

SUMMARY REPORT: COMPILATION OF VISUAL SURVEY EFFORT AND SIGHTINGS FOR MARINE SPECIES MONITORING IN THE HAWAII RANGE COMPLEX, 2005 - 2012

DRAFT FINAL REPORT



Hawaii Range Complex, 2010; NOAA permit #14451



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Cover Photo: Short-finned pilot whale (*Globicephala macrorhynchus*) photographed during the RIMPAC 2010 vessel survey by A. Milette.

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Acronyms and Abbreviations

ASW	Anti-submarine Warfare
BSS	Beaufort Sea State
COMPACFLT	Commander, U.S. Pacific Fleet
CRC	Cascadia Research Collective
ESA	Endangered Species Act
GIS	geographic information system
HFAS	high-frequency active sonar
HRC	Hawaii Range Complex
ICMP	Integrated Comprehensive Monitoring Program
km	kilometer(s)
m	meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MFAS	mid-frequency active sonar
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MTE	major training event
NMFS	National Marine Fisheries Service
PAM	passive acoustic monitoring
PMRF	Pacific Missile Range Facility
RIMPAC	Rim of the Pacific
SCC	Submarine Commanders Course
U.S.	United States
ULT	Unit Level Training
UNDET	underwater detonation
USWEX	Undersea Warfare Exercise

Section 1 Introduction

The United States (U.S.) Navy is responsible for compliance with a suite of Federal environmental laws and regulations that apply to marine mammals and other marine protected species, including the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). There are training activities in the Hawaii Range Complex (HRC) that the U.S. Navy predicts would result in the generation of sound levels in the water that the National Marine Fisheries Service (NMFS) has indicated are likely to result in the harassment of marine mammals. These activities involve the use of sonar (mid-frequency active sonar [MFAS] or high-frequency active sonar [HFAS]) or the use of live ordnance, including the underwater detonation (UNDET) of explosives. In order to train in realistic conditions (i.e., with sonar and explosives), the U.S. Navy obtains incidental take permits and Letters of Authorization (LOAs) from NMFS under the ESA and MMPA respectively. Marine species monitoring efforts partially fulfill requirements of the *Hawaii Range Complex Monitoring Plan* as specified in the LOA, and meet a variety of program objectives outlined in the Integrated Comprehensive Monitoring Program (ICMP). Monitoring of marine mammals and sea turtles includes visual surveys from aircraft (fixed-wing and helicopters) and vessels; marine mammal tagging; and passive acoustic monitoring (PAM).

The ICMP provides the overarching framework for coordination of the U.S. Navy Monitoring Program and coordination to compile data from range-specific monitoring plans. The Hawaii Range Complex Monitoring Plan is one component of the ICMP. The overall objective of the ICMP is to assimilate relevant data collected across U.S. Navy range complexes in order to answer questions pertaining to the impact of MFAS and explosives on marine mammals and sea turtles.

The first phase to integrate the historical sum of these U.S. Navy-sponsored visual survey efforts for marine species monitoring in the HRC was prepared by Uyeyama (2011). This report for the second phase represents the second phase of that effort, and presents an overview of monitoring survey effort to date in the HRC. The goal is to process and compile available data from visual surveys performed by both contractor-led efforts and U.S. Navy in-house surveys, in order to:

1. Compile a geographic information system (GIS)-based summation of all survey tracks that can be easily visualized
2. Construct a geo-referenced database of sightings can be queried by species, observer platform, Beaufort Sea State (BSS), season, or other sighting/survey variables.

Goals for future iterations of this report include:

- Continue to expand the geo-referenced survey database to incorporate additional past and future survey data.
- Expand the internal field structure of the geo-referenced database, which will enable more detailed data queries.
- Compare visual detections with results from past and ongoing PAM efforts.

- Conduct an enhanced analysis of sighting success with respect to location, platform, field protocol, season, and observational technique (visual or acoustic).
- Adjust data collection procedures on future surveys as needed to reflect lessons learned from sighting data compilation efforts presented here.

Section 2 Methods

The U.S. Navy has supported marine protected species monitoring in the HRC since 2005. These efforts included collection of baseline data and monitoring in conjunction with U.S. Navy training events. Monitoring methods included visual surveys using vessel and aircraft platforms. A total of 34 monitoring surveys have been conducted in the HRC since 2005 (**Appendix A**). Detailed sighting and effort data from a subset of 27 of these surveys have been entered into the newly developed comprehensive HRC Monitoring Survey Database, which has been used to generate the survey effort and sightings maps found in this report.

2.1 Compiled Monitoring Effort

This report presents sightings (see **Section 3**) made during both vessel and aerial surveys, conducted either as baseline or pilot surveys, and as monitoring during Unit-Level Training events (ULTs), major training events (MTEs), or Submarine Commanders Courses (SCCs).

Pilot/Baseline Monitoring

Four categories of baseline monitoring efforts supported by the U.S. Navy were conducted during 2005 through 2011. A brief summary of each of those efforts is presented below.

Deepwater Cetacean Survey. During February 2005, a pilot study was conducted that consisted of a combined visual (vessel-based)-acoustic cetacean survey, which included waters offshore of O‘ahu and Kaua‘i, with focused effort in Kaulakahi Channel between Kaua‘i and Ni‘ihau (Norris et al. 2005). This survey was designed to address a gap in information about deep-water species of cetaceans around the Main Hawaiian Islands. Visual and PAM detections of minke whales (*Balaenoptera acutorostrata*) were a highlight during this effort and were detailed in Rankin et al. (2007). This survey was funded by the non-profit Cetos organization, with funding from the Commander, U.S. Pacific Fleet (COMPACFLT) for report preparation. Sighting and trackline data from this survey will be included in future iterations of this report.

Vessel Survey at ‘Alenuihāhā Channel and the Island of Hawai‘i. Vessel-based monitoring was scheduled to take place in January-February 2007, during a planned Anti-Submarine Warfare (ASW) training event (Smultea et al. 2007). Ultimately, the sonar exercises were cancelled due to deteriorating weather conditions. The survey continued, and provided an opportunity for baseline studies in the HRC, in areas that typically are not surveyable due to prevailing weather conditions (Smultea et al. 2007). On-transect effort occurred in the ‘Alenuihāhā Channel and along the northeastern and eastern portions of waters off the island of Hawai‘i. Prior to this survey, no vessel-survey transects had been conducted along the eastern and northeastern coast of the island of Hawai‘i. Sighting and trackline data from this survey will be included in future iterations of this report.

Ka'ula Islet Vessel Surveys. There were four vessel-based surveys conducted by the U.S. Navy for marine mammals, sea turtles, and seabirds at Ka'ula, with additional effort at Ka'uai and Ni'ihau. Included in this data set compilation are the three Ka'ula Islet survey efforts for June 2010, February 2011, and June 2011. As noted by Uyeyama (2011), the July 2009 survey had no Global Positioning System (GPS) positions of the ship tracks or sightings, and therefore, did not fulfill the criteria required for compilation into the analysis.

Marine Mammal Monitoring on Navy Ranges (M3R) Tagging Survey. A small-vessel survey was conducted during July and August 2011 on and near the Pacific Missile Range Facility (PMRF) offshore of Kaua'i in conjunction with an SCC. The primary goals were to: (1) validate species identifications by the Marine Mammal Monitoring (M3R) hydrophone array and (2) deploy satellite tags in order to provide more data on residency patterns, habitat use, and movement patterns by toothed whales in the western half of the HRC, where naval activities are concentrated and little information is available for marine mammal usage of the area (Baird et al. 2012a). Only the sightings and associated effort data collected during the vessel survey are included in this data compilation.

PMRF Vessel and Tagging Survey. Vessel-based effort was conducted during January 2012 in waters west of Kaua'i off the PMRF (HDR 2012). The primary goals of this cruise on the U.S. Navy Ship *Sioux* were to: (1) validate species identifications by the M3R hydrophone array, (2) deploy satellite tags from a second vessel, a RHIB, in order to provide more data on residency patterns, habitat use, and movement patterns by toothed whales in the western half of the HRC, where naval activities are concentrated and little information is available for marine mammal usage of the area (Baird et al. 2012b), and (3) conduct a pilot acoustic study via deployment of sonobuoys. Effort and sightings from this survey are included in this data compilation.

Pearl Harbor Entrance Channel and Kaneohe Bay Sea Turtle Surveys. The U.S. Navy conducts natural resources assessments under the Integrated Natural Resources Management Plan for Pearl Harbor. As a result the U.S. Navy has a data set of in-water surveys for marine resources, including sea turtles. The Pacific Navy Marine Species Density Database contains data for sea turtles from 2000 to 2011 (Hanser et al. 2012). Included in this compilation are data from 12 April, 10 May, and 16 May 2011.

Major Training Events (MTEs)

MTEs typically involve numerous participants, last multiple days, and are conducted over large areas. In general, these exercises include Anti-Submarine Warfare (ASW) training, i.e., MFAS is deployed.

Rim of the Pacific (RIMPAC). RIMPAC is held biennially during June and July of even-numbered years. In 2006, surveys for marine mammals are performed on dates corresponding with scheduled dates for "choke point" maneuvers of the RIMPAC exercises. Surveys were conducted in the vicinity of the Kaulakahi Channel (between Kaua'i and Ni'ihau) and 'Alenuihāhā Channel (between the islands of Hawai'i and Maui) (Rivers 2006). RIMPAC 2006 was the first U.S. Navy training activity utilizing MFAS to receive an MMPA authorization and Incidental Take Statement (ITS). There is aerial and shipboard monitoring effort for two of the three RIMPAC events included in this data compilation—RIMPAC 2008 and RIMPAC 2010.

RIMPAC 2006 is not yet included in the data compilation, but will be included in future iterations of this report.

Koa Kai. Koa Kai is a semi-annual exercise in the waters around Hawaii designed to prepare independent deployers in multiple warfare areas and provide training in a multi-ship environment. There are two Koa Kai events included in this data compilation—Koa Kai-11 (November 2010), and Koa Kai 12-1 (November 2011).

Undersea Warfare Exercise (USWEX). USWEX is an advanced ASW exercise conducted by U.S. Navy Carrier Strike Groups and Expeditionary Strike Groups. There are three USWEX events included in this data compilation—USWEX 08-1, USWEX 09-1, and USWEX 09-3. USWEX 08-1 was primarily conducted to the northeast (extending far out to sea) of O‘ahu during November 2007. Two USWEX exercises were monitored during May and June 2008 (09-1 and 09-3, respectively) in offshore and coastal areas off the islands of O‘ahu, Moloka‘i, Lāna‘i, Kaho‘olawe, and Hawai‘i (western coastline).

Miscellaneous Training

Lookout Effectiveness (LOE). Studies of the effectiveness of U.S. Navy lookouts were conducted using U.S. Navy marine mammal observers (MMOs) to collect data that would characterize the likelihood of detecting marine species from a U.S. Navy warship. Included in this data compilation were the cruises using U.S. Navy MMOs conducted during November 2010 (Koa Kai-11); February 2011 (SCC 11-1 and USWEX); November 2011 (Koa Kai 12-1); and February 2012 (SCC and unspecified training exercise).

Submarine Commanders Course (SCC). SCCs are multi-unit events that are required to provide the necessary training to prospective submarine commanders in rigorous and realistic scenarios involving ASW. The SCC area includes the PMRF instrumented range off Kaua‘i and Ni‘ihau. There was aerial monitoring effort during six SCC events included in this data compilation—SCC August 2008, SCC February 2009, SCC February 2010, SCC August 2010, SCC November 2011, and SCC February 2012.

Sinking Exercise (SINKEX). In a SINKEX event, a vessel that is no longer sea-worthy (vessel “hulk”) is used as a target and intentionally sunk during the course of the exercise. The hulk ship is towed to a designated location where various platforms use multiple types of weapons to fire shots at the hulk. Platforms may include air, surface, and subsurface elements, and weapons may include missiles, precision and non-precision bombs, gunfire, and torpedoes. If none of these test shots succeeds in sinking the hulk, either a submarine shot or placed explosive charges are used to sink the ship. Included in this data compilation are two SINKEX events during RIMPAC 2010 that were monitored by MMOs.

Unit Level Training (ULT). ULT typically involves a single platform (e.g., surface ship), is of short duration (e.g., 1 to 5 hours), is conducted in a relatively small area, and focuses on a specific issue. One ULT is included in this data compilation: during June 2009, aerial monitoring was conducted for a Unit Level Training Assessment Certification event that assessed a ship’s ability to conduct drills, which include firefighting, anchoring, and defending the ship in simulated combat situations.

Underwater Detonations (UNDET). Underwater demolition exercises are designed to provide training in identifying and destroying or neutralizing inert ground mines, floating/moored mines, and possibly excess ship hulks. In the HRC, these events take place at various locations. Monitoring efforts for UNDET in this data compilation are all from the Pu‘uloa Underwater Range outside Pearl Harbor (O‘ahu)—aerial monitoring during June 2009; and U.S. Navy MMO monitoring from vessels during July 2010, April 2011, August 2011, and October 2011 at the Pu‘uloa Underwater Range. Data from November 2011 are not yet included in this data compilation but will be included in future iterations of this report.

Section 2.2 Survey Data Processing and Map Creation

Survey data, including sightings, vessel position, and environmental conditions for visual (aerial and vessel) surveys, were provided by multiple researchers and organizations. Survey data were collected using a variety of datalogging software, including WinCruz (developed by Robert Holland at the NMFS Southwest Fisheries Science Center; http://swfsc.noaa.gov/textblock.aspx?Division=PRD&Parent_MenuId=147&id=1446) and Whale Identification Logging and Display (WILD) geospatial mapping software (developed by the Space and Naval Warfare Systems Command; <http://sea-inc.net/2011/09/27/socal-brs-tools-wild-geospatial-mapping-software/>). Survey data files were imported into a web-based database created with Microsoft Sharepoint collaboration software (2010 version) (see **Figure 1**).

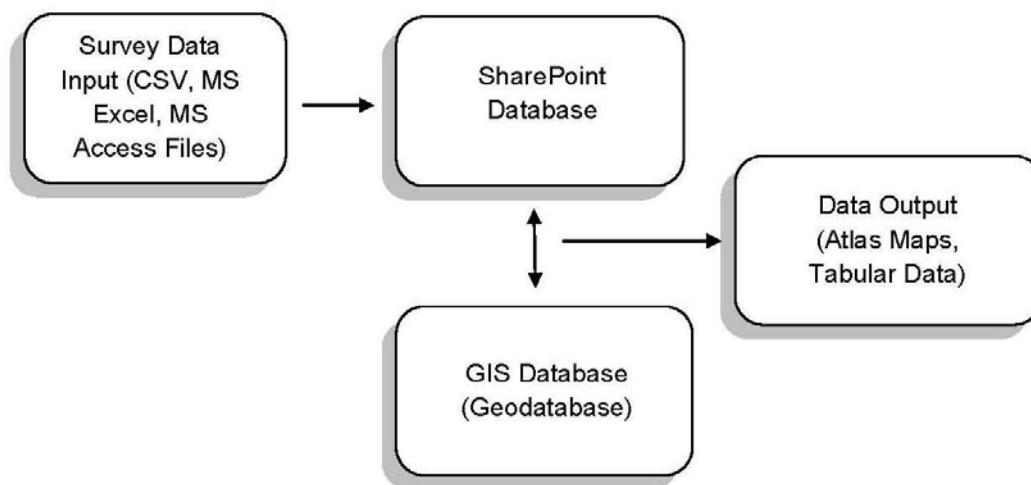


Figure 1. Data Processing Steps.

A collaborative SharePoint site was created to house all data in both unedited and modified forms. Each time new data files were received, they were uploaded to the SharePoint site in their raw format for archival purposes, as well as in formats that were more conducive to editing. The raw files were not edited during the data development process. In order to undergo editing, data files were “checked out” of the Sharepoint site so that only one person at a time could edit a file. Once editing was complete, the file was “checked-in” to the SharePoint site, and people with appropriate privileges could then access the edited file. This procedure ensured file version control and effectively tracked edits as new data were received.

Data were compiled into a series of “key” files and cross-referenced against a standardized set of fields in a comprehensive database that incorporated all fields from all datasets. Where appropriate, fields were added that further standardized the data. To provide a link between sightings data and trackline data, a field called “SurveyLink” was created in the comprehensive sightings database that combined a unique Survey ID for each survey and the date of each sighting. A four-letter species code was created for all sightings, which was made up of the first letter of the genus and the first three letters of the species (e.g., *Tursiops truncatus* = TTRU).

GIS data layers for species sightings and survey tracklines were created as part of the Atlas data development and mapping process. Survey data included surveys conducted by the U.S. Navy, HDR, and other U.S. Navy contractors and subcontractors. Once the data were consolidated from the original formats into a common format and table structure, a combination of processes was used to convert them to a GIS format. The species sightings locations were manipulated and stored in a tabular data format with all relevant attribute fields populated where the information was available. This table was imported into ArcGIS Desktop and the points were plotted using the Add XY function. The latitudes and longitudes were used as the location information for each point and a shapefile was created from the resulting plotted locations. The shapefile data layer was then loaded into a geodatabase and maps were created for specific species using the four-letter species codes.

The survey trackline data were received in multiple data formats including *.csv, *xls/xlsx or *.mdb tabular format. The raw data included point locations along a survey track that marked where certain environmental elements of the survey changed. Each point location contained related environmental elements including BSS, cloud cover, and glare, among others. Sightings and trackline data were converted to GIS point and line layers, respectively, with all available attributes included.

The Points-to-Lines tool was used to create a single line that connected all of the points generated from the raw survey track data. The final output layer for each survey track contained all linear features and associated attributes for an individual day of a survey. This process was repeated for all survey days, the individual layers were combined, and the final data layer was stored in a personal geodatabase. Attribute fields were added to the final survey trackline data layer to store the SurveyLink and a unique Segment ID. A relationship class was built in the geodatabase using the SurveyLink field. This created a relationship between the species sightings points and the associated survey tracklines for use in a GIS desktop environment that allows users to use the Identify tool on a species sightings point and see the associated survey tracklines, and vice versa.

Once the GIS database was completed, two types of maps were created: (1) survey effort maps, displaying comprehensive tracklines for all surveys (with available data) grouped by survey type, survey effort relative to BSS, and the bathymetry of the survey area; and (2) sighting maps with animal locations layered on top of the effort maps. Sighting maps depict sightings of a particular species seen on multiple surveys. Tracklines were color-coded for BSS 0-7, except in those cases where BSS information was not available for a particular survey or survey segment; in these cases, the trackline was colored in gray. No survey data were available for BSS greater than 7, and sighting conditions in fact deteriorate quickly in conditions with BSS above 4 (see **Appendix B**). Sighting events are denoted by gray circles, and larger circles represent larger group sizes, as indicated in each map legend. The survey tracks for the Lookout Effectiveness

Studies conducted on U.S. Navy vessels during training events (see **Figure C-6**) are represented as lines drawn between ship positions filtered to approximately once every several hours so that survey effort is generally represented, but the exact ship track is not. Frequently sighted species, and sightings that occurred close together, may not be clearly distinguishable because of overlapping circles. There is inevitably a tradeoff between clarity of map symbols and spatial resolution of sightings, and symbols indicating sighting locations may in some cases obscure other sightings, and cetacean sightings may appear to be on land (none were). The sighting and trackline data depicted in maps are limited to the survey data available at the time of writing; more detailed maps will be available in future iterations of this report.

Section 3 Results

3.1 Survey Effort

Descriptions below refer to 11 survey effort maps found in **Appendix C**. These maps display U.S. Navy monitoring efforts in the HRC. Survey effort is presented by sea state in four classes (BSS 0-2, 3-4, 5-7, and not recorded), and is grouped by survey type. In some cases surveys were performed from both aerial and vessel platforms. Sea state conditions during all surveys, when recorded, ranged from 0 to 7, with an overall mean BSS of 3.38 (**Table 1**). BSS conditions were not recorded for 314 of the 1,387 sightings currently available in the database. Five out of the 11 survey types employed line-transect methods: USWEX, RIMPAC, SCC, ULT and UNDET. Data from the same area and season in multiple years are available from the Pearl Harbor Sea Turtle, Kau'la Islet Vessel, RIMPAC, and SCC surveys.

Pearl Harbor Entrance Channel and Kaneohe Bay Sea Turtle Surveys. Diver surveys were conducted in coastal waters off O'ahu in April and May 2011 and in May 2012 (see **Figure C-1**). Surveys were conducted within 10 kilometers (km) of shore in depths <1,000 meters (m). Dives were conducted to the south of O'ahu off Pearl Harbor, and at U.S. Marine Corps (USMC) Base Kaneohe on the eastern shore of O'ahu. Surveys were opportunistic in nature and did not follow standardized track lines. Surveys were conducted in BSS 1-4 ($\chi=1.71$); on one day, BSS was not recorded (**Table 1**). BSS is of interest even for underwater surveys, because sea conditions can affect visibility (and therefore, turtle sightability) *via* turbidity (i.e., light penetration of the water surface and the amount of particulates in the water column).

USWEX Surveys. Aerial and vessel line-transect surveys were conducted off the islands of Hawai'i, Kaho'olawe, Lāna'i, O'ahu, and Kaua'i in November 2007, May and June 2008, and February 2011 (see **Figure C-2**). LOEs were also conducted on U.S. Navy platforms during these exercises. Effort was concentrated to the west of the islands of Hawai'i, Kaho'olawe, and Lāna'i; to the east and southwest of O'ahu; and to the south of Kaua'i. Surveys were conducted in BSS 1-6 ($\chi=2.69$, **Table 1**) and over waters with bottom depths <1,000 to 6,000 m.

Marine Mammal Monitoring on Navy Ranges (M3R) Tagging Survey. Satellite-tagging and photo-identification surveys were conducted in a small vessel off Kaua'i in July and August 2011 (see **Figure C-3**). Tagging surveys were opportunistic in nature and did not follow standardized tracklines. Surveys were conducted in waters with bottom depths <1,000 to 3,000 m. Effort was concentrated to the west of Kaua'i. Survey effort was conducted in BSS 0-6 ($\chi=2.55$, **Table 1**).

Table 1. Summary of Sea State Conditions during HRC Monitoring Surveys

Survey Type	Survey Title	Survey Timeframe	Monitoring Platform	BSS ¹		
				Mean	Max	Min
Pearl Harbor Entrance Channel and Kaneohe Bay Sea Turtle Surveys	Pearl Harbor Entrance Channel and Kaneohe Bay Sea Turtle Survey	April/May 2011	Vessel/Diver	2.81	4	1
	Pearl Harbor Entrance Channel Sea Turtle Survey	May 2012	Vessel/Diver	0.60	1	0
USWEX Surveys ²	Monitoring during USWEX 08-1	November 2007	Aerial	3.83	6	1
	Monitoring during USWEX 08-1	November 2007	Vessel	0.00	0	0
	Monitoring during USWEX 08-2	May/June 2008	Aerial	4.26	6	2
	SCC 11-1 & USWEX Lookout Effectiveness Study	February 2011	Vessel	N/A	N/A	N/A
Marine Mammal Monitoring on Navy Ranges (M3R) Tagging Survey	Tagging Survey in the Western Main Hawaiian Islands	July/August 2012	Vessel	2.55	6	0
Ka'ula Islet Vessel Surveys	Kau'la Islet Vessel Surveys	June 2010	Vessel	N/A	N/A	N/A
	Kau'la Islet Vessel Surveys	February 2011	Aerial	2.84	5	1
	Kau'la Islet Vessel Surveys	February 2011	Vessel #1 ³	2.26	3	1
	Kau'la Islet Vessel Surveys	February 2011	Vessel #2 ³	N/A	N/A	N/A
	Kau'la Islet Vessel Surveys	July 2012	Vessel	6.19	7	6
	Kau'la Islet Vessel Surveys "Baseline Monitoring at Kau'la Island"	June 2012	Vessel	N/A	N/A	N/A
Koa Kai Surveys	Monitoring during Koa Kai-11	November 2010	Aerial	3.03	5	1
	Monitoring during Koa Kai-11	November 2010	Vessel	2.88	7	0

Survey Type	Survey Title	Survey Timeframe	Monitoring Platform	BSS ¹		
				Mean	Max	Min
LOE Study Surveys	Lookout Effectiveness Study - Koa Kai 11	November 2010	Vessel	N/A	N/A	N/A
	Lookout Effectiveness Study - Koa Kai 12-1	November 2011	Vessel	3.35	6	1
	Lookout Effectiveness Study - SCC OPS	February 2012	Vessel	4.29	6	1
RIMPAC Aerial and Vessel Surveys	Monitoring during RIMPAC 2010	July 2010	Vessel	N/A	N/A	N/A
	Monitoring during RIMPAC 2008	July 2008	Aerial	4.02	7	0
	Monitoring during RIMPAC 2008	July 2008	Vessel	3.87	7	0
SCC Surveys	Monitoring during SCC OPS 08	August 2008	Aerial	4.90	7	0
	Monitoring during SCC 09-1	February 2009	Aerial	N/A	N/A	N/A
	Monitoring during SCC	February 2010	Aerial	4.53	6	0
	Monitoring during SCC 11-1 & USWEX	February 2011	Aerial	4.49	6	0
	Monitoring during SSC 09-3	August 2009	Vessel	4.54	6	0
SINKEX 2010 Survey	Monitoring during SINKEX	July 2010	Aerial	N/A	N/A	N/A
UNDET Surveys ⁴	Monitoring during ULT and UNDET at Pu'uloa Underwater Range	June 2009	Aerial	N/A	N/A	N/A
	Monitoring during UNDET at Pu'uloa Underwater Range	October/November 2011	Vessel	2.42	4	1

Notes:

¹ N/A indicates that no BSS data was available at the time of this report² Includes one joint USWEX/SCC Survey³ Two types of vessels were used on the same survey⁴ Includes one joint Unit Level Training/UNDET Survey

Kau‘la Islet Vessel Surveys. Aerial and vessel surveys were conducted off Kau‘la Islet in June 2010, June and February 2011, and July 2012 (see **Figure C-4**). Surveys employed a combination of line-transect and opportunistic methods, and were conducted in waters with bottom depths <1,000 to 3,000 m. Surveys transited past Kaua‘i and Ni‘ihau and made circumnavigations of Kau‘la. In February 2011, the waters north of Kaua‘i were also surveyed. BSS ranged from 1 to 6 for these surveys ($\chi=3.76$, **Table 1**).

Koa Kai Surveys. Aerial and vessel surveys were conducted in November 2010 (see **Figure C-5**). Surveys were conducted in waters with bottom depths <1,000 to 6,000 m. A portion of survey effort concentrated on scanning island shorelines for stranded animals, and, surveys did not follow standardized tracklines. Effort was concentrated along the shorelines of Maui, Kaho‘olawe, Lāna‘i, and Moloka‘i; the northwestern shoreline of Hawai‘i; the southeastern shoreline of O‘ahu, and deep water areas south of O‘ahu and west of the island of Hawai‘i. LOEs were also conducted on U.S. Navy platforms during these exercises. Sea state conditions for these surveys ranged from BSS 0 to 7 ($\chi=2.96$, **Table 1**).

LOE Study Surveys. LOE studies were conducted using naval vessels off Kaua‘i and O‘ahu in conjunction with naval exercises in the months of February and November 2011 and February 2012 (see **Figure C-6**). MMOs were stationed aboard naval vessels that deployed MFAS during the course of these exercises. Data was recorded opportunistically while the vessel was underway, and surveys therefore did not follow standardized tracklines. Surveys were conducted in waters with bottom depths <1,000 to 6,000 m. Effort was concentrated to the northwest of Kaua‘i and to the south of O‘ahu. Conditions for LOE Study surveys ranged from BSS 1 to 6 ($\chi=3.82$, **Table 1**).

RIMPAC Aerial and Vessel Surveys. Vessel and aerial surveys were conducted off O‘ahu, Ni‘ihau, and Kaua‘i in July 2008 and July 2010, and followed standardized tracklines (see **Figure C-7**). Surveys were conducted in waters with bottom depths <1,000 to 6,000 m. Effort was concentrated to the northwest of O‘ahu, south of Kaua‘i, and in waters surrounding Ni‘ihau and Kaua‘i. Conditions for RIMPAC surveys ranged from BSS 0 to 7 ($\chi=3.94$, **Table 1**).

SCC Surveys. Vessel and aerial surveys were conducted in February 2006, August 2008, February and August 2009, and February 2011 off O‘ahu, Ni‘ihau, and Kaua‘i (see **Figure C-8**). Aerial monitoring involved two methods: 1) line-transects and 2) circling in front of the naval vessel as it transited using MFAS. This results in the “corkscrew” appearance of some aerial tracklines. Surveys were conducted in waters with bottom depths <1,000 to 6,000 m. The majority of survey efforts were conducted northwest and southwest of Kaua‘i, and concentrated in the PMRF range. LOEs were also conducted from U.S. Navy platforms during SCCs. BSS ranged from 0 to 7 for these surveys ($\chi=4.62$, **Table 1**).

SINKEX 2010 Survey. Vessel surveys were conducted on 10 and 17 July 2010 off Kaua‘i, and were opportunistic in nature (see **Figure C-9**). Surveys were considered opportunistic, because they did not use a dedicated survey platform, and were conducted at altitudes of 90 m to 3,000 m and in waters with bottom depths <1,000 to 6,000 m. Effort occurred in waters northwest of Kaua‘i. BSS data was not available for these surveys, and no sightings occurred during this survey.

UNDET Surveys. Aerial surveys for UNDET events were conducted from a helicopter south of O‘ahu in June 2009 and monitoring from small vessels in October and November 2011. All surveys followed line-transect methods (see **Figure C-10**). Surveys were conducted at the mouth of Pearl Harbor and off the south shore of O‘ahu, over waters with bottom depths <1,000 m. Sea state conditions for these surveys ranged from BSS 1 to 4 ($\chi=2.42$, **Table 1**).

Unit Level Training (ULT) Surveys. Aerial surveys were performed in conjunction with a ULT event off O‘ahu, Hawai‘i in June 2009 (see **Figure C-11**). The ULT involved a U.S. Navy vessel that deployed MFAS. A fixed-wing aircraft tracked the vessel while it was underway. Post-ULT line transect surveys were performed in both inshore and offshore areas after the vessel had returned to port. Monitoring techniques involved a combination of line-transect methods (post-ULT) and circling of transiting U.S. Navy vessels (during ULT). Surveys were conducted over waters with bottom depths <1,000 to 6,000 m. BSS data were not available for the ULT surveys.

3.2 Marine Mammal and Sea Turtle Species

Twenty-seven marine mammal and five sea turtle species have documented occurrence in the Hawaiian Islands (DoN 2005). From the compiled U.S. Navy monitoring data sets covering the period of 2007-2012, 68 percent ($n=950$) of a total of 1,387 sightings were identified to species (19 marine mammal and one sea turtle species, see **Table 2**). Sightings for each of these 20 species are presented in **Appendix D**. Of 1,103 sightings associated with a particular BSS, 84 percent ($n=925$) were made in $BSS \leq 4$, and 34 percent ($n=370$) were made in $BSS \leq 3$ (**Table 2**).

Each species map in **Appendix D** displays survey tracklines and sighting locations, and therefore, shows surveyed areas where no sightings were recorded. Species' sightings trends portrayed in **Appendix D** may be due to survey design, and do not necessarily indicate biologically significant patterns in habitat use. It should also be noted that sightings information, including BSS, bottom depth, and group size, reflect surveys currently available in the HRC Monitoring Survey Database, and may not accurately reflect a species' occurrence, habitat preferences, etc.

Sixty percent ($n=570$) of the 950 confirmed species sightings were of the humpback whale, while the green turtle accounted for 13 percent ($n=120$). The spinner dolphin ($n=60$; 6 percent), rough-toothed dolphin ($n=58$; 6 percent), bottlenose dolphin ($n=32$; 3 percent), and short-finned pilot whale ($n=30$; 3 percent) were also frequently recorded. There was a total of eight beaked whale sightings, with 5 (63 percent) of those identified as Blainville's beaked whale. Bryde's whales (*Balaenoptera edeni*), Pygmy sperm whales (*Kogia breviceps*), Killer whales (*Orcinus orca*), and Cuvier's beaked whales (*Ziphius cavirostris*) were each identified only once.

In terms of numbers of individuals, 5,416 animals were confirmed to species (or in the case of beaked whales, to family level); 97 percent ($n=5,248$) of animals identified to species were marine mammals, while 3 percent ($n=168$) were green turtles. The spinner dolphin was the most frequently sighted marine mammal species (42percent; $n=2,216$).

Table 2. Summary of HRC Monitoring Survey Sighting Data

Scientific Name	Common Name	BSS			Number of sightings per BSS level									# of Sightings	# of Animals	Group Size			Depth (m)
		Mean	Min	Max	0	1	2	3	4	5	6	N/A ¹	Mean			Max	Min		
<i>Balaenoptera acutorostrata</i>	Minke whale	2.50	2	3	0	0	1	1	0	0	0	0	2	2	1.00	1	1	2000-4000	
<i>Balaenoptera borealis</i>	Sei whale	3.00	2	4	0	0	1	1	1	0	0	0	3	5	1.67	3	1	4000-5000	
<i>Balaenoptera edeni</i>	Bryde's whale	3.00	3	3	0	0	0	1	0	0	0	0	1	1	1.00	1	1	4000-4000	
<i>Chelonia mydas</i>	Green sea turtle	3.63	1	6	0	8	13	23	14	15	13	21	107	149	1.39	14	1	<1000	
<i>Feresa attenuata</i>	Pygmy killer whale	2.00	1	3	0	1	0	1	0	0	0	0	2	25	12.50	20	5	<1000-4000	
<i>Grampus griseus</i>	Risso's dolphin	4.50	3	6	0	0	0	1	0	0	1	1	3	54	18.00	40	5	3000-5000	
<i>Globicephala macrorhynchus</i>	Short-finned pilot whale	2.79	1	5	0	2	13	7	3	4	0	1	30	436	14.53	64	1	<1000-5000	
<i>Kogia breviceps</i>	Pygmy sperm whale	2.00	2	2	0	0	1	0	0	0	0	0	1	1	1.00	1	1	4000	
All Beaked Whales	Family Ziphiidae	3.13	2	6	0	0	3	4	1	0	1	0	8	19	2.38	6	1	2000-4000	
<i>Mesoplodon densirostris</i>	Blainville's beaked whale	3.40	2	6	0	0	2	2	1	0	1	0	5	12	2.17	6	1	2000-3000	
Unidentified <i>Mesoplodon</i> spp.	Mesoplodont	2.50	2	3	0	0	1	1	0	0	0	0	2	4	2.00	3	1	2000-4000	
<i>Ziphius cavirostris</i>	Cuvier's beaked whale	3.00	3	3	0	0	0	1	0	0	0	0	1	3	3.00	3	3	3000	

Scientific Name	Common Name	BSS			Number of sightings per BSS level									# of Sightings	# of Animals	Group Size			Depth (m)
		Mean	Min	Max	0	1	2	3	4	5	6	N/A ¹	Mean			Max	Min		
<i>Megaptera novaeangliae</i>	Humpback whale	3.48	1	6	0	25	110	129	128	103	25	223	743	1254	1.69	9	1	<1000-5000	
<i>Monachus schauinslandi</i>	Hawaiian monk seal	3.15	1	6	0	1	5	8	3	2	1	21	41	59	1.44	5	1	<1000-2000	
<i>Orcinus orca</i>	Killer whale	3.00	3	3	0	0	0	1	0	0	0	0	1	4	4.00	4	4	2000	
<i>Pseudorca crassidens</i>	False killer whale	3.00	2	4	0	0	2	0	2	0	0	1	5	22	4.40	12	1	<1000-3000	
<i>Physeter macrocephalus</i>	Sperm whale	5.25	5	6	0	0	0	0	0	3	1	0	4	4	1.00	1	1	2000	
<i>Stenella attenuata</i>	Pantropical spotted dolphin	2.29	2	3	0	0	5	2	0	0	0	1	8	250	31.25	110	1	<1000-4000	
<i>Steno bredanensis</i>	Rough-toothed dolphin	2.42	1	5	0	7	27	18	2	3	0	2	59	551	9.34	85	1	<1000-5000	
<i>Stenella coeruleoalba</i>	Striped dolphin	2.25	2	3	0	0	3	1	0	0	0	1	5	179	35.80	75	9	2000-5000	
<i>Stenella longirostris</i>	Spinner dolphin	2.75	1	6	0	4	25	15	6	2	3	7	62	2430	39.19	120	2	<1000-2000	
<i>Tursiops truncatus</i>	Bottlenose dolphin	3.27	1	6	0	1	10	9	4	2	4	5	35	459	13.11	200	1	<1000-4000	

Note: ¹ No BSS data was available at the time of this report

***Balaenoptera acutorostrata* (minke whale).** There were two confirmed sightings of solitary minke whales; both whales were seen during vessel-based surveys (see **Figure D-1**). One individual was observed west of Hawai'i during the November 2010 Koa Kai monitoring effort, while the other was observed west of Kaua'i during the January 2012 PMRF Vessel and Tagging Survey. Bottom depths for the sightings were 4,000 m and 2,000 m, and sightings occurred at BSS 2 and BSS 3, respectively. There were three sightings of "unidentified small whales," each with one individual per sighting. These occurred during the 2007 USWEX, 2010 Koa Kai, and 2011 USWEX LOE surveys. The notes for the sighting during the 2011 USWEX LOE survey indicate that this individual was a "possible minke" (Farak et al. 2011b). Rankin et al. (2007) noted that the lack of sightings of minke whales in the Hawaiian Islands may be due to misidentification (i.e., confusion with other balaenopterid species) and/or poor sighting conditions. Minke whale vocalizations have been detected at several locations near Kaua'i and O'ahu during U.S. Navy monitoring efforts during winter months (Rankin et al. 2007, Martin et al. 2010).

***Balaenoptera borealis* (sei whale).** There were three confirmed sighting of sei whales—all made from vessels (see **Figure D-2**). Two sightings were northeast of O'ahu during the November 2007 USWEX survey effort, while the third was west of Hawai'i during the November 2010 Koa Kai survey effort. The 2007 sightings were detailed by Smultea et al. (2010). Bottom depths for the sei whale sightings were 4,000 to 5,000 m. Sightings were made during BSS 2-4. Smultea et al. (2010) noted that the lack of sightings of sei whales in the Hawaiian Islands may be due to misidentification (i.e., confusion with other balaenopterid species) and/or poor sighting conditions. Groups ranged in size from one to three individuals.

***Balaenoptera edeni* (Bryde's whale).** There was only one confirmed sighting of a Bryde's whale, which was recorded northeast of O'ahu during a baseline vessel survey in November 2007 (Smultea et al. 2007, 2010, see **Figure D-3**). The solitary individual was observed for 50 minutes (Smultea et al. 2007, 2010). Bottom depth was approximately 4,500 m, and the sighting was made during BSS 3 (Smultea et al. 2007, 2010). Smultea et al. (2010) noted that the lack of sightings of Bryde's whale in the Hawaiian Islands may be due to misidentification (i.e., confusion with other balaenopterid species) and/or poor sighting conditions. There were five unidentified balaenopterid sightings on the February 2009 SCC Aerial Monitoring Survey, and two on the 2012 February LOE Study (Mobley et al. 2009, Watwood et al. 2012b).

Beaked whales (Family Ziphiidae). There were 8 beaked whale sightings for a total of 19 individuals, identified to species or genus (see **Figure D-4**). Two sightings were of *Mesoplodon* spp., one of *Ziphius cavirostris*, and five of *Mesoplodon densirostris*. Sightings were recorded during the July 2008 RIMPAC aerial survey, 2010 Koa Kai vessel survey, and January 2012 PMRF Vessel and Tagging Survey. Sightings were made off Kaua'i, Ni'ihau, and within the Kaulakahi Channel; northeast of O'ahu; and west of Hawai'i in waters over bottom depths <1,000 to 4,000 m. Group size ranged from one to six individuals during BSS 2-6. See write-ups for the *Ziphius cavirostris* (Cuvier's beaked whale) and *Mesoplodon densirostris* (Blainville's beaked whale) for sightings identified to species, as well as unidentified *Mesoplodon* species.

***Globicephala macrorhynchus* (short-finned pilot whale).** There were 30 short-finned pilot whale sightings for a total of 436 individuals (see **Figure D-5**). These sightings were made off Kaua'i, Ni'ihau, O'ahu, and Lāna'i during the November 2007 and February 2011 USWEX

aerial surveys, July 2008 RIMPAC aerial survey, February 2010 aerial survey, July 2010 RIMPAC vessel survey, 2010 Koa Kai vessel survey, February 2011 vessel and aerial surveys, November 2011 and February 2012 LOE Study surveys, and January 2012 PMRF Vessel and Tagging Survey. Sightings were made in waters over bottom depths <1,000 to 5,000 m in BSS 1-5. Groups ranged in size from one to 64 individuals.

***Grampus griseus* (Risso's dolphin).** There were three sightings for a total of 54 Risso's dolphins (see **Figure D-6**). These sightings were centered generally around O'ahu during the November 2007 USWEX vessel survey; June 2009 UNDET aerial survey; and February 2011 LOE Study conducted during SCC and USWEX. Sightings were made in waters over bottom depths of 3,000 to 5,000 m in BSS 3-6. Groups ranged in size from 5 to 40 individuals.

***Megaptera novaeangliae* (humpback whale).** There were 743 humpback whale sightings for a total of 1,254 individuals (see **Figure D-7**). Humpbacks were recorded throughout the islands (with the exception of the island of Hawai'i) with clustering around Kaua'i and Ni'hau, including within the Kaulakahi Channel; south of O'ahu; and in the Kaiwi Channel (Moloka'i Channel between O'ahu and Moloka'i) (see **Figure D-7**). Group sizes ranged from one to nine individuals. Humpback whales were sighted in waters with bottom depths <1,000 to 5,000 m. Sixty-four humpback whale sightings (11 percent of total, $n=107$) were observed within the boundaries of the Hawaiian Islands Humpback Whale National Marine Sanctuary (see **Figure D-7**), defined by the 100 fathom (183 m) isobaths off portions of the Main Hawaiian Islands. This species was sighted during BSS 1-6 with 79 percent ($n=450$) of observations recorded in BSS 2-5 (**Table 2**). Mobley (2011) remarked on the doubling of this species' sighting rate during a 2011 aerial survey (0.04 sightings/km) when compared to the 2006 North Pacific Acoustic Laboratory aerial survey (0.02 sightings/km, Mobley 2011). This sighting rate further increased to 0.065 sightings/km during the February 2012 SCC aerial survey (Mobley and Pacini 2012).

***Feresa attenuata* (pygmy killer whale).** There were two confirmed sightings of pygmy killer whales for a total of 25 individuals. A sighting of five individuals was recorded off the southwestern coast of Kaua'i during the August 2009 SCC event, while the other was of 20 individuals in deep water off the western coast of the island of Hawaii during the November 2010 Koa Kai event (see **Figure D-8**). Pygmy killer whales were sighted at depths <1,000 to 4,000 m. The sighting of five individuals was made during BSS 3, and the sighting of 20 individuals was during BSS 1. Pygmy killer whales are often confused with melon-headed whales and false killer whales (Jefferson et al. 2008). Therefore, identification to species might account for the low number of confirmed sightings.

***Kogia breviceps* (pygmy sperm whale).** There was only one sighting of a single *Kogia*, which observers were able to determine was a pygmy sperm whale (see **Figure D-9**). The sighting was made during the November 2010 Koa Kai vessel survey. This solitary individual was sighted during BSS 2 in waters with a bottom depth between 4,000 and 5000 m, off the west coast of Hawai'i.

***Mesoplodon densirostris* (Blainville's beaked whale).** There were five confirmed sightings for a total of 12 Blainville's beaked whales during the July 2008 RIMPAC aerial survey and January 2012 PMRF Vessel and Tagging Survey (see **Figure D-4**). Sightings were made off Kaua'i and Ni'hau in waters with bottom depths of 2,000 to 3,000 m. Group size ranged from one to six

individuals sighted during BSS 2-6. There were two sightings for a total of four individuals identified to the genus *Mesoplodon*. One sighting of three animals was seen during the 2010 Koa Kai event, and another sighting of one individual was seen during the January 2012 PMRF Vessel and Tagging Survey. Sightings were made in waters west and northwest of Kaua'i, in depths of 2,000 to 4,000 m during BSS 2-3. See also "Beaked whales (Family Ziphiidae)" summary above.

***Monachus schauinslandi* (Hawaiian monk seal).** There were 41 sightings of Hawaiian monk seals for a total of 59 individuals on (or near) Ni'ihau, O'ahu, and Moloka'i (see **Figure D-10**). Thirty-nine (66 percent) individuals were seen during aerial surveys, and 20 (34 percent) during vessel surveys. Fifty-two (88 percent) individual seals were observed hauled out, and seven (12 percent) were in the water. Sightings were reported during the 2007 USWEX aerial surveys, July 2008 and 2010 RIMPAC vessel surveys, August 2009 SCC vessel survey, February 2011 Kau'la vessel survey, October and November 2011 UNDET monitoring from vessels, and June 2011 and July 2012 Kau'la surveys. Sighted individuals were hauled-out or in waters as deep as 2,000 m. Sightings were made during BSS 1-6. Group sizes ranged from 1 to 5 individuals.

***Orcinus orca* (killer whale).** There was one confirmed killer whale sighting, which was made off the west coast of Kaua'i during a July-August 2011 tagging and photo-identification effort (see **Figure D-11**, Baird et al. 2012). The sighting was made in waters over a bottom depth between 2,000 and 3000 m. The sighting was made during BSS 3. Group size was 4 individuals.

***Physeter macrocephalus* (sperm whale).** Four confirmed sperm whale sightings, of single animals each time, were made off the west coast of Kaua'i during the January 2012 PMRF Vessel and Tagging Survey (see **Figure D-12**). Farak et al. (2011b) noted a possible sperm whale sighting during the February 2011 LOE Study (SCC and USWEX) survey. Bottom depth for these sightings was between 2,000 and 3,000 m. BSS during this survey was often 3-7; the sperm whale sightings were made during BSS 5-6. Norris et al. (2005) reported on an acoustic detection of this species in the same general area as the sightings mapped in **Figure D-12**. An additional sighting of a probable sperm whale was reported for the 'Alenuihāhā Channel area by Smultea et al. (2007).

***Pseudorca crassidens* (false killer whale).** There were five confirmed sightings for a total of 22 false killer whales (see **Figure D-13**). Sightings occurred off Kaua'i, Ni'ihau, Hawai'i, and Lāna'i from the August 2009 SCC surveys, February 2010 aerial surveys, June 2010 Kau'la survey, and November 2010 Koa Kai aerial survey. This species was sighted during either BSS 2 or 4 in waters with bottom depths <1,000 to 3,000 m. Group size ranged from 1 to 12 individuals.

***Stenella attenuata* (pantropical spotted dolphin).** There were eight sightings of 250 pantropical spotted dolphins, primarily off the western and northern coasts of Kaua'i, with one sighting far offshore of Ni'ihau (see **Figure D-14**). Sightings were made during the June 2009 UNDET monitoring, August 2009 SCC, February 2010 aerial survey, November 2010 Koa Kai survey, and a July-August 2011 tagging and photo-identification survey. Sightings were made during BSS 2-3 in waters with bottom depths <1,000 to 4,000 m. Group sizes ranged from 1 to 120 individuals.

***Stenella coeruleoalba* (striped dolphin).** There were five sightings of striped dolphins for a total of 179 individuals. Sightings were made off Kaua'i and Ni'ihau, including within the Kaulakahi Channel; in the Ka'ie'ie Waho Channel (between Kaua'i and O'ahu); and south of O'ahu (see **Figure D-15**). Striped dolphins were recorded during the May-June 2008 USWEX vessel survey, July 2008 RIMPAC aerial survey, June 2009 UNDET aerial monitoring, February 2010 aerial survey, and February 2011 SCC vessel survey. Sightings were made in BSS 2-3 in waters over bottom depths of 2,000 to 5,000 m. Group size ranged from 1 to 75 individuals.

***Stenella longirostris* (spinner dolphin).** There were 62 sightings of spinner dolphins for a total of 2,430 individuals around all the islands in the HRC, in particular, around the islands of Kaua'i and Ni'ihau (see **Figure D-16**). Sightings were made during the November 2007 USWEX aerial and vessel surveys, August 2008 SCC aerial survey, May-June 2008 USWEX survey, July 2008 RIMPAC aerial and vessel surveys, August 2009 SCC survey, February 2010 aerial survey, June 2010 Kau'la survey, July 2010 RIMPAC vessel survey, November 2010 Koa Kai aerial and vessel surveys, February 2011 SCC surveys, May 2011 turtle surveys, January 2012 PMRF Vessel and Tagging Survey, and July 2012 Kau'la survey. Sightings were made over bottom depths of <1,000 to 2,000 m in BSS 1-6. Sixty-seven percent of ($n=40$) were made in BSS 2-3 (**Table 2**). Group size ranged from 2 to 110 individuals.

***Steno bredanensis* (rough-toothed dolphin).** There were 59 sightings for a total of 551 rough-toothed dolphins (see **Figure D-17**). All sightings save one were made around Kaua'i and Ni'ihau, including within the Kaulakahi Channel, during the July 2010 RIMPAC vessel survey; June 2010, February 2011, and June 2011 Ka'ula surveys; November 2011 LOE Study survey; July-August 2011 satellite-tagging and photo-identification survey; and January 2012 PMRF Vessel and Tagging Survey. The remaining sighting was made west of Hawaii during the November 2010 Koa Kai vessel survey. Sightings were made in waters over bottom depths of <1,000 to 5,000 m in BSS 1-5. Seventy-eight percent of sightings ($n=45$) were made in BSS 2-3 (**Table 2**). Groups ranged in size from one to 85 individuals.

***Tursiops truncatus* (bottlenose dolphin).** There were 25 sightings of bottlenose dolphins for a total of 459 individuals. The majority of sightings were made off Kaua'i and Ni'ihau, including within the Kaulakahi Channel; O'ahu; and Moloka'i (see **Figure D-18**). Sightings were made during the November 2007 USWEX aerial survey, July 2008 RIMPAC aerial and vessel surveys, February 2010 aerial survey, June 2010, June 2011 and July 2012 Ka'ula surveys, November 2010 Koa Kai vessel-based monitoring effort, February 2011 vessel-based surveys, July-August 2011 CRC tagging and photo-identification survey, and January 2012 PMRF Vessel and Tagging Survey. This species was sighted in waters with bottom depths <1,000 to 4,000 m. Sightings were made in BSS 1-6, with over 50percent of sightings ($n=19$) made in BSS 2-3 (**Table 2**). Group sizes ranged from 1 to 200 individuals.

***Ziphius cavirostris* (Cuvier's beaked whale).** There was one confirmed sighting of a group of three Cuvier's beaked whales east of Kaua'i made during the July 2008 RIMPAC aerial survey (see **Figure D-4**). The sighting was in waters over a bottom depth of 2,000 to 3,000 m during BSS 3. The reader is referred earlier to the "Beaked Whales" section for a summary of all beaked whale sightings included in this data compilation.

Sea Turtle Species

Chelonia mydas (green turtle). There were 107 sightings of 149 individual green turtles in the data compilation recorded during vessel, aerial-based, and in-water (diver) monitoring efforts. Sixty-eight sightings (97 individuals) were made during aerial surveys, and 39 sightings (52 individuals) were made during vessel surveys. Sightings occurred predominantly around Kaua‘i, O‘ahu and Moloka‘i, with a clustering at Pearl Harbor (see **Figure D-19**), reflecting the U.S. Navy’s in-water monitoring effort in this area. Green turtles were seen during BSS 1-6, with a fairly even distribution of animals seen in all sea states (**Table 2**). Group sizes ranged from one to 14 individuals, and all sightings were made in waters with bottom depths $\leq 1,000$ m.

Section 4 Discussion

Sighting distributions presented in this report are related to survey efforts that may be unevenly distributed due to multiple goals in survey design, and as such, only limited claims can be made about animal abundance and habitat use from this information. Monitoring surveys in the HRC are conducted using a variety of platforms; designed for different objectives; and are employed using various data collection methods. Interpretation of compiled data is therefore challenging, since it cannot be easily compared across different surveys. Any attempt at a meta-analysis must be mindful of these limitations. Nonetheless, several broad patterns in species distribution and relative abundance are suggested by the available data. It should be noted that some sighting data may be biased by poor sea state conditions, the altitude of aircraft when making species identifications, and mismatches between species’ seasonal occurrences and spatial and temporal patterns of naval monitoring efforts (for example, humpback whales are only seen November-April in the HRC, when the species seasonally uses Hawaiian waters as a major breeding ground).

Nineteen marine mammal and one sea turtle species were identified to species from HRC visual monitoring effort. Of a total of 1,387 sightings, 83 percent ($n=1146$) of these were identified to species. The majority of sightings during monitoring surveys were comprised of *Megaptera novaeangliae* (65 percent of total), *Chelonia mydas* (12 percent of total), *Stenella longirostris* (5 percent of total), *Steno bredanensis* (5 percent of total), *Monachus schauinslandi* (5 percent of total), *Tursiops truncatus* (3 percent of total), and *Globicephala macrorhynchus* (3 percent of total). The large amount of sighting data collected for these species may make them good candidates for future density estimation. The most frequently sighted large whale species in the HRC was *Megaptera novaeangliae*; *Stenella longirostris* was the most frequently sighted odontocete species. The most frequently (and only) sighted sea turtle species was *Chelonia mydas*. All other species comprised <1 percent of the total number of sightings. There were 8 confirmed beaked whale sightings; 5 of these were determined to be *Mesoplodon densirostris* and one was determined to be *Ziphius cavirostris*, with the remaining two identified only to the genus *Mesoplodon*.

Confirmed sightings of rorquals (besides *Megaptera novaeangliae*) during U.S. Navy monitoring efforts were *Balaenoptera acutorostrata*, *Balaenoptera borealis*, and *Balaenoptera edeni*. No blue whales (*Balaenoptera musculus*) or fin whales (*Balaenoptera physalus*) were visually detected and confirmed to species. However, PAM data supports the use of this area (and central

North Pacific) by fin whales at all times of the year and by blue whales in all seasons except summer, as modeled from acoustic detections (Hanser et al. 2012). Additionally, there are published sighting records for fin whales in Hawaiian waters: one north of O'ahu during May 1976; one in the Ka'ie'ie Waho Channel (between Kaua'i and O'ahu) during February 1979; one north of Kaua'i from February 1994 (DoN 2005); one stranded on Maui (Shallenberger 1981); one sighted north of Kaua'i during an aerial survey in 1996 (Mobley et al. 1996); several offshore sightings during a NMFS shipboard survey in 2002 (Barlow 2006); and a single juvenile reported off Kaua'i in 2011 (DoN 2011).

Figure 2 shows all monitoring survey effort currently in the HRC Monitoring Survey Database. Overall, there has been little offshore monitoring effort north of O'ahu, off Maui, or off the island of Hawai'i. The most heavily surveyed areas are the waters off Kaua'i and Ni'ihau; the area of the PMRF range; south of O'ahu; and northwest of Moloka'i and northeast of O'ahu.

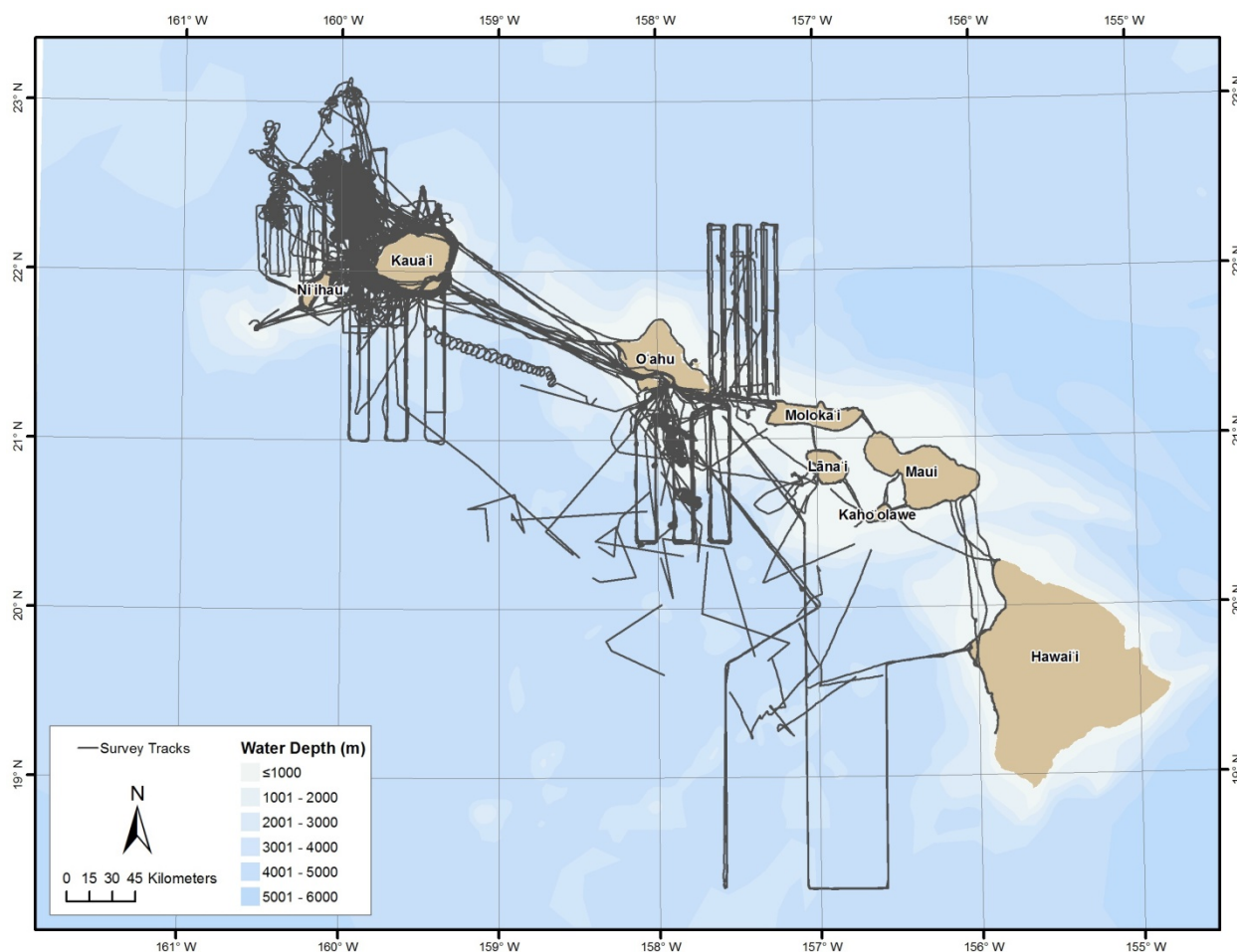


Figure 2. Survey tracks for all efforts in HRC Monitoring Survey Database.

Although the PMRF range itself is well-sampled visually, other areas surrounding the range have never been surveyed, or are rarely surveyed. These include the areas east of the range and north of Kaua'i; the areas west and southwest of the PMRF range around Ni'ihau; the area south of the Kaulakahi Channel (Kaua'i/Ni'ihau channel); the deep waters around Ka'ula, southwest of the

range; and waters around Middle Bank, northwest of the PMRF range (**Figure 2**). As a consequence, it is difficult to draw conclusions about animal movements on and off the instrumented range in response to training exercises given existing visual survey monitoring data. For example, recent studies conducted in The Bahamas and off Southern California have shown that some beaked whales leave U.S. Navy training ranges during exercises involving MFAS, and that these animals return to the range when sonar activity ceased (McCarthy et al. 2011, Melcon et al. 2011, Southall et al. 2012, Tyack 2011, Tyack et al. 2011).

Future iterations of this sightings and effort summary will include additional information from surveys not currently included in the HRC Monitoring Survey Database (see **Appendix A**). The geo-referenced HRC Monitoring Survey Database will be expanded as additional past and future survey data are incorporated. Future goals also include more comprehensive comparisons of visual detections with results from past and ongoing PAM efforts, and conducting an enhanced analysis of sighting success with respect to location, platform, field protocol, season, and observational technique (visual, acoustic and telemetry).

Section 5 Acknowledgements

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APPENDIX A

List of HRC Monitoring Surveys, 2005-2012

Survey ID	Year	Survey Dates	Survey Title	Platform	Survey Effort			Sightings		Total # of Species Identified	Contract No.	Source
					Days	Hours	NM of Trackline (km)	Groups	Individuals			
1	2005	17-24 Feb	Deepwater Cetacean Survey "Baseline monitoring at Ni'ihau, Kaua'i, and portions of O'ahu"	Vessel, PAM	8	30	316 (586)	78	179	5	Cetos/Geo-Marine, Contract #2057sa05-F	Norris et al. 2005†
2	2006	16, 17, 20, 24-26 Jul	Monitor during RIMPAC 2006	Aerial	6	18	1,728 (3,200)	13	71	4	MMRC, Contract #N62742-06-P-1887	Mobley 2006†
3	2007	7 Jan – 2 Feb	Baseline survey near the 'Alenuihāhā Channel and the Island of Hawai'i ‡	Vessel	7	60.8	240 (444)	97	n/a	6	Cetos, Contract #N62742s-07-P-1895	Smultea et al. 2007†
4	2007	11-17 Nov	Monitor during USWEX 08-1	Aerial	5	17.3	1,701 (3,150)	26	195	5	MMRC, Contract #N62742-07-P-1914	Mobley 2008a
5	2007	11-17 Nov	Monitor during USWEX 08-1	Vessel	7	66	492 (911)	8	29	5	Cetos, N62742-07-P-1915	Smultea et al. 2008
6	2008	26-27 May & 2-4 Jun	Monitor during USWEX 08-2	Aerial	5	20.4	n/a	15	173	2	MMRC, Contract #N62742-08-P-1933	Mobley 2008b
7	2008	13-17 Jul	Monitor during RIMPAC 2008	Vessel	5	65	474 (879)	9	283	3	MMRC, Contract No. N62742-08-P-1934	Smultea 2008
8	2008	13-17 Jul	Monitor during RIMPAC 2008	Aerial	5	15.4	n/a	24	196	8	MMRC, Contract No. N62742-08-P-1935	Mobley 2008c

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Survey ID	Year	Survey Dates	Survey Title	Platform	Survey Effort			Sightings		Total # of Species Identified	Contract No.	Source
					Days	Hours	NM of Trackline (km)	Groups	Individuals			
9	2008	18-21 Aug	Monitor during SCC OPS 08	Aerial	4	28.5	n/a	21	135	2	MMRC, Contract No. N62742-09-P-1942	Smultea and Mobley 2009
10	2009	16-19 Feb	Monitor during SCC 09-1	Aerial	5	27.3	n/a	63	106	1	SES & MMRC, Contract #N62742-09-P-1956	Smultea et al. 2009a
11	2009	17-25 Jun	Monitor during ULT and UNDET at Pu'uloa Underwater Range	Aerial	9	45	n/a	42	91	3	MMRC, Contract #28H-1087365	Mobley et al. 2009a
12	2009	26-30 Aug	Monitor during SSC 09-3	Aerial	5	31.4	3806 (7048)	19	238	6	MMRC & SES, Contract #N62742-09-P-1966	Smultea et al. 2009b
13	2010	16-21 Feb	Monitor During SCC	Aerial	6	33	n/a	265	467	1	MMRC, Contract #N62742-08-P-1803	Mobley and Millette 2010
14	2010	26-28 Jun	Ka'ula Island survey	Vessel	3	n/a	n/a	7	34	4	NAVFAC Pacific	Uyeyama and Hanser 2010a
15	2010	10 & 17 Jul	Monitor during SINKEX	Aerial	2	27.5	n/a	0	0	0	NAVFAC Pacific	Hanser and Uyeyama 2010
16	2010	15 Jul	Monitor during UNDET at Pu'uloa Underwater Range	Vessel	1	2.2	n/a	0	0	0	NAVFAC Pacific	Uyeyama and Hanser 2010b†
17	2010	17-25 Jul	Monitor during RIMPAC 2010	Vessel	8	66	329 (609)	9	132	4	HDR, Contract #N62470-10-D-3011 CTO KB01	HDR e ² M 2010
18	2010	10-17 Nov	Lookout Effectiveness Study -Koa Kai-11	Vessel	5	35	n/a	8	54	3	NAVFAC Pacific	Farak et al. 2011a

Survey ID	Year	Survey Dates	Survey Title	Platform	Survey Effort			Sightings		Total # of Species Identified	Contract No.	Source
					Days	Hours	NM of Trackline (km)	Groups	Individuals			
19	2010	11-23 Nov	Monitor during Koa Kai-11	Vessel	12	95	607 (1,124)	26	202	11	HDR, Contract #N62470-10-D-3011 CTO KB05	HDR 2011
20	2010	11-23 Nov	Monitor during Koa Kai-11	Aerial	2	14	1254 (2,322)	125	854	4	HDR, Contract #N62470-10-D-3011 CTO KB05	HDR 2011
21	2011	15-20 Feb	Ka'ula Islet Vessel Survey	Vessel	6	60	471 (873)	56	254	5	NAVFAC Pacific	Richie and Fujimoto 2011
22	2011	15-22 Feb	SCC 11-1 & USWEX Lookout Effectiveness Study	Vessel	8	60.5	n/a	34	176	6	NAVFAC Pacific	Farak et al. 2011b
23	2011	16 Feb – 5 Mar	Monitor during SCC 11-1 & USWEX	Aerial	8	46	n/a	76	131	1	HDR, Contract #N62470-10-D-3011 CTO KB05	Mobley 2011
24	2011	12 Apr; 10, 14 & 16 May	Pearl Harbor Entrance Channel Sea Turtle Survey	Vessel, Diver	n/a	n/a	n/a	n/a	n/a	n/a	NAVFAC Pacific	R. Uyeyama, pers. comm., 2011
25	2011	26-27 Apr	Monitor during UNDET at Pu'uloa Underwater Range	Vessel	2	5.5	n/a	6	9	1	NAVFAC Pacific	Uyeyama and Richie 2011
26	2011	30-Jun	Ka'ula Islet Vessel Surveys "Baseline monitoring at Ka'ula Island"	Vessel	1	11.5	n/a	6	62	4	NAVFAC Pacific	Uyeyama et al. 2011
27	2011	22 Jul - 3 Aug	Marine Mammal Monitoring on Navy Ranges (M3R) Tagging Survey in the Western Main Hawaiian Islands	Vessel	18	118.8	1065 (1972)	65	1,050	5	CRC, Grant No. N00244-10-1-0048	Baird et al. 2012a
28	2011	10-11 August	Monitor during UNDET at Pu'uloa Underwater Range	Vessel	2	4	n/a	8	14	2	NAVFAC Pacific	Richie et al. 2011†
29	2011	19 & 26 Oct & 2 Nov	Monitoring during UNDET at Pu'uloa Underwater Range	Vessel	3	8.5	n/a	4	5	2	NAVFAC Pacific	Uyeyama et al. 2012
30	2011	10-17 Nov	Lookout Effectiveness Study - Koa Kai 12-1	Vessel	8	48	n/a	7	83	2	NAVFAC Pacific	Watwood et al. 2012a

Survey ID	Year	Survey Dates	Survey Title	Platform	Survey Effort			Sightings		Total # of Species Identified	Contract No.	Source
					Days	Hours	NM of Trackline (km)	Groups	Individuals			
31	2012	10-19 Jan	Pacific Missile Range Facility Vessel and Tagging Survey "Baseline survey and tagging effort for SCC OPS" (Feb 2012)	Vessel	9	42.2	354 (656)	13	422	5	HDR, Contract N62470-10-D-3011, CTO KB14	Baird et al. 2012b†
32	2012	11-19 Jan	2012 January survey off Kaua'i	Vessel	9	96	718 (1,330)	160	544	8	HDR, Contract N62470-10-D-3011, CTO KB14	HDR 2012
33	2012	13-17 Feb	Lookout Effectiveness Study – SCC OPS	Vessel	5	28.4	n/a	14	39	2	NAVFAC Pacific	Watwood et al. 2012b
34	2012	15-25 Feb	Monitor during SCC and Navy training exercise	Aerial	6	29	n/a	14	20	1	HDR, Contract N62470-10-D-3011, CTO KB14	Mobley and Pacini 2012†

Key:

† Report data not currently reflected in species or trackline maps

‡ Anti-submarine warfare exercise had been planned, but did not take place during survey effort

CRC = Cascadia Research Collective

CTO = Contract Task Order

MMRC=Marine Mammal Research Consultants

NAVFAC – Naval Facilities Engineering Command

OPS = Operations

PAM = Passive Acoustic Monitoring

RIMPAC=Rim of the Pacific

SCC=Submarine Commanders Course

SES=Smultea Environmental Sciences LLC

SINKEX=Sinking Exercise

ULT=unit level training (anti-submarine warfare exercise)

UNDET=underwater detonation

USWEX = Undersea Warfare Exercise

APPENDIX B

Beaufort Sea State Scale

Beaufort Scale	Wind Speed		Descriptive Term	Effects Observed at Sea
	Km/h	Knots		
0	Less than 1	Less than 1	Calm	Sea surface like a mirror, but not necessarily flat.
1	1 - 5	1 - 3	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	6 - 11	4 - 6	Light breeze	Small wavelets, still short but more pronounced. Crests do not break. When visibility good, horizon line always very clear.
3	12 - 19	7 - 10	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered whitecaps.
4	20 - 28	11 - 16	Moderate breeze	Small waves, becoming longer. Fairly frequent whitecaps.
5	29 - 38	17 - 21	Fresh breeze	Moderate waves, taking a more pronounced long form. Many whitecaps are formed. Chance of some spray.
6	39 - 49	22 - 27	Strong breeze	Large waves begin to form. The white foam crests are more extensive everywhere. Probably some spray.
7	50 - 61	28 - 33	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	62 - 74	34 - 40	Gale	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	75 - 88	41 - 47	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	89 - 102	48 - 55	Storm	Very high waves with long overhanging crests. Dense white streaks of foam. Surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.
11	103 - 117	56 - 63	Violent storm	Exceptionally high waves. Sea completely covered with long white patches of foam. Visibility affected.
12	118 - 133	64 - 71	Hurricane	Air filled with foam and spray. Sea entirely white with foam. Visibility seriously impaired.

APPENDIX C

Survey Trackline Maps

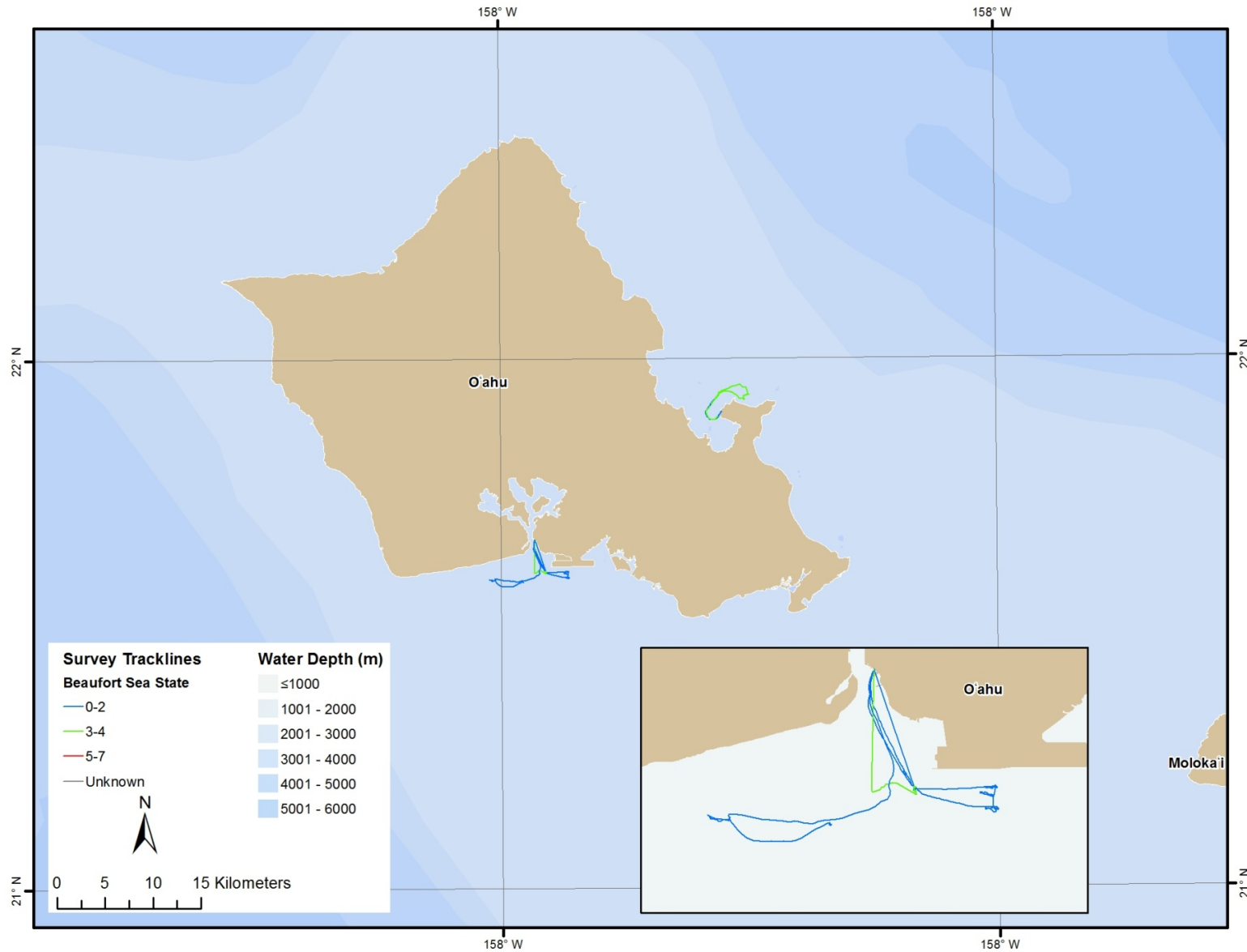


Figure C-1. Tracklines for U.S. Navy-conducted diver-turtle surveys at Pearl Harbor and Kaneohe Bay.

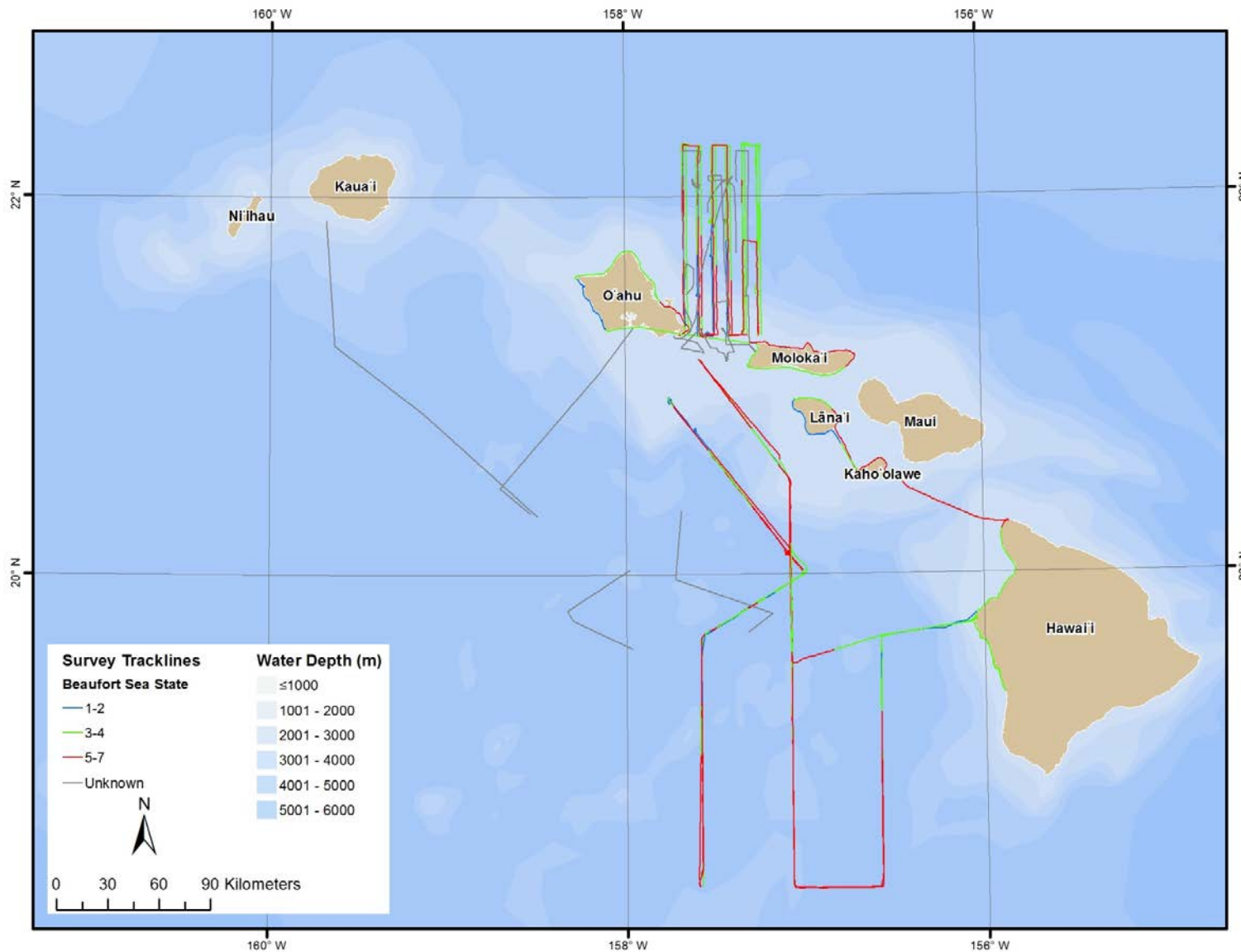


Figure C-2. Aerial and vessel tracklines for USWEX monitoring effort during November 2007, May 2008, and June 2008.

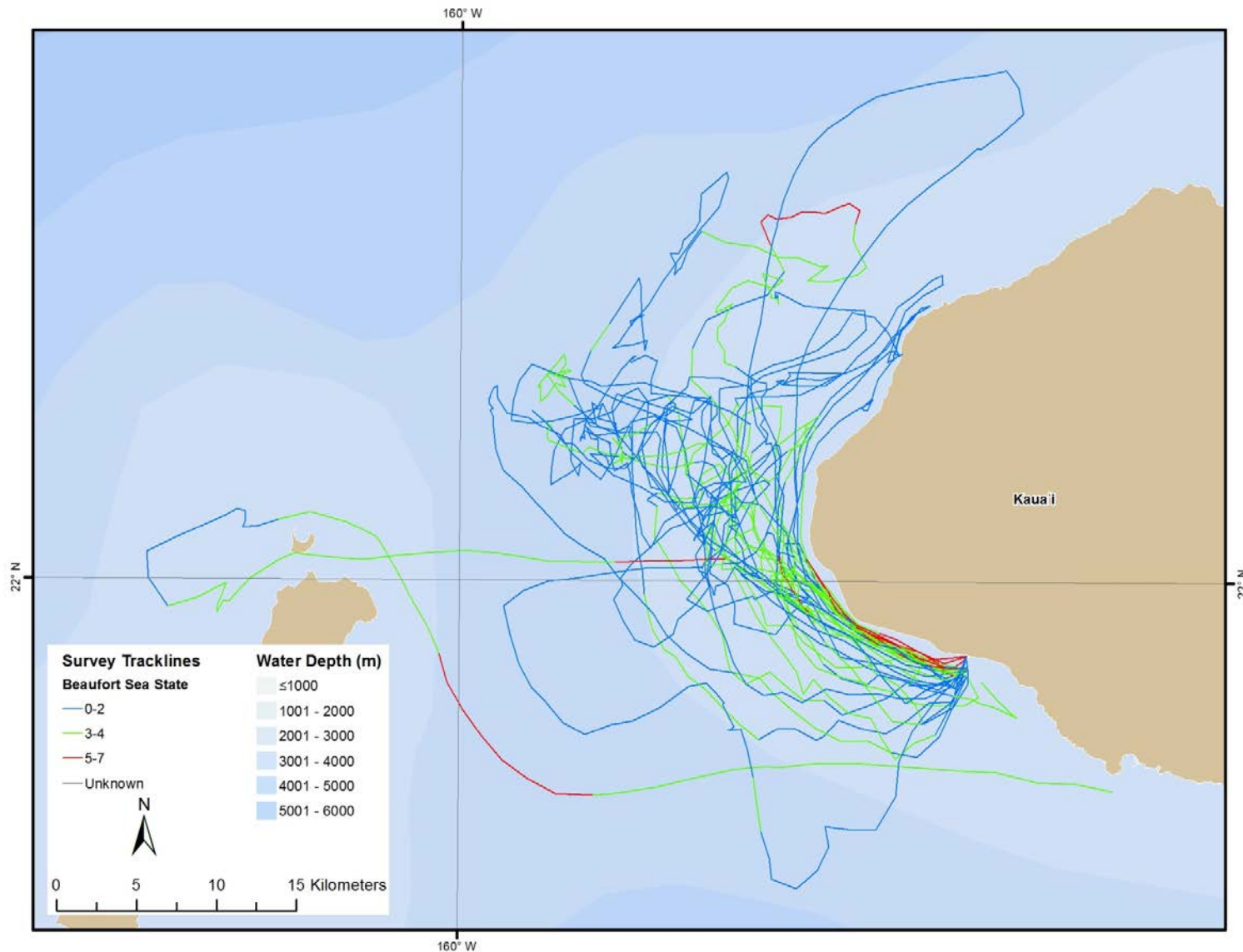


Figure C-3. Tracklines for tagging and photo-identification survey conducted during July-August 2011 (Baird et al. 2012a).

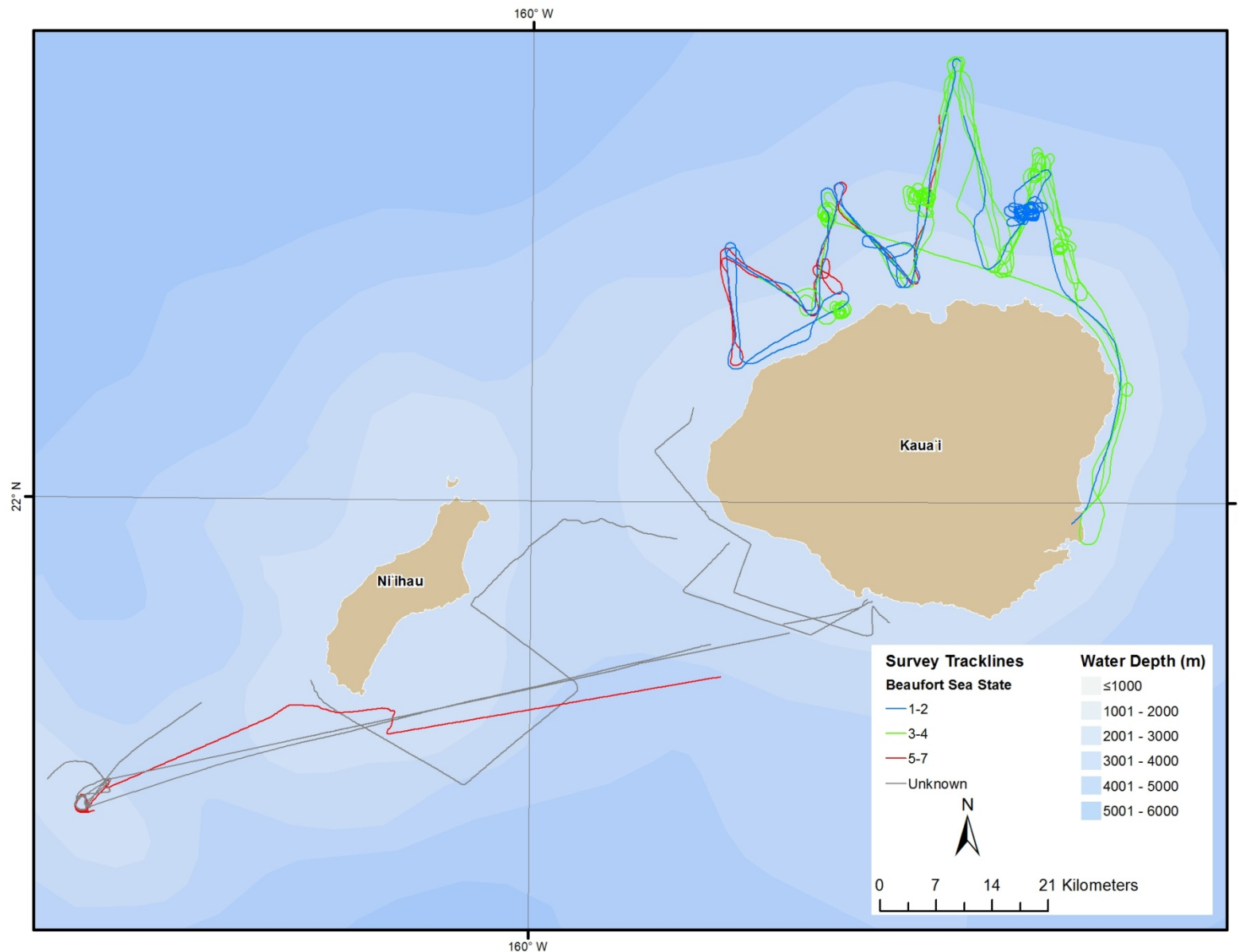


Figure C-4. Tracklines for Ka'ula monitoring effort and February 2011 Kaua'i tagging effort.

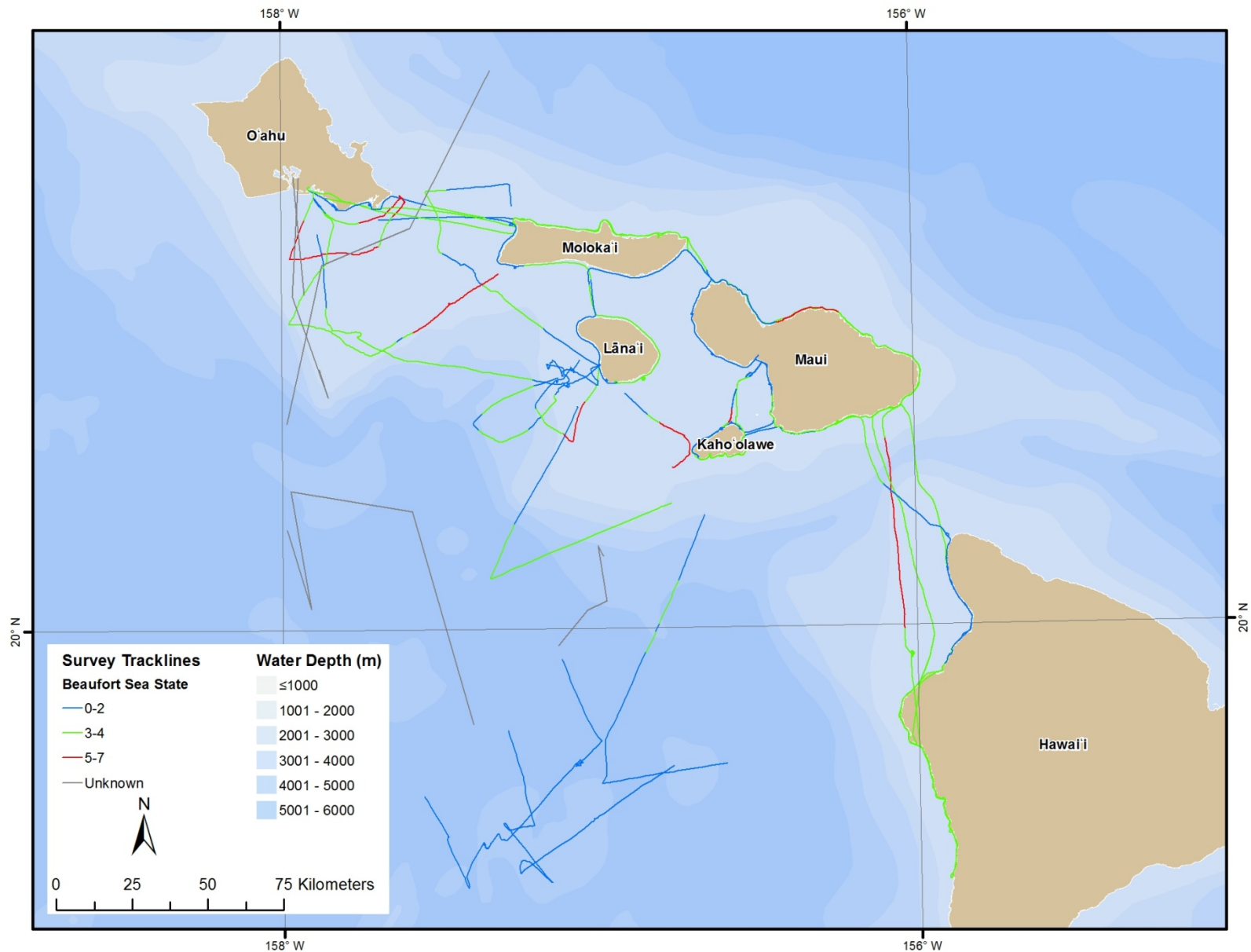


Figure C-5. Aerial and vessel tracklines for Koa Kai monitoring effort.

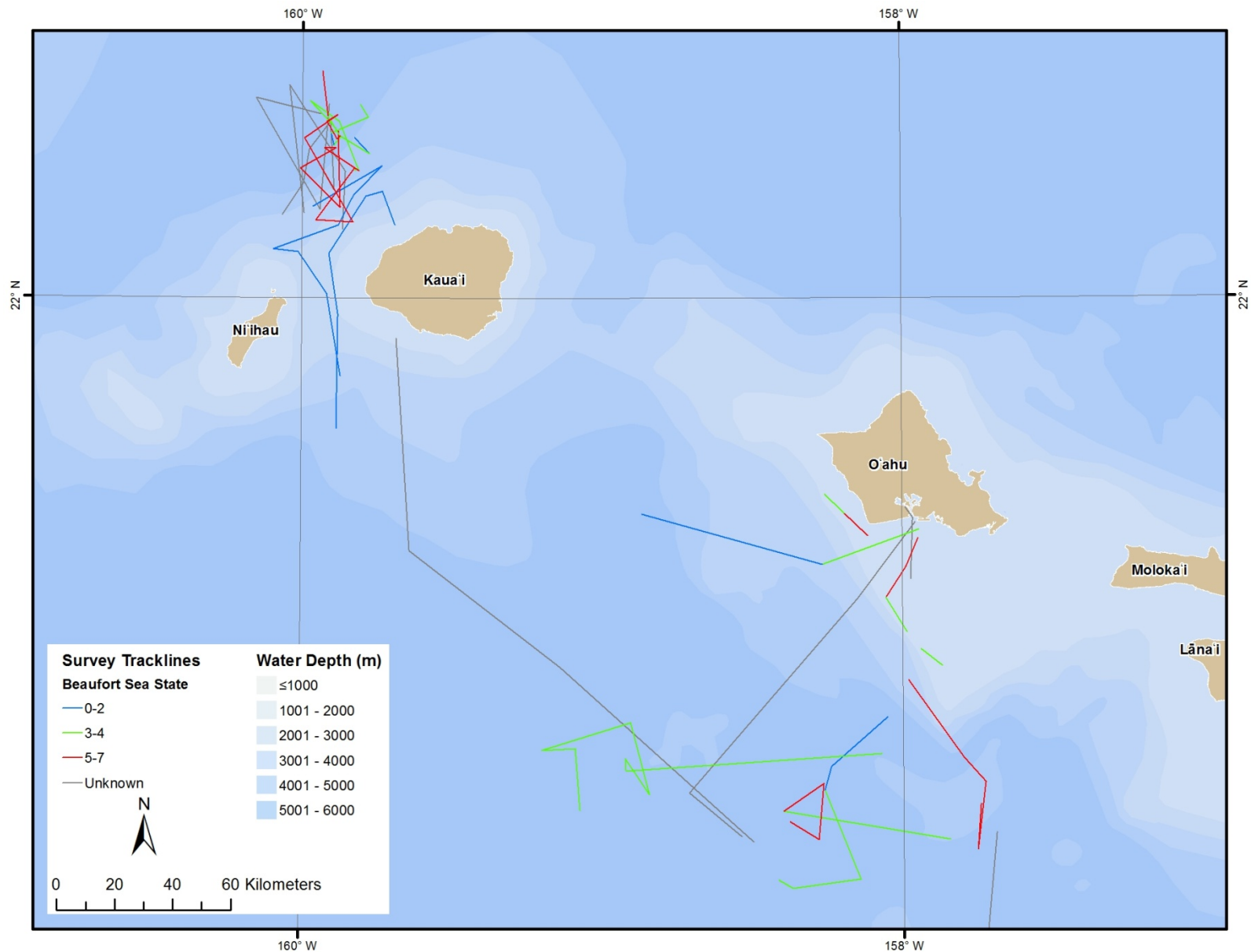


Figure C-6. Tracklines for LOE Study surveys.

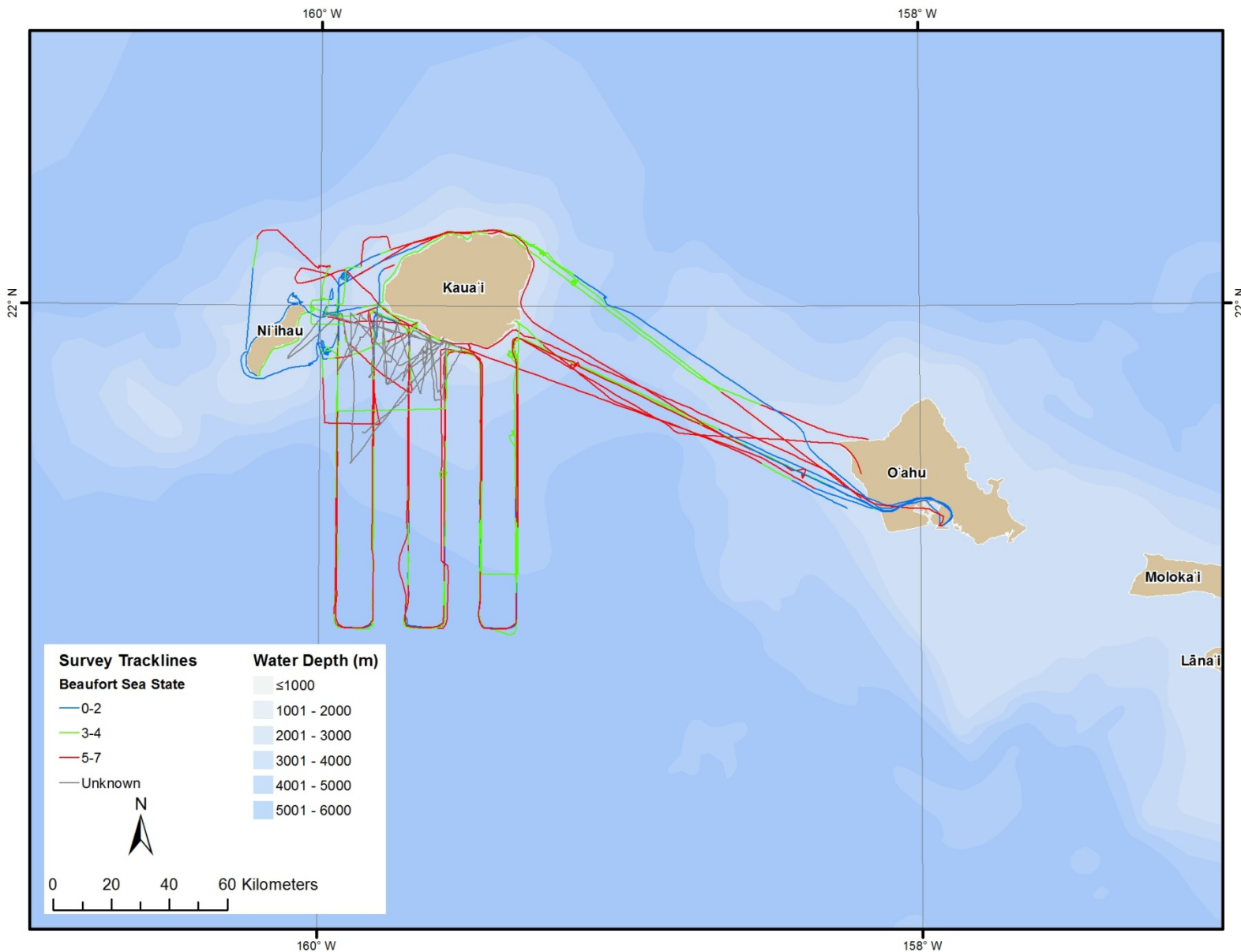


Figure C-7. Aerial and vessel tracklines for RIMPAC surveys conducted during 2008 and 2010.

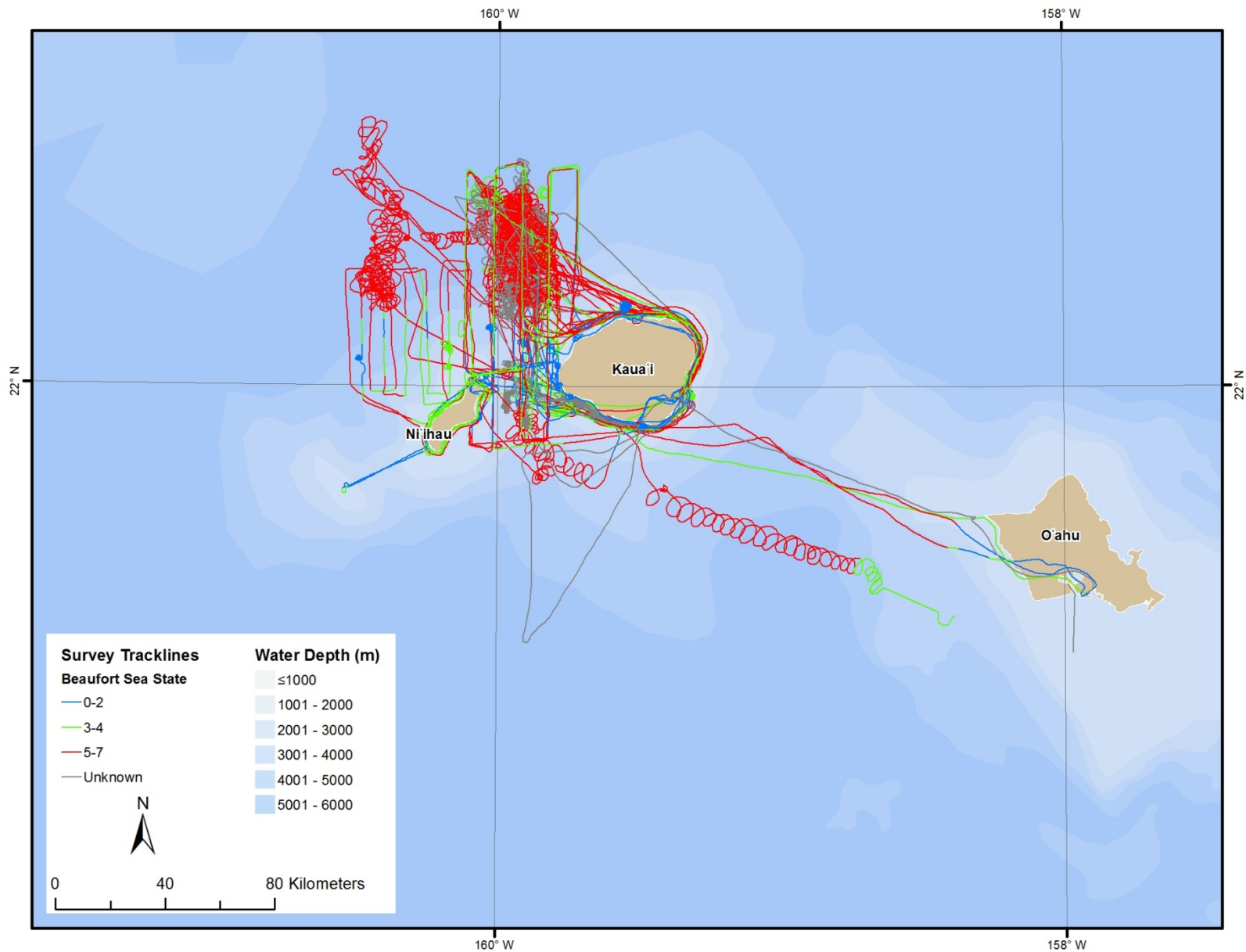


Figure C-8. Aerial and vessel tracklines for SCC surveys.

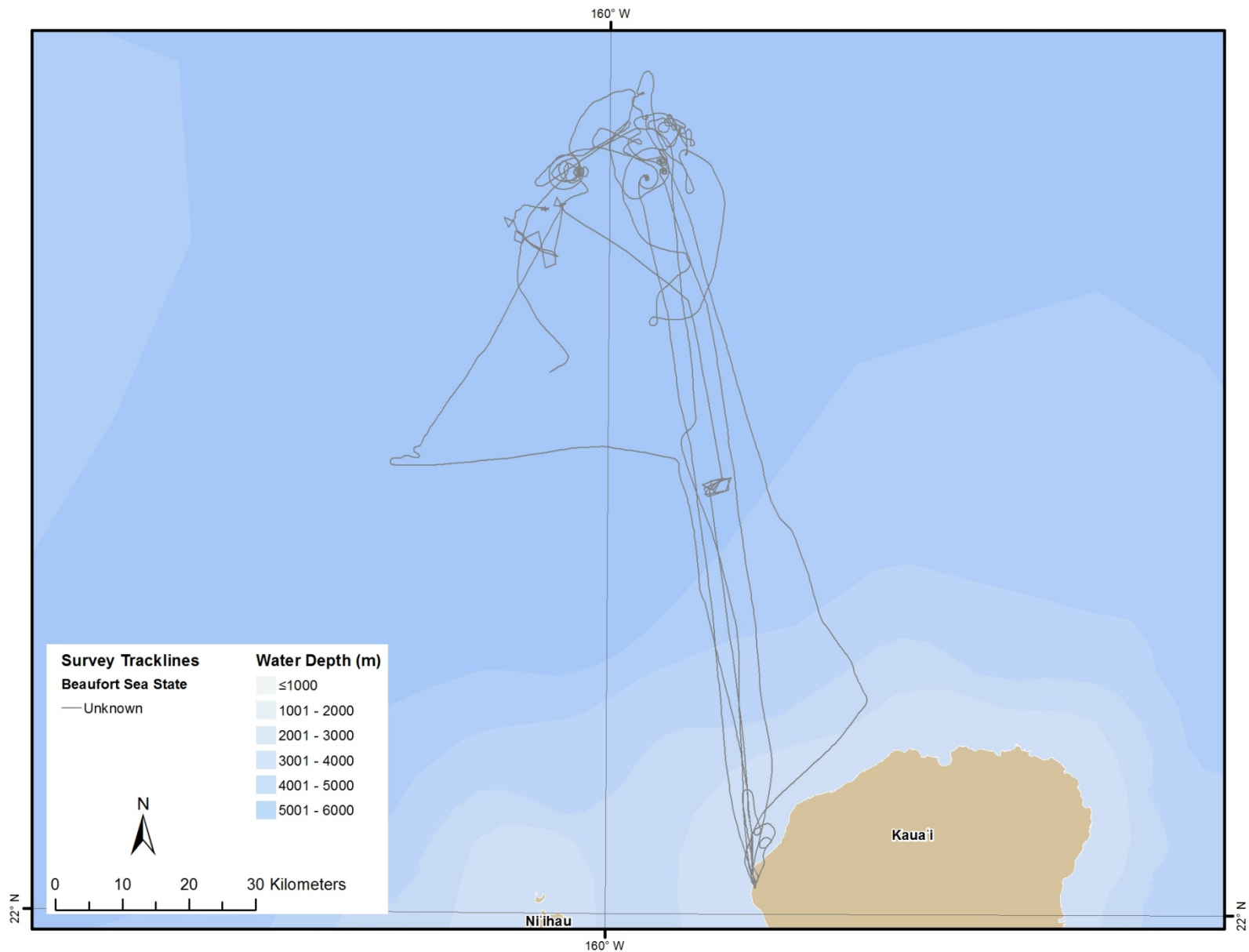


Figure C-9. Tracklines for SINKEX surveys.

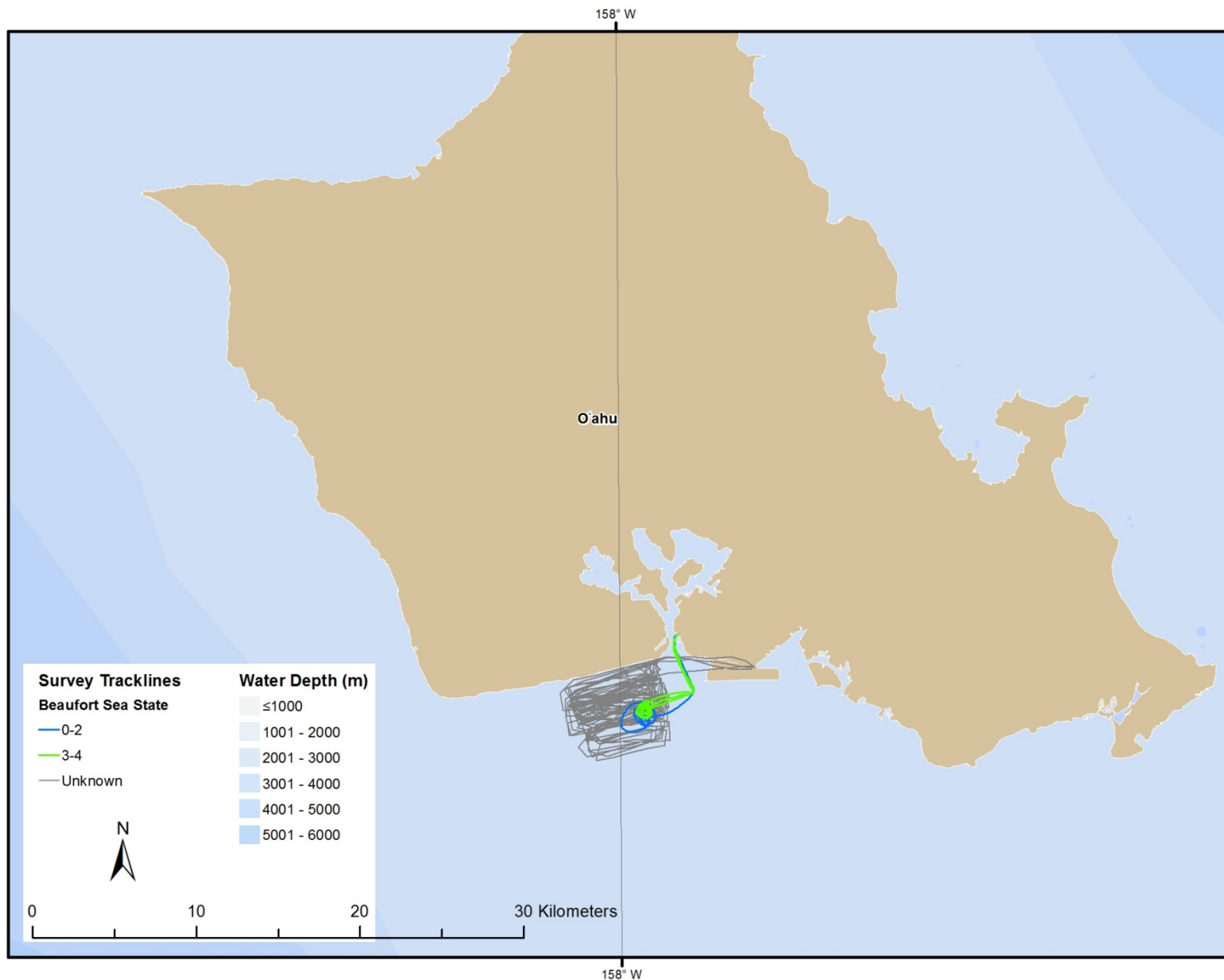


Figure C-10. Tracklines for UNDET surveys.

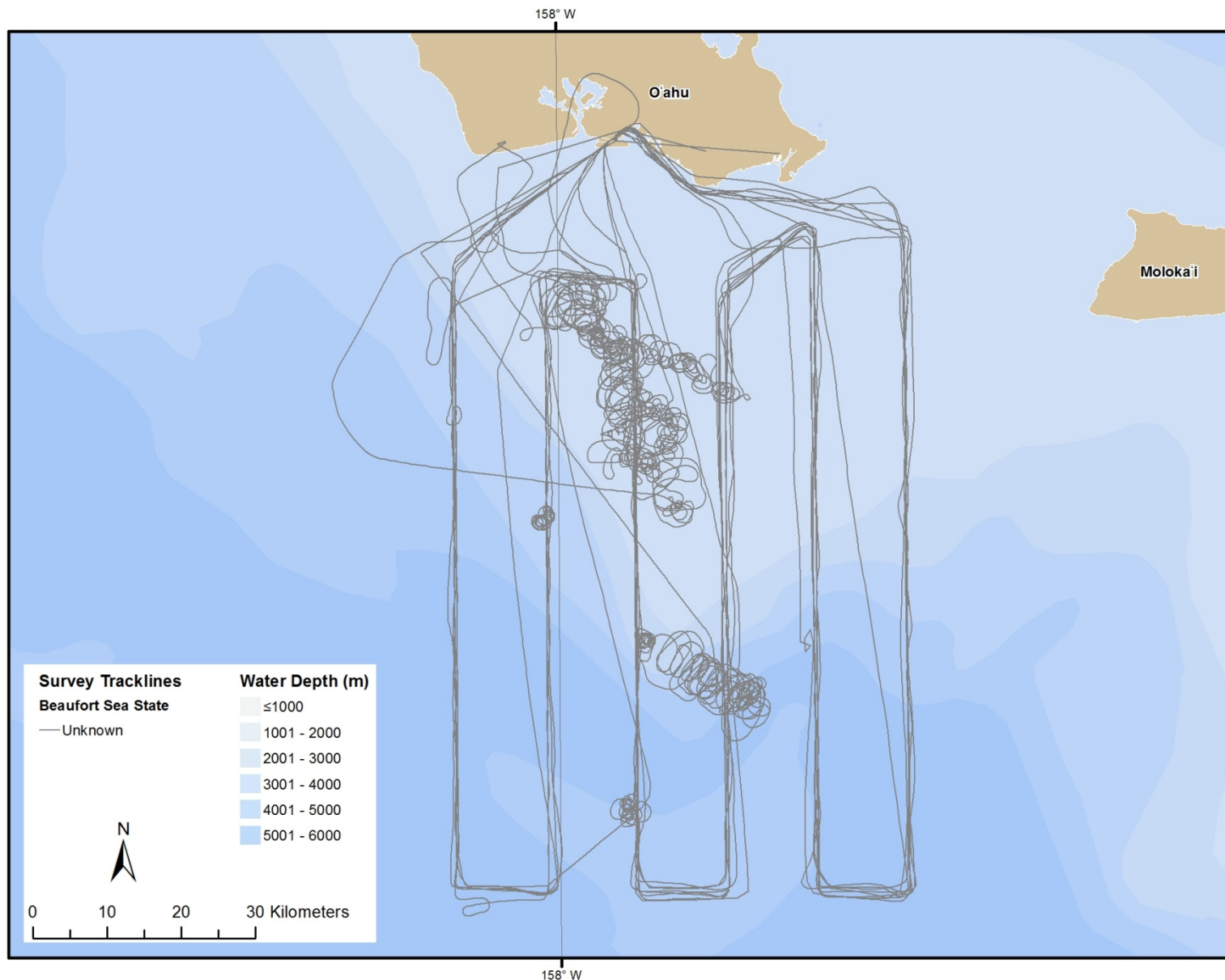


Figure C-11. Tracklines for ULT surveys.

APPENDIX D

Species Sightings Maps

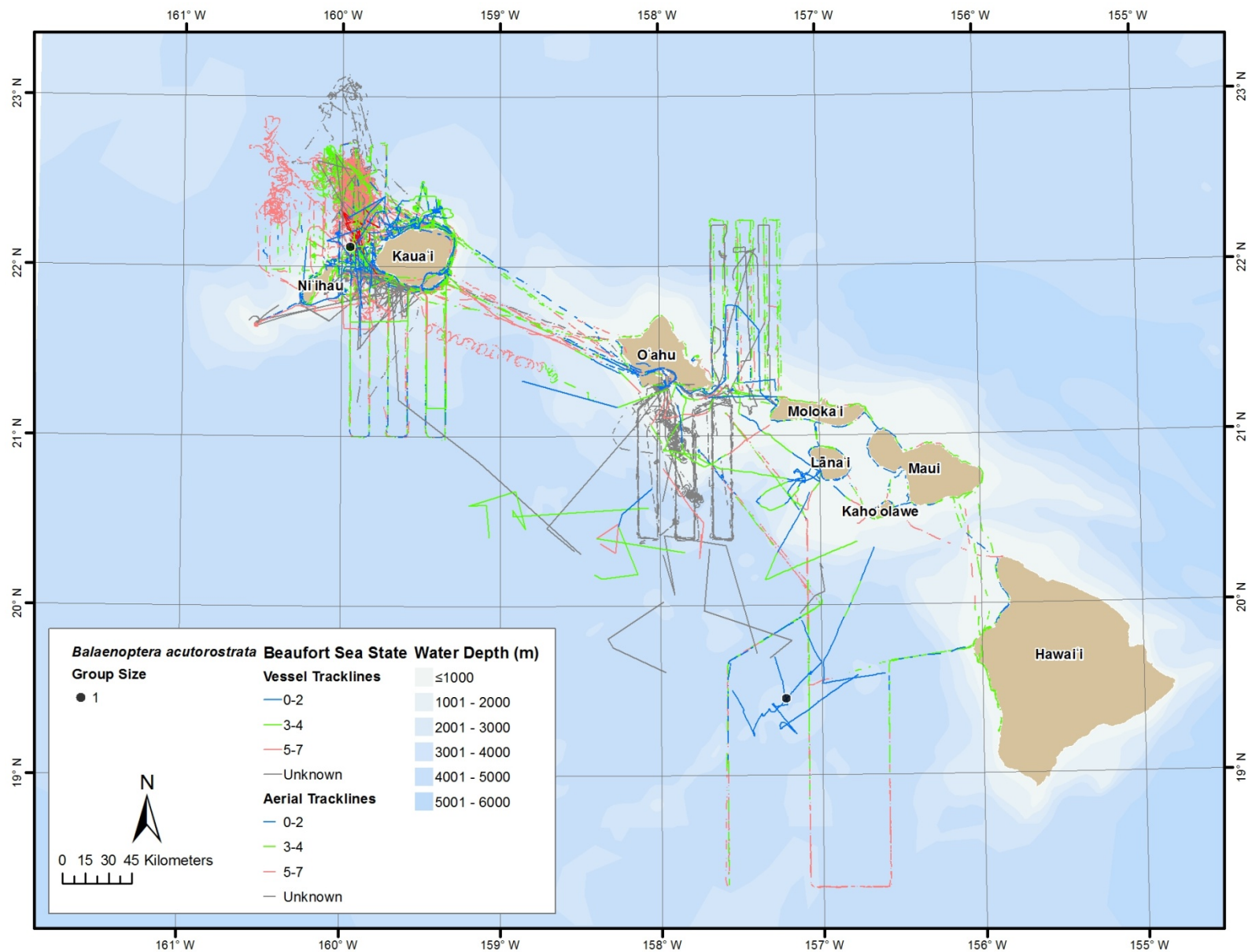


Figure D-1. Minke whale (*Balaenoptera acutorostrata*) sightings.

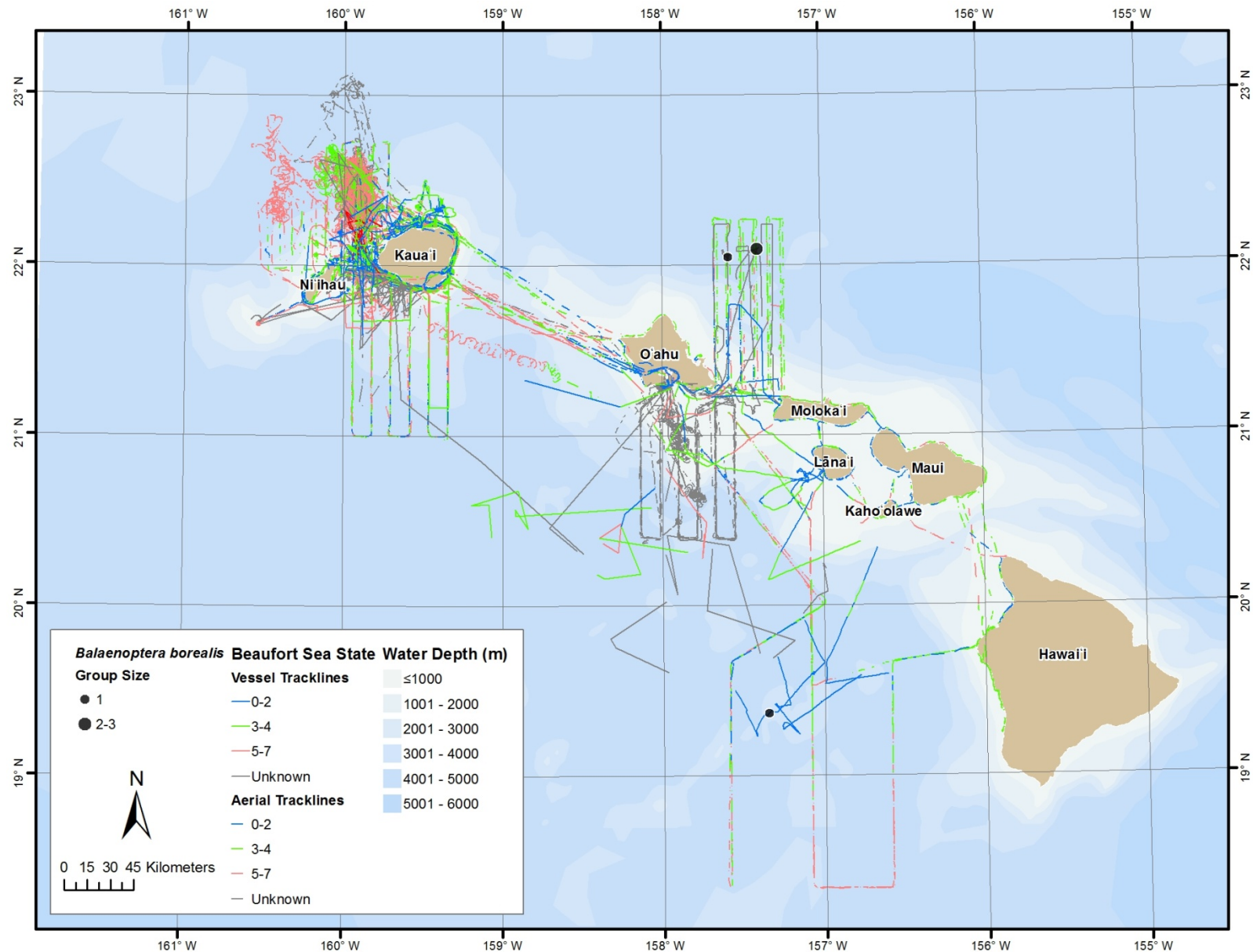


Figure D-2. Sei whale (*Balaenoptera borealis*) sightings.

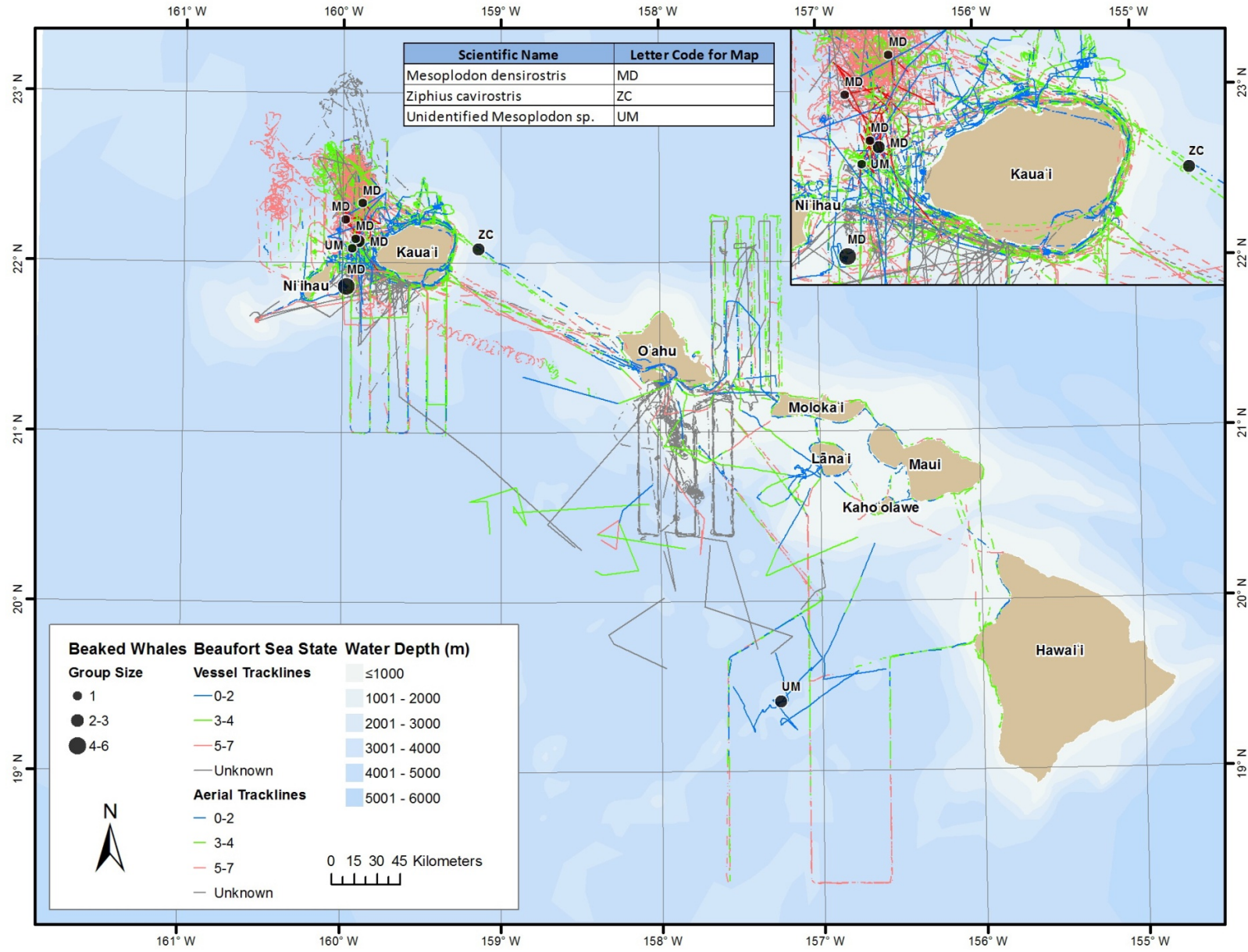


Figure D-4. Beaked whales (Family Ziphiidae) sightings.

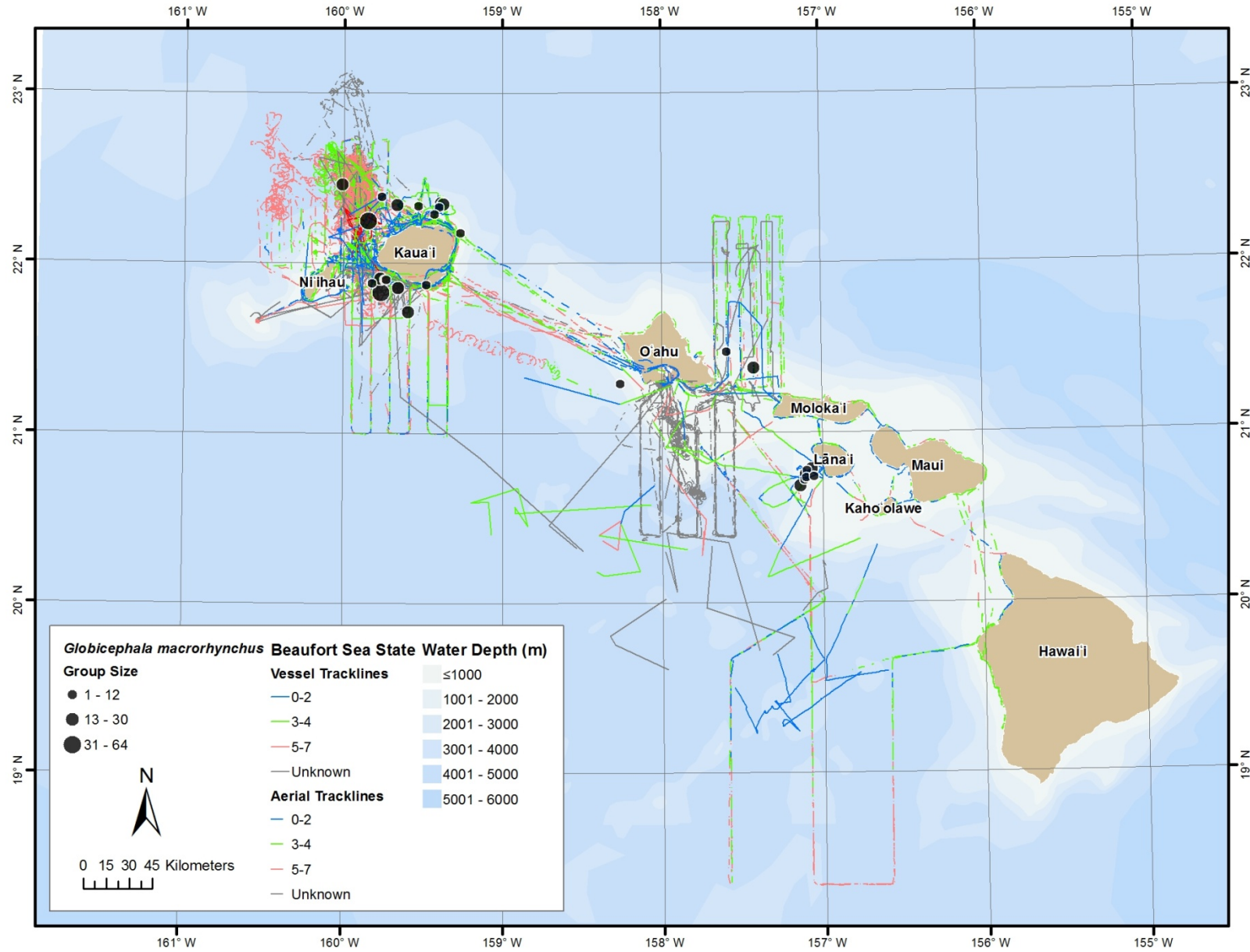


Figure D-5. Short-finned pilot whale (*Globicephala macrorhynchus*) sightings.

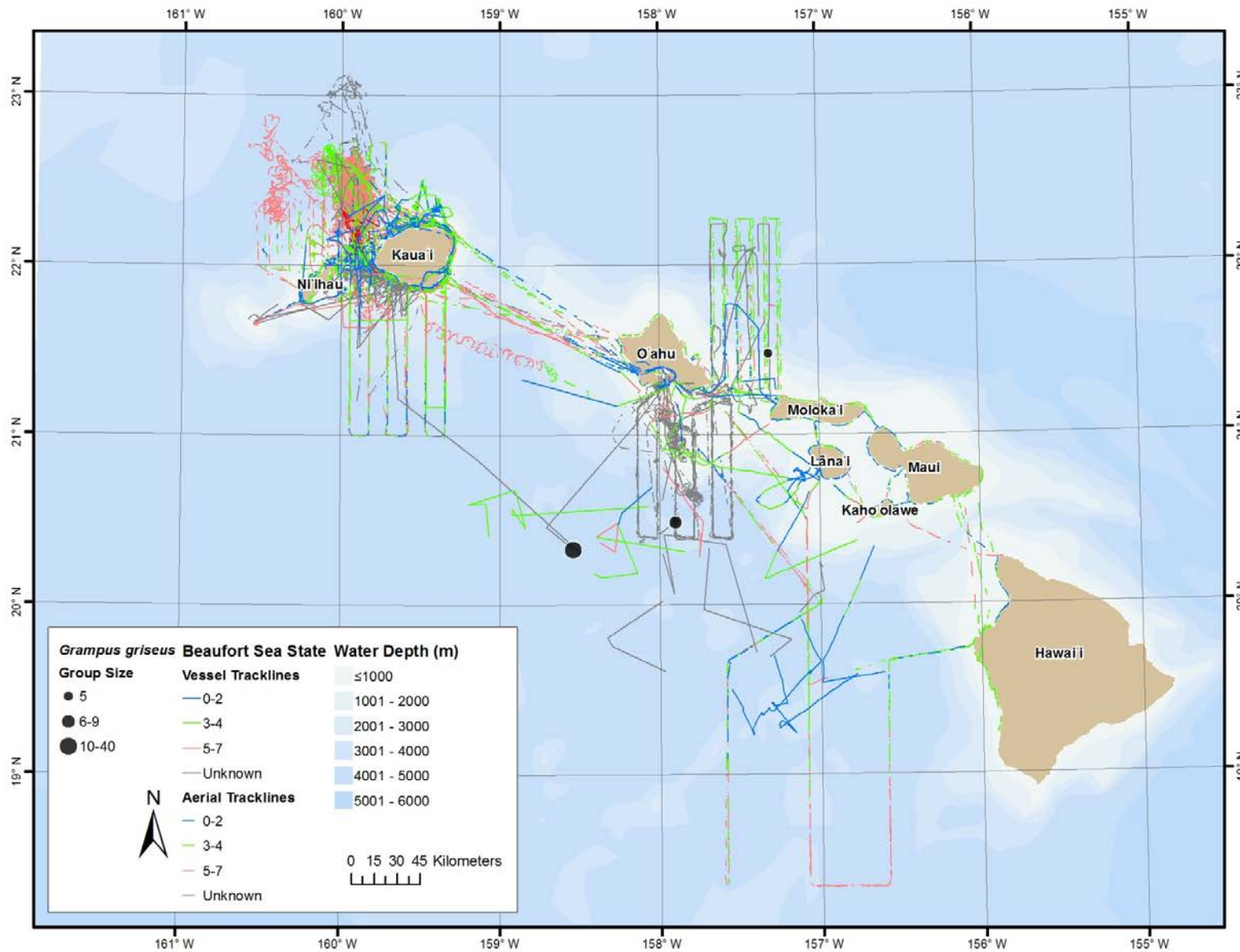


Figure D-6- Risso's dolphin (*Grampus griseus*) sightings.

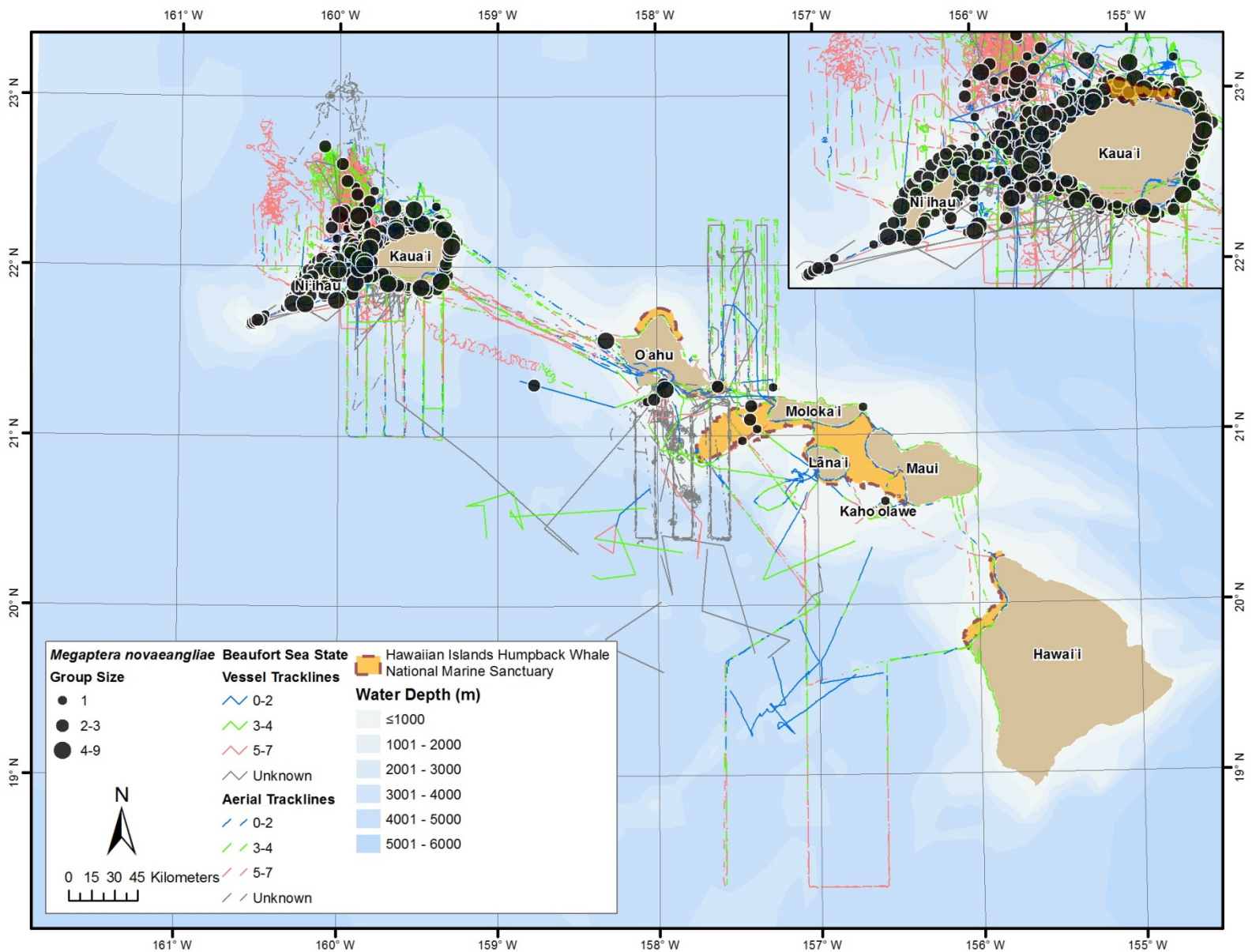


Figure D-7. Humpback whale (*Megaptera novaeangliae*) sightings.

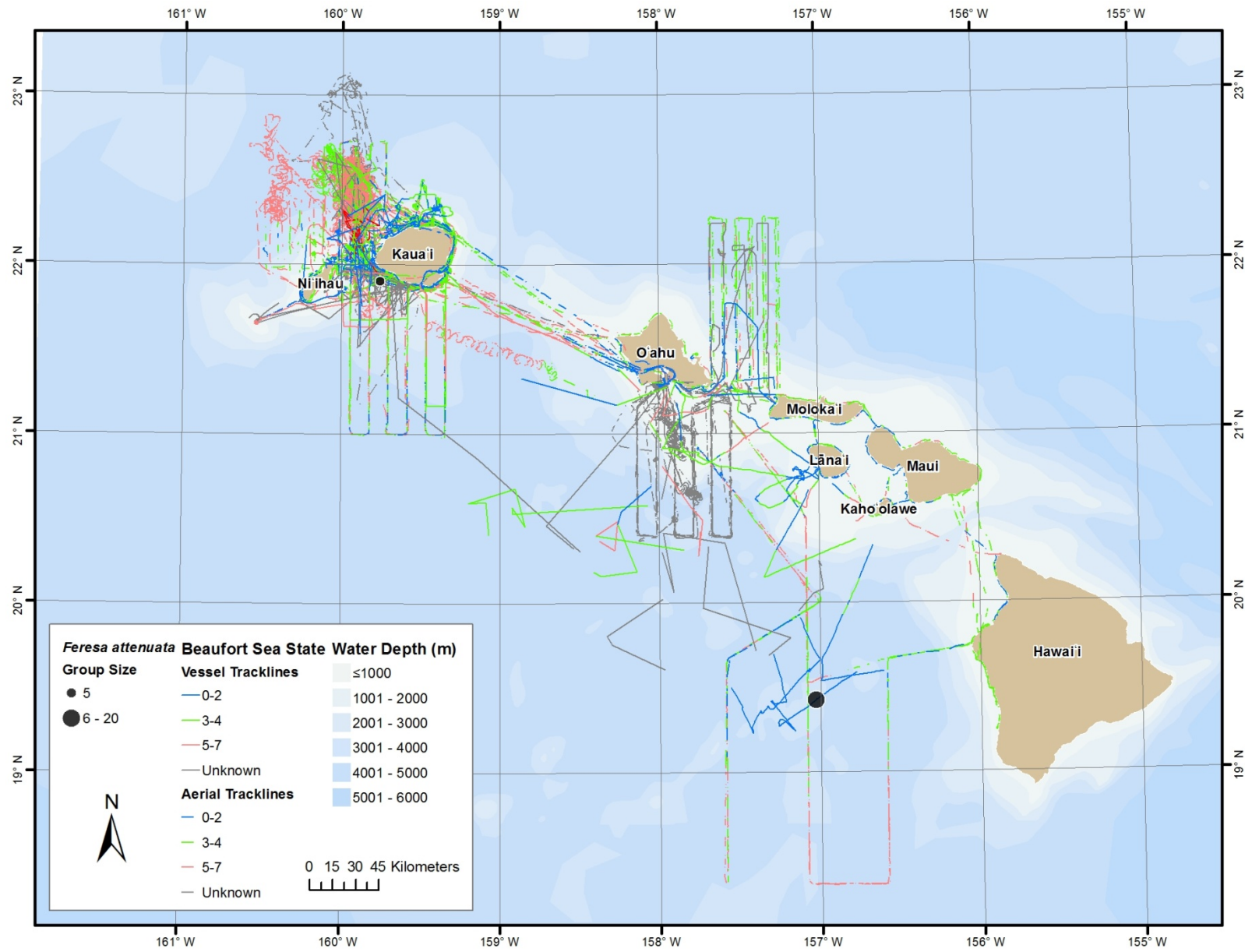


Figure D-8. Pygmy killer whale (*Feresa attenuata*) sightings.

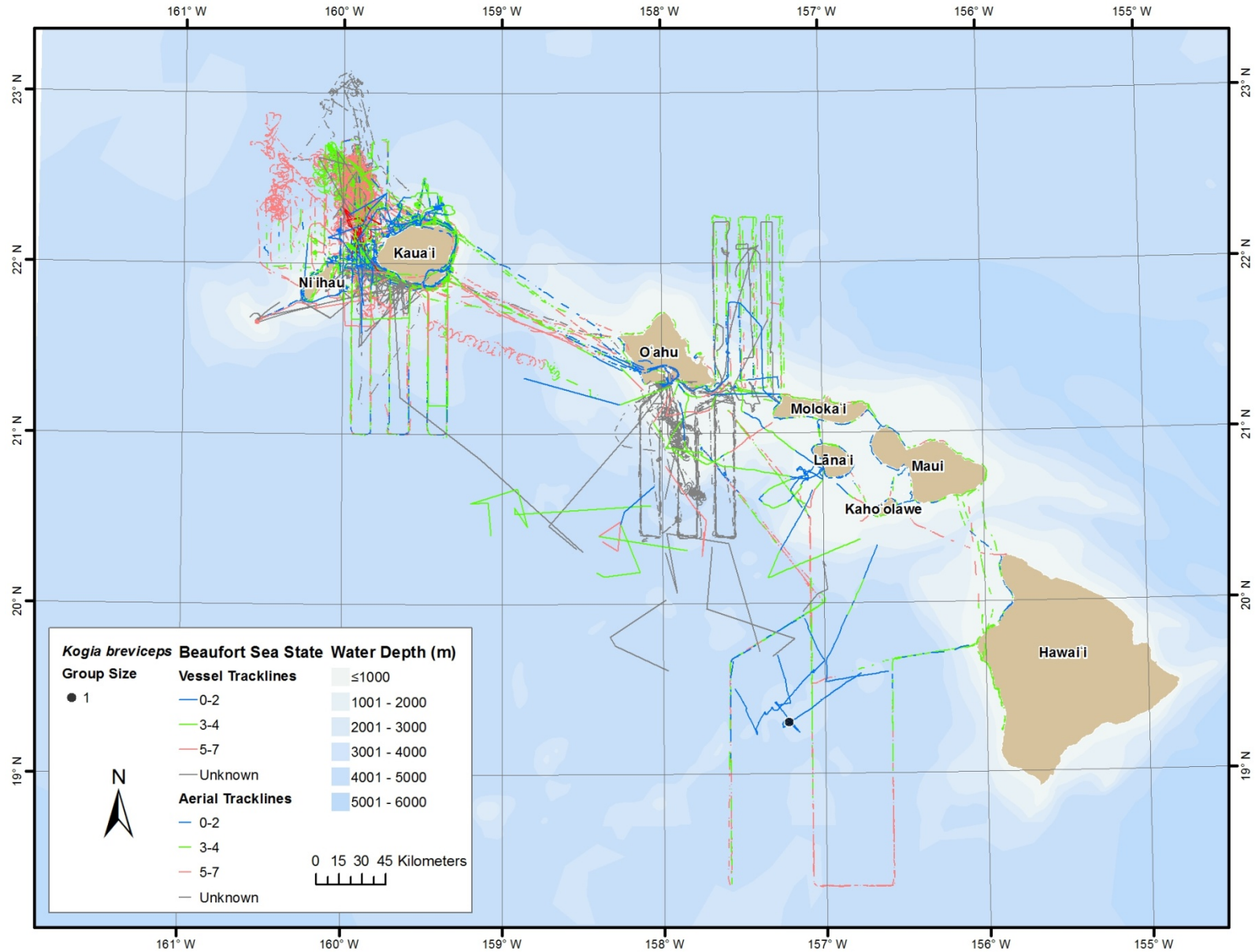


Figure D-9. Pygmy sperm whale (*Kogia breviceps*) sightings.

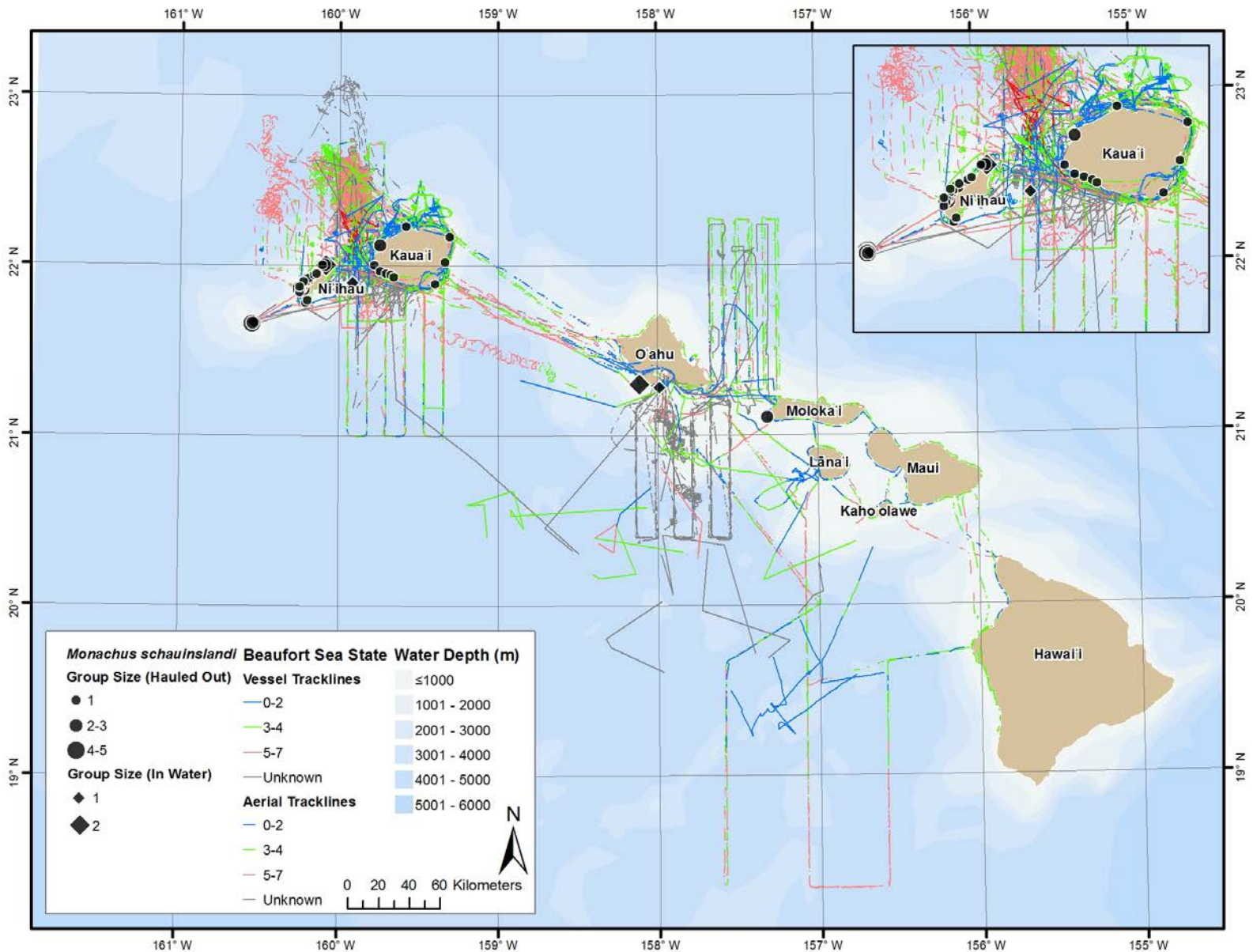


Figure D-10. Hawaiian monk seal (*Monachus schauinslandi*) sightings.

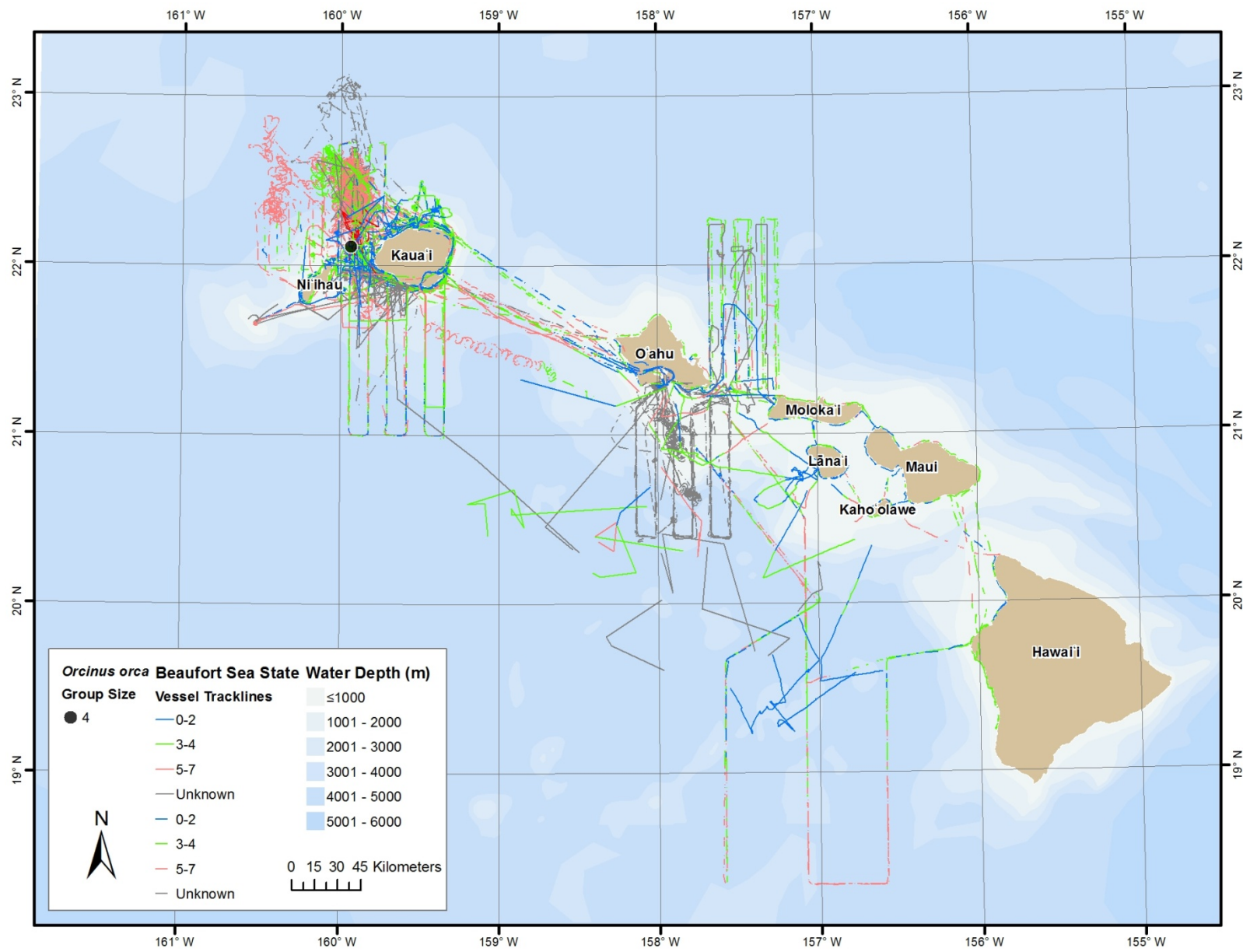


Figure D-11. Killer whale (*Orcinus orca*) sightings.

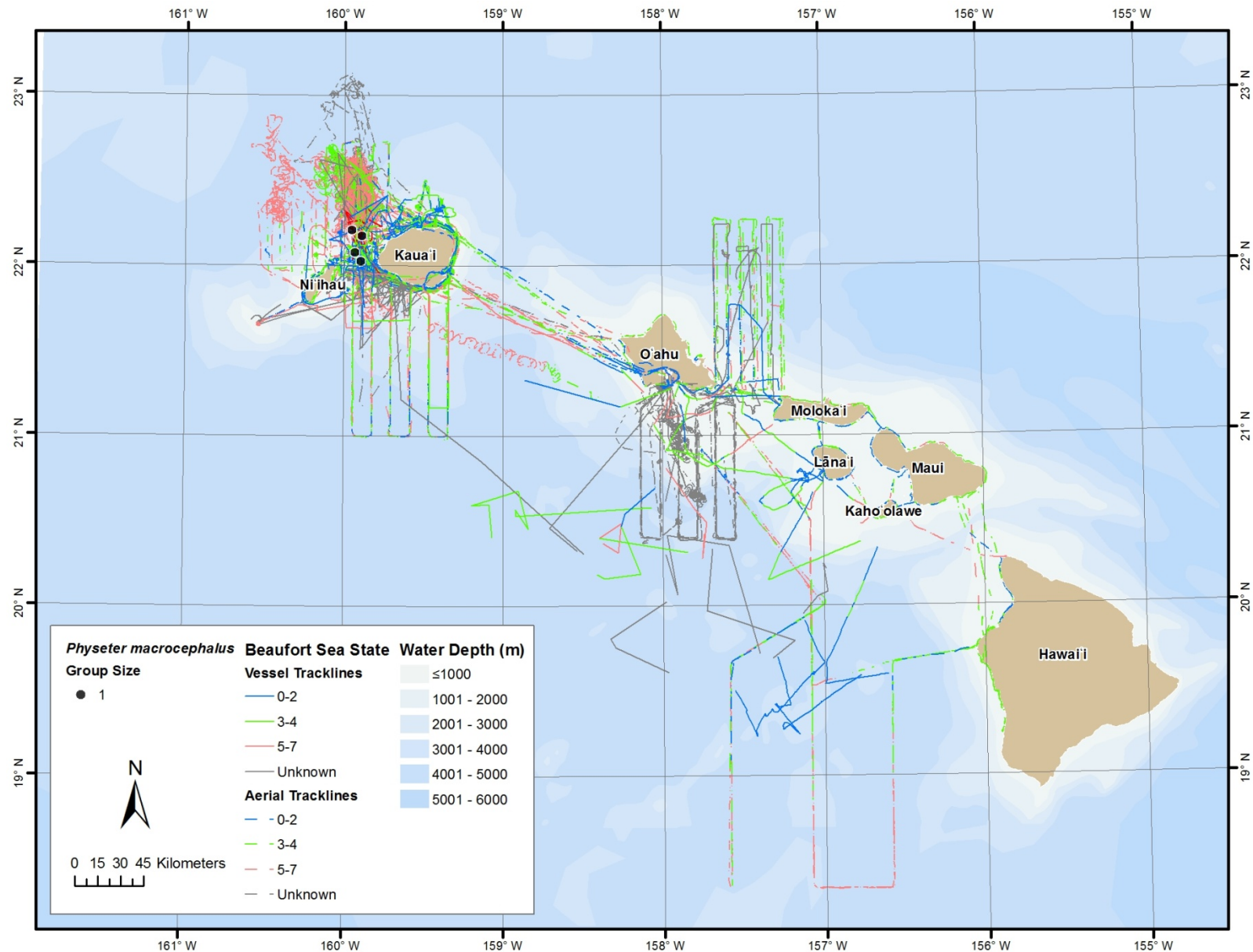


Figure D-12. Sperm whale (*Physeter macrocephalus*) sightings.

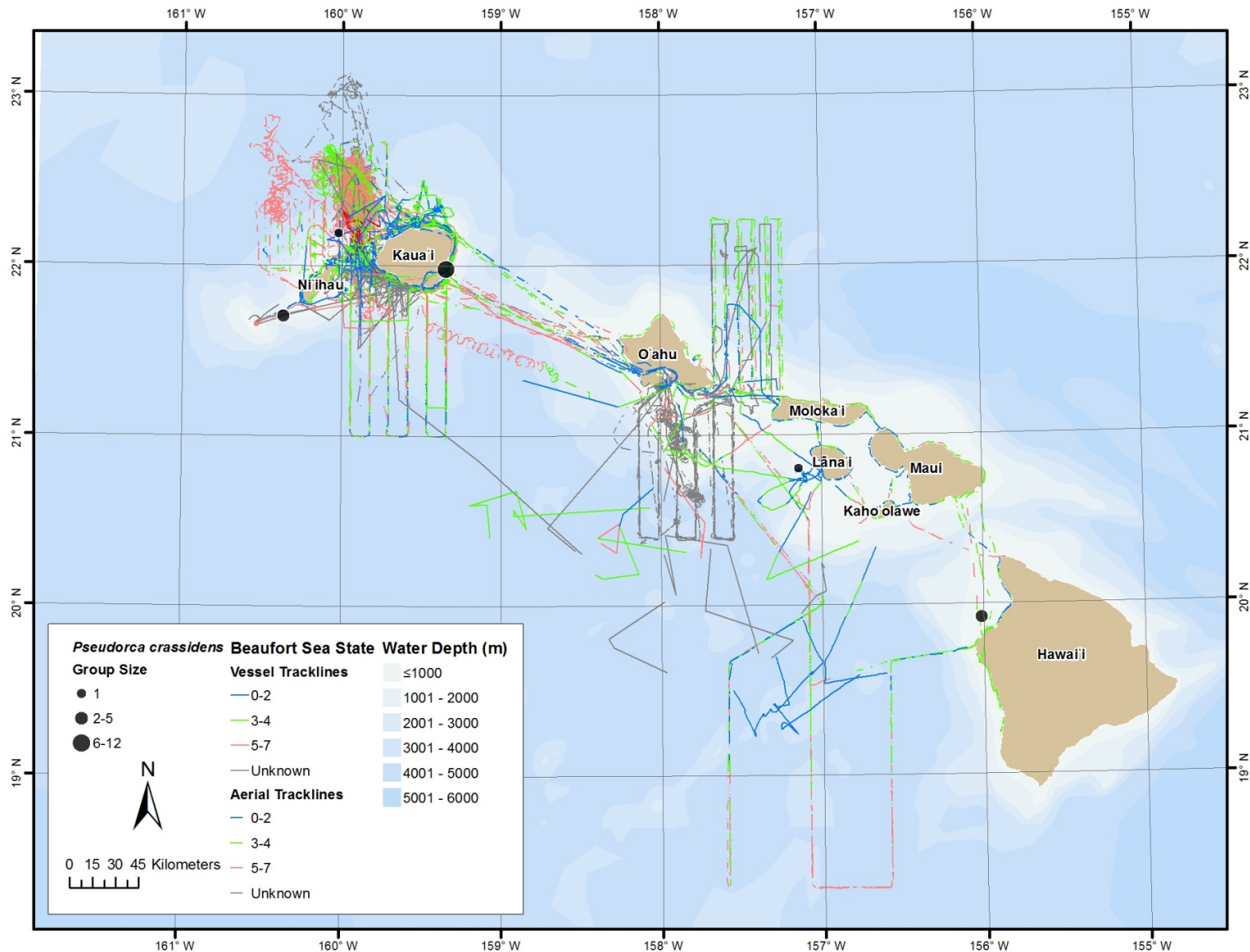


Figure D-13. False killer whale (*Pseudorca crassidens*) sightings.

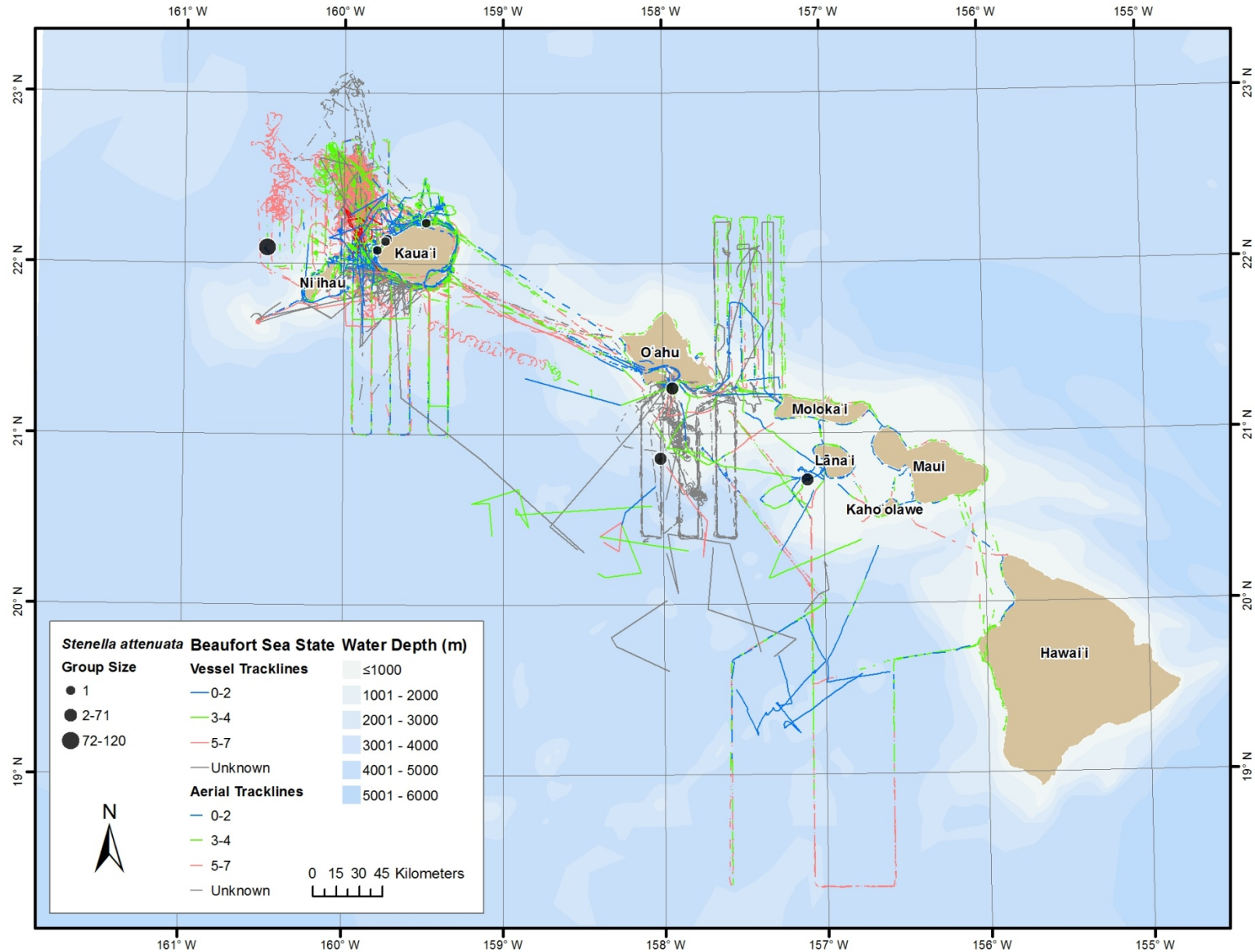


Figure D-14. Pantropical spotted dolphin (*Stenella attenuata*) sightings.

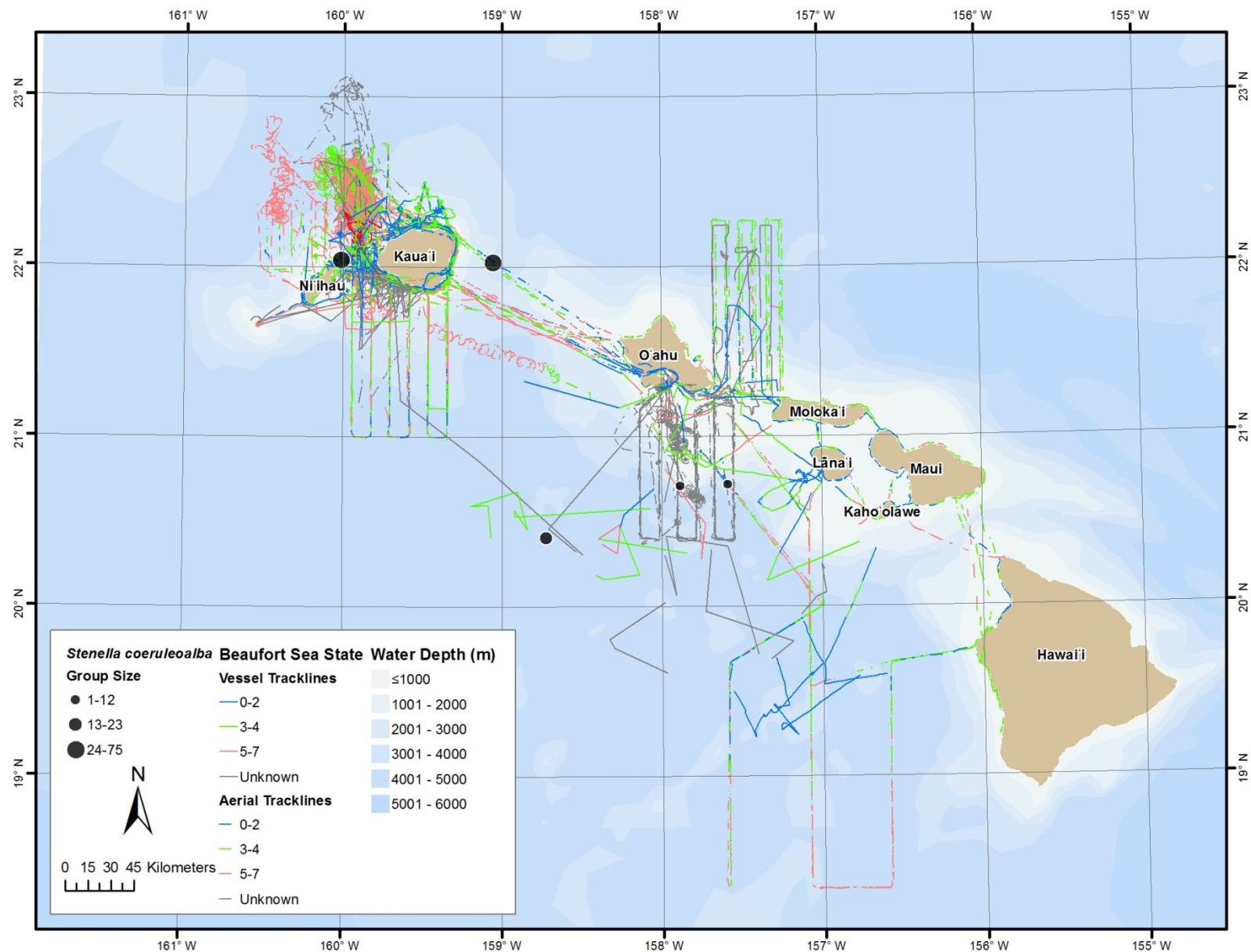


Figure D-15. Striped dolphin (*Stenella coeruleoalba*) sightings.

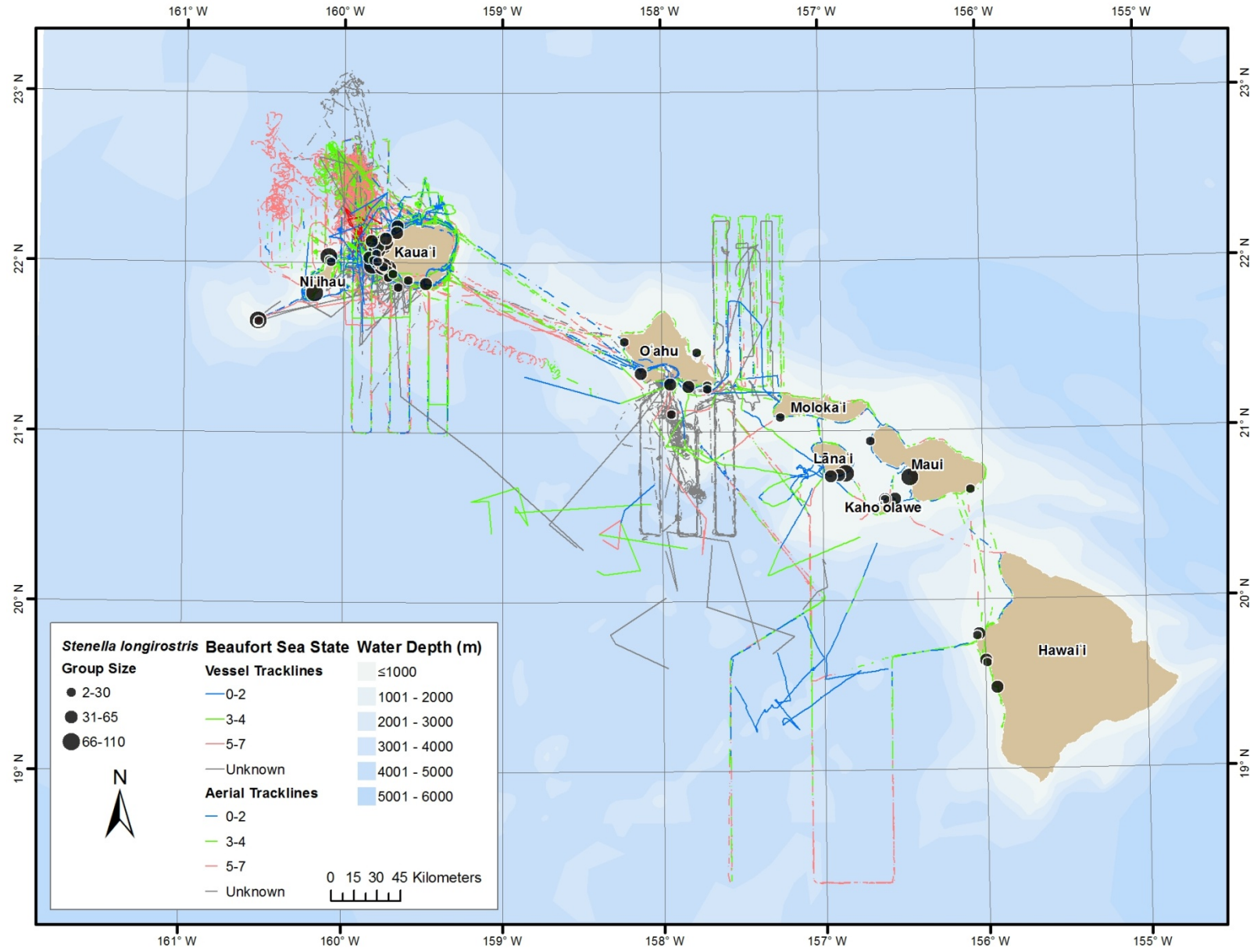


Figure D-16. Spinner dolphin (*Stenella longirostris*) sightings.

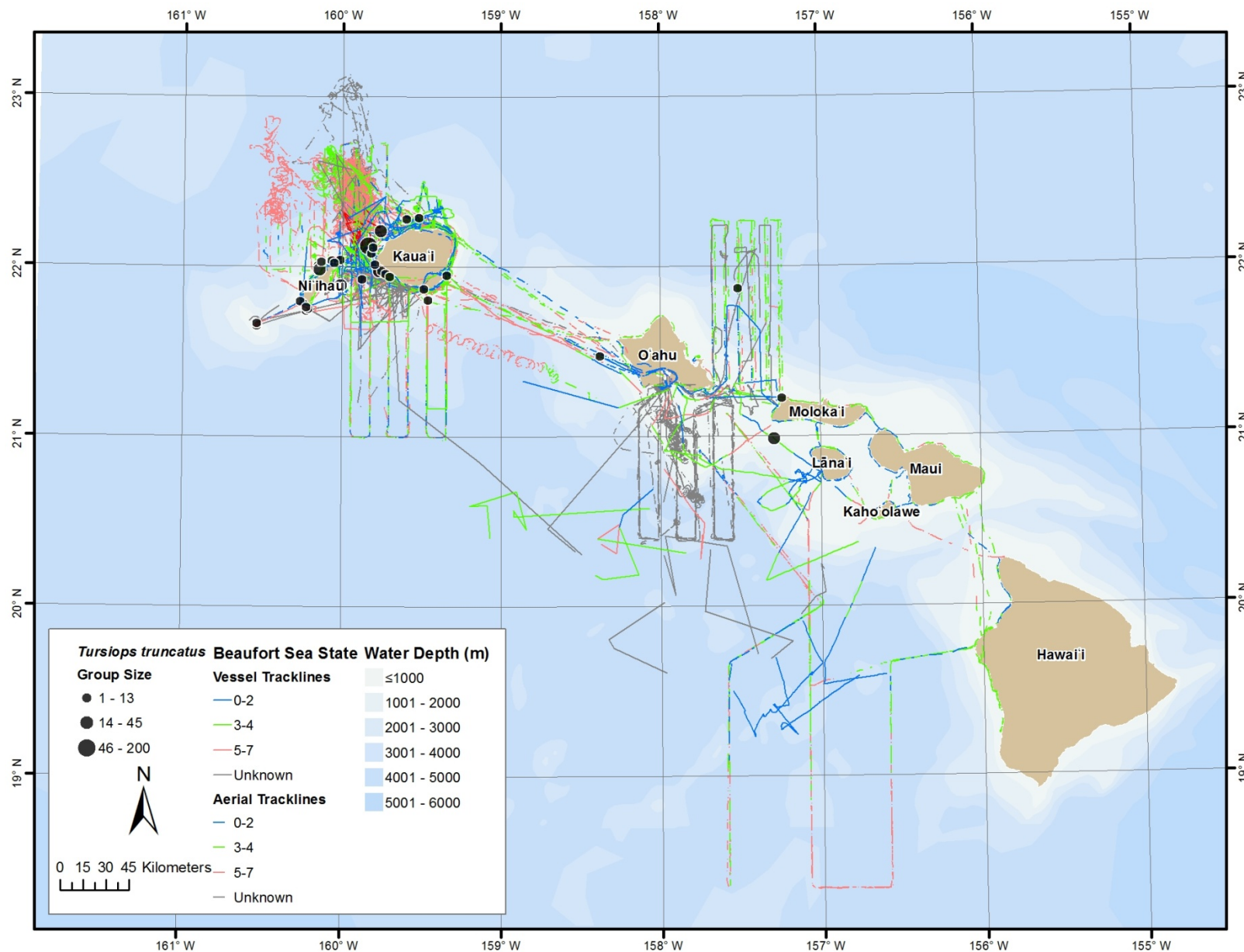


Figure D-18. Bottlenose dolphin (*Tursiops truncatus*) sightings.

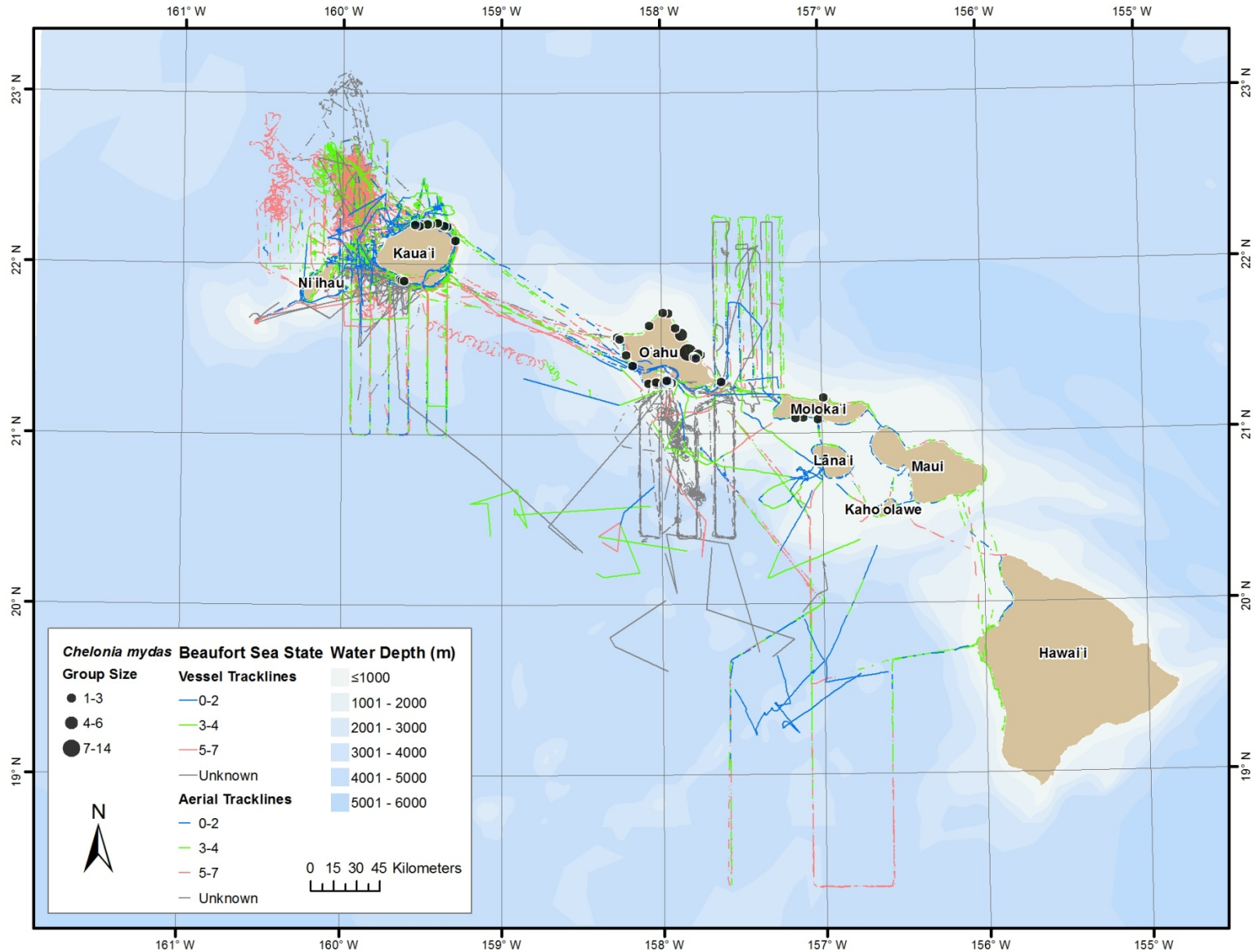


Figure D-19. Green turtle (*Chelonia mydas*) sightings.