team locate the animals for group size estimation.
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.

a. After 10 mins, the initial three on-effort observers should record independent Best/High/Low group size estimates in their green book.
b. 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.
c. All sperm whale clusters should be entered into WinCruz using the subgroup functionality, as is used for false killer whales. Subgroup names should start with A and continue with new subgroups until the end of the 60/90-min period. If groups join or if there is uncertainty on group ID, enter a new group and notate the uncertainty with a comment in WinCruz.

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) unless they were encountered on-effort by the acoustics team.
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.
    a. There will be a field for the number of males in the group.
    b. Observers will enter calf and neonate estimates as numbers, not percentages.
    c. 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.
- Each new sighted subgroup should be entered into WinCruz as a Subgroup (DO NOT use Object) with the subgroup letter designation (e.g., A, B, C, D, etc.) in the “ID Label” field.
    - The subgroup function in WinCruz should 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).
    - 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 B).
    - Use external clues to link subgroups that were previously sighted (e.g., re-sight 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.

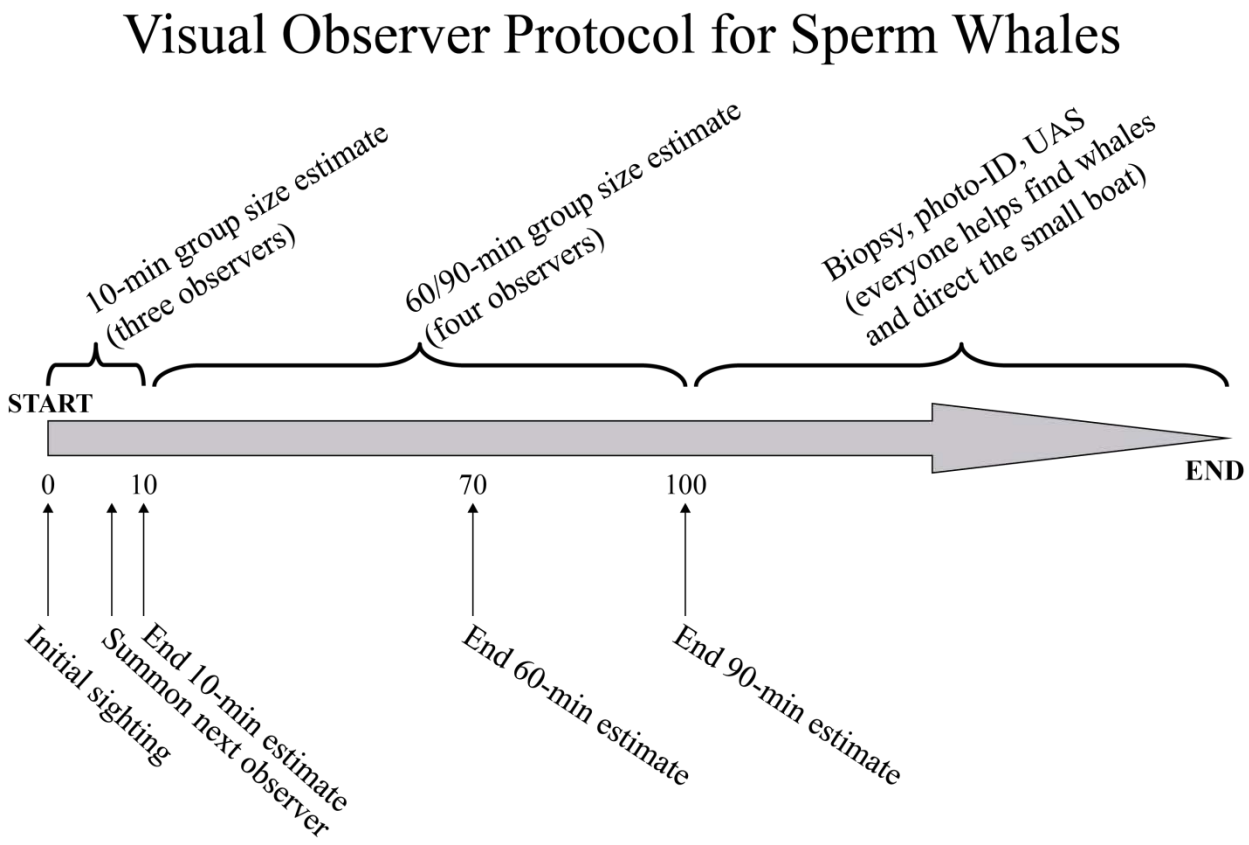

Figure D1. Sperm Whale Protocol diagram for visual observers.

Revised January 2020

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 take direction of the ship, and Acoustics continues to assist in tracking animals. If the animal is deemed to be solo and within 3 nmi then Visuals will not chase the animal but a 60° turn will be requested to the bridge to resolve whether the whales is on the left or right side of the trackline. After 5 min, the ship may return to course and speed, independent of whether the whale was localized. If ALL animals are seen past the beam, but not within 3 nmi, a 20° turn is requested to resolve left/right ambiguity of the detection. A turn less than 20° allows Visuals to remain ON EFFORT during this exercise. After 5 min, the ship may return to course and speed independent of whether the whale was localized.

Appendix E: Humpback Whale Protocol

Humpback Whale Protocol for Visual Observers

We may encounter a large number of humpbacks during Winter HICEAS 2020. The following points are to provide guidance on surveying high-density areas.

SIGHTINGS

- Each group should be marked as its own WinCruz Sighting Number with its associated group-size estimate by the on-effort observers.
- As with other species sightings, obtaining species ID and group size estimates is most important whereas photos and biopsies are lower priority.
- If we encounter an area with a large number of humpbacks, we will remain in Passing Mode and continue surveying along the line-transect. This should help minimize double-counting groups.
- Within Maui Nui inner waters, turns should only be initiated for group-size estimation, as needed by the visual team. Photos and biopsy samples in this region are not required given this area is well-surveyed by other researchers.

SIGHTING INFORMATION AND PHOTOS

- For each sighting, we are interested in age and group composition–are there mom-calves, escorts, competitive groups?
- Fluke photos are the most valuable for photo-ID, but we are also interested in full-body photos–body condition, skin condition (bumpy?), left and right dorsal fin.
- Be conscious of how many photos you take of each individual–we don't need 20 photos of the same individual at the same angle by 4 photographers.

SMALL BOAT OPS

- In regions rarely surveyed by other researchers, the Cruise Leader may elect to launch the small boat to obtain ID photographs and biopsy samples. In some cases the ship may continue to survey along the transect line while the small boat works an aggregation of humpback whales.

Appendix F: DASBR Deployment and Retrieval Details

Table F1. Details of the 14 Drifting Acoustic Spar Buoy Recorder (DASBR) deployed during Winter HICEAS 2020.

DASBR deployment and retrieval details include the identification number (ID), deployment and retrieval location (latitude, longitude), deployment and retrieval time, and total duration of deployment.

	DEPLOYMENT			RETRIEVAL			
ID	**LAT (°N)**	**LON (°E)**	**Time (UTC)**	**LAT (°N)**	**LON (°E)**	**Time (UTC)**	**Duration (day)**
DS1	21.16	−158.18	1/19/20 01:49	21.01	−157.44	1/30/20 18:02	11
DS2	22.23	−129.90	1/19/20 20:48	22.62	−159.69	1/23/20 21:54	4
DS3	22.60	−159.08	1/23/20 15:29	22.36	−159.61	1/28/20 05:37	4.5
DS4	21.07	−159.45	1/28/20 17:01	20.74	−159.28	2/01/20 01:16	3
DS5	20.63	−158.16	1/29/20 06:37	20.16	−157.70	2/02/20 14:33	4
DS6	20.61	−155.36	2/04/20 13:06	21.28	−156.14	2/09/20 10:25	4
DS7	20.39	−155.08	2/04/20 17:08	20.73	−155.32	2/09/20 19:16	5
DS8	20.12	−154.07	2/04/20 23:54	20.43	−154.06	2/07/20 03:35	2
DS9	19.66	−153.61	2/05/20 07:41	20.01	−154.05	2/07/20 07:52	2
DS10	21.47	−157.43	2/12/20 07:41	----	----	----	----
DS11	21.92	−157.17	2/18/20 12:36	22.13	−157.54	2/23/20 08:13	5
DS12	21.80	−156.64	2/19/20 13:36	22.05	−157.11	2/23/20 15:10	4
DS13	21.95	−156.43	2/23/20 20:48	22.08	−156.44	2/25/20 07:24	1.5
DS14	21.17	−159.92	3/08/20 16:21	21.13	−160.21	3/10/20 07:08	1.5

Appendix G: Science Personnel

Table G1. Winter HICEAS 2020 science personnel.

PIFSC (Pacific Islands Fisheries Science Center, NMFS, NOAA); JIMAR (Joint Institute for Marine and Atmospheric Research, University of Hawai‘i at Manoā); Azura (Azura Consulting LLC); UCSD (University of San Diego); PIRO (Pacific Islands Regional Office)

Last, First Name	Role	Affiliation	Sailed
Oleson, Erin	Chief Scientist, Cruise Leader	PIFSC	Leg 1
Hill, Marie	Cruise Leader	JIMAR	Leg 2
Salinas, Juan Carlos	Visual Survey Lead	Azura	Leg 1 & 2
Vazquez, Ernesto	Visual Survey Lead	Azura	Leg 1 & 2
Ligon, Allan	Visual Survey	Contractor	Leg 1 & 2
Yin, Suzanne	Visual Survey	Azura	Leg 1 & 2
Bendlin, Andrea	Visual Survey	Azura	Leg 1 & 2
Hoefer, Christopher	Visual Survey	Azura	Leg 1 & 2
Force, Michael	Seabird Survey	Azura	Leg 1 & 2
Breese, Dawn	Seabird Survey	Azura	Leg 1 & 2
McCullough, Jennifer	Acoustic Survey Lead	JIMAR	Leg 1 & 2
Norris, Erik	Acoustic Survey	JIMAR	Leg 1 & 2
Gruden, Pina	Acoustic Survey	JIMAR	Leg 1
Ziegenhorn, Morgan	Visiting Scientist	UCSD	Leg 1
Allen, Ann	Acoustic Survey	PIFSC	Leg 2
Ellgen, Sarah	Visiting Scientist	PIRO	Leg 2