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MARINE MAMMAL DATA COLLECTED DURING THE PACIFIC ISLANDS CETACEAN AND ECOSYSTEM ASSESSMENT SURVEY (PICEAS) CONDUCTED ABOARD THE NOAA SHIP *McARTHUR II*, JULY - NOVEMBER 2005

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NOAA-TM-NMFS-SWFSC-420

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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INTRODUCTION

This report documents the first comprehensive survey of cetaceans in the U.S. Exclusive Economic Zones (EEZ) surrounding Palmyra Atoll & Kingman Reef, the U.S. EEZ surrounding Johnston Atoll, and in the adjacent international waters south of the Hawaiian Islands. The survey was conducted from 28 July to 29 November 2005 using the 62-m NOAA R/V *McArthur II*. This survey complements similar marine mammal assessment surveys in U.S. EEZ waters of the West Coast of the contiguous United States (Von Saunder and Barlow 1999, Appler et al. 2004) and Hawaii (Barlow et al. 2004).

SURVEY OBJECTIVES

The primary goal of this expedition was to estimate the abundance and distribution of all cetaceans in the region south of the Hawaiian EEZ, where the U.S. longline fleet fishes. The primary focal species for this cruise was the false killer whale (*Pseudorca crassidens*), because the bycatch of this species in the U.S. longline fishery for tuna may not be sustainable (Carretta et al. 2006). We used a line-transect survey design with visual and passive acoustic detection methods. Concurrent with these cetacean surveys, the expedition participants collected oceanographic data, seabird sighting data, as well as other forms of biological data, to contribute to a more thorough understanding of the habitat of cetaceans in these waters. Oceanographic data from this survey will be summarized in a separate report.

ITINERARY

The survey began in San Francisco, ended in San Diego, and was composed of five legs. The first and last legs were 11-d transits from California to Hawaii and back to California. The survey within the study area included three 30-d legs. The itinerary is below:

Leg 1: Depart 28 July San Francisco, CA	Arrive 08 August Honolulu, HI
Leg 2 – Depart: 11 August Honolulu, HI	Arrive: 09 September Honolulu, HI
Leg 3 – 13 September Honolulu, HI	Arrive: 11 October Honolulu, HI
Leg 4 – 17 October Honolulu, HI	Arrive: 15 November Honolulu, HI
Leg 5 – Depart: 19 November Honolulu, HI	Arrive: 29 November San Diego, CA

SCIENTIFIC PERSONNEL

The scientific complement per leg included 13 to 14 scientists. The Appendix lists the scientists and survey legs on which they participated.

EQUIPMENT AND PROCEDURES

Visual Line-Transect Survey

The visual component of this cetacean survey was conducted using line-transect methods (Buckland et al. 2001) that have been used consistently by the Southwest Fisheries Science Center (Kinzey et al. 2000). These methods required the survey vessel to follow predetermined tracklines at a cruising speed of approximately 10 kts (through-the-water).

This is close to the maximum speed of the *McArthur II*, so the speed-over-ground (SOG) varied with the currents. As the ship traveled along the trackline, a team of marine mammal observers maintained a watch for marine mammals when visibility and weather conditions allowed. This watch was stationed on the flying bridge of the ship at a height of approximately 15.2 m above water. Observers used Fujinon[1] 25x150 power pedestal-mounted binoculars to scan the area forward of the ship's beam.

The survey tracklines for the expedition were designed to systematically cover the waters within the study area (Fig. 1). To avoid surveying at right angles to or directly into the dominant swells (generated by the northeasterly to easterly trade winds), the survey was designed with a series of parallel transect lines oriented in a NNE to SSW direction. The location of a baseline was selected by choosing a random latitude along a chosen longitude, and the primary transect lines were parallel to this baseline and were spaced ~111 km (60 nmi) apart. Initially, the survey was designed with three strata, each with a uniform density of survey effort. The U.S. EEZ of Palmyra Atoll & Kingman Reef (henceforth the Palmyra EEZ) and the U.S. EEZ of Johnston Atoll (henceforth the Johnston EEZ) were designed to receive twice the density of survey effort as the third stratum (the international waters in the remainder of the study area). This was accomplished by establishing a set of "in between" transect lines midway between the primary transect lines within these EEZ areas. After Leg 2, it became obvious that, given the loss of sea days due to weather in this area, we would not be able to complete the original design. The "in-between" lines were dropped from the Johnston EEZ and only the Palmyra EEZ received a higher density of survey effort. Completed transect lines are shown in Figure 1.

There were three marine mammal observer stations: a data recording station in the center of the flying bridge with a forward view from beam to beam, and port and starboard binocular stations, where the 25x150 binoculars were mounted such that there were clear fields of view from 90˚ directly abeam the ship to 10º across the opposite bow. Observers obtained sighting angles from an azimuth incorporated into the mount of the 25X binoculars. This azimuth was calibrated to zero along the ship's midline. The observers entered a watch rotation at the port binocular station and, during a 120-minute watch, moved to the center recorder station, then finally to the starboard binocular station, such that 40 minutes were spent at each location. The center observer scanned the full 180˚ forward of the beam using unaided eye and (occasionally) 7x50 binoculars.

This rotation was continued through all daylight hours when weather conditions allowed (generally when it was not raining and when Beaufort sea states were six or calmer). At the discretion of the cruise leader, a fourth, independent observer searched from the flying bridge using 7x50 binoculars and unaided eye. The independent observer did not announce the presence of marine mammals until after they had passed abeam and had been clearly missed by the primary observation team.

[1] Mention of brand names does not imply endorsement by the National Marine Fisheries Service.

The act of scanning for marine mammals while moving along the trackline is termed "effort", and observers on watch were considered "on-effort" when the observer team determined that conditions were adequate for sightings. Cues or other information about possible sightings noted by off-effort individuals were not shared with on-effort observers.

The watch team typically went off-effort following a sighting of cetaceans that were within three nmi of the trackline, and directed the ship to approach the animals for species identification and group size estimation. This mode of survey (where the ship approaches the animals) is called "closing mode". Each on-duty observer independently estimated group sizes (recorded as their "best", "high" and "low" estimates of the total number of animals) and their estimates of the percentages of each species in the group. For some species, if conditions were appropriate, small boats were then launched to obtain biopsy samples for genetic analysis and photographs for photo-identification. Sightings of new animals made while closing on an existing sighting were recorded as "off-effort sightings." Search effort was maintained in normal "closing mode" on Legs 1 and 5 during the transits to and from Hawaii. Search effort was typically in "passing mode" (where the ship did not depart from the transect line to approach animals) during the transits between Honolulu and the PICEAS study area on Legs 2, 3 and 4.

After observers obtained groups size estimates and any small boat operations concluded, the ship would generally resume effort on a parallel course to the trackline. If the ship had strayed more than five nmi from the trackline in pursuing a group of cetaceans, effort would resume on a course angled at 20º towards the trackline. If a group that had been previously recorded as an off-effort sighting during closing mode was re-sighted during searching, it was recorded as an on-effort sighting and the previous off-effort sighting was deleted from the computer record.

At all times during survey operations, the center observer recorded information on survey conditions and sightings using a computer and the SWFSC WinCruz software. These data were backed up, printed, and reviewed by the cruise leader at the close of effort each day. A data edit program (DASCHECK) was used to find any errors in the electronic data files. At the end of each day, the cruise leader also corrected those errors and transferred the observers' independent estimates of group size and species proportions from their field notebooks into the electronic data record.

Cetacean Acoustic Monitoring

There were four main goals of the acoustic program for the PICEAS 2005 survey: 1) to determine whether acoustic detections of dolphins could significantly improve the estimation of dolphin abundance, 2) to gather additional information on the range of acoustic detection of sperm whales (*Physeter macrocephalus*), 3) to examine vocal characteristics of large baleen whales, and 4) to test the ability of a new software program (ROCCA - Real-time Cetacean Call Classification Algorithm) (Oswald 2006) to accurately determine dolphin species from their whistles. Two distinct methods were used for passive acoustic monitoring: 1) continuous monitoring and recording of dolphin, sperm whale, and minke whale (*Balaenoptera acutorostrata*) vocalizations obtained from a towed hydrophone array and 2) opportunistic deployment of Navy surplus sonobuoys for recording other baleen whales.

The primary hydrophone array was towed 300 m behind the ship at a depth of 11 m and a speed of 10 kts. The primary array consisted of four hydrophone elements, with a separation of 3 m between elements. The first three elements were built in-house (frequency sensitivity 1 kHz to 40 kHz ± 5 dB). The fourth element was a high frequency element designed by Seiche Measurements Limited (frequency sensitivity 1 kHz to 150 kHz ± 2 dB). This hydrophone array worked well for the first two legs, but it was damaged on September 14 and was not used after that. Legs 3 and 4 were marked by repeated breakages of hydrophone elements, and this array was frequently repaired and re-built in various configurations during these legs. The hydrophone array was not used on Leg 5.

Two acoustic technicians rotated on three-hour shifts during daylight hours. Signals received from the array were monitored aurally and visually using a scrolling spectroscopic display in ISHMAEL (Mellinger, 2001). Bearing angles to a sound source were estimated via beamforming and phone-pair (cross-correlation) algorithms in ISHMAEL. These angles were plotted using WHALTRAK, a plotting program with GPS interface. Locations to vocalizing cetacean groups were determined using the convergence of these plotted bearing angles. Whistles that were selected for species identification were processed with ROCCA using a Matlab interface within ISHMAEL. Clear cetacean sounds were recorded on a Tascam DA-78 multi-channel recorder. Signals from the high-frequency element were recorded continuously to a computer hard disk using a National Instruments data acquisition board (NI-DAQ 6062E) at 200 kHz sampling rate. A record of acoustic effort, comments, and five-minute acoustic updates was logged using WHALTRAK.

The sperm whale protocol differed from previous SWFSC acoustic surveys during which neither the visual nor the acoustic team announced the presence of sperm whales until they had passed abeam (or until the cruise leader had determined that both teams had detected the group). On this PICEAS survey, the visual observers immediately informed the acoustic team when they had a sperm whale sighting. If that sighting was within 3 nmi of the transect line, the visual observers immediately went off-effort to approach the animals and obtain group size information. Therefore, the visual and acoustic detections of this species were not independent. However, the acousticians did not inform the visual observers of sperm whale or other cetacean detections until they had passed abeam. Visual observers frequently relayed information about delphinid sightings to the acoustic team to aid them in documenting delphinid whistle recordings.

False killer whales were a primary focus of the PICEAS survey effort. When ROCCA software identified a cetacean whistle as being a “probable” false killer whale, the acoustic team notified the cruise leader. If this group was not seen by the visual observers by the time that the acoustic detection passed abeam, the cruise leader would typically initiate an “acoustic chase”. In these cases, real-time localization of the animals was communicated to the visual observers until they sighted the animals. When sighted, the visual team would continue the chase to identify the animals, and, if possible, collect identification photographs and biopsies.

Sonobuoys were deployed to record cetacean sounds that could not be successfully recorded from the hydrophone array. The focus of these efforts was to obtain recordings of Bryde’s whales, *Balaenoptera edeni*, especially for animals from which genetic samples were obtained. Sonobuoys (type 53 or 77) were typically deployed within ½ nmi of baleen whales sighted by the visual team. Sonobuoy signals were received using a 2-channel ICOM receiver and recorded to a Sony DAT recorder.

Photo-documentation

Photographs of cetacean groups and individuals were taken with digital single lens reflex (SLR) cameras using 100-300 and 400 mm lenses to assist with stock delineations and to contribute to ongoing studies of identifiable individuals (to document individual movements and, for some whale species, as an alternative means of estimating population sizes).

Biopsy Studies

Biopsies of cetaceans were taken from either the bow of the McArthur II or from one of its launches. Two different types of biopsy tips were propelled by crossbow (Barnett Wildcat, a Barnett Quad 300, or a Barnett Quad 400). A 25 mm long tip was used to sample smaller odontocete species, while larger odontocete species and all mysticete species were sampled with a 40 mm tip. For sampling some species, a small piece of rubber vacuum hose was added to the tips as a bumper to reduce the depth of tip penetration and to increase the probability that the tip would rebound. The sampling tips were mounted on modified crossbow arrow shafts with threaded adapters to allow tips to be easily fitted and removed. Biopsies will be used in future studies of genetic population structure, pollutants, stable isotopes, maturity, and pregnancy rates.

Behavioral Studies

When time permitted, data on behavioral responses of cetaceans to the survey ships was collected. The observer priority was to record behavior of all odontocete species. Data included both a written narrative as well as seventeen categorical questions regarding individual and group behavior (NOAA Form 88-208).

RESULTS AND DISCUSSION

Visual Sightings and Search Effort

A total of 290 sightings were made during the 2005 PICEAS survey, comprised of at least 22 cetacean species (Table 1). Most species were found in single-species groups, and only short-beaked common dolphins (*Delphinus delphis*) and melon-headed whales (*Peponocephala electra*) were found in equal or greater frequency in mixed-species groups (Tables 1 & 2). Several temperate species (*Delphinus delphis, Phocoena phocoena, Phocoenoides dalli, and Lagenorhynchus obliquidens*) were seen only near the coast of California, en route to or from the study area. The on-effort transects totaled ~13,000 km during 84 actual survey days (Table 3), for an average of 154 km per day. Search effort was distributed evenly across the study area, but with a slightly lower coverage in the northeastern corner (Figure 1). Very little search effort (less than four percent) was achieved in calm weather conditions (Beaufort sea states 1 & 2). Approximately 7% of search effort was in Beaufort 3 conditions, 40% in Beaufort 4, 36% in Beaufort 5, and 14% in Beaufort 6

(Table 4). As expected, sighting rates generally declined with increasing sea state (Table 4). The locations of sightings for each species (or higher taxonomic category) are illustrated in Figures 2-39.

Acoustics

There were a total of 248 acoustic detections of dolphins, including 112 dolphin groups that were detected by the visual team and 136 dolphin groups that were not (Figure 40). Recordings of visually detected sightings from the towed hydrophone array included vocalizations from striped dolphins (*Stenella coeruleoalba*), spotted dolphins (*Stenella attenuata*), spinner dolphins (*Stenella longirostris*), rough-toothed dolphins (*Steno bredanensis*), bottlenose dolphins (*Tursiops truncatus*), Fraser's dolphins (*Lagenodelphis hosei*), Risso's dolphin (*Grampus griseus*), melon-headed whales (*Peponocephala electra*), false killer whales (*Pseudorca crassidens*), and pilot whales (*Globicephala* spp.) (Table 5). All non-sighted acoustic detections, with the exception of minke whales and sperm whales, were recorded as "unidentified dolphins" (Table 6). No known acoustic vocalizations from tropical bottlenose whales or beaked whales were detected with this equipment.

There were a total of 36 acoustic detections of sperm whales, of which 12 were sighted by the visual observation team and 24 were only detected by the acoustics team (Tables 5-6; Figure 41). There were two acoustic detections of minke whales, neither of which was detected by the visual observation team (Table 6, Figure 41).

Twelve of the sighted dolphin groups, and two of the sperm whale detections, were initially detected by the acoustics team and were not seen or identified until after the acoustics team had directed the vessel to their approximate location. Not all of the acoustic detections of cetaceans were within the effort range for the visual observers.

A total of 17 low-frequency sonobuoys were deployed from the *McArthur II* (Figure 42). A total of 6 of the 17 sonobuoys were functional. One sonobuoy was deployed on one sighting of an unidentified whale (probable Bryde's whale), and the remainder were deployed during four sightings of Bryde's whales. Vocalizations were detected on two of the Bryde's whale sightings, including a possible new vocalization attributed to Bryde's whales.

Photo-Documentation

Seventeen cetacean species were photographed in the 281 sightings (Table 7). The most commonly photographed species were *Globicephala macrorhynchus* (17), *Stenella longirostris* (11), and *Stenella coeruleoalba* (9).

Biopsy Studies

The biopsy team collected 91 biopsy samples (Table 8) from two mysticete and at least eight odontocete species during the cruise. The greatest number of samples came from melon-headed whales (*Peponocephala electra*), false killer whales (*Pseudorca crassidens*), and bottlenose dolphins (*Tursiops truncatus*).

Behavioral Studies

Notes on marine mammal behavior were recorded on the behavior section of the marine mammal sighting form used by the observers. These data are being analyzed in conjunction with behavioral data from several other SWFSC cruises.

Preliminary Abundance of False Killer Whales

Barlow and Rankin (2007) used visual and acoustic survey data from this cruise to estimate the abundance of false killer whales (*Pseudorca crassidens*) in the study area. Using visual survey data, they estimated that 1,329 (CV=0.65) false killer whales were in the Palmyra EEZ and that 906 (CV=0.68) were in the remainder of the PICEAS study area. The acoustic survey data verified that the percentage of groups missed by visual observers within 4.5 km of the transect line (55%) closely approximated the percentage that was estimated from traditional line-transect methods (58%).

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Table 1. Sightings summary. A summary of the number of sightings and average group size for each species. Sighting tallies include pure, single-species groups and mix-species groups. Both on-effort and off-effort sightings are included.

Species Code	Name	# Pure	# Mixed	# Total	Average group size
Cetaceans					
177	unid. small delphinid	21	3	24	23.4
002	*Stenella attenuata* (offshore)	15	8	23	50.2
036	*Globicephala macrorhynchus*	15	6	21	24.3
013	*Stenella coeruleoalba*	19	2	21	46.4
077	unid. dolphin	14	3	17	13.3
033	*Pseudorca crassidens*	13	1	14	8.8
018	*Tursiops truncatus*	10	4	14	11.8
046	*Physeter macrocephalus*	14	0	14	7.9
040	*Phocoena phocoena*	12	0	12	2.6
044	*Phocoenoides dalli*	12	0	12	2.2
015	*Steno bredanensis*	9	3	12	13.4
076	*Megaptera novaeangliae*	10	0	10	1.7
072	*Balaenoptera edeni*	8	0	8	3.8
099	*Balaenoptera borealis/edeni*	8	0	8	1.1
101	*Stenella longirostris* (southwestern)	6	2	8	92.9
003	*Stenella longirostris* (unid. subsp.)	5	3	8	41.7
022	*Lagenorhynchus obliquidens*	5	1	6	21.2
061	*Ziphius cavirostris*	6	0	6	3.0
031	*Peponocephala electra*	3	3	6	100.8
017	*Delphinus delphis*	1	3	4	129.5
070	*Balaenoptera* sp.	4	0	4	1.3
021	*Grampus griseus*	4	0	4	13.9
049	ziphiid whale	4	0	4	1.0
037	*Orcinus orca*	3	0	3	5.3
078	unid. small whale	3	0	3	4.0
102	*Stenella longirostris* (Gray's)	2	1	3	154.6
051	*Mesoplodon* sp.	2	0	2	3.5
026	*Lagenodelphis hosei*	1	1	2	182.2
377	unid. large delphinid	2	0	2	4.5
065	*Indopacetus pacificus*	1	0	1	14.2
079	unid. large whale	1	0	1	1.0
048	*Kogia sima*	1	0	1	1.0
096	unid. cetacean	1	0	1	1.0
098	unid. whale	1	0	1	1.6
277	unid. medium delphinid	1	0	1	2.0
Pinnipeds					
ZC	*Zalophus californianus*	5	0	5	4.0
CU	*Callorhinus ursinus*	2	0	2	1.0
MA	*Mirounga angustirostris*	2	0	2	1.0
	Total	246	44	290	

Table 2. Groups of mixed species composition. A tally of sightings that included more than one species. See Table 1 for full genus names.

Species 1	Species 2	Species 3	Total
002 *S. attenuata*	003 *S. longirostris* (unid.)		3
002 *S. attenuata*	101 *S. longirostris* (SW)		2
002 *S. attenuata*	177 unid. small dolphin		2
031 *P. electra*	015 *S. bredanensis*		2
036 *G. macrorhynchus*	018 *T. truncatus*		2
036 *G. macrorhynchus*	077 unid. dolphin		2
002 *S. attenuata*	102 *S. longirostris* (Gray's)		1
026 *L. hosei*	036 *G. macrorhynchus*	077 unid. small dolphin	1
036 *G. macrorhynchus*	015 *S. bredanensis*		1
031 *P. electra*	018 *T. truncatus*		1
033 *P. crassidens*	018 *T. truncatus*		1
017 *D. delphis*	013 *S. coeruleoalba*		1
017 *D. delphis*	013 S. *coeruleoalba*	177 unid. small dolphin	1
017 *D. delphis*	022 *L. obliquidens*		1

Table 3. Kilometers of effort per day including Beaufort sea states from 0 to 6.

Date	Effort (km)	Date	Effort (km)	Date	Effort (km)
12 Aug 05	164.6	21 Sep 05	217.9	29 Oct 05	201.8
13 Aug 05	220.9	22 Sep 05	113.9	30 Oct 05	177.3
14 Aug 05	112.8	23 Sep 05	176.0	31 Oct 05	180.5
15 Aug 05	180.4	24 Sep 05	125.6	1 Nov 05	156.9
16 Aug 05	131.3	25 Sep 05	213.5	2 Nov 05	151.1
17 Aug 05	150.5	26 Sep 05	206.2	3 Nov 05	145.6
18 Aug 05	136.6	27 Sep 05	227.5	4 Nov 05	109.1
19 Aug 05	93.1	28 Sep 05	215.3	5 Nov 05	37.2
21 Aug 05	108.4	29 Sep 05	216.4	6 Nov 05	149.5
22 Aug 05	81.3	30 Sep 05	98.3	8 Nov 05	113.2
23 Aug 05	121.8	1 Oct 05	192.0	9 Nov 05	41.0
25 Aug 05	92.1	3 Oct 05	220.9	10 Nov 05	110.1
26 Aug 05	121.5	4 Oct 05	188.7	11 Nov 05	176.3
27 Aug 05	152.8	5 Oct 05	225.3	12 Nov 05	181.1
28 Aug 05	176.0	6 Oct 05	165.3	13 Nov 05	201.2
29 Aug 05	106.3	7 Oct 05	194.5	14 Nov 05	187.8
30 Aug 05	138.6	8 Oct 05	176.0	19 Nov 05	40.0
31 Aug 05	57.8	9 Oct 05	168.0	20 Nov 05	190.1
1 Sep 05	214.8	10 Oct 05	48.8	21 Nov 05	195.9
2 Sep 05	114.3	19 Oct 05	81.1	22 Nov 05	195.6
3 Sep 05	146.5	20 Oct 05	158.5	23 Nov 05	208.2
4 Sep 05	71.0	21 Oct 05	214.5	24 Nov 05	200.7
8 Sep 05	198.6	22 Oct 05	159.6	25 Nov 05	146.5
15 Sep 05	209.8	23 Oct 05	127.7	26 Nov 05	133.7
16 Sep 05	204.9	24 Oct 05	183.6	28 Nov 05	124.9
17 Sep 05	176.9	25 Oct 05	143.0	29 Nov 05	33.3
18 Sep 05	175.8	26 Oct 05	137.7		
19 Sep 05	196.1	27 Oct 05	151.9	Total	12967.6
20 Sep 05	210.3	28 Oct 05	164.8		

Table 4. PICEAS survey effort (kilometers), number of sightings, and sighting rates stratified by Beaufort sea state.

Beaufort	Kilometers of effort	No. of sightings	Sightings per 1000 km
1	64.1	1	15.59
2	410.8	16	38.95
3	948.0	22	23.21
4	5124.3	63	12.29
5	4630.4	36	7.77
6	1790.0	6	3.35
Total	12967.6	144	11.10

Table 5. Number of sighted cetacean groups per leg for which acoustic recordings were obtained using a towed hydrophone array on the *McArthur II* during PICEAS 2005, listed in order of the number of recordings obtained. This includes recordings of mixed species groups.

Species	Leg 1	Leg 2	Leg 3	Leg 4	Total
Stenella attenuata	6	12	1	2	21
Stenella longirostris	0	12	0	4	16
Pseudorca crassidens	1	4	0	9	14
Globicephala macrorhynchus	0	10	1	3	14
Physeter macrocephalus	3	9	0	0	12
Stenella coeruleoalba	0	9	0	3	12
Unidentified dolphins	1	9	2	0	12
Steno bredanensis	3	5	2	1	11
Tursiops truncatus	1	5	0	1	7
Lagenodelphis hosei	0	2	0	0	2
Peponocephala electra	1	1	0	0	2
Grampus griseus	0	0	0	1	1
Total	16	78	6	24	124

Table 6. Number of non-sighted cetacean groups per leg for which acoustic recordings were obtained using a towed hydrophone array on the *McArthur II* during PICEAS 2005, listed in order of the number of recordings obtained

Species	Leg 1	Leg 2	Leg 3	Leg 4	Total
Unidentified dolphins	10	65	18	43	136
Physeter macrocephalus	10	8	2	4	24
Balaenoptera acutorostrata	0	0	0	2	2
Total	20	73	20	49	162

Table 7. Species and corresponding sighting numbers for cetaceans photographed during the PICEAS survey.

Species	# of Sightings Photographed	Sighting #s
Stenella attenuata (offshore)	9	57,58,64,94,96,131,137,163,191
Stenella longirostris (unidentified subspecies)	2	96,211
Stenella coeruleoalba	9	71,99,113,116,128,161,198,241,247
Steno bredanensis	5	54,59,78,168,183
Delphinus delphis	3	241,246,254
Tursiops truncatus	7	88,123,124,172,207,200,000
Grampus griseus	4	181,231,238,245
Lagenorhynchus obliquidens	2	253,258
Lagenodelphis hosei	2	101,130
Peponocephala electra	5	59,122,183,197,222
Pseudorca crassidens	5	61,74,149,207,216
Globicephala macrorhynchus	17	36,62,65,69,72,95,97,98,100,105,112,172, 175,189,203,228,229
Physeter macrocephalus	5	48,91,148,150,157
Indopacetus pacificus	1	174
Balaenoptera edeni	6	104,109,114,115,121,000
Megaptera novaeangliae	2	21,24
Stenella longirostris (southwestern)	7	142,162,163,208,210,000,000
Stenella longirostris (Gray's)	2	125,137
Orcinus orca	2	50,180
Unidentified small delphinid	1	133

Table 8. Number of biopsy samples obtained from cetacean species.

Species	Total
Balaenoptera edeni	1
Globicephala macrorhynchus	2
Megaptera novaeangliae	3
Peponocephala electra	40
Physeter macrocephalus	4
Pseudorca crassidens	18
Stenella attenuata	2
Stenella longirostris	3
Steno bredanensis	2
Tursiops truncatus	12
Unidentified small delphinid	4
Grand Total	**91**

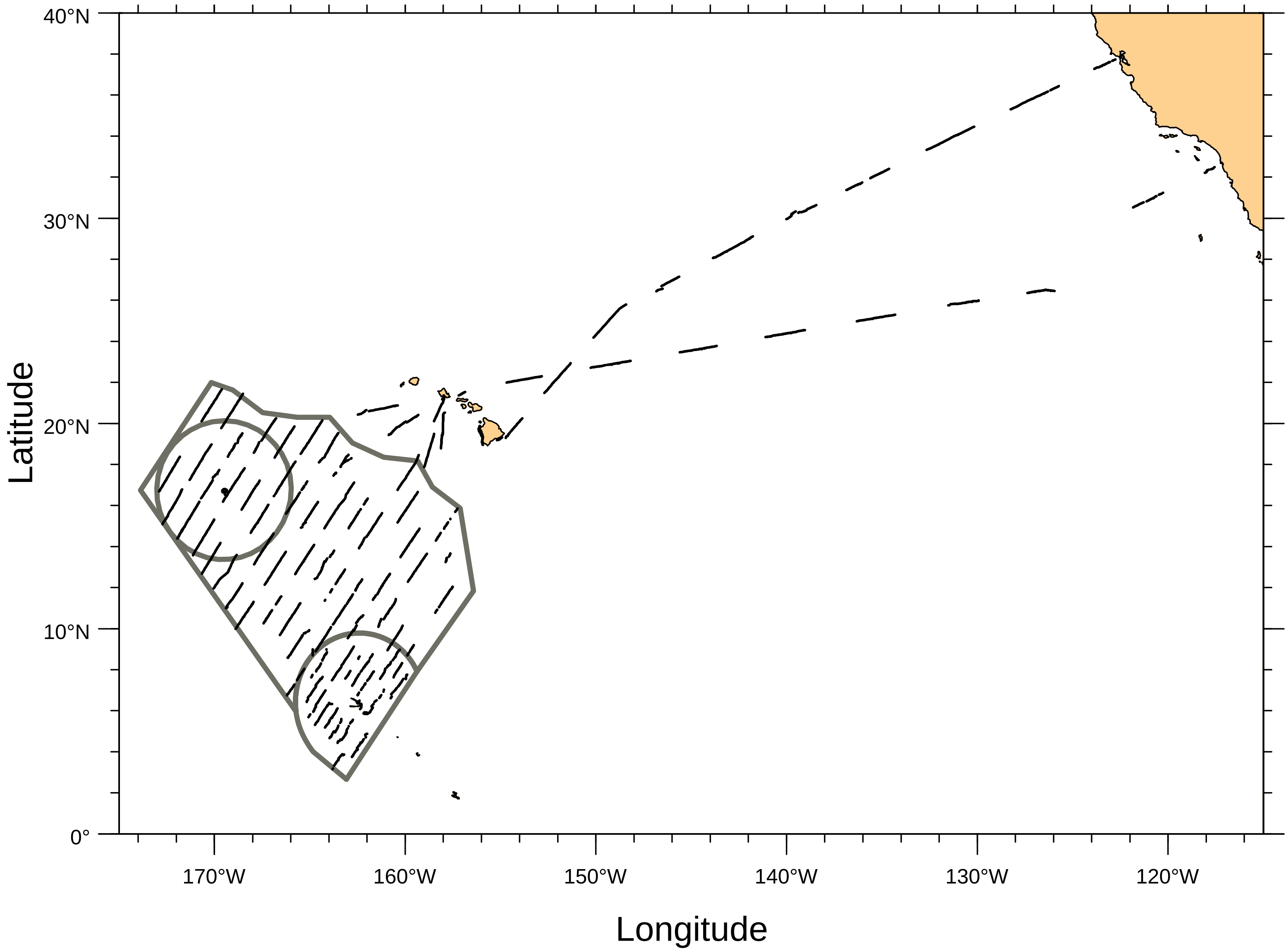

Figure 1. Coverage of survey tracklines during PICEAS 2005, including unplanned segments such as departures from ports.

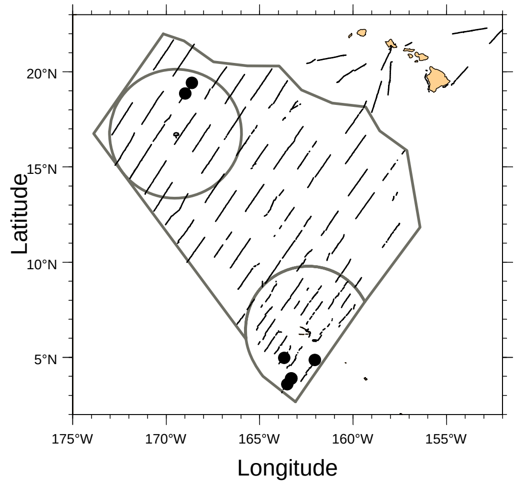

Figure 2. Sightings of *Balaenoptera borealis*/*edeni*, n=8.

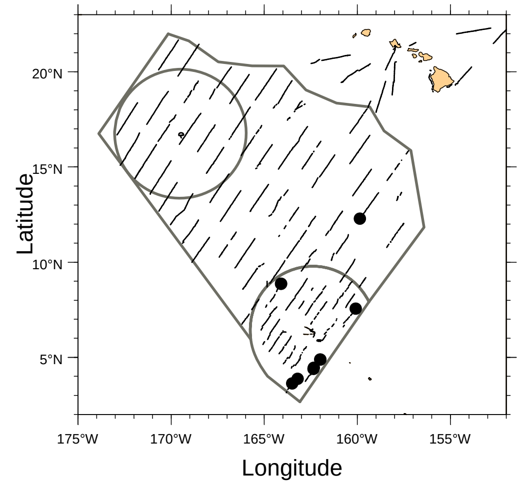

Figure 3. Sightings of *Balaenoptera edeni*, n=8.

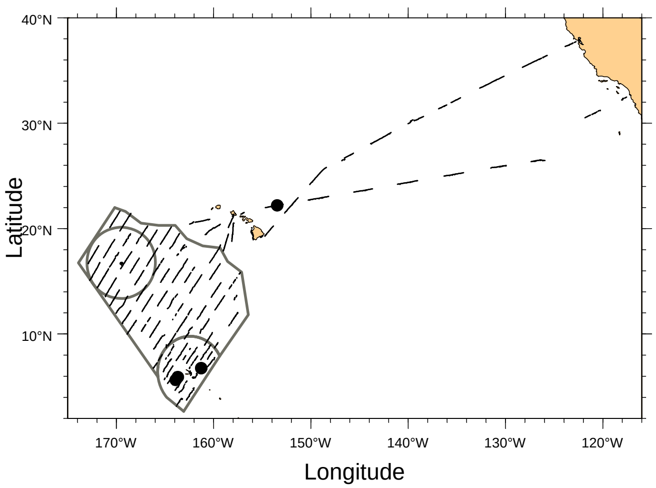

Figure 4. Sightings of *Balaenoptera* sp., n=4

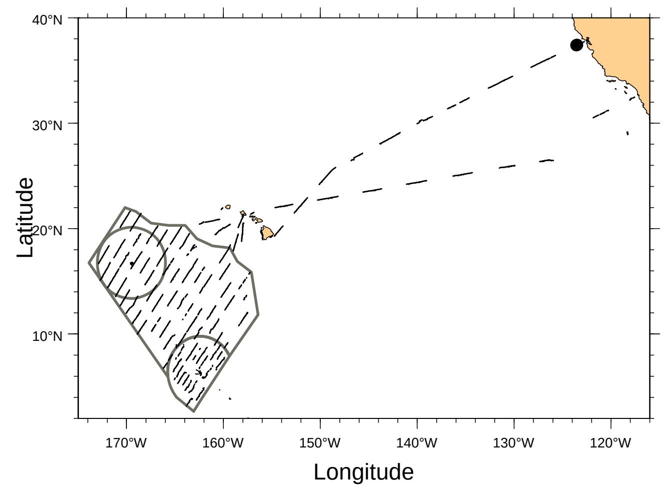

Figure 5. Sightings of *Callorhinus ursinus*, n=2.

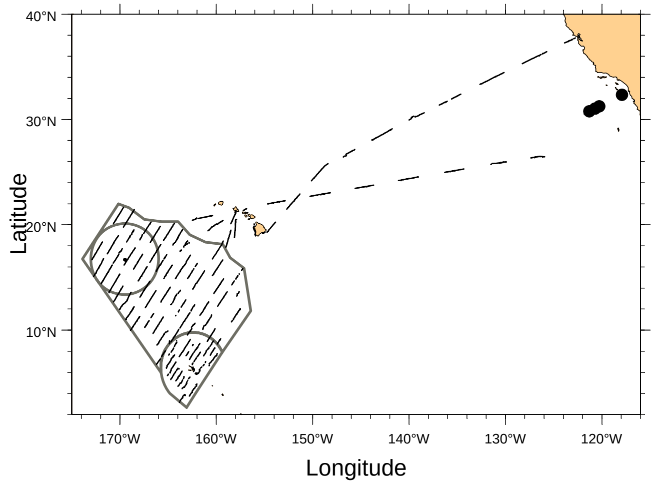

Figure 6. Sightings of *Delphinus delphis*, n=4.

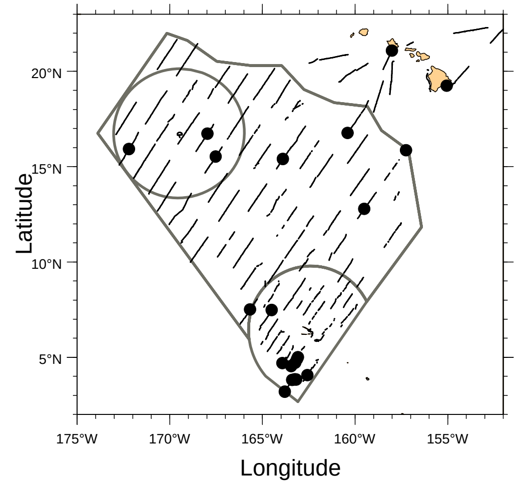

Figure 7. Sightings of *Globicephala macrorhynchus*, n=21.

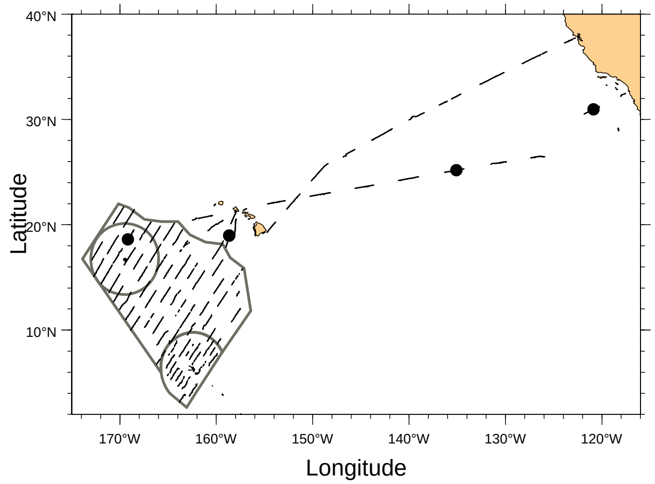

Figure 8. Sightings of *Grampus griseus*, n=4.

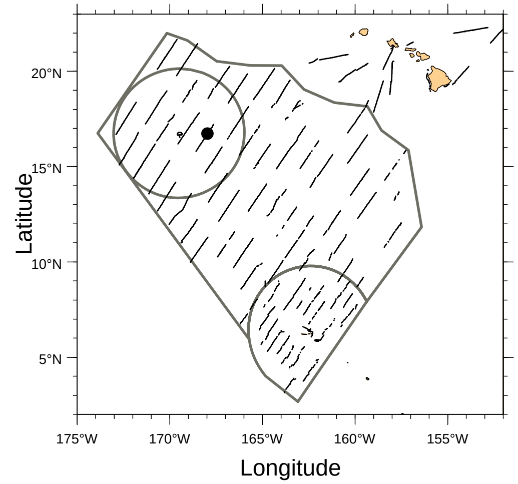

Figure 9. Sightings of *Indopacetus pacificus*, n=1.

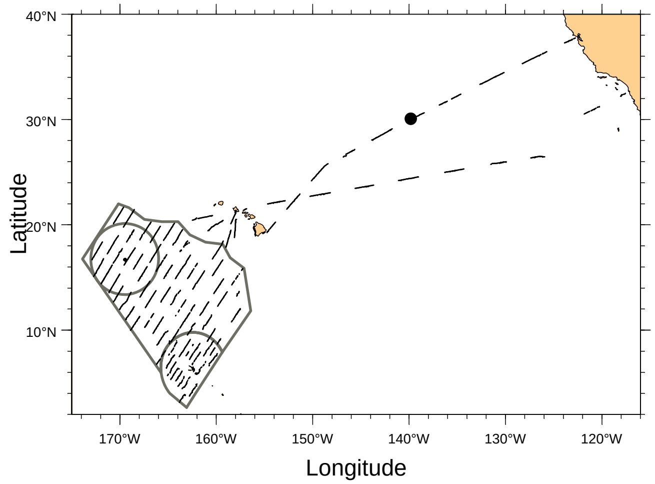

Figure 10. Sightings of *Kogia sima*, n=1.

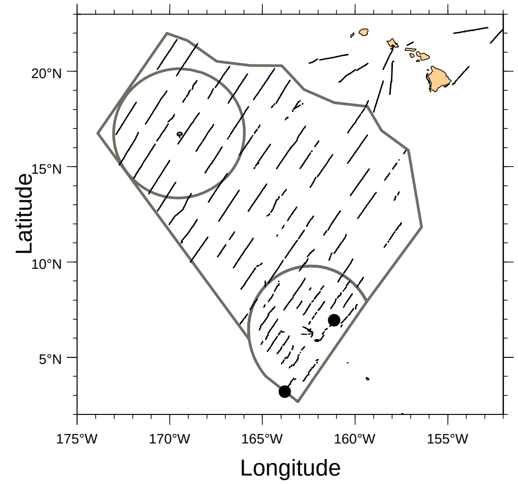

Figure 11. Sightings of *Lagenodelphis hosei*, n=2.

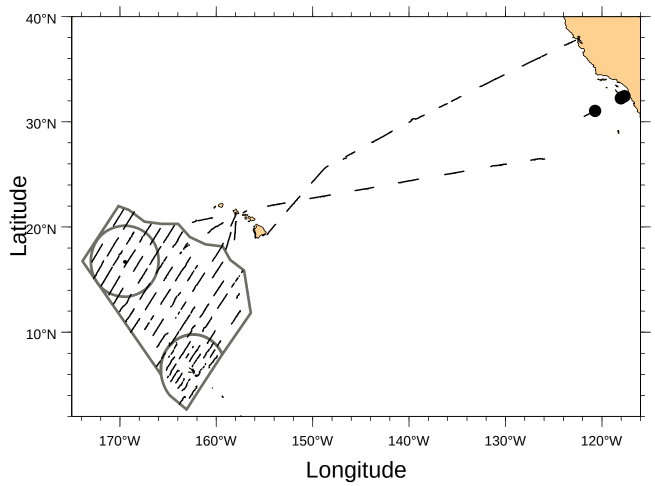

Figure 12. Sightings of *Lagenorhynchus obliquidens*, n=6.

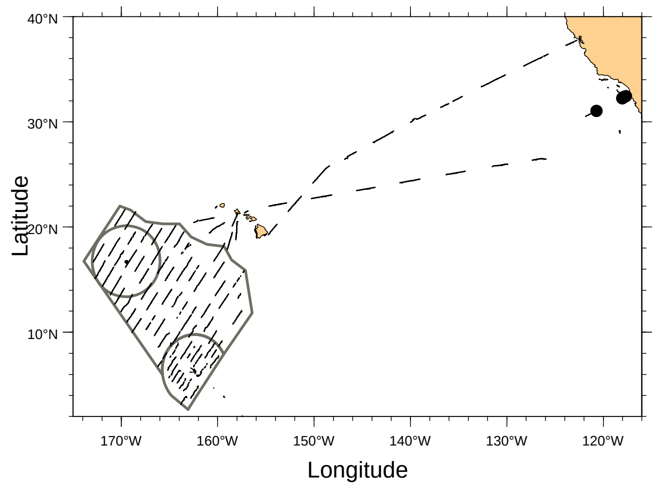

Figure 13. Sightings of *Megaptera novaeangliae*, n=10.

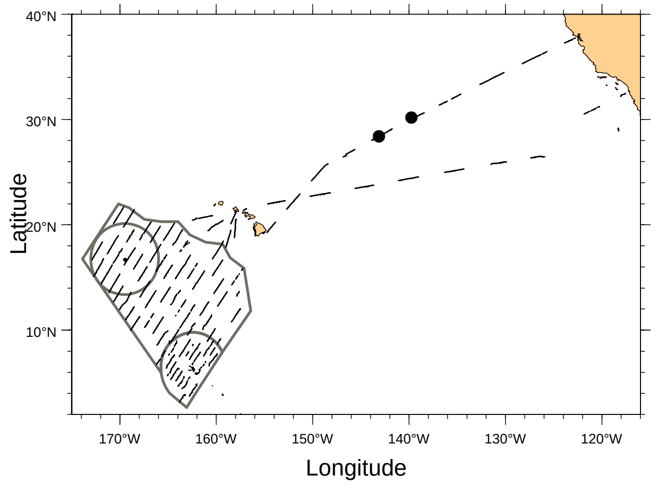

Figure 14. Sightings of *Mesoplodon* sp., n=2.

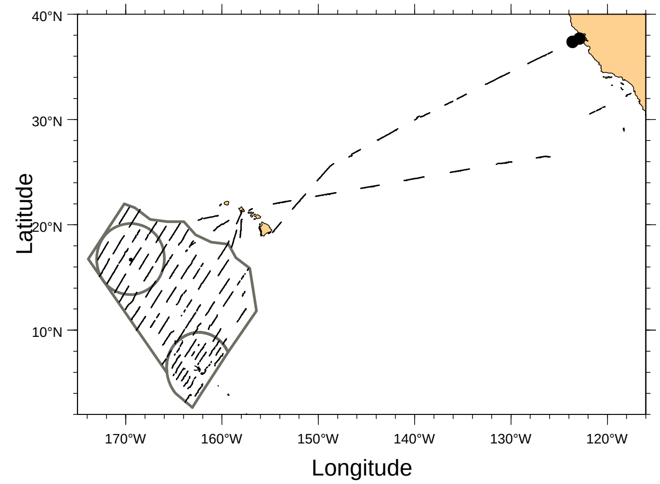

Figure 15. Sightings of *Mirounga angustirostris*, n=2.

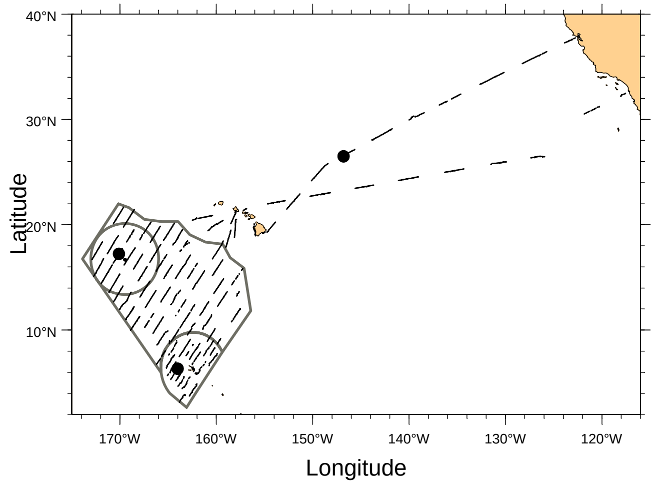

Figure 16. Sightings of *Orcinus orca*, n=3.

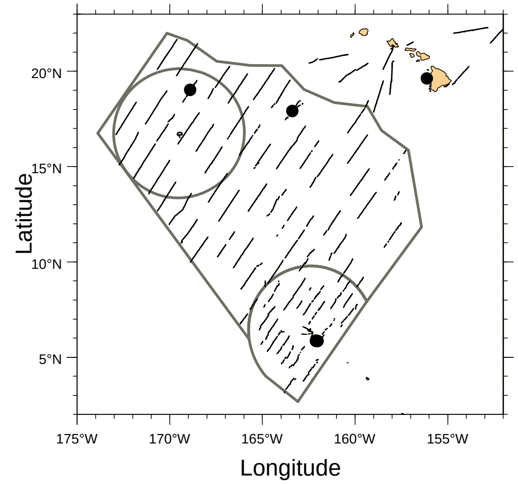

Figure 17. Sightings of *Peponocephala electra*, n=6.

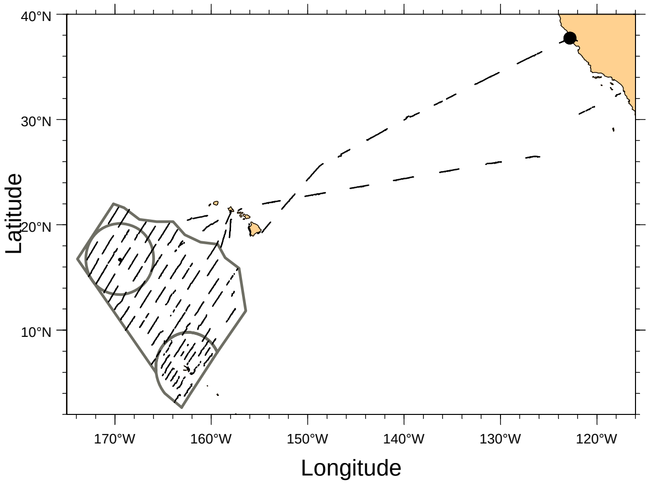

Figure 18. Sightings of *Phocoena phocoena*, n=12.

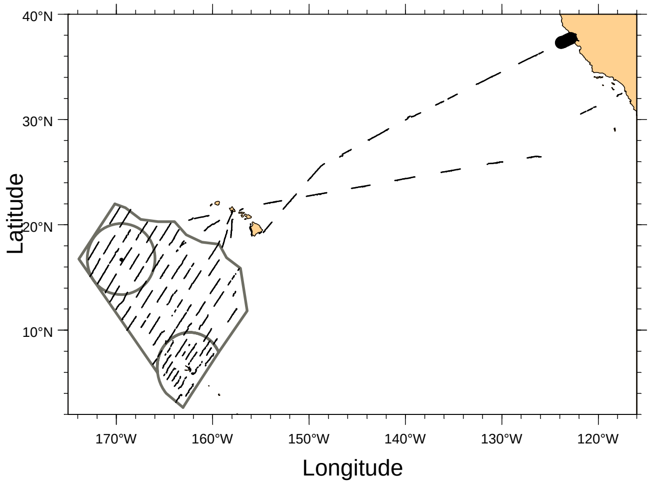

Figure 19. Sightings of *Phocoenoides dalli*, n=12.

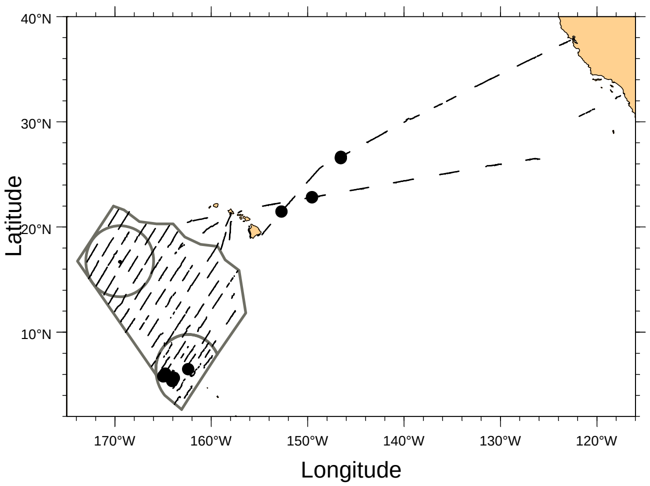

Figure 20. Sightings of *Physeter macrocephalus*, n=14.

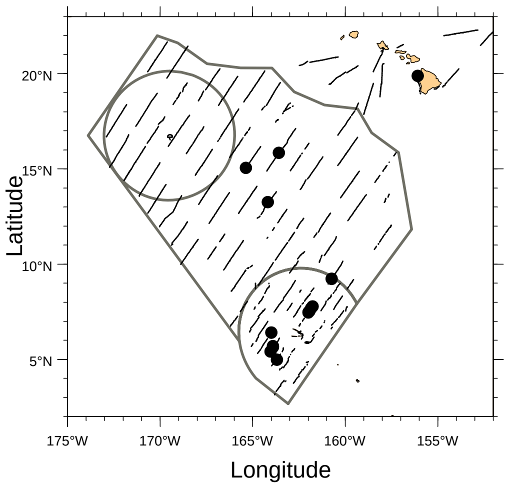

Figure 21. Sightings of *Pseudorca crassidens*, n=14

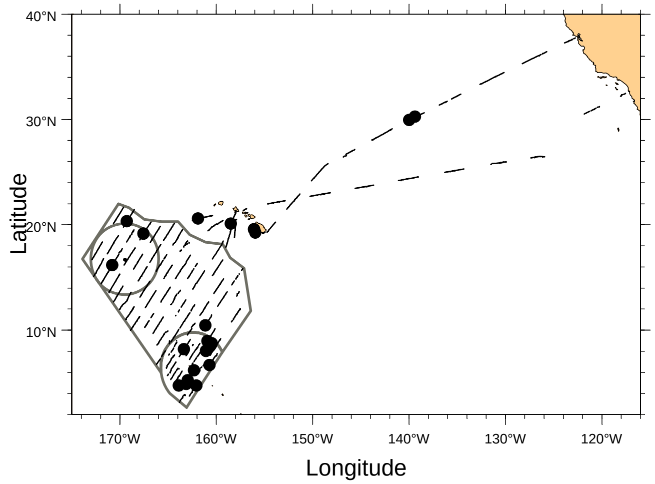

Figure 22. Sightings of *Stenella attenuata* (offshore), n=23.

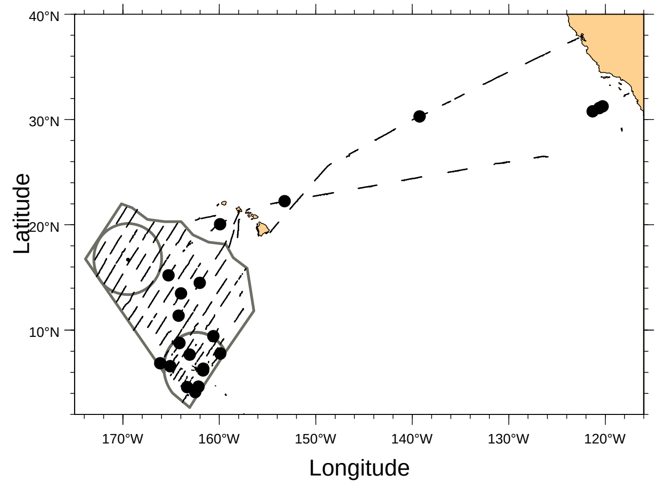

Figure 23. Sightings of *Stenella coeruleoalba*, n=21.

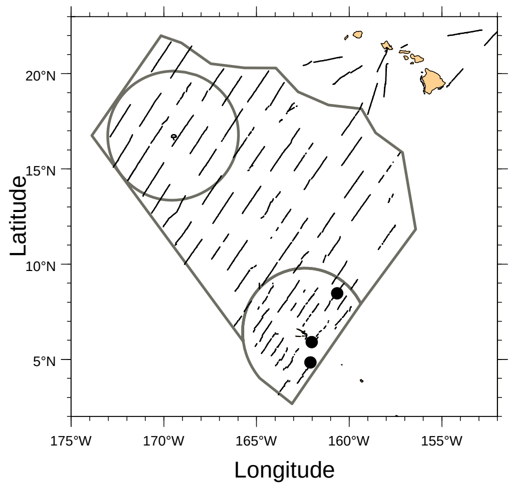

Figure 24. Sightings of *Stenella longirostris* (Gray's), n=3.

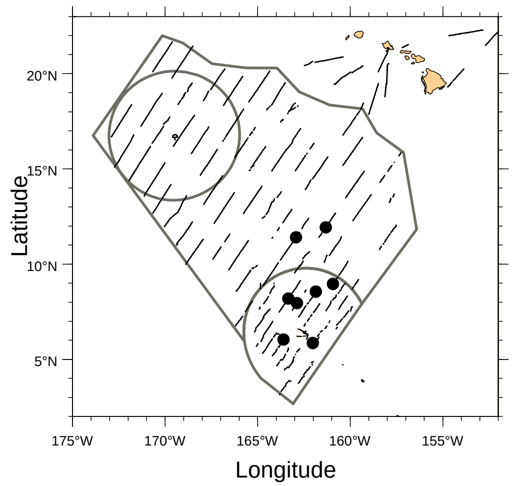

Figure 25. Sightings of *Stenella longirostris* (southwestern), n=8.

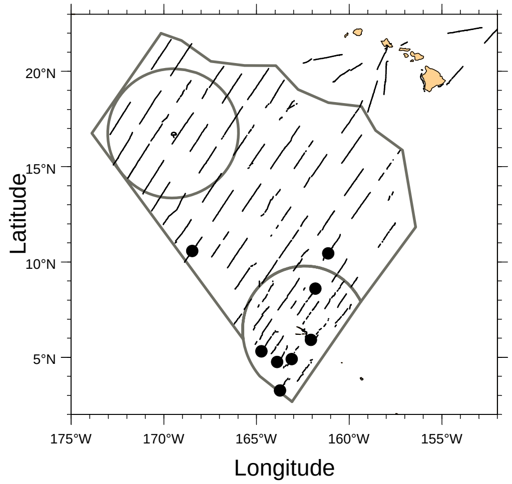

Figure 26. Sightings of *Stenella longirostris* (unid. subsp.), n=8.

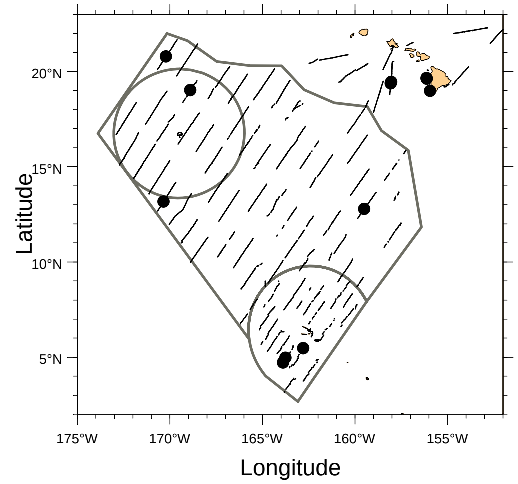

Figure 27. Sightings of *Steno bredanensis*, n=12.

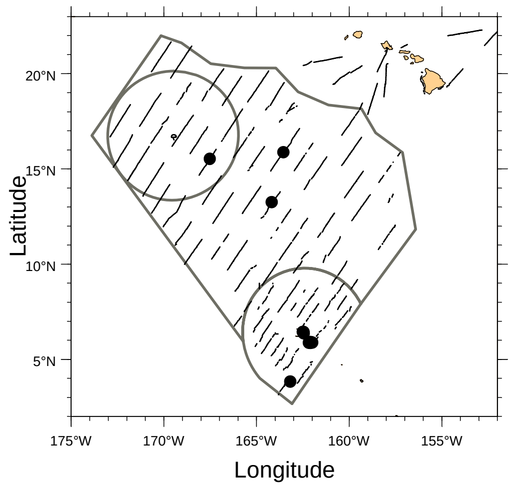

Figure 28. Sightings of *Tursiops truncatus*, n=14.

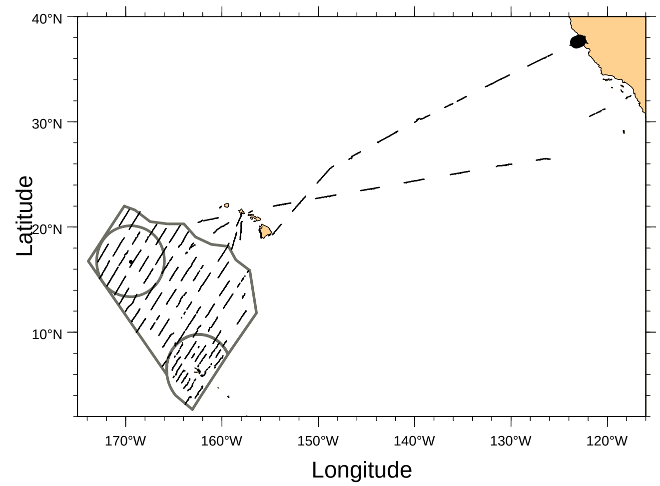

Figure 29. Sightings of *Zalophus californianus*, n=5.

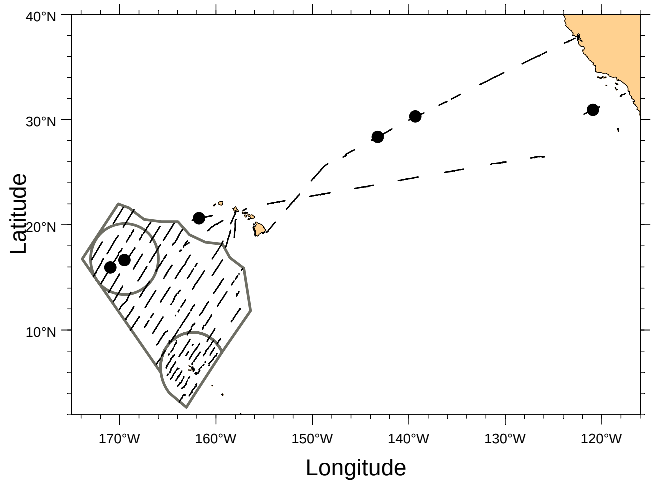

Figure 30. Sightings of *Ziphius cavirostris*, n=6.

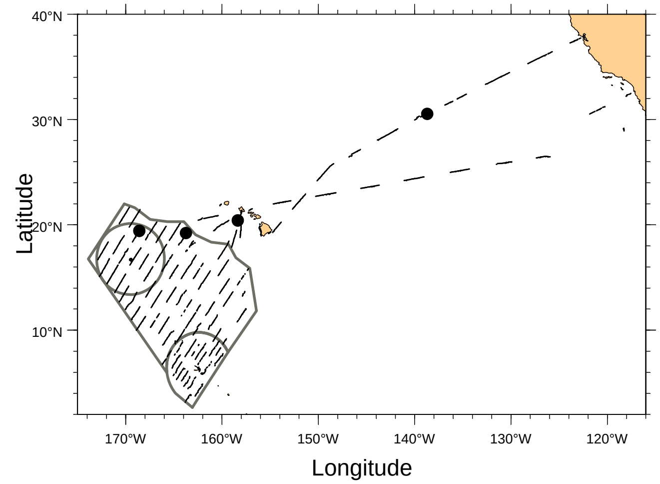

Figure 31. Sightings of ziphiid whale, n=4.

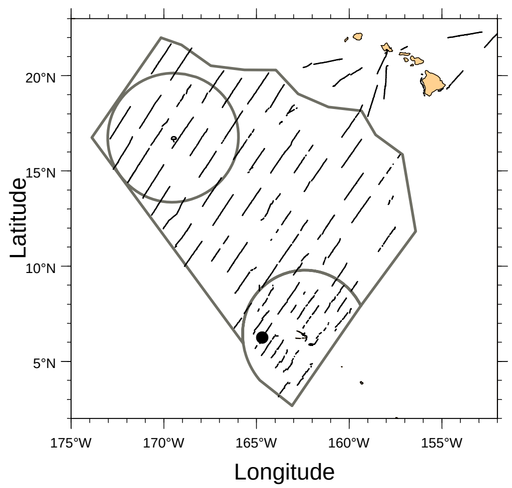

Figure 32. Sightings of unidentified cetacean, n=1.

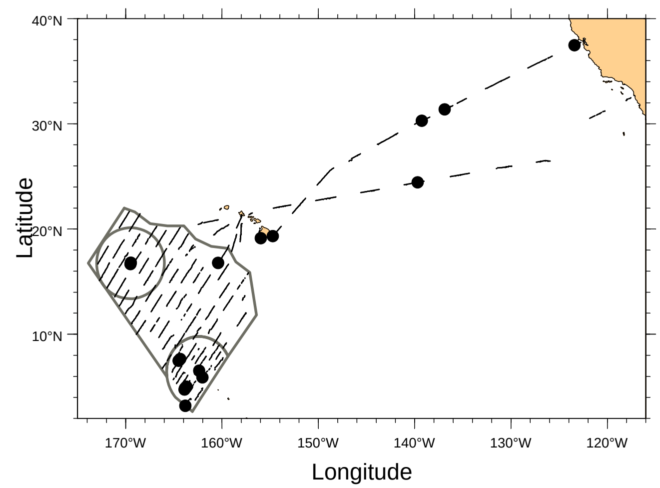

Figure 33. Sightings of unidentified dolphin, n=17.

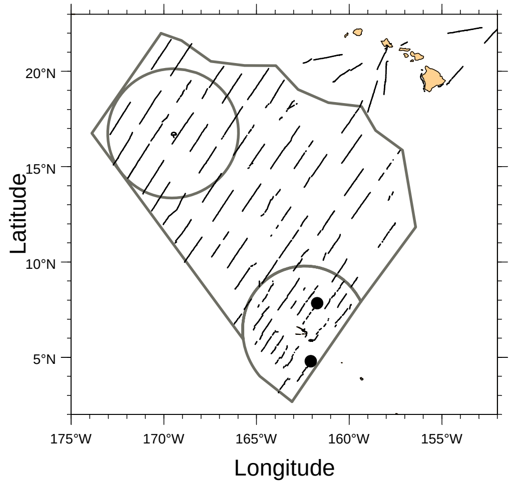

Figure 34. Sightings of unidentified large delphinid, n=2.

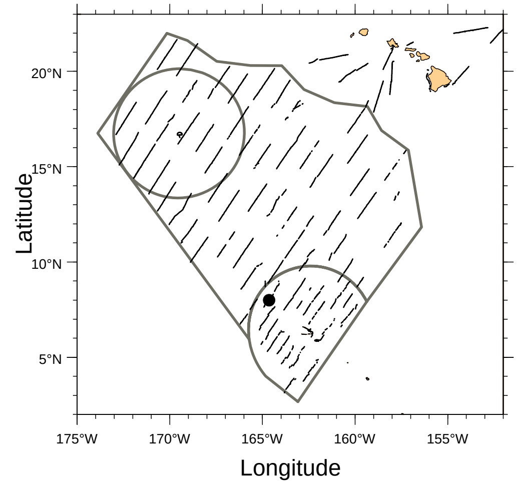

Figure 35. Sightings of unidentified large whale, n=1.

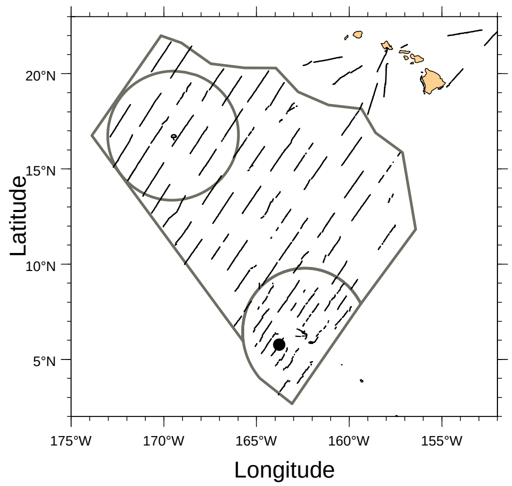

Figure 36. Sightings of unidentified medium delphinid, n=1.

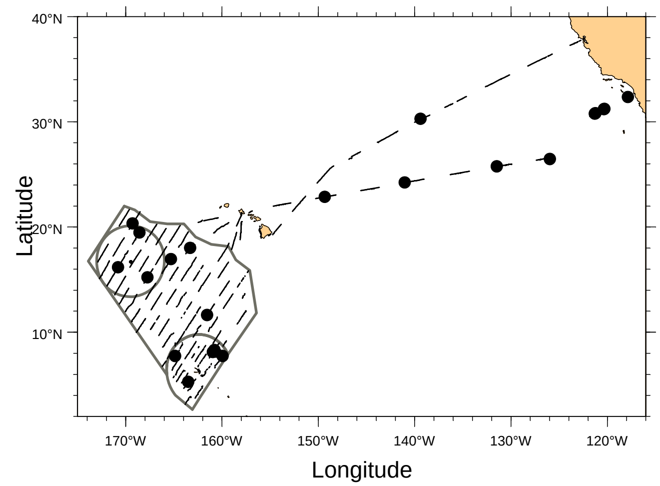

Figure 37. Sightings of unidentified small delphinid, n=24.

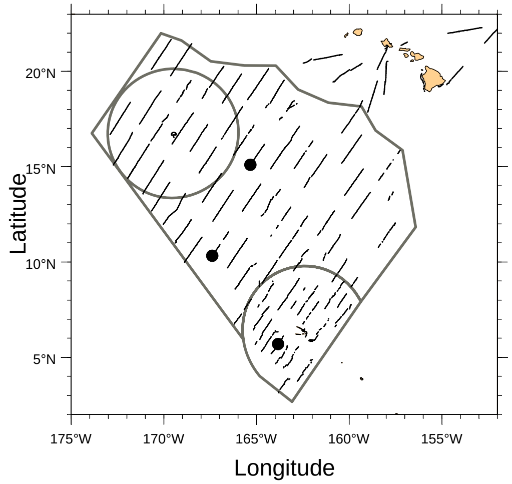

Figure 38. Sightings of unidentified small whale, n=3.

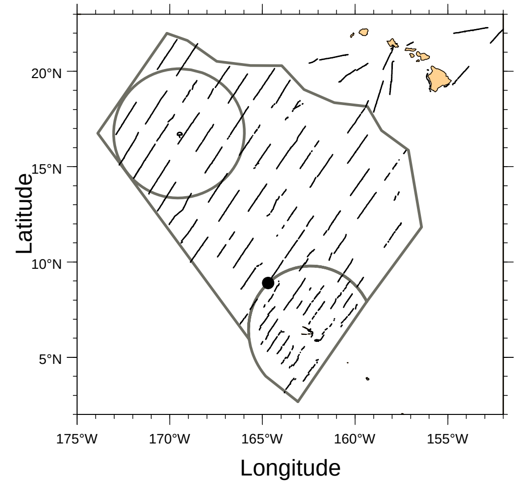

Figure 39. Sightings of unidentified whale, n=1.

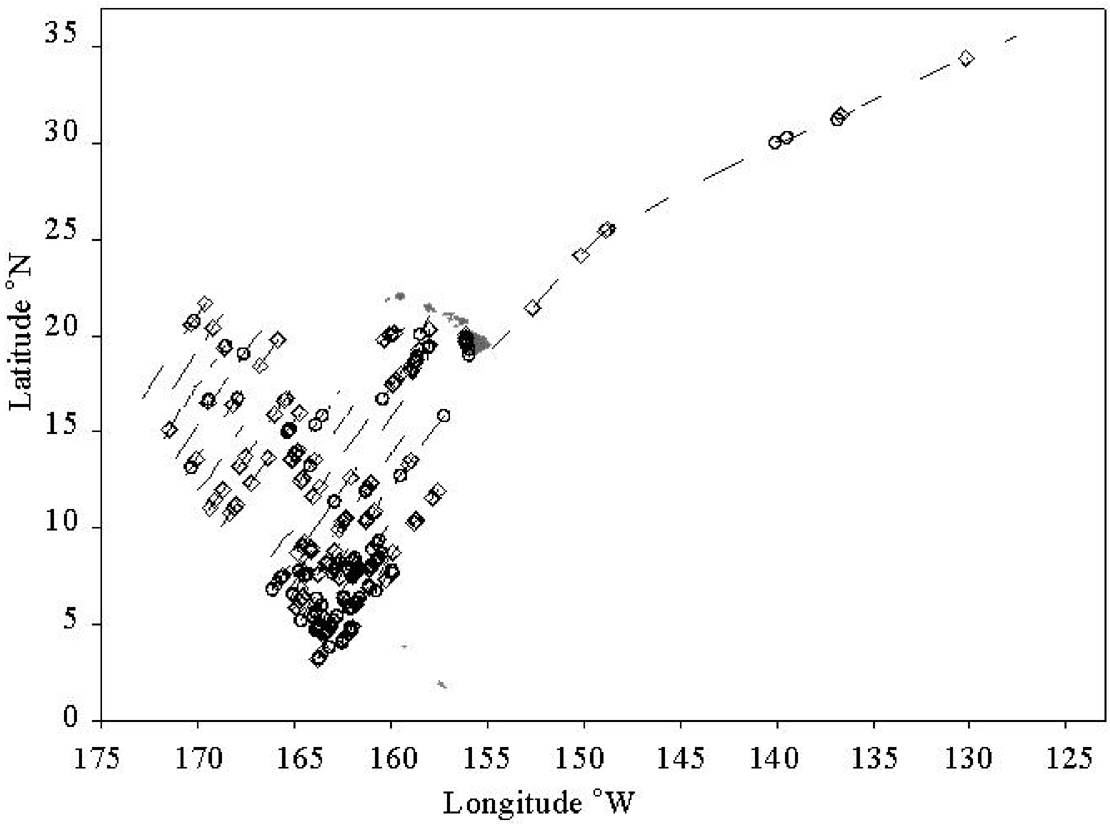

Figure 40. Acoustic detection of dolphin groups plotted with acoustic effort during PICEAS 2005. Acoustic effort using a towed hydrophone array is shown as a thin black line. Circles are acoustic detections of dolphins matched to visual sightings, diamonds are acoustic detections not sighted by the visual team.

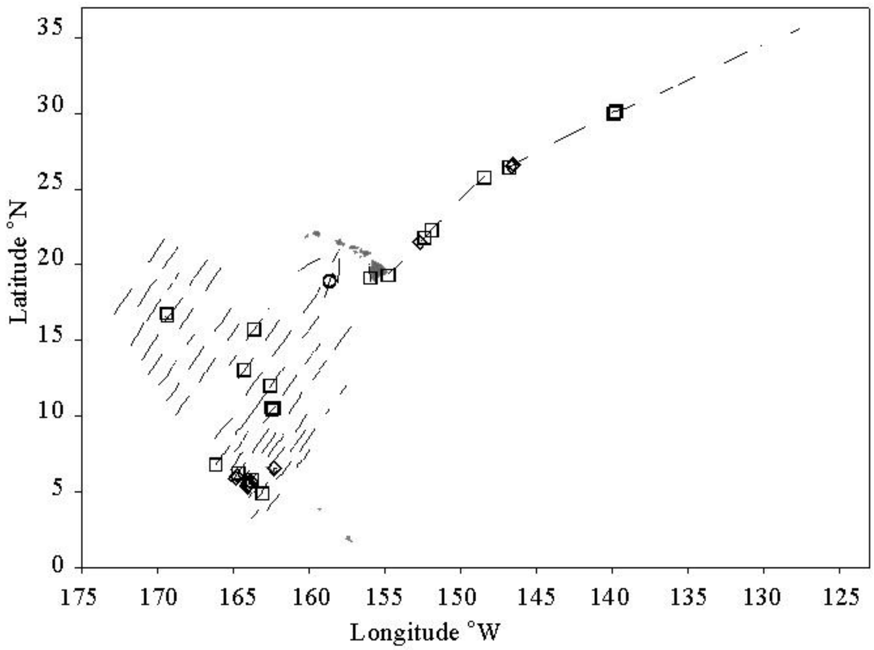

Figure 41. Acoustic detection of sperm whales and minke whales plotted with acoustic effort during PICEAS 2005. Acoustic effort using a towed hydrophone array is shown as a thin black line. Circles are acoustic detections of minke whales, diamonds are acoustic detections of sperm whales matched to visual sightings, and squares are acoustic detections of sperm whales not sighted by the visual team.

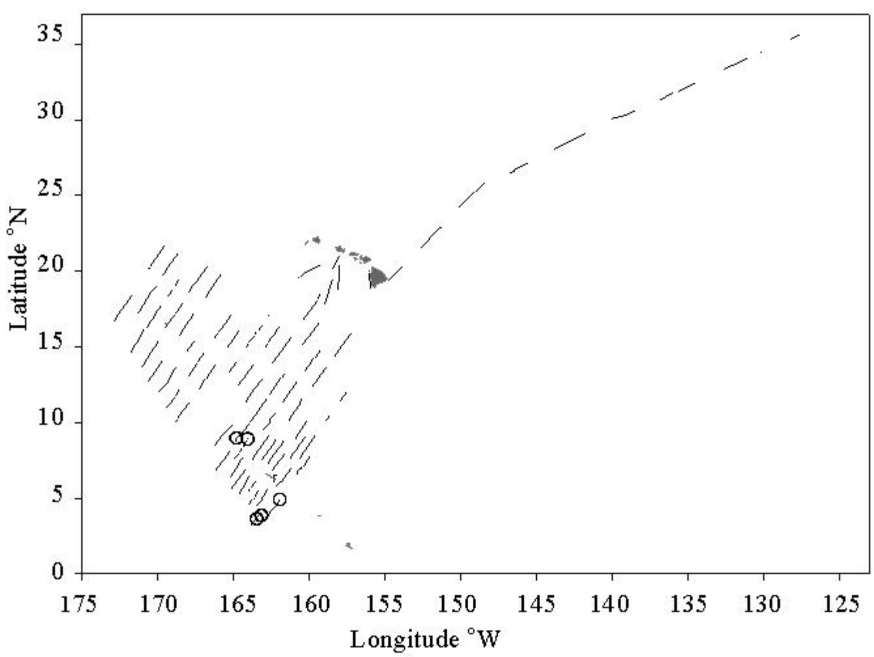

Figure 42. Sonobuoy locations during PICEAS 2005. Acoustic effort using a towed hydrophone array is shown for perspective.

APPENDIX. PICEAS 2005 Personnel by Leg.

Leg 1:

Position	**Name**	**Affiliation**
Chief Scientist	Jay Barlow	SWFSC
Senior Mammal Observer	Jim Cotton	SWFSC
Senior Mammal Observer	Richard Rowlett	SWFSC
Biopsy/Mammal Observer	Juan Carlos Salinas	AFL
Mammal Observer Christopher	Christopher Cutler	AFL
Mammal Observer	Suzanne Yin	AFL
Seabird Observer	Michael Force	AFL
Seabird Observer	Sophie Webb	AFL
Oceanographer	Melinda Kelley	AFL
Acoustician	Shannon Rankin	SWFSC
Acoustic Technician	Julie Oswald	AFL/SIO
Visiting Scientist	Alyssa Campbell	Marine Mammal Commission
Teacher-at-sea	Katie Roberts	Boston School District

Leg 2:

Position	**Name**	**Affiliation**
Chief Scientist	Jay Barlow	SWFSC
Senior Mammal Observer	Jim Cotton	SWFSC
Senior Mammal Observer	Richard Rowlett	SWFSC
Biopsy/Mammal Observer	Juan Carlos Salinas	AFL
Mammal Observer	Christopher Cutler	AFL
Mammal Observer	Suzanne Yin	AFL
Mammal Observer	Beth Goodwin	AFL
Seabird Observer	Michael Force	AFL
Seabird Observer	Sophie Webb	AFL
Oceanographer	Melinda Kelley	AFL
Acoustician	Shannon Rankin	SWFSC
Acoustic Technician	Julie Oswald	AFL/SIO
Visiting Scientist	Kerri Danil	SWFSC
Visiting Scientist	Stephanie Grassia	Visiting Scientist

Leg 3:

Position	**Name**	**Affiliation**
Cruise Leader	Lisa Ballance	SWFSC
Senior Mammal Observer	Jim Cotton	SWFSC
Senior Mammal Observer	Richard Rowlett	SWFSC
Mammal Observer	Lilian Carswell	AFL
Mammal Observer	Christopher Cutler	AFL
Biopsy/Mammal Observer	Suzanne Yin	AFL
Mammal Observer	Beth Goodwin	AFL
Seabird Observer	Michael Force	AFL
Seabird Observer	Sophie Webb	AFL
Oceanographer	Melinda Kelley	AFL
Acoustician	Shannon Rankin	SWFSC
Acoustic Technician	Sara Heimlich	OSU
Visiting Scientist	Robert Pitman	SWFSC
Visiting Scientist	Luis Vilchis	AFL/SIO

APPENDIX (Continued)

Leg 4:

Position	**Name**	**Affiliation**
Cruise Leader	Karin Forney	SWFSC
Senior Mammal Observer	Jim Cotton	SWFSC
Senior Mammal Observer	Richard Rowlett	SWFSC
Biopsy/Mammal Observer	Mark Deakos	HAMER
Mammal Observer	Christopher Cutler	AFL
Mammal Observer	Suzanne Yin	AFL
Mammal Observer	Beth Goodwin	AFL
Seabird Observer	Michael Force	AFL
Seabird Observer	Sophie Webb	AFL
Oceanographer	Melinda Kelley	AFL
Acoustician	Shannon Rankin	SWFSC
Acoustic Technician	Jen Pettis	AFL
Visiting Scientist	Dave Johnson	PIFSC
Visiting Scientist	Scott Benson	SWFSC

Leg 5:

Position	**Name**	**Affiliation**
Cruise Leader	Dave Johnson	PIFSC
Senior Mammal Observer	Jim Cotton	SWFSC
Senior Mammal Observer	Richard Rowlett	SWFSC
Biopsy/Mammal Observer	Mark Deakos	HAMER
Mammal Observer	Christopher Cutler	AFL
Mammal Observer	Suzanne Yin	AFL
Mammal Observer	Beth Goodwin	AFL
Seabird Observer	Michael Force	AFL
Seabird Observer	Sophie Webb	AFL
Oceanographer	Melinda Kelley	AFL
Acoustician	Shannon Rankin	SWFSC
Acoustic Technician	Jen Pettis	AFL
Teacher-at-sea	Lorayne Meltzer	Prescott College

Abbreviations:

SWFSC- Southwest Fisheries Science Center
PIFSC- Pacific Islands Fisheries Science Center
AFL- Aquatic Farms, Ltd.
SIO- Scripps Institution of Oceanography
OSU- Oregon State University

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(December 2007)

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