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OCTOBER 2010

ECOSYSTEM SURVEY OF *Delphinus species* cruise report

Susan J. Chivers, Wayne L. Perryman, Nicholas M. Kellar, James V. Carretta, Frederick I. Archer, Jessica V. Redfern, Annette E. Henry, Morgan S. Lynn, Candice Hall, Al Jackson, Gabriela Serra-Valente, Thomas J. Moore, Claire Surrey-Marsden, and Lisa T. Ballance

NOAA-TM-NMFS-SWFSC-464

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

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U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
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Ecosystem Survey of *Delphinus* Species
Cruise Report

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James V. Carretta, Frederick I. Archer, Jessica V. Redfern,
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Platform: NOAA Ship *McArthur II*

Cruise Number: M2-09-05, SWFSC Cruise Number 1640

Cruise Dates: 07 September – 09 December 2009

Study Area: Near-shore waters from the southern tip of Baja California, México to Monterey Bay, California, to a distance of less than 100 nm.

Sponsoring Institution: NOAA-National Marine Fisheries Service, Southwest Fisheries Science Center (SWFSC), Protected Resources Division (PRD), 3333 North Torrey Pines Court, La Jolla, California, USA 92037

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CONTENTS

CRUISE DESCRIPTION

The "Ecosystem Survey of *Delphinus* Species" research survey focused on the two species of common dolphin, *Delphinus delphis* and *D. capensis*, found off southern California, USA, and Baja California, Mexico. The primary objective was to provide information to improve conservation and management plans for these species. The project used a multidisciplinary approach. For both *Delphinus* species, data were collected to estimate abundance, pregnancy and birth rates, timing of reproduction, gene flow, and contaminant concentrations. Oceanographic data were collected to characterize habitat, and data on distribution and abundance of seabirds, prey fishes, and squids were collected to further characterize the ecosystem in which these dolphins live. Photographs of dolphin schools were taken from a NOAA Twin Otter aircraft while the survey was being conducted. The aerial photographs will provide count and measurement data to calibrate observer estimates of school size and to estimate timing of reproduction and birth rates. This research will facilitate understanding population demography of these species in an ecosystem framework. Essential information about the primary focal species, *D. capensis*, will greatly increase our knowledge about this coastal species and the geographic extent of a Mexico-U.S. transboundary stock. For additional information about the *Delphinus* cruise, please see http://swfsc.noaa.gov/prd-delphinus.aspx.

OPERATIONS

1.0 CETACEAN RESEARCH

1.1 Cetacean Visual Survey – The survey extended from central California, USA to the southern tip of Baja California, Mexico. Survey legs of approximately 30 days (see "Logistics" section for details) targeted three different geographic areas. Survey grids for Legs 1 and 2 were designed within the study area boundaries defined to encompass all historical sightings of *Delphinus capensis* during previous SWFSC research cruises. These boundaries will be used to define the strata for estimating *D. capensis* abundance. Leg 1 of this survey targeted U.S. coastal waters from central California to the USA/Mexico border. Leg 2 targeted waters off Baja California. Leg 3 targeted the same southern California inshore waters surveyed during Leg 1 (i.e., south of Point Conception, California), with additional offshore transects that were extensions of the Leg 1 transects out to the shelf break (Figure 1a, Table 1).

Visual survey methods generally followed the line-transect survey protocols described by Kinzey et al. (2000). Weather permitting, a team of three marine mammal observers searched for cetaceans from the flying bridge during daylight hours (approximately 0600 to 1900). Six (6) marine mammal observers worked in 2-hour rotations, staffing three stations on the flying bridge for 40 minutes: a port side 25x150-binocular station, a center-line data recorder position, and a starboard 25x150-binocular station. The observers followed standard line-transect protocols to survey a systematic grid of transect lines (Figure 1a). At the beginning of each day, search effort started on the trackline. The NOAA Ship *McArthur II* traveled at approximately 10 knots (through the water) along the designated trackline. While on search effort, if the ship's speed through the water deviated from this by more than two knots, the bridge personnel notified the mammal team on watch or the Cruise Leader. Bridge personnel notified the marine mammal team of any course changes.

1.1.1 Logging of Data – A log of observation conditions, watch effort, sightings, and other required information was entered into a computer, which was linked to the ship's GPS (for course, speed and position information) and Scientific Computing System (SCS; for weather and heading information). All science computers were linked to the same GPS and networked to the timeserver thus synchronizing all data with the same position and time. Additional data on each sighting were recorded on a paper sighting form. Behavioral data were recorded on the back of the sighting form for all cetacean sightings.

1.1.2 Departures from the Trackline – On sighting a cetacean group or other feature of interest, the Cruise Leader or Senior Marine Mammal Observer on watch typically requested that the vessel be maneuvered to approach the group or feature for investigation. As the ship approached a group of marine mammals, observers made independent estimates of group size. Weather permitting, biopsy and photographic

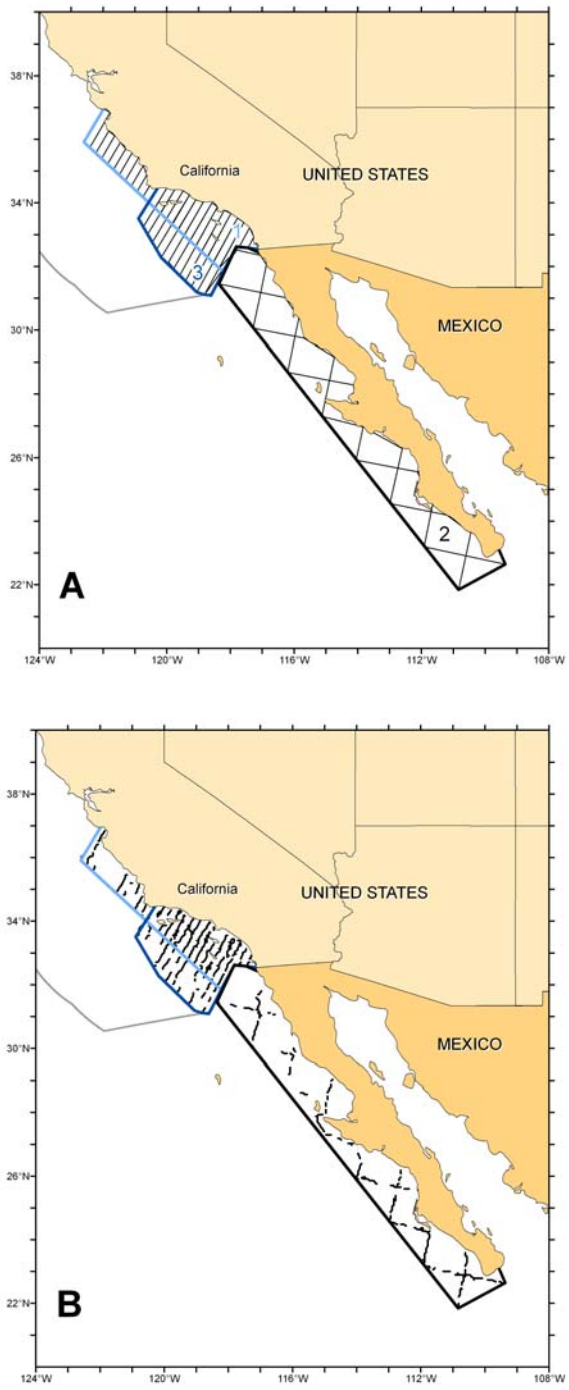

Figure 1. The survey effort planned (A) and the standard effort completed (B) during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II* are shown. Leg 1 surveyed the inshore rectangle off California, USA (light blue border); Leg 2 surveyed offshore of Baja California, Mexico (black border); and Leg 3 surveyed the Southern California Bight, off California, USA, including the inshore area covered on Leg 1 (dark blue border). The USA exclusive economic zone is shown for reference with a light gray line.

Table 1. Study area boundary coordinates are presented from north to south by Leg for the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

Leg	Waypoint	Latitude	Longitude
1	1	36.96	-121.98
	2	35.91	-122.60
	3	31.94	-118.36
	4	31.85	-118.24
	5	32.59	-117.82
	6	32.58	-117.45
	7	32.43	-117.10
2	1	32.43	-117.10
	2	32.58	-117.45
	3	32.62	-117.82
	4	31.44	-118.36
	5	21.84	-110.84
	6	22.64	-109.36
	7	23.1	-109.57
3	1	34.46	-120.29
	2	33.51	-120.89
	3	32.27	-120.17
	4	31.18	-119.05
	5	31.11	-118.82
	6	31.08	-118.61
	7	32.62	-117.82
	8	32.54	-117.13

sampling (see sections 1.3 and 1.4) was conducted on all sightings of *Delphinus* species and on selected occasions on other cetacean species. All operations were conducted from the ship and were directed by the Cruise Leader or Senior Marine Mammal Observers. In some instances, the Cruise Leader requested the small boat be deployed for additional biopsy and/or photographic sampling. After the observers completed scientific operations for the sighting, the ship resumed the same course and speed as prior to the sighting. If pursuit of the Sighting took the ship more than 3 nm from the trackline, the observers were notified. It was occasionally necessary to divert the ship's course from the established trackline during regular effort due to glare or adverse sea conditions. Under these circumstances, the ship was diverted up to 30 degrees from the established course. This deviation was continued until the ship was 3 nm from the trackline, at which point the ship turned back toward the trackline.

1.1.3 Resuming Effort – When the observers completed operations for the sighting, the ship resumed the same course and speed as prior to the sighting. The Cruise Leader or Senior Marine Mammal Observers occasionally requested that the ship take a

heading angling back toward the trackline, rather than proceeding directly toward the next waypoint.

1.1.4 Cruise-Specific Instructions – The Chief Scientist gave the observers and Cruise Leaders several instructions that were specific to this project. Generally, time spent on non-*Delphinus* species sightings was limited and determined on a case-by-case basis. Daily operations were modified when the ship worked with the plane to simultaneously sample *Delphinus* species sightings.

1.1.5 Survey Data Collected – During the survey, 4533 km of standard survey effort were completed (Figure 1b, Table 2). There were 1156 marine mammal sightings of 23 cetacean and 4 pinniped species (Table 3); sightings of *Delphinus* spp. are shown in Figures 2 through 4 and for other selected cetacean species are shown in Figures 5 through 16. The data format together with the species codes and observer codes used during the survey are presented in Appendix 1. Ecosystem studies data summaries are presented in section 2.0.

Table 2. Standard survey effort completed during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II* are presented by Beaufort sea state.

Beaufort	Survey Effort (km)
0	0
1	178
2	761
3	1064
4	2067
5	463
6	0
Total	4533

Table 3. Summary of all marine mammal sightings recorded on and off effort during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*. Figures 2 through 16 show sighting locations for selected cetacean species.

Species or Taxon category	Leg 1	Leg 2	Leg 3	Total
Arctocephalus townsendi	0	11	0	11
Balaenoptera acutorostrata	10	0	2	12
Balaenoptera borealis/edeni	0	11	0	11
Balaenoptera edeni	0	1	0	1
Balaenoptera musculus	30	26	6	62
Balaenoptera physalus	36	4	37	77
Balaenoptera sp.	23	22	21	66
Berardius bairdii	3	0	1	4
Callorhinus ursinus	19	3	1	23
Delphinus capensis	74	63	25	162
Delphinus delphis	66	22	38	126
Delphinus sp.	34	19	22	75
Globicephala macrorhynchus	0	12	0	12
Grampus griseus	34	2	17	53
Lagenorhynchus obliquidens	21	23	15	59
Lissodelphis borealis	2	0	16	18
Megaptera novaeangliae	32	4	4	40
Mirounga angustirostris	9	2	8	19
Orcinus orca	2	0	4	6
Phocoena phocoena	9	0	0	9
Phocoenoides dalli	5	0	5	10
Physeter macrocephalus	1	15	3	19
Stenella attenuata (offshore)	0	9	0	9
Stenella attenuata (unid. subsp.)	0	1	0	1
Stenella coeruleoalba	0	3	0	3
Stenella longirostris orientalis	0	6	0	6
Steno bredanensis	0	2	0	2
Tursiops truncatus	19	20	3	42
Unidentified (Unid.) cetacean	1	2	1	4
Unid. dolphin	8	9	4	21
Unid. fur seal	0	3	4	7
Unid. large whale	8	3	8	19
Unid. medium delphinid	6	3	1	10
Unid. pinniped	3	28	20	51
Unid. porpoise	0	0	1	1
Unid. sea lion	0	2	0	2
Unid. small delphinid	10	23	25	58
Unid. small whale	0	1	0	1
Unid. whale	0	0	3	3
Zalophus californianus	14	7	14	35
Ziphiid whale, unid. to species	1	0	0	1
Ziphius cavirostris	0	0	5	5
Total	**480**	**362**	**314**	**1156**

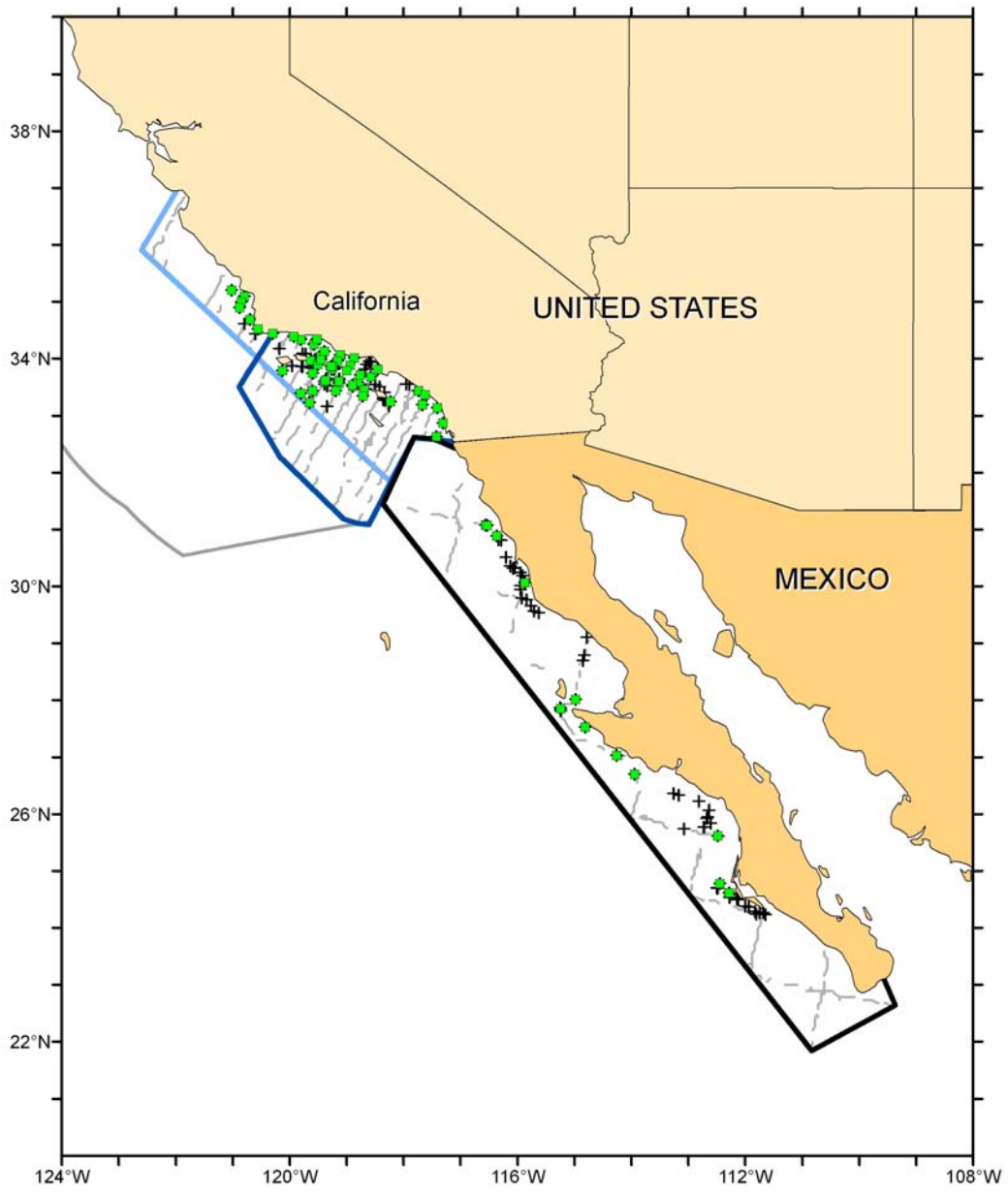

Figure 2. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of long-beaked common dolphins (*Delphinus capensis*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

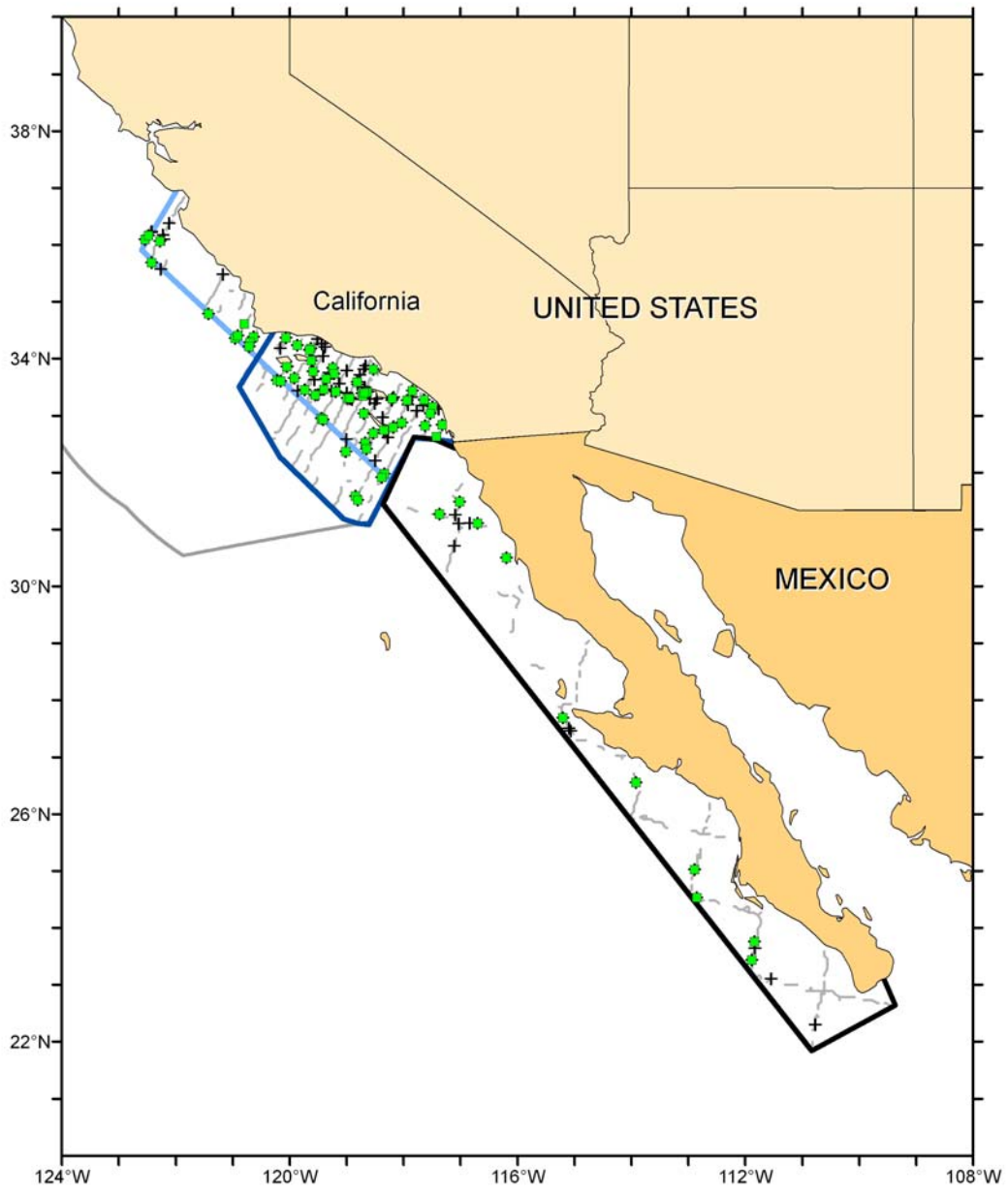

Figure 3. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of short-beaked common dolphins (*Delphinus delphis*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

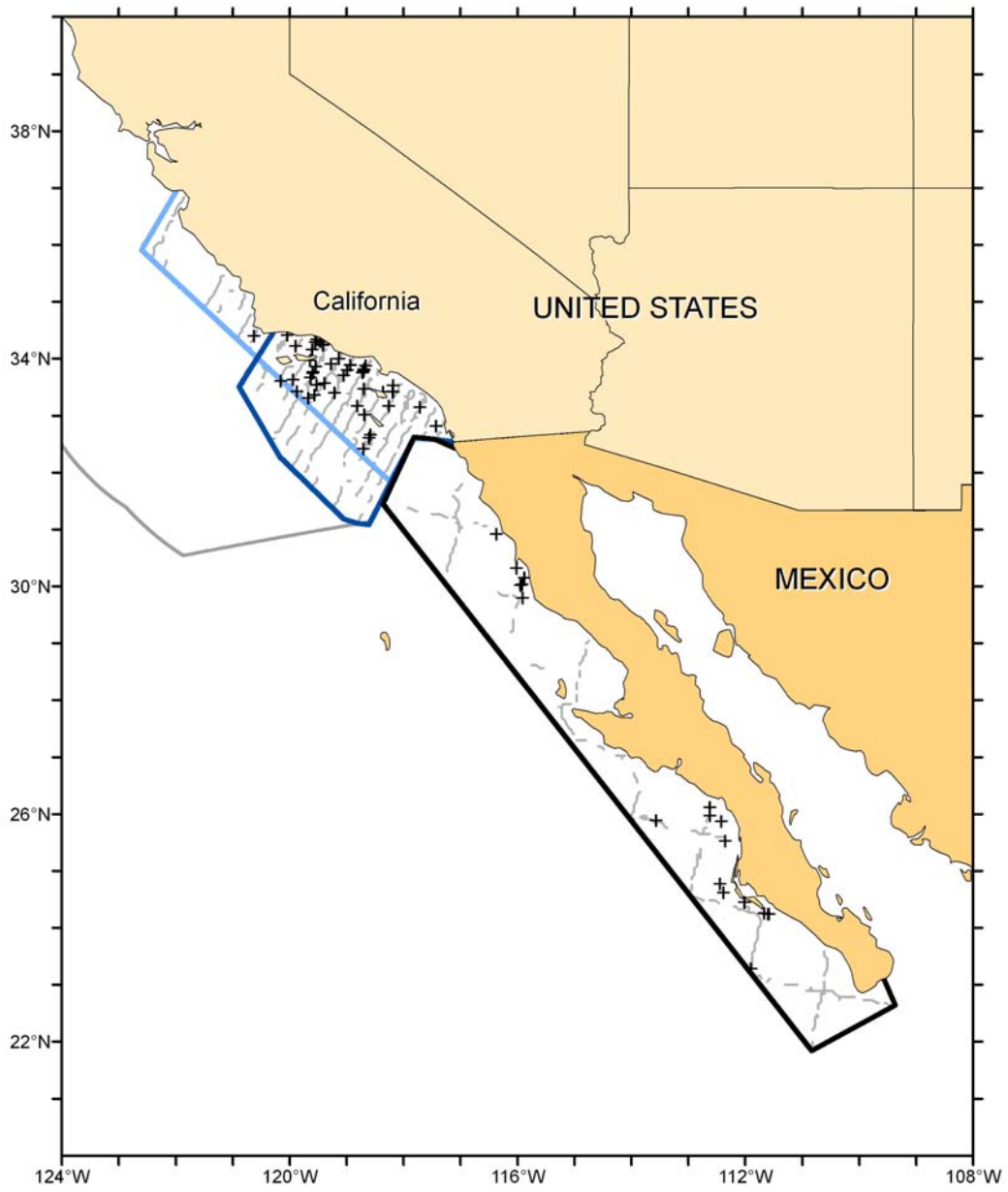

Figure 4. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of common dolphins unidentified to species (*Delphinus* sp.) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

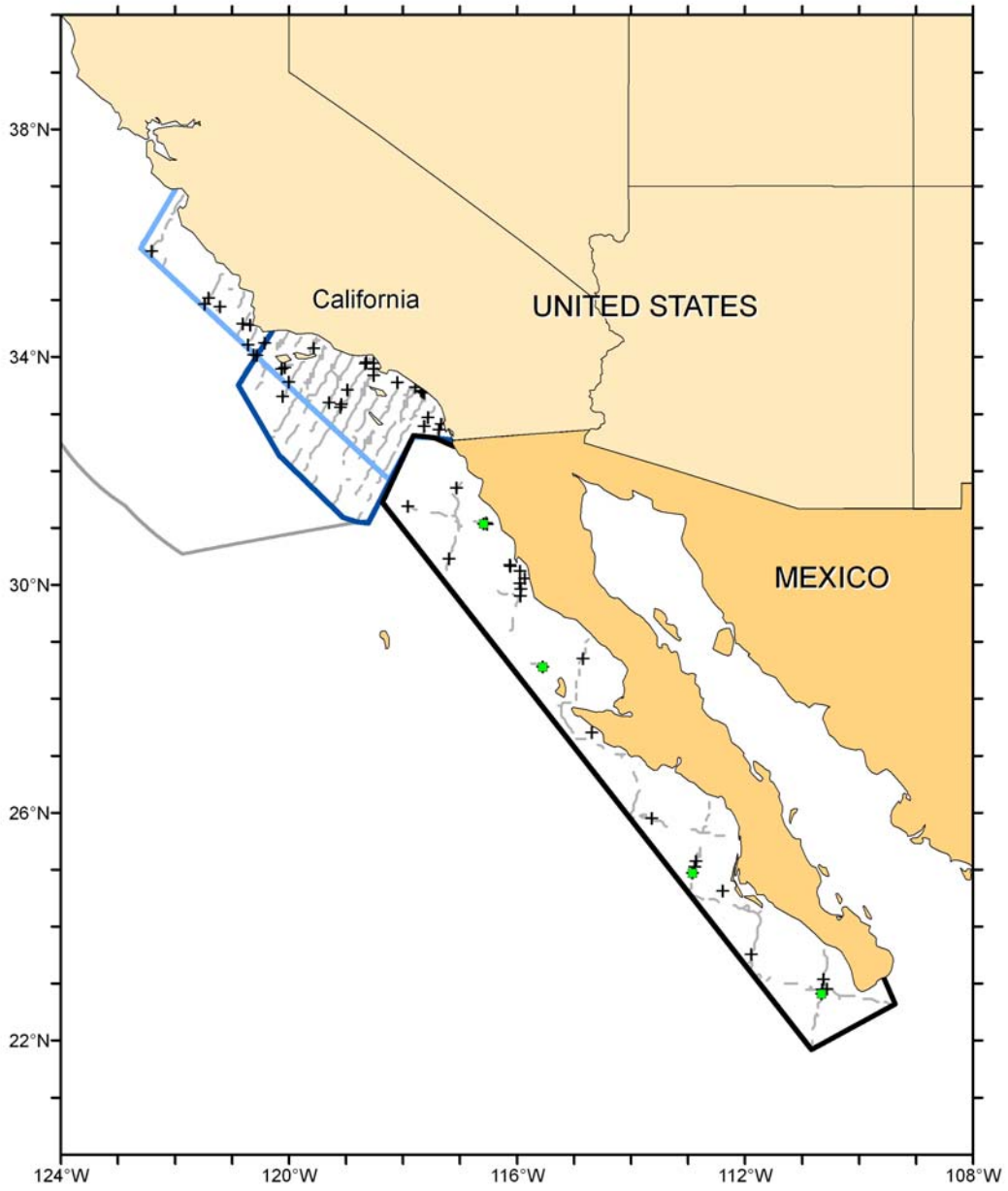

Figure 5. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of blue whales (*Balaenoptera musculus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

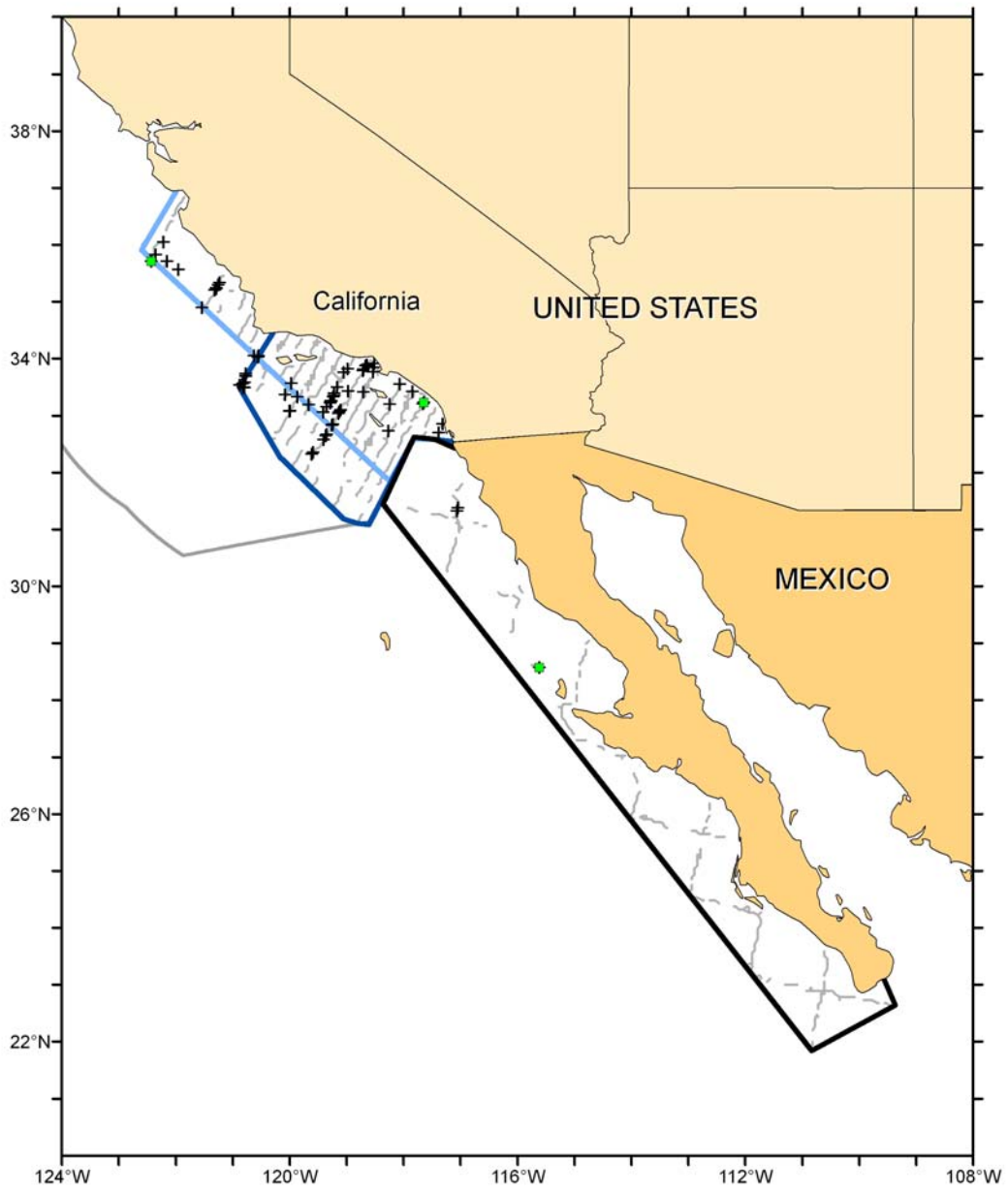

Figure 6. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of fin whales (*Balaenoptera physalus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

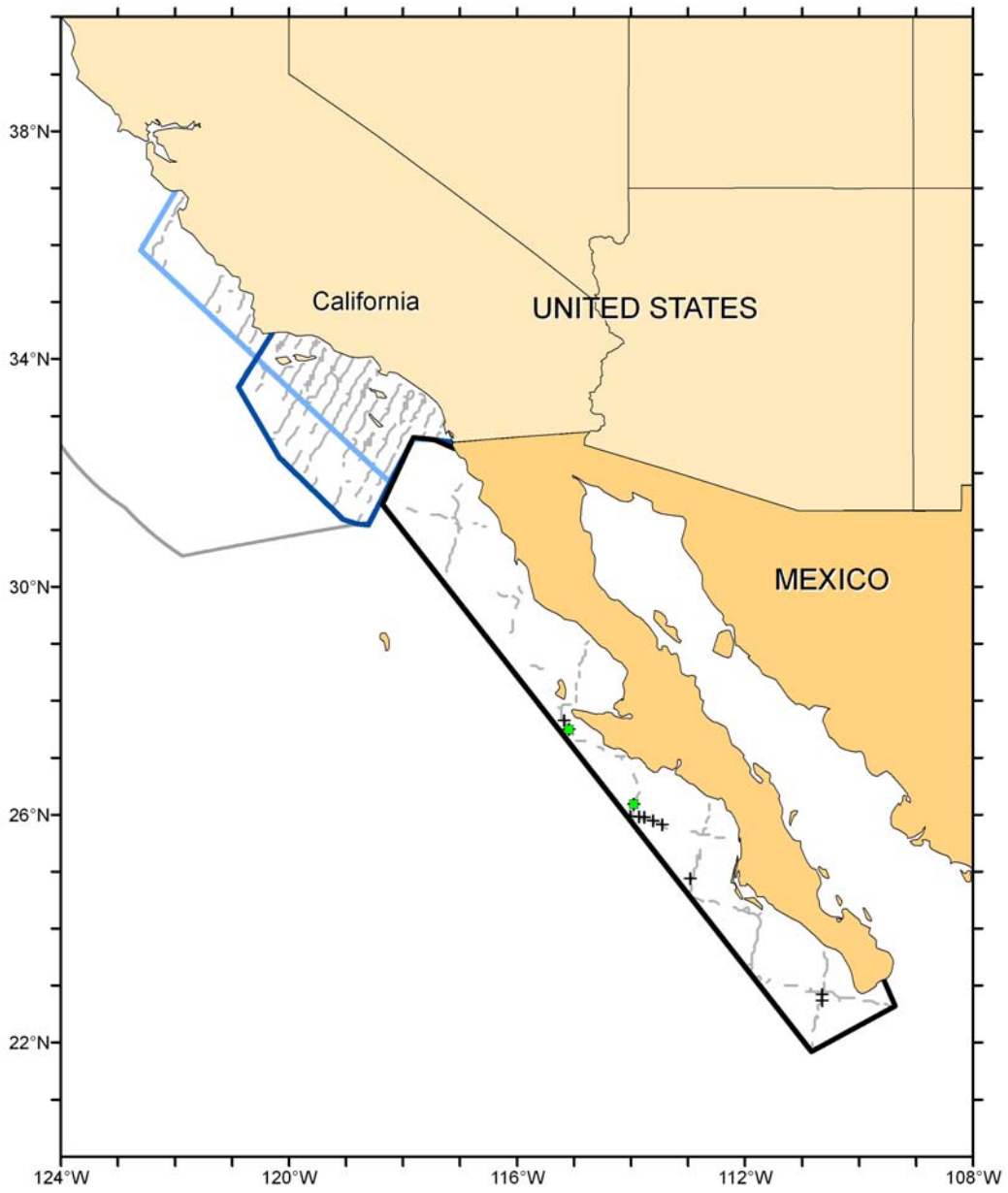

Figure 7. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of short-finned pilot whales (*Globicephala macrorhynchus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

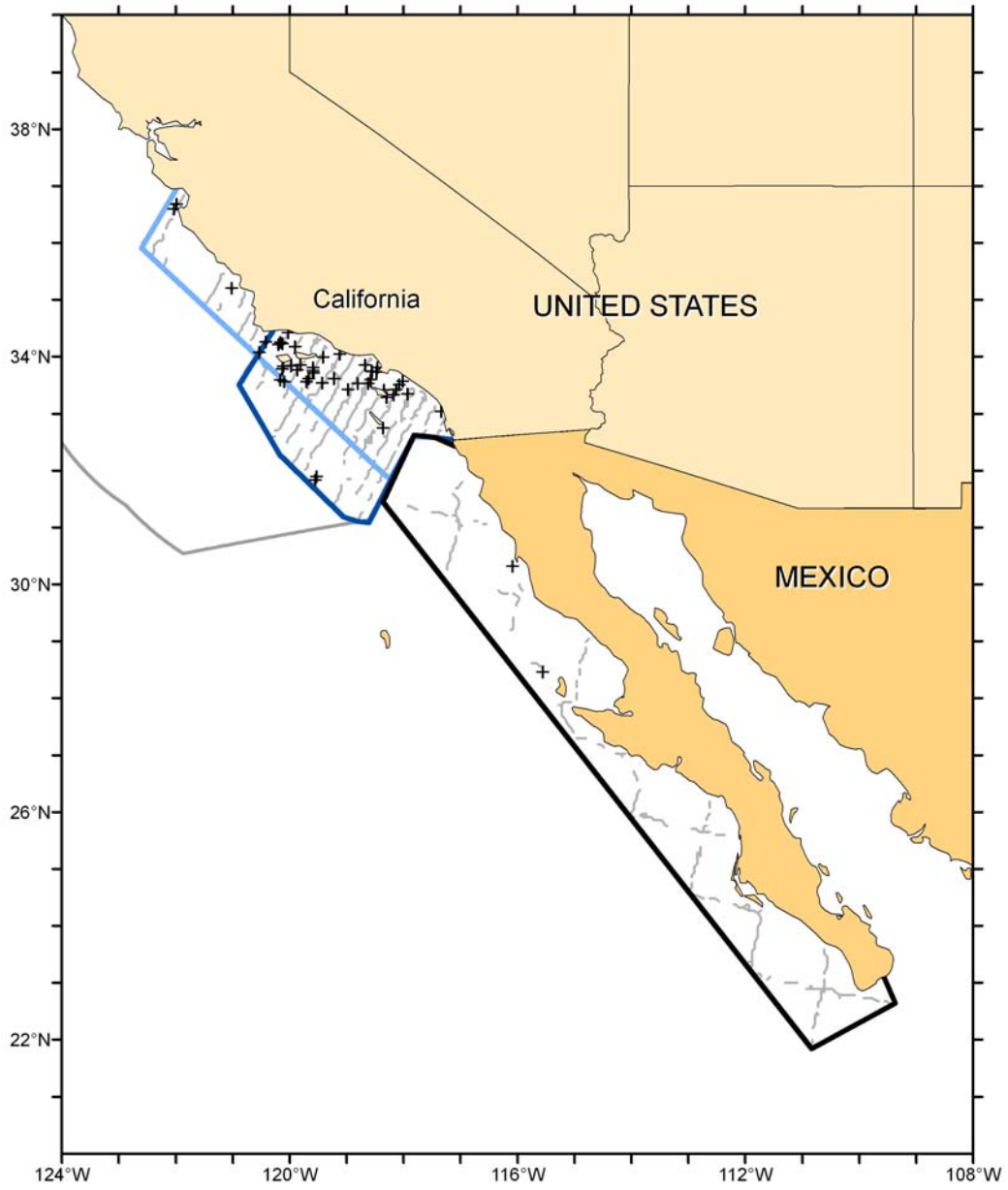

Figure 8. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of Risso's dolphins (*Grampus griseus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

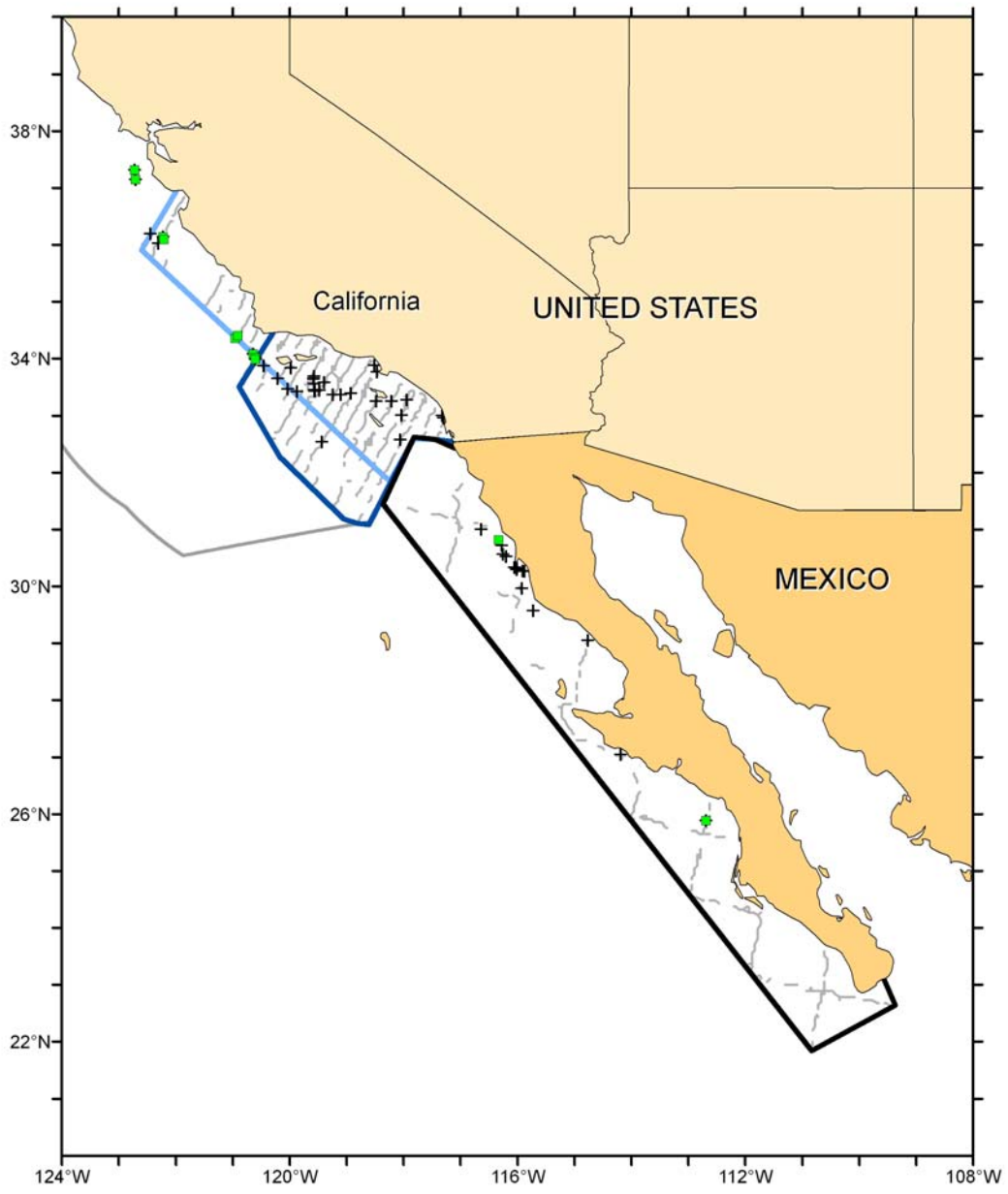

Figure 9. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

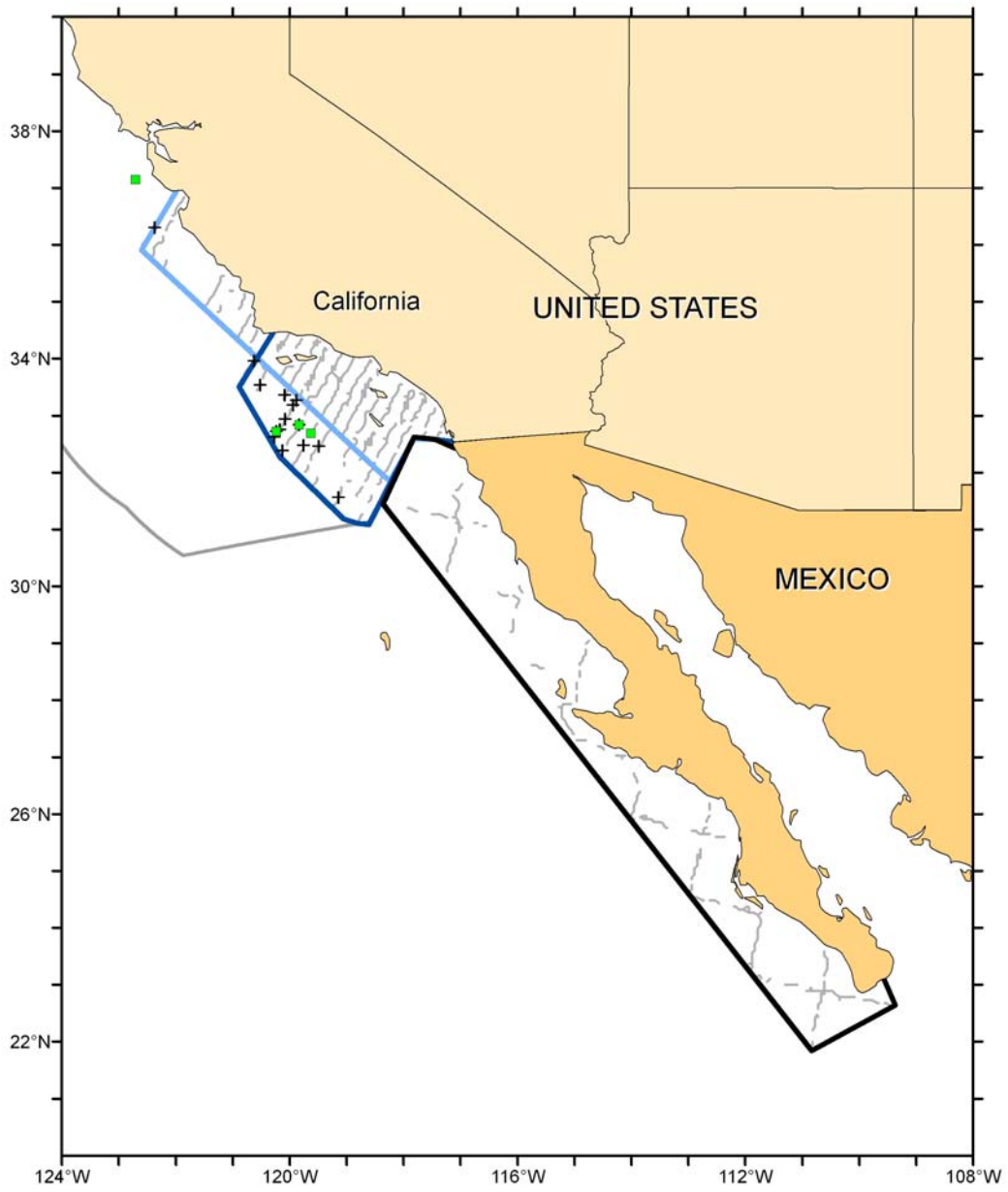

Figure 10. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of northern right whale dolphins (*Lissodelphis borealis*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

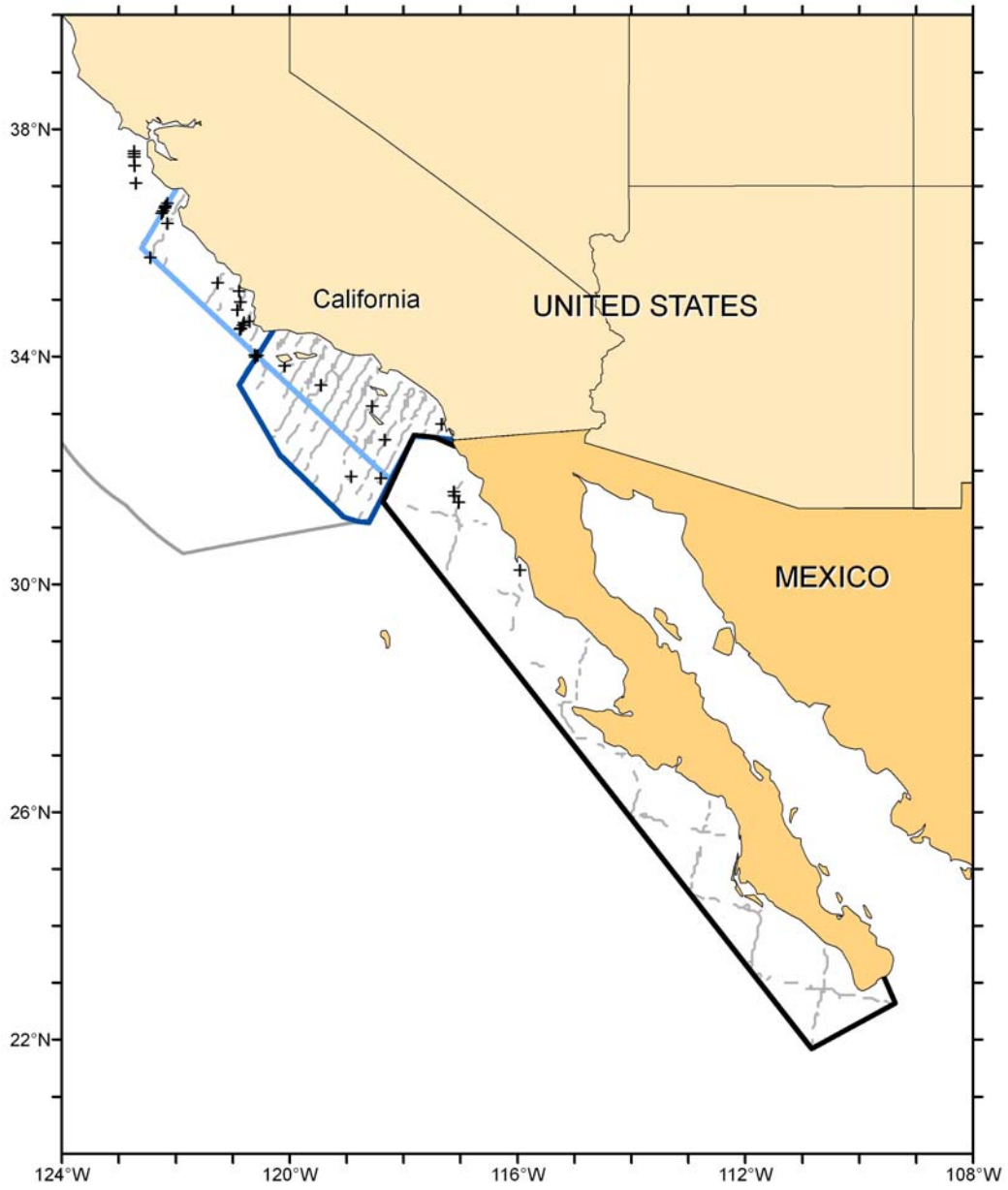

Figure 11. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of humpback whales (*Megaptera novaeangliae*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

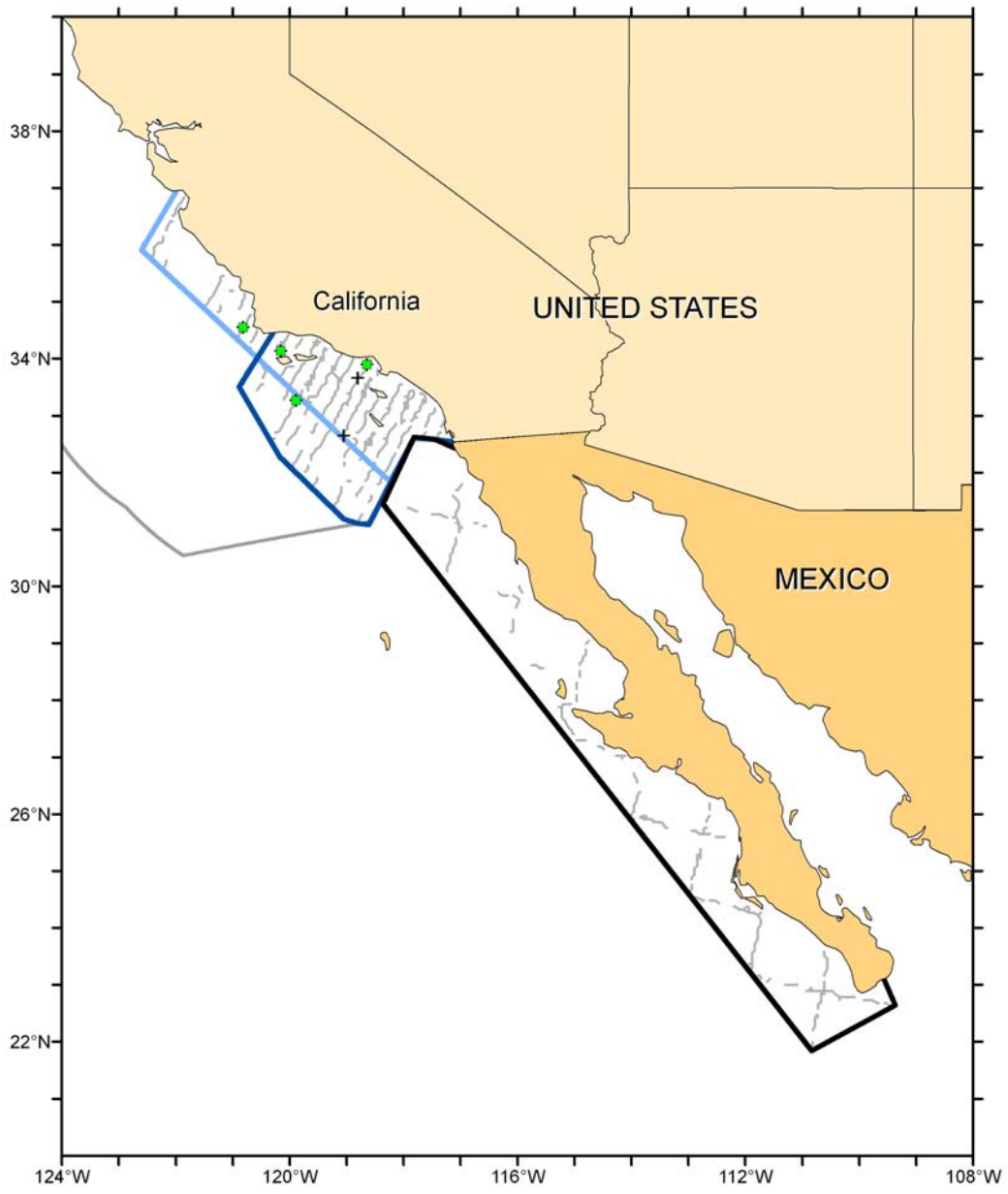

Figure 12. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of killer whales (*Orcinus orca*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

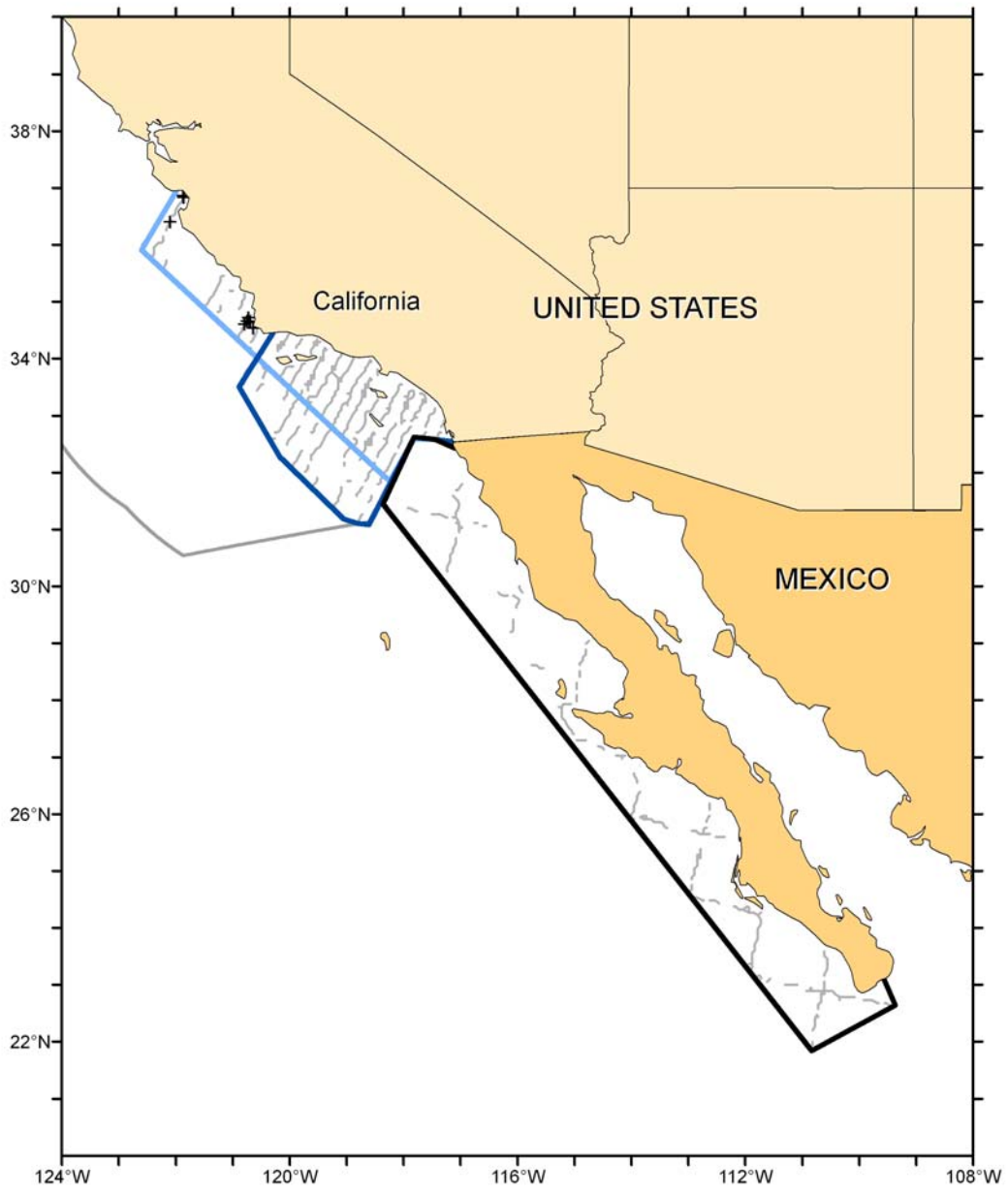

Figure 13. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of harbor porpoise (*Phocoena phocoena*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

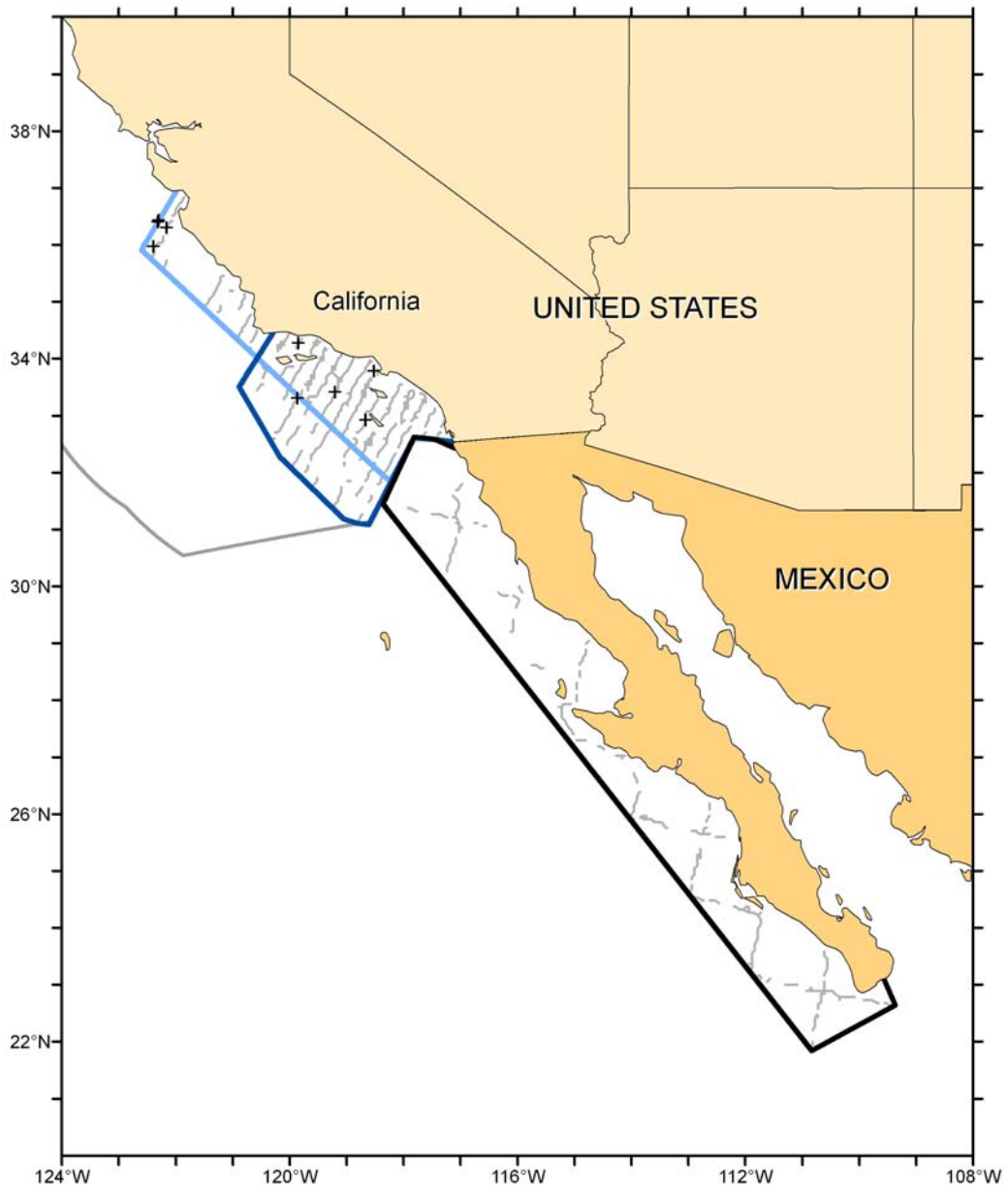

Figure 14. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of Dall's porpoise (*Phocoenoides dalli*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

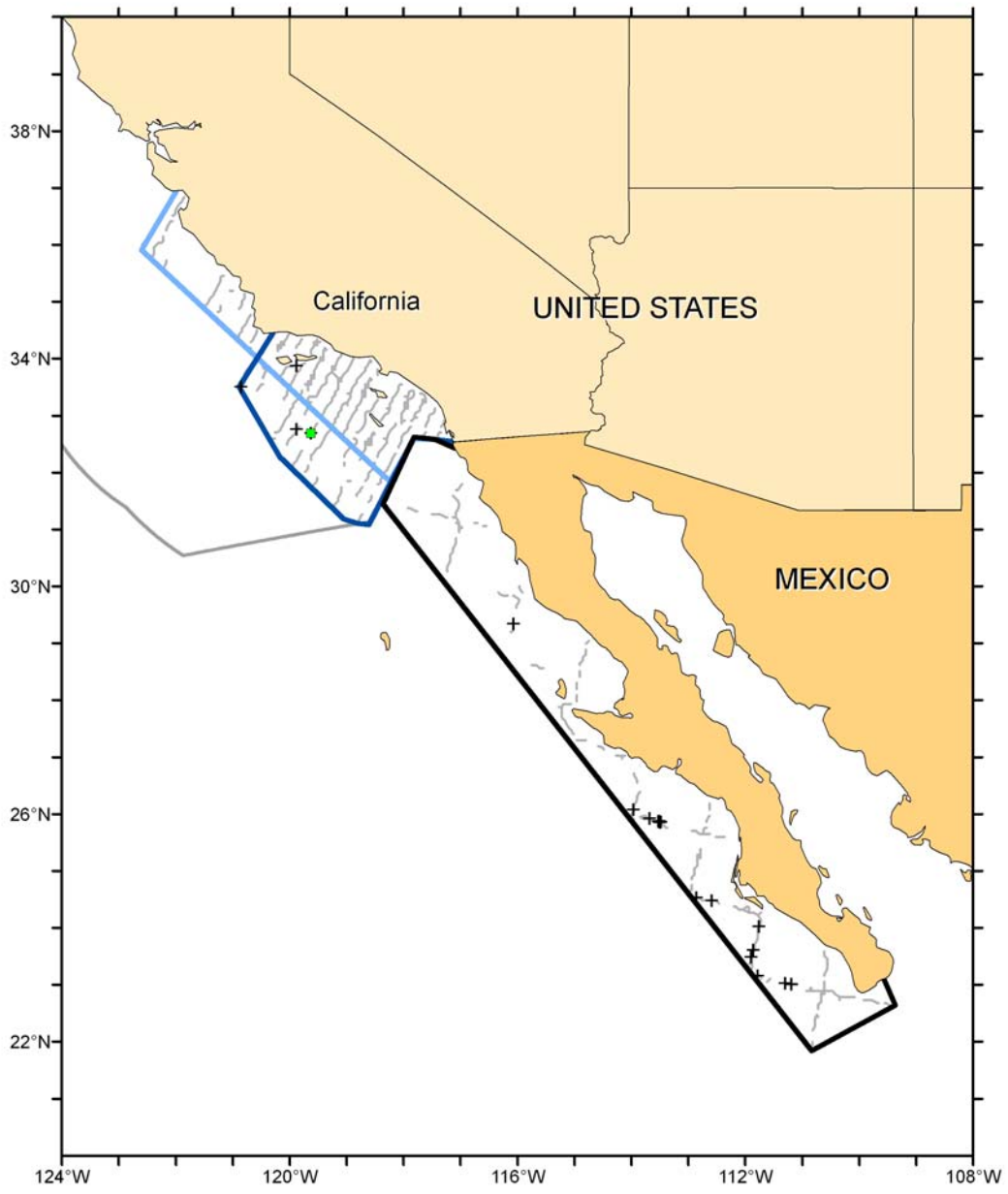

Figure 15. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of sperm whales (*Physeter macrocephalus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

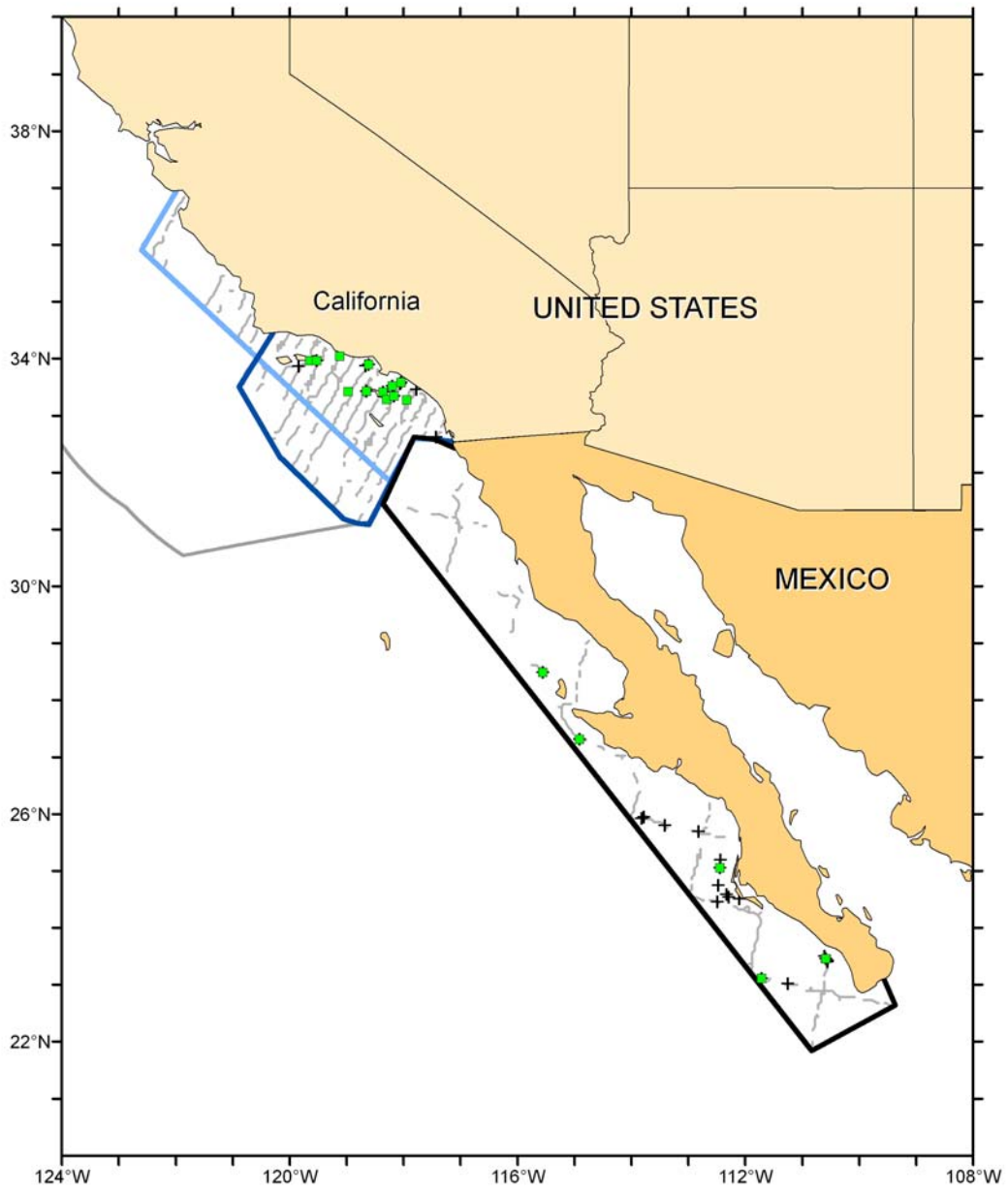

Figure 16. On- and off-effort sightings (crosses) and sightings with biopsy samples collected (squares) of common bottlenose dolphins (*Tursiops truncatus*) recorded during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

1.2 Biopsy Sampling – Samples for molecular genetic analyses (e.g. stock structure studies and pregnancy determinations) were collected from cetaceans on an opportunistic basis. Necessary permits were present on the vessel. Personnel sampling cetaceans on this cruise were instructed to avoid sampling calves < 1-year-old and their attendant adult in order to meet the conditions of the research permits and to randomly sample all individuals (i.e., adults, juveniles and calves > 1 year old) without regard to size or color pattern to minimize sampling bias. Cetaceans sampled were approached by the research vessel during normal survey operations, approached the vessel on their own, or were approached by a small boat. Samples were collected from animals within 10 m to 30 m of the bow of the vessel using a dart fired from a crossbow or rifle. Small boat deployment was requested by the Cruise Leader on an opportunistic basis during all daylight hours, sometimes multiple times in a single day, providing the Commanding Officer concurred that operating conditions were safe. The small boat remained within radio contact at all times while deployed and typically remained within sight of the ship.

There were 1343 biopsy samples collected from *Delphinus* species and 117 samples collected from 11 other cetacean species (Table 4). Sightings with biopsy samples collected are plotted for *Delphinus* spp. in Figures 2 through 4 and for other selected cetacean species in Figures 5 through 16.

Table 4. Cetacean biopsy samples collected during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

Species	Leg 1	Leg 2	Leg 3	All
Balaenoptera physalus	2	1		3
Balaenoptera musculus		4		4
Delphinus capensis	369	145	165	679
Delphinus delphis	383	79	202	664
Globicephala macrorhynchus		2		2
Lagenorhynchus obliquidens	9	9	1	19
Lissodelphis borealis	1		3	4
Orcinus orca	8		4	12
Physeter macrocephalus			9	9
Stenella attenuata		1		1
Stenella longirostris subsp.		2		2
Stenella coeruleoalba		1		1
Tursiops truncatus	38	10	12	60
Total	810	254	396	1460

1.3 Photography – Marine mammals were photographed (1) to document at-sea species identifications for each sighting, (2) to contribute information about movements and abundance to on-going photo-identification studies of large whales and small dolphins, (3) to document unusual events or sightings, (4) to document color patterns and body proportions of dolphins to aid in stock identification, and (5) to identify the stage classes of dolphins on the bow available for biopsy sampling. Cetaceans photographed were approached by the research vessel during normal survey operations, approached the vessel on their own, or were approached by a small boat. Personnel were instructed to randomly sample small cetaceans by taking photographs of individuals throughout the school without regard to size or color pattern. To meet the objectives of this cruise, which included documenting species identifications for the two *Delphinus* species (i.e., oblique or horizontal photographs) and measuring individuals that rode the bow of the research vessel (i.e., vertical bow photographs), more effort was dedicated to collecting photographs than on standard SWFSC research surveys (Table 5). Photography was closely coordinated with biopsy sampling to aid in confirming some species identifications of *Delphinus* species. Vertical bow photographs were taken with a camera outfitted with a wide angle lens and parallel laser sights, which provide a scale to convert image measurements to total body lengths for individual dolphins measured. Personnel collecting vertical bow images were instructed to take photographs in short discrete burst pulses while individuals of both *Delphinus* species were riding the bow. Only digital cameras were used.

Table 5. (a) The number of sightings photographed and the number of oblique, or horizontal, photographs taken, and (b) the number of sightings photographed and the number of vertical bow photographs taken by species during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

(a)

Species	Leg 1		Leg 2		Leg 3		All	
	sightings	photos	sightings	photos	sightings	photos	sightings	photos
Balaenoptera edeni			1	67			1	67
Balaenoptera physalus	7	327	2	442	2	36	11	805
Balaenoptera musculus	4	142	7	1864			11	2006
Balaenoptera borealis/edeni			5	27			5	27
Delphinus capensis	46	2724	45	1387	13	614	101	4725
Delphinus delphis	48	3781	21	1895	24	1203	91	6879
Globicephala macrorhynchus			8	859			8	859
Grampus griseus	7	154	4	16	6	108	16	278
Lagenorhynchus obliquidens	3	19	11	181	5	57	12	127
Lissodelphis borealis					5	142	5	142
Orcinus orca	2	578			4	1755	6	2333
Phocoenoides dalli	1	2					1	2
Physeter macrocephalus					1	937	1	937
Stenella attenuata			11	164			10	164
Stenella longirostris orientalis			6	126			1	81
Stenella coeruleoalba			4	39			2	21
Steno bredanensis			1	2			1	2
Tursiops truncatus	10	321	13	423	2	42	23	786
Total	128	8048	139	7492	62	4894	306	20241

Table 5 (continued)
(b)

Species	Leg 1		Leg 2		Leg 3		All	
	sightings	photos	sightings	photos	sightings	photos	sightings	photos
Delphinus capensis	47	13311	47	8072	12	2128	106	23511
Delphinus delphis	41	11098	14	2795	26	4942	81	18835
Lagenorhynchus obliquidens	3	62					3	62
Lissodelphis borealis					1	4	1	4
Tursiops truncatus	2	171	7	316			9	487
Total	93	24642	68	11183	39	7074	200	42899

1.4 Aerial Photogrammetry – The ship conducted coordinated operations with a NOAA Twin Otter aircraft (NOAA-48) operating out of airports along the west coast of the USA (Oxnard, Santa Barbara and San Diego) and Mexico (Loreto) between 16 September and 17 November. On days with excellent weather (Beaufort 2 and less), the aircraft flew to the area where the ship was surveying to collect vertical photographs of dolphin schools detected from the ship. Data from the aerial photographs will be used to calibrate observer estimates of school size and to estimate timing of reproduction and birth rates. During days of ship/aircraft operations, school size calibration took precedence over line-transect sampling. The Cruise Leader coordinated communications with the aircraft and kept the Command and Operations Officer informed of plans for daily operations. The aircraft also attempted to locate groups of dolphins and whales independently within the study area when coordinated activities with the ship were not possible. The aircraft continued to sample the study area during the ship's in-ports. The aerial photographs were taken using three Canon EOS-1 DS Mark III digital cameras that were fired simultaneously from a forward-motion-compensating mount placed in the belly of the plane. The three cameras are fired simultaneously as passes are made over cetacean groups. A single image is assembled from each camera's image for each shot taken to achieve an image with a field of view comparable to the large-format film cameras used on previous missions (Perryman and Lynn 1993). This system replaces the film cameras (Figure 17). Aerial photographs were taken of 156 cetacean groups during the project (Table 6), including 116 schools of *Delphinus* species (Figure 18). Aerial photographs of 10 *D. capensis* and two *D. delphis* schools will be used to calibrate shipboard observer estimates of school size.

1.5 Salvage of Marine Mammals – No marine mammals were salvaged.

Table 6. Number of cetacean groups with aerial photographs taken from the NOAA-48 Twin Otter airplane during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II.*

Species	All
Balaenoptera acutorostrata	2
Balaenoptera edeni	2
Balaenoptera musculus	14
Balaenoptera physalus	5
Delphinus capensis	74
Delphinus delphis	33
Delphinus unid. to species	9
Grampus griseus	8
Lagenorhynchus obliquidens	1
Megaptera novaeangliae	3
Orcinus orca	1
Tursiops truncatus	4
Total	156

Figure 17. Schematic of the mount for three digital cameras used to take aerial photographs of cetaceans from the NOAA Twin Otter aircraft NOAA-48 during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

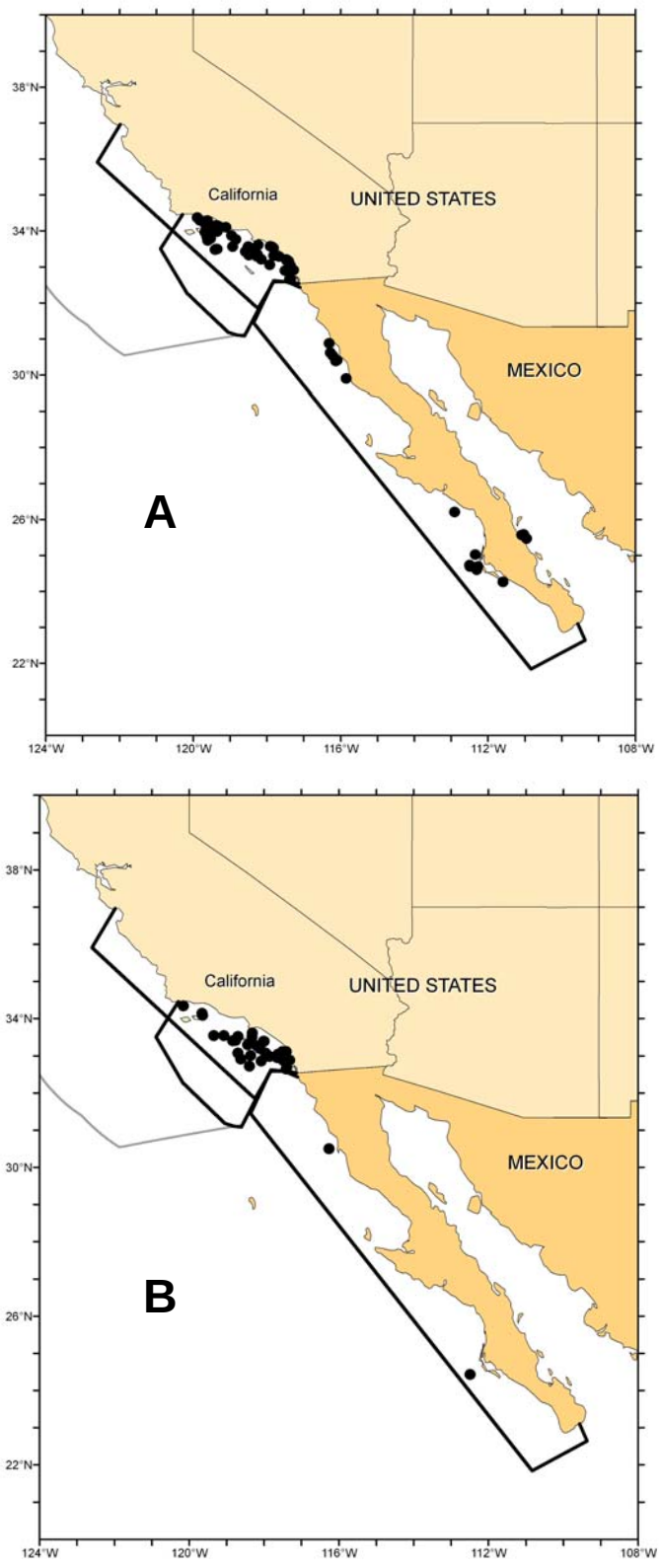

Figure 18. Locations of schools photographed with high-resolution digital cameras from the NOAA Twin Otter NOAA-48 during the 2009 *Delphinus* survey for (A) *Delphinus capensis* and (B) *D. delphis*.

2.0 ECOSYSTEM STUDIES

The goal of the Ecosystem Studies Program is to describe the physical and biological habitat, prey, predators, competitors, and commensals of marine mammal species. Sampling was conducted by two oceanographers, two seabird observers, the ship's Survey Technician, and visiting scientists. A summary of the data collected is presented in Table 7. Chronological records of sampling in Coordinated Universal Time (UTC) were kept by the oceanographer and in the ship's Marine Operations Log. The ship provided an electronic copy of their operation logs, including the weather log and other meteorological data, to the Ecosystem Studies Program upon completion of the cruise.

Table 7. Summary of ecosystem data collected during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*. Figures 19 through 23 show data specific sampling locations. See section 2.3.2 for a summary of seabird data collected.

Leg	CTD stations	Surface chlorophyll sampling stations	HAB stations	UCTD stations	XBT stations	Bongo tows	IKMT	Squid stations	UCTD yo-yo stations	UCTD, CTD, XBT comparison stations
1	24	141	96	123	20	23	19	23	2	2
2	25	152	105	116	42	23	22	24	2	2
3	31	120	89	80	33	20	20	19	2	2
Total	80	413	290	319	95	66	61	66	6	6

2.1 Oceanography – All oceanographic data were processed by the Ecosystem Studies Program of the Protected Resources Division at the Southwest Fisheries Science Center, NOAA Fisheries.

2.1.1 Thermosalinograph sampling – A Micro Thermosalinograph (TSG) SBE 45 was used to measure temperature and conductivity, and derive salinity, of surface seawater at approximately 30-second intervals. The ship's Scientific Computing System (SCS) recorded these data. The Micro TSG is located in the wet lab and measures water that has traveled through the ship's seawater system. In 2003, an SBE 38 temperature sensor was installed in the engine room to measure the temperature of the water closer to the intake, which is 3 m below the surface.

Discrete surface salinity samples were collected weekly from the TSG outflow to verify the TSG readings. Salinity samples were analyzed on a Guildline Instruments Portasal salinometer (Model 8410A) calibrated during each run with IAPSO (The International Association for Physical Science of the Ocean) Standard Seawater, manufactured by Ocean Scientific International.

2.1.2 Discrete surface chlorophyll sampling – Discrete bucket surface temperatures and chlorophyll samples were collected six times per day, at approximately 0800, 1000, 1200, 1400, 1600, and 1800 hrs local ship time. An additional sample was collected at the end of marine mammal survey effort, if effort extended beyond 1900 hrs. Water samples of 265 ml were filtered through Whatman 25 mm GF/F (glass fiber) filters, which retain particles of 0.7 µm and greater. Filters were immersed in 10 ml of 90% acetone for extraction and refrigerated for 24 to 36 hours before analysis.

Shipboard chlorophyll *a* and phaeophytin analyses (detailed in Holm-Hansen *et al*. 1965) were conducted using a Turner Designs Model 10-AU fluorometer; results were recorded using FLog, version 0804 (author: Jim Wilkinson, Scripps Institution of Oceanography, 2008). The fluorometer was calibrated with chlorophyll *a* liquid standards prior to the survey. In total, 413 surface chlorophyll samples were collected.

2.1.3 Water column properties: CTD profiles – Conductivity, temperature, and depth (CTD) casts were made each morning an hour before sunrise using a Sea-Bird Electronics 911*plus* CTD unit. During Leg 3, evening CTD casts were conducted to resolve equipment issues. The CTD was lowered to 1,000 m, and sensors connected to a shipboard computer measured conductivity, temperature, oxygen, and pressure (depth). Dual temperature and conductivity sensors were deployed to verify the accuracy of each sensor. CTD cast data were recorded using Sea-Bird Electronics Seasave software, version 7.18 (2008) for Legs 1 and 2, and version 7.19 (2009) for most of Leg 3. Deck pressure tests with a zero pressure offset were conducted at the beginning of each leg. Offsets from the deck pressure tests are used to calculate depth offsets during post-cruise data processing. Additional deck pressure tests were conducted following all equipment changes to the CTD. Specifically, a new SBE9 fish was installed during Leg 1 when spiking across all sensors was observed. During Leg 3, an additional pressure test was conducted after a system failure. The SBE 11*plus* deck unit registered an overload and shut down while the CTD was descending; it was only possible to restart the system upon nearing the surface. The primary source of this problem was two faulty oxygen cables. However, many improvements were made to the CTD system while exploring this problem. The following steps were taken and improvements made:

- the winch slip rings were replaced because arcing had occurred
- 200m of the conductive cabling was removed
- multiple casts were performed with varying sensor configurations
- temperature, conductivity, pressure, and oxygen sensors and cables were systematically replaced
- an updated version of Sea-Bird Electronics Seasave software, version 7.19 (2009) was installed
- deck tests were conducted when the CTD was not connected to the winch and cabling
- the deck unit was replaced.

Micro7-washed General Oceanics Niskin bottles were retrofitted with silicone rubber o-rings in the valves and end-caps. Silicone rubber tubing was used as the bottle closing

mechanism. Before the first regular CTD cast of each leg, a bottle test cast was conducted to validate CTD sensor calibration and detect evidence of Niskin bottle leakage. During this cast, all 12 Niskin bottles were fired at 500 m and salinity samples were collected from each bottle.

On all regular CTD casts, Niskin bottles were tripped at standard depths (0, 20, 40, 60, 80, 100, 120, 140, 170, 200, 500, and 1000 m). Water samples were collected from Niskin bottles fired at ≤ 200 m for chlorophyll *a* and phaeophytin analyses. Three replicate salinity samples were taken weekly from the 500 m bottle to validate CTD sensor calibration. Protocols for analyzing CTD salinity samples were the same as those described for the TSG samples. In total, 77 standard and three bottle test CTD casts were completed.

2.1.4 Water column properties: UCTD profiles – Underway CTD (UCTD, developed by Jochen Klinke, Oceanscience) casts were made six times per day, in conjunction with surface chlorophyll sampling. An additional cast occurred at the end of marine mammal survey effort, if effort extended beyond 1900 local ship time. A UCTD cast was also conducted if a CTD station was canceled. Casts were conducted after all surface water sampling. A total of 319 UCTD stations were completed; most stations had a single cast, but occasionally multiple casts were conducted at a station (see the UCTD Yo-Yo sampling section).

We used the UCTD for the first time on this cruise, and protocols changed throughout the cruise as we gained experience with this equipment. The UCTD probe was lowered to 400 m during Leg 1. Near the end of Leg 2, we lost two probes and a large portion of the Spectra line used to deploy the probe. Consequently, we only deployed the probe to 250 m during the final 11 days of Leg 2. We received replacement Spectra line for Leg 3 and were able to sample to 400 m. The depth of the cast is not available in real time and must be approximated by the amount of line deployed. The UCTD probe recorded temperature, conductivity, and pressure during both the down and up cast. After each cast, the data were downloaded and archived using Sea-Bird Electronics UCTDTerm, version 1.1 (2007). The UCTD system was used instead of XBT's, when possible, because it contains SeaBird Electronics temperature, conductivity, and pressure sensors. Consequently, we obtained more accurate temperature data and were able to record conductivity and pressure data. The direct measurement of pressure by the UCTD system allows for flexibility in ship heading and speed (e.g., the ship can be stationary or moving at varying speeds up to 10 knots), which minimizes the impact of this sampling on marine mammal effort and other ship operations. Additionally, the UCTD probe can be used for repeated casts, making it more cost effective and better for the environment.

2.1.5 Water column properties: XBT profiles – Expendable Bathythermograph (XBT) probes measure the temperature of the water column to 760 m (Sippican MK21 USB Surface Ship Bathythermograph Data Acquisition System). Data were recorded using the Sippican WinMK21 Data Acquisition and Post-processing Software, version 2.7.1 (2006). XBT probes were dropped when the UCTD probe could not be deployed because the water was too shallow, depth was changing rapidly, there

was too much debris (biological or anthropogenic) in the water, or it was not safe to deploy the ± 1000 m of Spectra line from the stern of the ship because other vessels were nearby, biopsy operations required the option of having the ship make sharp turns, or the UCTD malfunctioned. A total of 95 successful XBT drops were completed during the cruise.

2.1.6 Underway pCO_2 System – The Pacific Marine Environmental Laboratory's (PMEL) underway pCO_2 system continuously measured the partial pressure of CO_2 in the air and surface water during the cruise. The pCO_2 values, along with wind, temperature, and salinity data were used to calculate the flux of CO_2 at the air-sea interface. The system uses 3 liters of seawater per minute and determines CO_2 content with a Licor infrared detector. For more information, contact the PMEL Carbon Group, http://www.pmel.noaa.gov/co2/uwpco2/.

2.1.7 Harmful Algal Bloom (HAB) Sampling – HAB samples were collected in collaboration with Raphael Kudela's laboratory at the University of California, Santa Cruz. Water samples were collected to analyze pigments, as a diagnostic measure of the general phytoplankton assemblage, and toxins. Toxins of particular interest are domoic acid (produced by species of the diatom *Pseudo-nitzschia*), which causes Amnesic Shellfish Poisoning in humans, and saxitoxin (produced by the dinoflagellate *Alexandrium*), which causes Paralytic Shellfish Poisoning in humans.

Replicate surface water samples of 250 ml were collected at the morning CTD station and at alternate daily chlorophyll stations (i.e., at approximately 0600, 1000, 1400, and 1600 local ship time) for analysis of phycotoxin, qPCR (molecular identification), and phytopigment samples. These samples were filtered onto 25 mm Whatman GF/F filters, which retain particles of 0.7 µm and greater. The filters were placed in 2 ml cryovials and stored in the -80° C freezer. Water samples of 10 – 15 ml were collected and stored in the -20° C freezer for post-cruise nutrient analyses (i.e., N, P, and Si). Throughout *Delphinus* 2009, 1160 filtered HAB phycotoxin, qPCR, and phytopigment samples were collected from 290 HAB sampling locations.

2.1.8 Concurrent UCTD, CTD and XBT sampling – Comparative UCTD, CTD and XBT sampling stations were completed twice per leg. Stations were conducted by dropping an XBT to 760 m while approaching the CTD station, and after the CTD cast, a stationary UCTD cast to 400 m was made in the same location. These data were used to confirm the correction factor for the XBT drop rate equation and the accuracy of the CTD and UCTD sensors. Operational protocols were the same as those detailed in the sections above.

2.1.9 UCTD Yo-Yo sampling – UCTD yo-yo stations were conducted on each leg to assess fine-scale variability in thermal profiles. During Leg 1, two stations of 12 and 13 consecutive casts to 430 – 470 m were completed in 2.5 hours. During Leg 2, one station of 28 consecutive casts to 220 – 280 m was completed in 4.5 hours. A second station was aborted after two casts to 440 m because Humboldt squid were attracted to the UCTD probe. A third station was attempted when marine mammal survey effort was

suspended due to inclement weather; however, the station ended after one cast to 160 m because the ship was able to transit to an area with better weather for survey effort. During Leg 3, one station of 26 consecutive casts to 280 – 400 m was completed in six hours; a second station of 34 consecutive casts to 275 – 320 m was completed in 4.5 hours.

2.2 Mid-trophic Sampling

2.2.1 Oblique Bongo Tows – Bongo tows were conducted each evening after the CTD station (i.e., approximately 2.5 hours after sunset) to sample subsurface ichthyoplankton and macrozooplankton; 66 tows were completed during the cruise. The Bongo net was towed obliquely from 200 m depth for 15 minutes. This paired zooplankton net frame had a 505-µm mesh codend on the starboard side and a 333-µm mesh codend on the port side. A digital flowmeter (General Oceanics model 2030R) was placed in the mouth of the starboard net to measure the volume of water sampled during the tow. All samples are quantified using the number of revolutions measured by the flowmeter, the angle of the wire during the tow, the duration of the tow, and the length of wire out.

The sample from the 505-µm-mesh starboard codend was preserved in 5% buffered formalin and sodium benzoate, labeled, and stored for post-cruise analysis. A 15 ml sample from the 333-µm-mesh port codend was frozen in scintillation vials for the HAB project; the rest of the sample was frozen in Ziploc bags for isotope analysis.

2.2.2 Isaacs-Kidd Midwater Trawl – Isaacs-Kidd Midwater Trawls (IKMT) followed the Bongo net tow each evening (approximately 3.5 hours after sunset); 61 trawls were completed during the cruise. This net samples the larger macrozooplankton and micronekton; these samples will be used to determine the species composition of the acoustic backscatter data (see section 2.2.3). Trawl depth was 150 m; sampling time was approximately one hour. Samples from trawls were preserved in 5% buffered formalin and sodium benzoate. Labeled samples were stored for post-cruise analysis. One opportunistic daytime trawl was conducted when the acoustic backscatter data showed an appropriate target; the acoustic target determined trawl depth.

2.2.3 Acoustic Backscatter – Acoustic backscatter data were collected on the ship at 38, 120, and 200 kHz frequencies using a Simrad EK60 transceiver system and the ER60 software program. Pre-cruise calibration was not performed because values were available from a CalCOFI cruise conducted on the ship earlier in the year. Post-cruise calibration was not successful. A transmitted pulse of 1.024 msec (i.e., the pulse duration of an individual ping transmitted by the transducer), a ping interval of two seconds, and a maximum depth of 700 m was used throughout the survey. Data were recorded on a computer's internal hard drive and backed up on two external hard drives.

On 6 November 2009, Josiah Renfree and David Demer made impedance measurements on each of the five Simrad transducers mounted on the hull of the ship. Results indicated

that the 38 and 200 kHz transducers were operating within manufacturer's specifications. Results for the 120 kHz transducer, however, indicated that quadrants 1 and 4 were dysfunctional. We do not know when these quadrants failed.

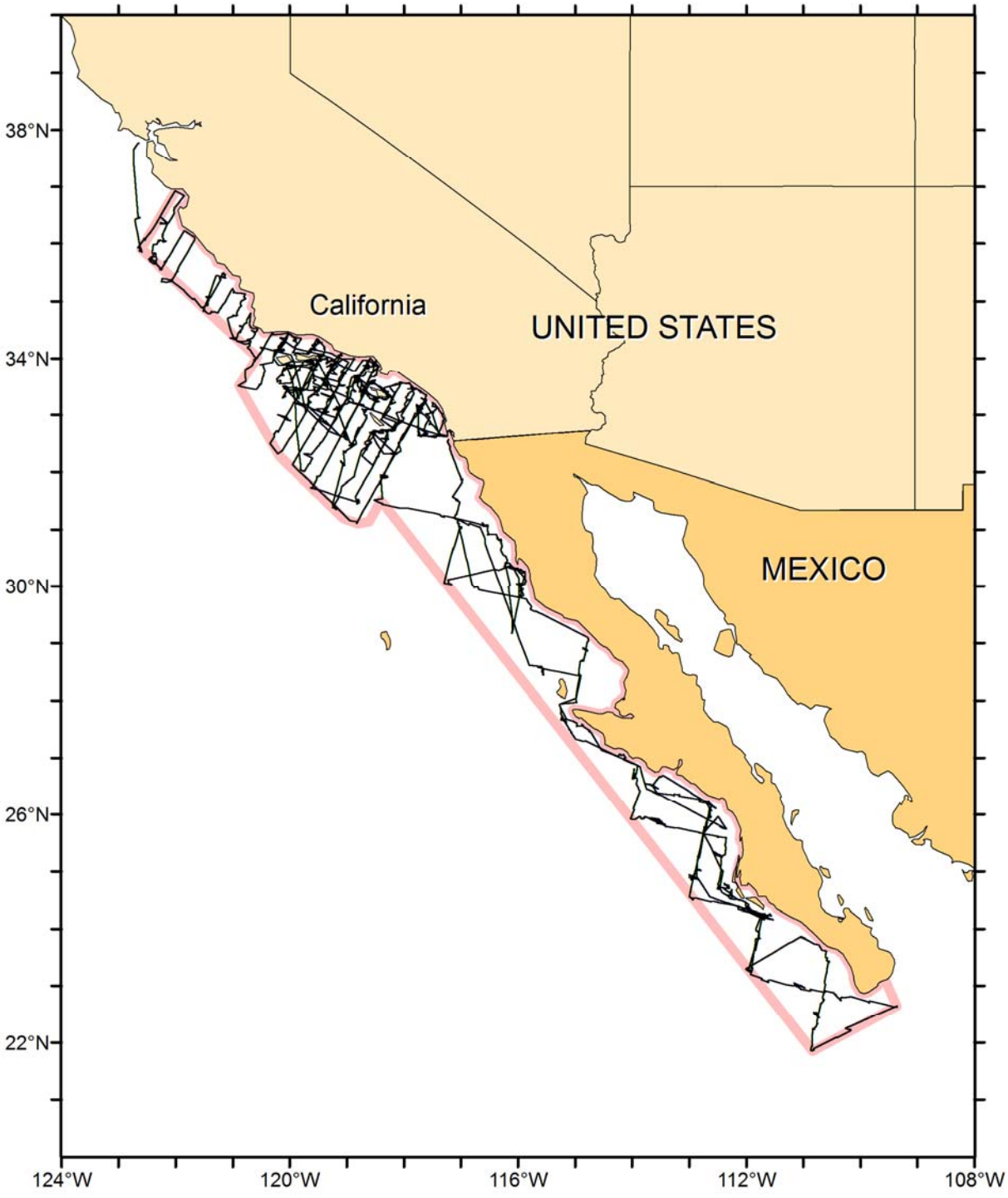

Figure 19. Thermosalinograph sampling during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

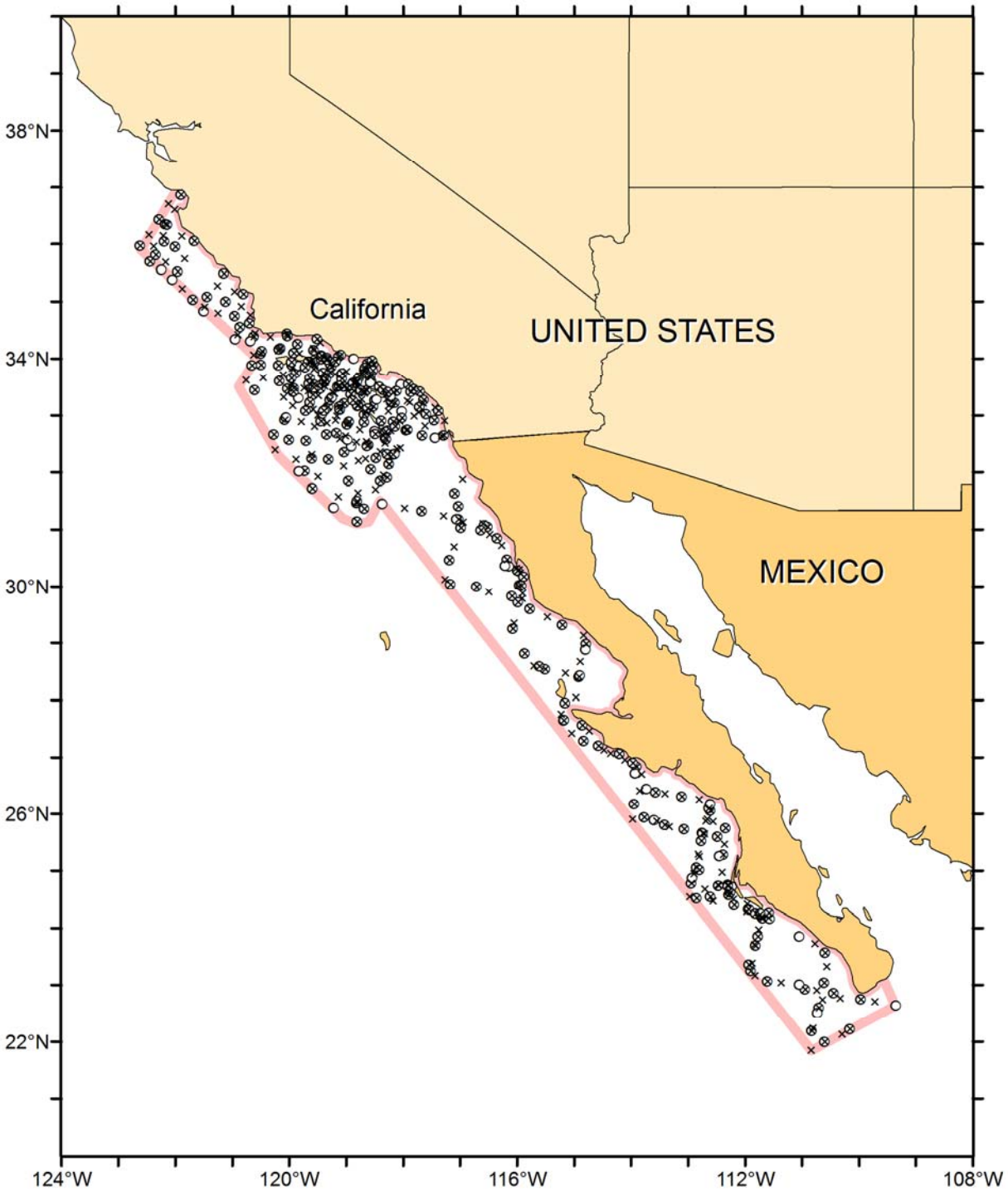

Figure 20. Surface chlorophyll (crosses) and harmful algal bloom (circles) sampling during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

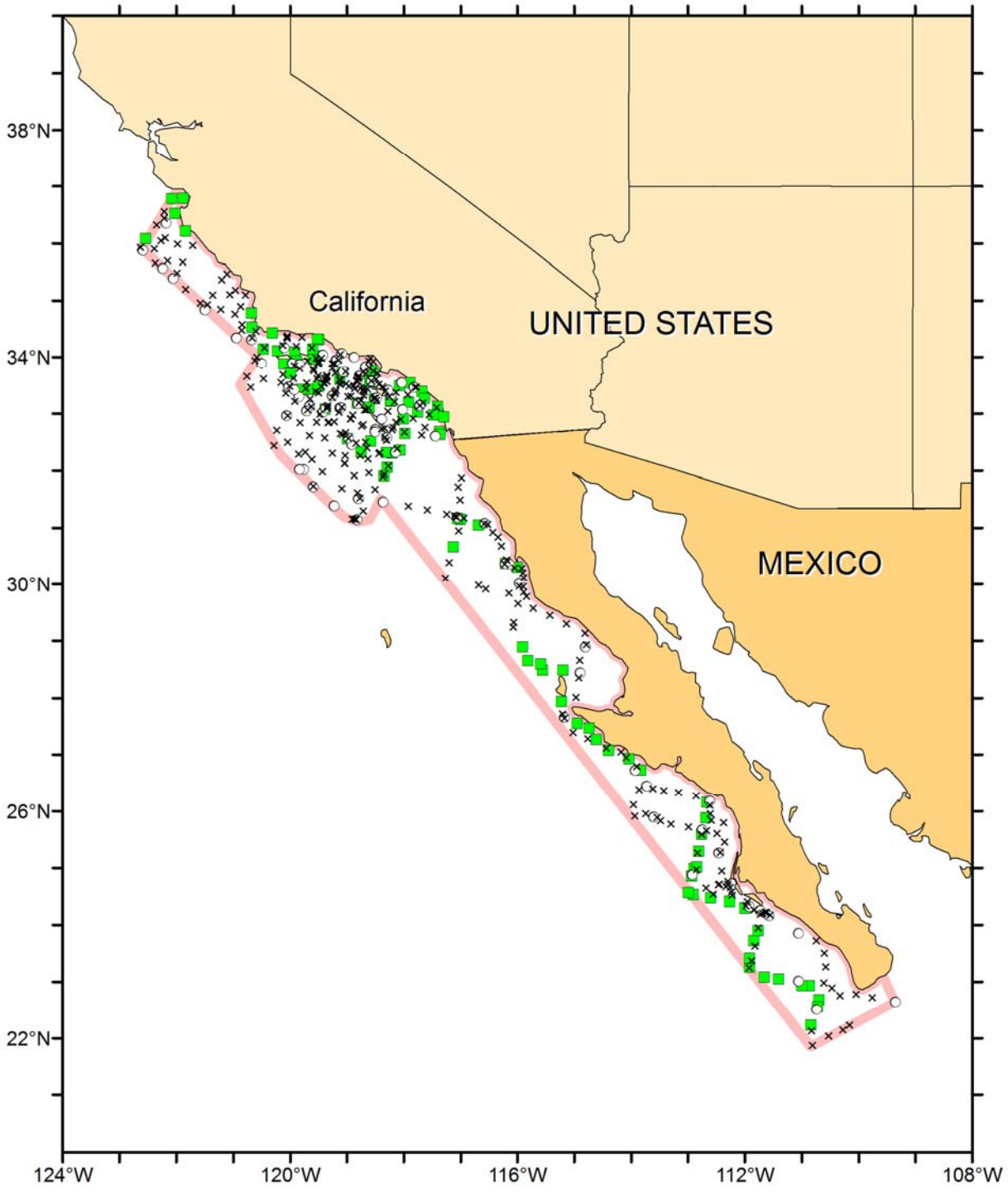

Figure 21. CTD (circles), UCTD (crosses), and XBT (green squares) sampling during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

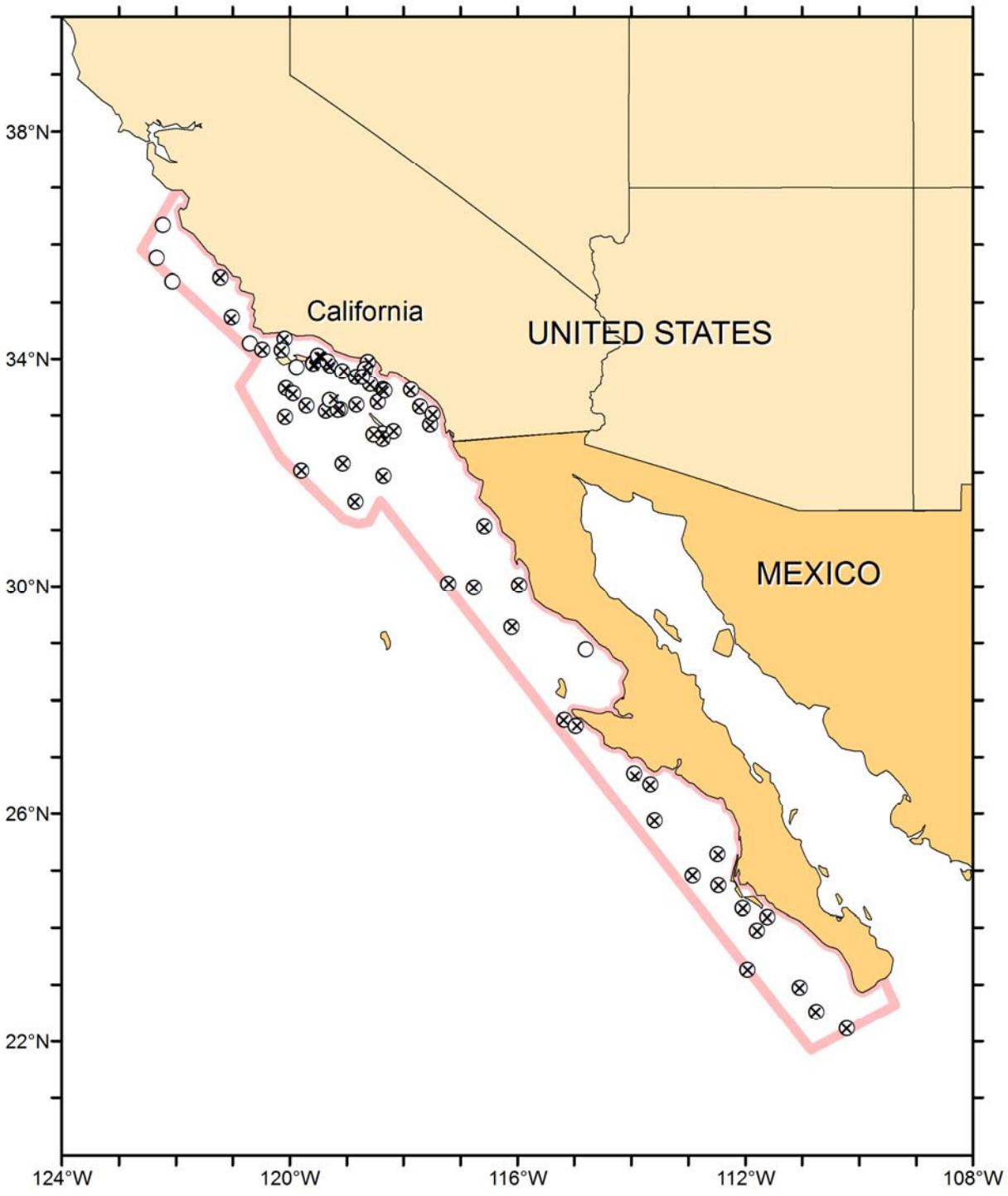

Figure 22. Bongo (circles) and IKMT (crosses) sampling during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

2.3 Apex predators

2.3.1 Squid Sampling – Squid sampling targeted Humboldt squid, *Dosidicus gigas*. Between 30 and 60 minutes of squid jigging by two jiggers was conducted during the evening CTD station, which began one hour after sunset. Jigging effort, using one manual and one electric jigging reel, began with 300 meters of fishing line; attracting lights were used throughout jigging effort. A total of 66 squid stations were completed during *Delphinus* 2009, resulting in the collection of 53 squid (42 *Dosidicus gigas* and 11 unidentified squid; Figure 23). Whole specimens were frozen in plastic bags and labeled for further identification, morphometric analysis, and tissue collection.

2.3.2 Seabirds – Weather permitting, visual surveys for seabirds were conducted from the flying bridge during daylight hours from sunrise to sunset. One observer surveyed the quadrant ahead of the ship (bow to beam) on the side with best visibility and recorded in real time all birds within 300 m using strip transect methods. Data were entered directly into a computer connected to the ship's GPS using the program "SEEBIRD". The SWFSC Cruise Number for this survey and the type of effort (0 = position update, 1 = begin effort, 2 = on-effort sighting, 3 = end effort, 4 = cumulative counts of animals recorded during specific time blocks instead of in real time, 5 = off-effort sighting) were recorded as well as the following variables for each sighting:

- date (local and UTC: 2-digit year, 2-digit month, 2-digit day)
- position (automatically entered from the ship's GPS in decimal degrees)
- Beaufort sea state
- wind speed (knots) and direction
- ship's course (automatically entered from the ship's GPS)
- "Observation Condition" (see Table 8 below)
- side of ship from which observations were made (1 = left; 2 = right)
- observer identification (21 = Michael Force, 32 = Sophie Webb, 33 = Richard Rowlett, 99 = other)
- time (local and UTC: 2-digit hour in 24-hr time, 2-digit minute)
- species (Appendix 2)
- number of individuals ("9999" represents present but unknown number)
- distance from ship (1 = 0 – 100 m, 2 = 100 – 200 m, 3 = 200 – 300 m, 4 = outside of the quadrant surveyed)
- association with other animals or objects (1 = no association, 2 = associated, 3 = unknown)
- behavior (1 = sitting, 3 = following the ship, 4 = feeding, 5 = piracy, 6 = other, 7 = unknown, 8 = directional flight, 9 = non-directional flight)
- flight direction (for birds in directional flight, recorded relative to the ship's bow)
- age (1 = unknown, 2 = not full adult, 3 = adult)
- sex (1 = unknown, 2 = female, 3 = male)
- UTC offset
- comments

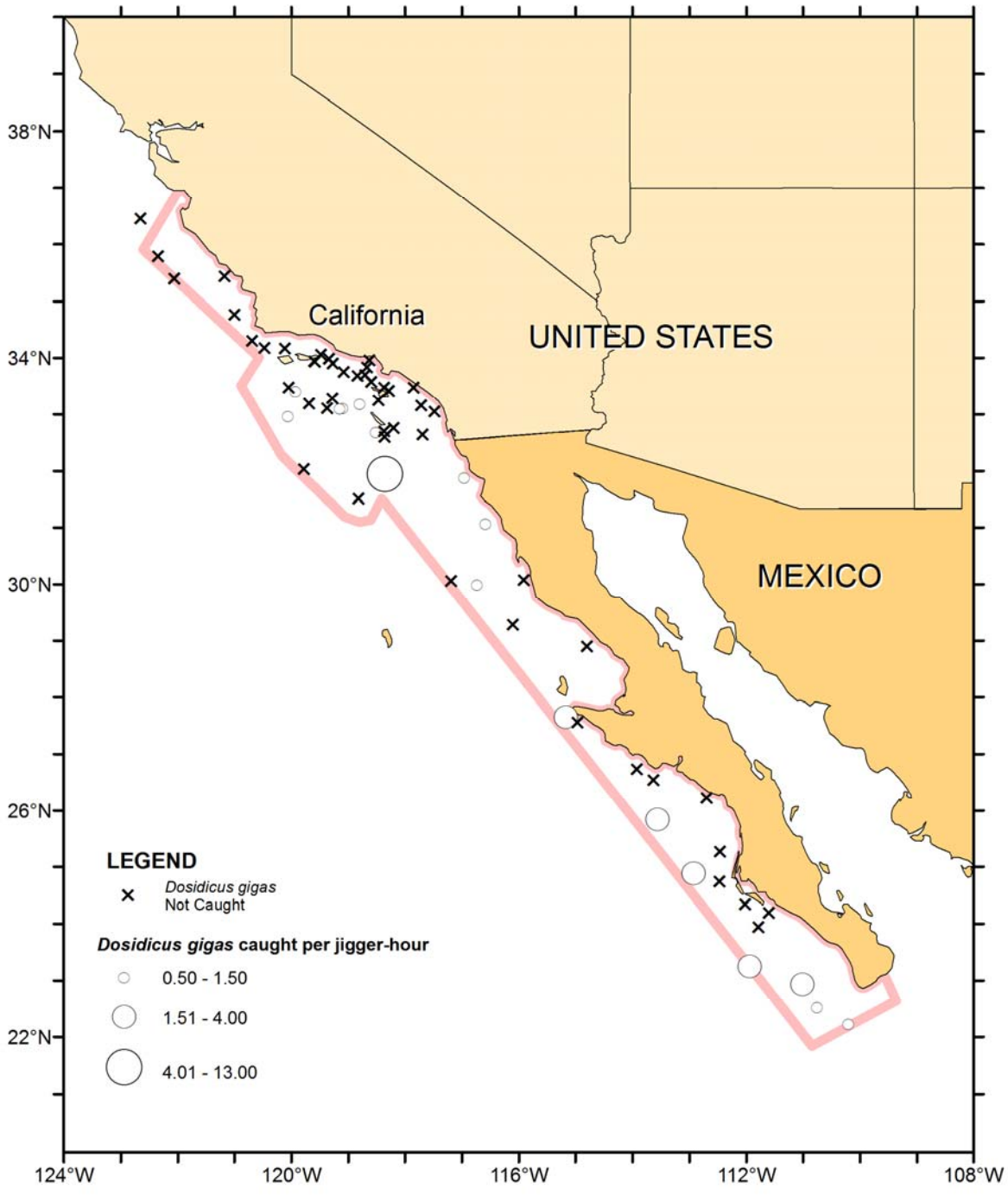

Figure 23. Humboldt squid, *Dosidicus gigas*, catch-per-unit-effort (CPUE) during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*. CPUE is calculated as the number of Humboldt squid caught divided by the amount of effort at each station. Effort is a sum over all jiggers of the number of jigging hours. Fishing gear was consistent across all stations during this cruise; hence, it was not included in the CPUE calculations. However, caution is needed when comparing these results to previous cruises because an electronic reel was used during the *Delphinus* 2009 survey.

See Table 9 for a summary of seabird sightings recorded by taxon, and the data format is presented in Appendix 2.

Table 8. The variable "Observation Condition" combined all environmental and sighting conditions into a single value that was directly related to strip width as follows:

Observation Condition	Strip Width (m)	Taxa
5	300	All
4	300	All
3	200	Storm-Petrels, Phalaropes, Small Auklets
	300	All others
2	100	Storm-Petrels, Phalaropes, Small Auklets
	200	All others

Table 9. Summary of seabird sightings recorded using 300 m strip transect methods during 2009 *Delphinus* survey aboard NOAA Ship *McArthur II*.

Common Name	Taxon	Leg 1	Leg 2	Leg 3	Total
albatrosses	Diomedeidae	18	2	6	26
fulmars	*Fulmarus*	29	13	368	410
shearwaters	*Puffinus*	3,780	1,244	3,703	8,727
petrels	*Pterodroma*	4	1	2	7
storm-petrels	Hydrobatidae	764	1,163	32	1,959
tropicbirds	Phaethontidae	1	26	4	31
pelicans	Pelecanidae	99	79	109	287
boobies	Sulidae	4	138	1	143
cormorants	Phalacrocoracidae	62	91	67	220
frigatebirds	Fregatidae	0	45	0	45
phalaropes	Phalaropodidae	680	3,234	86	4,000
skuas and jaegers	Stercorariidae	125	60	72	257
gulls	*Larus, Rissa*	1,240	876	6,177	8,293
terns	*Sterna, Chlidonias*	1,436	125	26	1,587
auks	Alcidae	474	286	365	1,125
Total		8,716	7,383	11,018	27,117

Seabird observers also recorded the presence of pinnipeds and flyingfish within 300 m of the ship. Species codes and the format for these data files are provided in Appendix 2.

A separate strip transect survey was conducted for seabird feeding flocks. Two marine mammal observers using 25x mounted binoculars and scanning ahead of the ship from beam to beam informed the seabird observer on watch of any seabird feeding flocks detected within 4.8 km (1.0 binocular "reticle") of the ship. The seabird observer then identified all species in the flock, counted number of individuals (for each species), and recorded behavior and association with any other animals or objects. The format for these data files is provided in Appendix 2.

3.0 RADAR DETECTION OF WHALES

During Leg 3, scientists contracted by the Navy were aboard to refine techniques for detecting whales with the radar. A modification to the radar was made prior to the cruise to increase sensitivity of the ship's radar. During daylight hours personnel were in contact with the visual observers on the flying bridge about sightings.

4.0 END OF OPERATIONS

When scientific operations were completed for the night, the ship resumed course along the trackline, at a speed determined by the Cruise Leader, until it was necessary to stop for the pre-dawn CTD station. The ship usually transited between 10 and 50 nm per night. The Cruise Leader determined the nightly transit length on a daily basis.

LOGISTICS

1.0 ITINERARY

This survey began with the NOAA Ship *McArthur II* sailing from Seattle, WA to San Francisco, CA. Scientific personnel for the Ecosystem Studies Program sailed with the ship from Seattle, WA to install and test the UCTD while all other scientists joined the ship in San Francisco, CA to finalize preparations for the cruise before sailing to begin the survey on September 7, 2009 (Table 10).

Table 10. Itinerary of the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

Date	Event
9/1/2009	Ship Transit - Depart Seattle, WA
9/4	Arrive San Francisco, CA
9/5 – 9/6	Ship staging - San Francisco, CA
9/7	Leg 1 - Depart San Francisco, CA
10/02	Arrive San Diego, CA
10/08	Leg 2 - Depart San Diego, CA
11/06	Arrive San Diego, CA
11/12	Leg 3 - Depart San Diego, CA
12/09	Arrive San Diego, CA

2.0 SCIENTIFIC PERSONNEL

Table 11. Participating Scientists sailing aboard NOAA Ship *McArthur II* and their role during the 2009 *Delphinus* survey.

Name	Affiliation	Nationality	Position	Legs
Susan Chivers	SWFSC	USA	Cruise Leader, Chief Scientist	1
Eric Archer	SWFSC	USA	Cruise Leader	2
James Carretta	SWFSC	USA	Cruise Leader	3
James Cotton	SWFSC	USA	Senior Mammal Observer	1-3
Richard Rowlett	SWFSC	USA	Senior Mammal Observer	1-3
Juan Carlos Salinas	AFL	Mexico	Senior Mammal Observer	1-3
Suzanne Yin	SWFSC	USA	Mammal Observer	1-3
Ernesto Vazquez	AFL	Mexico	Mammal Observer	1-3
Richard Pagen	SWFSC	USA	Mammal Observer	1-3
Michael Force	AFL	Canada	Senior Seabird Observer	1-3
Sophie Webb	SWFSC	USA	Seabird Observer	1-3
Paul Fiedler	SWFSC	USA	Oceanographer	Transit
Candice Hall	AFL	United Kingdom	Oceanographer	Transit, 1-3
Justin Garver	SWFSC	USA	Oceanographic Technician	Transit, 1-3
Corey Sheredy	SWFSC	USA	Photographic and Oceanographic Assistant	1-3
Jochen Klinke	Ocean Sciences	Germany	Consultant: Ocean Sciences	Transit
Elizabeth Zele	SWFSC	USA	Acoustic Backscatter Specialist	Transit
Robert Holland	SWFSC	USA	Computer Specialist	Transit
Robert Pitman	SWFSC	USA	Biopsy Specialist	1
Nicholas Kellar	SWFSC	USA	Project Specialist	1
Siri Hakala	SWFSC	USA	Visiting Scientist	1
Heriberto Santana	Instituto Nacional de Pesca (INP)	Mexico	Visiting Scientist	2
Iris Segura	Instituto Nacional de Ecologia (INE)	Mexico	Visiting Scientist	2
Amanda Bowman	SWFSC	USA	Visiting Scientist	3
Adam Knudsen	Arete Associates	USA	Radar Scientist	3
Jodie Morgan	Arete Associates	USA	Radar Scientist	3

3.0 POST-SURVEY DATA PROCESSING

Table 12. Disposition of data collected during the 2009 *Delphinus* survey aboard the NOAA Ship *McArthur II*.

Data	Principle Investigator	Affiliation	Contact
Marine Mammal Sightings	Susan Chivers	NOAA Fisheries - SWFSC	Susan.Chivers@noaa.gov 858-546-7093
Shipboard Photographs	Nicholas Kellar	NOAA Fisheries - SWFSC	Nick.Kellar@noaa.gov 858-546-7090
Aerial Photographs	Wayne Perryman	NOAA Fisheries - SWFSC	Wayne.Perryman@noaa.gov 858-546-7014
Biopsy Samples	Barbara Taylor	NOAA Fisheries - SWFSC	Barbara.Taylor@noaa.gov 858-546-5620
Seabird Sightings	Lisa Ballance	NOAA Fisheries - SWFSC	Lisa.Ballance@noaa.gov 858-546-7173
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APPENDIX 1

Format of marine mammal visual survey effort data recorded in the DAS file (Table A1-1) created by the SWFSC program WINCRUZ during the 2009 *Delphinus* survey conducted by the Protected Resources Division of Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA aboard the NOAA Ship *McArthur II*. The marine mammal species and observer codes used during the survey are presented in Tables A1-2 and A1-3, respectively.

Table A1-1. Format of the DAS file created by WINCRUZ during the 2009 *Delphinus* survey.

Variable Name	Column	Type	Char OK?	Codes or Range of Values
SEQUENCE	1-3	NUM	OK	(N/A)
EVENT	4	CHR	NO	*, 1-8, A, B, C, E, F, f, K, k, N, P, Q, R, r, S, s, t, V, W, ?, #
ON_EFFORT	5	CHR	OK	.
HOUR	6-7	NUM	OK	0-24
MINUTE	8-9	NUM	OK	0-59
SECOND	10-11	NUM	OK	0-59
MONTH	13-14	NUM	OK	1-12
DAY	15-16	NUM	OK	1-31
YEAR	17-18	NUM	OK	00-09, 74-99
N_OR_S	20	CHR	OK	N, S
LATD	21-22	NUM	OK	0-90
LATM	24-28	NUM	OK	0.00-59.99
E_OR_W	30	CHR	OK	E, W
LONGD	31-33	NUM	OK	0-180
LONGM	35-39	NUM	OK	0.00-59.99
(B)CRUISE_NUMBER	41-44	NUM	NO	
MODE	46-49	CHR	NO	C, c, P, p
DEV_FROM_UTC	51-54	NUM	NO	-11-11
ECHO_SOUNDER	56-59	CHR	NO	Y, N
(R)EFFORT_TYPE	41-44	CHR	NO	S, N, F
(E)ND_EFFORT	41-44	CHR	NO	A, C, D, M, O, S, U, W, X
(C)OMMENT	41-180	CHR	OK	(N/A)
(t)TDETEC_BY	41-44	NUM	NO	(OBSCODES.DAT – Table A1-3)
SP_CODE	48-49	CHR	NO	CC, CM, DC, EI, LV, PU, UH, UO, UT
TBEARING	51-54	NUM	OK	0-359
TDISTANCE	56-59	NUM	OK	0.0-3.0
NUM_TURTLES	61-64	NUM	NO	1-20
ASSOC_JFR	66-69	CHR	OK	F-RJF
(P)LEFT_BINO	41-44	NUM	NO	(OBSCODES.DAT – Table A1-3)
REC	46-49	NUM	NO	(OBSCODES.DAT – Table A1-3)
RIGHT_BINO	51-54	NUM	NO	(OBSCODES.DAT – Table A1-3)
IND_OBS	56-59	NUM	OK	(OBSCODES.DAT – Table A1-3)
(V)BEAUFORT	41-44	NUM	NO	0-6
SWELL_HT	46-49	NUM	OK	0.0-12.0
SWELL_DIR	51-54	NUM	OK	0-360
WIND_SPEED	61-64	NUM	OK	0.0-30.0
(N)COURSE	41-44	NUM	NO	0-359
SPEED	46-49	NUM	OK	5.0-13.9
(W)FOG_OR_RAIN	41-44	NUM	NO	1-5
HORIZ_SUN	46-49	NUM	OK	0-12
VERT_SUN	51-54	NUM	OK	0, 1, 2, 3, 12
WIND_DIR	56-59	NUM	OK	0-360
VISIBILITY	61-64	NUM	OK	1.0-10.0
(S,K)SIGHT	41-44	NUM	NO	1-5000
DETEC_BY	46-49	NUM	NO	(OBSCODES.DAT – Table A1-3)
SIGHTING_Q	51-54	NUM	NO	1-7

SIGHTING_METHOD	56-59	NUM	NO	1, 2, 4, 5, 6, 7
BEARING	61-64	NUM	NO	0-359
RETICLE	66-69	NUM	OK	0.1-20.0
DISTANCE	71-74	NUM	NO	0.0-6.0
INITIAL_ID	76-79	CHR	OK	(SPPCODES.DAT – Table A1-2)
CALIB_SCHL	86-89	CHR	NO	Y, y, N, n
AERO_PHOTO	91-94	CHR	NO	Y, y, N, n
BIOPSY	96-99	CHR	NO	Y, y, N, n
(A)SIGHT	41-44	NUM	NO	1-5000
PHOTOS	51-54	CHR	OK	Y, y, N, n
BIRDS	56-59	CHR	NO	Y, y, N, n
SP1_CODE	61-64	CHR	NO	(SPPCODES.DAT – Table A1-2)
SP2_CODE	66-69	CHR	OK	(SPPCODES.DAT – Table A1-2)
SP3_CODE	71-74	CHR	OK	(SPPCODES.DAT – Table A1-2)
SP4_CODE	76-79	CHR	OK	(SPPCODES.DAT – Table A1-2)
(s,k)SIGHT	41-44	NUM	NO	1-5000
BEARING	46-49	NUM	OK	0-359
RETICLE	51-54	NUM	OK	0.1-20.0
DISTANCE	56-59	NUM	OK	0.0-6.0
COURSE	61-64	NUM	OK	0-359
(F,f)BOAT_DET_BY	41-44	NUM	NO	(OBSCODES.DAT – Table A1-3)
BEARING	46-49	NUM	OK	0-359
DISTANCE	51-54	NUM	OK	0.0-6.9
RETICLE	56-59	NUM	OK	0.1-20.0
(Q)OBS_A (TRACKER)	41-44	NUM	OK	(OBSCODES.DAT – Table A1-3)
OBS_B	46-49	NUM	OK	(OBSCODES.DAT – Table A1-3)
OBS_C	51-54	NUM	OK	(OBSCODES.DAT – Table A1-3)
OBS_D	56-59	NUM	OK	(OBSCODES.DAT – Table A1-3)
(?)SIGHT	41-44	NUM	NO	1-5000
SP1_CODE	61-64	NUM	NO	(SPPCODES.DAT – Table A1-3)
SP2_CODE	66-69	NUM	OK	(SPPCODES.DAT – Table A1-3)
SP3_CODE	71-74	NUM	OK	(SPPCODES.DAT – Table A1-3)
SP4_CODE	76-79	NUM	OK	(SPPCODES.DAT – Table A1-3)
(1-8)OBS_CODE	41-44	NUM	NO	(OBSCODES.DAT – Table A1-3)
BST_EST_SCHL	46-49	NUM	OK	1-2000
HI_EST_SCHL	51-54	NUM	OK	1-2000
LO_EST_SCHL	56-59	NUM	NO	1-2000
SP1_PERCENT	61-64	NUM	NO	1-100
SP2_PERCENT	66-69	NUM	OK	0-99
SP3_PERCENT	71-74	NUM	OK	0-98
SP4_PERCENT	76-79	NUM	OK	0-97

Table A1-2. Marine mammal species codes used in the DAS file created by WINCRUZ during the 2009 *Delphinus* survey.

Species	Common Name	Code
Arctocephalus townsendi	Guadalupe fur seal	AT
Balaenoptera acutorostrata	Minke whale	071
Balaenoptera borealis/edeni	Rorqual, Sei or Bryde's whale	099
Balaenoptera edeni	Bryde's whale	072
Balaenoptera musculus	Blue whale	075
Balaenoptera physalus	Fin whale	074
Balaenoptera sp.	Unidentified Rorqual	070
Berardius bairdii	Baird's beaked whale	063
Callorhinus ursinus	Northern fur seal	CU
Delphinus capensis	Long-beaked common dolphin	016
Delphinus delphis	Short-beaked common dolphin	017
Delphinus sp.	Unidentified common dolphin	005
Globicephala macrorhynchus	Short-finned pilot whale	036
Grampus griseus	Risso's dolphin	021
Lagenorhynchus obliquidens	Pacific white-sided dolphin	022
Lissodelphis borealis	Northern right whale dolphin	027
Megaptera novaeangliae	Humpback whale	076
Mirounga angustirostris	Northern elephant seal	MA
Orcinus orca	Killer whale	037
Phocoena phocoena	Harbor porpoise	040
Phocoenoides dalli	Dall's porpoise	044
Physeter macrocephalus	Sperm whale	046
Stenella attenuata (offshore)	Pantropical spotted dolphin	002
Stenella attenuata (unid. subsp.)	Unidentified pantropical spotted dolphin	090
Stenella coeruleoalba	Striped dolphin	013
Stenella longirostris orientalis	Eastern spinner dolphin	010
Steno bredanensis	Rough-toothed dolphin	015
Tursiops truncatus	Bottlenose dolphin	018
Unidentified (Unid.) cetacean	Unidentified cetacean	096
Unid. dolphin	Unidentified dolphin or porpoise	077
Unid. fur seal	Unidentified fur seal	UA
Unid. large whale	Unidentified large whale	079
Unid. medium delphinid	Unidentified medium delphinid (e.g., Feresa, Grampus, Steno or Tursiops)	277
Unid. pinniped	Unidentified pinniped	PU
Unid. porpoise	Unidentified porpoise (e.g., Phocoena or Phocoenoides)	477
Unid. sea lion	Unidentified sea lion	UO
Unid. small delphinid	Unidentified small delphinid (e.g., Delphinus, Lagenorhynchus, Lissodelphis, or Stenella)	177
Unid. small whale	Unidentified small whale	078
Unid. whale	Unidentified whale	098
Zalophus californianus	California sea lion	ZC
Ziphiid whale, unid. to species	Unidentified beaked whale	049
Ziphius cavirostris	Cuvier's beaked whale	061

Table A1-3. Observer codes used in the DAS file created by WINCRUZ during the 2009 *Delphinus* survey.

Observer Code	Last Name	First Name
004	PITMAN	ROBERT
007	COTTON	JAMES
071	CARRETTA	JAMES
073	ROWLETT	RICHARD
098	FORCE	MICHAEL
125	VAZQUEZ	ERNESTO
126	SALINAS	JUAN
197	YIN	SUZANNE
229	WEBB	SOPHIE
231	PAGEN	RICHARD

APPENDIX 2

Format of seabird visual survey effort (Table A2-1) and flock (Table A2-2) data recorded by the SWFSC program SEEBIRD during the 2009 *Delphinus* survey conducted by the Protected Resources Division of Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA aboard the NOAA Ship *McArthur II*. The species codes recorded in the data are presented in Table A2-3.

Table A2-1. Format for seabird survey data using 300 m strip transect methods.

ABBREVIATION	VARIABLE NAME	COLUMNS RECORDED IN DATA SET	ALPHA/ NUMERIC	RANGE OF VALUES
CRUISE #	Cruise Number	1 - 4	Numeric	0000 - 9999
UT DATE	Coordinated Universal Date (YYMMDD)	6 - 11	Numeric	All accepted
LM DATE	Local Mean Date (YYMMDD)	13 - 18	Numeric	All accepted
LATITUDE	Latitude (+/- DD.DDD)	20 - 26	Numeric	All accepted
LONGITUDE	Longitude (+/- DDD.DDD)	28 - 35	Numeric	All accepted
BEAUFORT	Sea State	37	Numeric	0 – 7
WIND SPEED	Wind Speed	39 - 40	Numeric	
WIND DIRECTION	Wind Direction	42 – 44	Numeric	000 - 359
SHIP COURSE	Ship's Course	46 - 48	Numeric	000 – 359
OBSERVER CONDITION	Observation Conditions	50	Numeric	1 - 5
OBSERVATION SIDE	Observation Side	52	Numeric	1 - 2
OBSERVER CODE	Observer Code	54 - 55	Numeric	1 - 99
EVENT	Event Code	57	Numeric	1 – 5
UT TIME	Coordinated Universal Time (HHMMSS)	59 - 64	Numeric	000000 -235959
LM TIME	Local Mean Time (HHMMSS)	66 - 71	Numeric	000000 -235959
SPECIES CODE	Species Code	73 - 76	Alpha	AAAA – ZZZZ
SPECIES NUMBER	Species Number	78 - 81	Numeric	0001 – 9999
DISTANCE	Distance	83	Numeric	1 – 4
ASSOCIATION	Association	85	Numeric	1 – 3
BEHAVIOR	Behavior	87	Numeric/ Alpha	1 - 9 A - E
FLIGHT DIRECTION	Flight Direction	89 - 91	Numeric	000 - 359, 999
AGE	Age	93	Numeric	1 – 3
SEX	Sex	95	Numeric	1 - 3
COMMENTS	Comments	97	Numeric	1 - 2
UTC OFFSET	UTC offset (+ hours)	99 - 100	Numeric	1 - 11
TEXT	Text of comments	102 - ___	Alpha	AAAA – ZZZZ

Table A2-2. Format for seabird feeding flock data using strip transect methods.

ABBREVIATION	VARIABLE NAME	COLUMNS RECORDED IN DATA SET	ALPHA/ NUMERIC	RANGE OF VALUES
CRUISE #	Cruise Number	1 - 4	Numeric	0000 - 9999
UT DATE	Coordinated Universal Date (YYMMDD)	6 - 11	Numeric	All accepted
LM DATE	Local Mean Date (YYMMDD)	13 - 18	Numeric	All accepted
LATITUDE	Latitude (+/- DD.DDD)	20 - 26	Numeric	All accepted
LONGITUDE	Longitude (+/- DDD.DDD)	28 - 35	Numeric	All accepted
ANGLE	Angle to Flock	37 - 39	Numeric	000 - 359
RETICLE	Reticles to Flock	41 - 44	Numeric	0.0 - 15.0
OBSERVER CODE #1	Observer Code #1	47 - 48	Numeric	1 – 99
EVENT	Event Code	50	Numeric	1 - 6
UT TIME	Coordinated Universal Time (HHMMSS)	52 - 57	Numeric	000000 -235959
LM TIME	Local Mean Time (HHMMSS)	59 - 64	Numeric	000000 -235959
SPECIES CODE	Species Code	66 - 69	Alpha	AAAA - ZZZZ
SPECIES NUMBER	Species Number	71 - 74	Numeric	0001 - 9999
DISTANCE	Distance	76	Numeric	1 - 4
ASSOCIATION	Association	78	Numeric	1 - 3
BEHAVIOR	Behavior	80	Numeric/ Alpha	1 - 9 A - E
FLIGHT DIRECTION	Flight Direction	82 - 84	Numeric	000 - 359, 999
AGE	Age	86	Numeric	1 - 3
SEX	Sex	88	Numeric	1 - 3
COMMENTS	Comments	90	Numeric	1 - 2
FLOCK ID	Flock Identification No.	92 - 95	Numeric	0001 - 9999
NAUTICAL MILES	Nautical Miles to Flock	97 - 99	Numeric	0.0 - 7.0
UTC OFFSET	UTC Offset (+ hours)	101 - 102	Numeric	1 - 11
TEXT	Text of Comments	104 - ___	Alpha	AAAA - ZZZZ

Table A2-3. Four-letter species codes used in the seabird survey data. Only codes recorded in the data collected during the 2009 *Delphinus* survey are included.

Seabirds

ALLA	Laysan Albatross, *Phoebastria immutabilis*
ALBF	Black-footed Albatross, *Phoebastria nigripes*
FUND	Northern Fulmar (dark morph), *Fulmarus glacialis*
FUNI	Northern Fulmar (intermediate morph), *Fulmarus glacialis*
FUNL	Northern Fulmar (light morph), *Fulmarus glacialis*
SHSP	Unidentified shearwater, *Puffinus sp.*
SHNZ	Buller's (New Zealand) Shearwater, *Puffinus bulleri*
SHFF	Flesh-Footed Shearwater, *Puffinus carneipes*
SHPF	Pink-Footed Shearwater, *Puffinus creatopus*
SHSO	Sooty Shearwater, *Puffinus griseus*
SHCH	Christmas Shearwater, *Puffinus nativitatus*
SHBV	Black-Vented Shearwater., *Puffinus opisthomelas*
SHWD	Wedge-Tailed Shearwater – Dark Morph, *Puffinus pacificus*
SHWI	Wedge-Tailed Shearwater – Intermediate Morph, *Puffinus pacificus*
SHWW	Wedge-Tailed Shearwater – Light Morph, *Puffinus pacificus*
SHSB	Slender-Billed Shearwater., *Puffinus tenuirostris*
SHSS	Sooty/Slender-Billed Shearwater, *Puffinus griseus/tenuirostris*
PECO	Cook's Petrel, *Pterodroma cookii*
PEMO	Mottled Petrel, *Pterodroma inexpectata*
SPWR	Unidentified White-Rumped Storm Petrel
SPWI	Wilson's Storm Petrel, *Oceanites oceanicus*
SPGA	Wedge-Rumped (Galapagos) Storm Petrel, *Oceanodroma tethys*
SPLE	Leach's Storm Petrel, *Oceanodroma leucorhoa*
SPAS	Ashy Storm Petrel, *Oceanodroma homochroa*
SPFT	Fork-Tailed Storm Petrel, *Oceanodroma furcata*
SPBL	Black Storm Petrel, O*ceanodroma melania*
SPLS	Least Storm Petrel, *Oceanodroma microsoma*
SPLW	White-Rumped Leach's Storm-Petrel, *Oceanodroma leucorhoa*
SPLD	Dark-Rumped Leach's Storm-Petrel, *Oceanodroma leucorhoa*
SPLI	Intermediate-Rumped Leach's Storm-Petrel, *Oceanodroma leucorhoa*
TROP	Unidentified Tropic Bird, *Phaethon sp*.
TBRB	Red-Billed Tropicbird, *Phaethon aethereus*
PEBR	Brown Pelican, *Pelecanus occidentalis*
BOBF	Blue-Footed Booby, *Sula nebouxii*
BORF	Red-Footed Booby, *Sula sula*
BOBR	Brown Booby, *Sula leucogaster*
BOMA	Masked/Nazca Booby, *Sula dactylatra/granti*
BOMO	Nazca Booby, *Sula granti*
BOMY	Masked Booby, *Sula dactylatra*
CORM	Unidentified cormorant, *Phalacrocorax sp*.
CODC	Double-Crested Corm., *Phalacrocorax auritus*
COBR	Brandt's Cormorant, *Phalacrocorax penicillatus*
COPE	Pelagic Cormorant, *Phalacrocorax pelagicus*
FRMA	Magnificent Frigatebird, *Fregata magnificens*
FRGR	Great Frigatebird, *Fregata minor*
PHAL	Unidentified phalarope, *Phalaropus fulicarius/lobatus*
PHRE	Red Phalarope, *Phalaropus fulicarius*
PHNO	Red-Necked (Northern) Phalarope, *Phalaropus lobatus*
SKSP	South Polar Skua, *Stercorarius maccormicki*
JAEG	Unidentified jaeger, *Stercorarius sp*.

Table A2-3 (continued)

JAPO	Pomarine Jaeger, *Stercorarius pomarinus*
JAPA	Parasitic Jaeger, *Stercorarius parasiticus*
JALT	Long-Tailed Jaeger, *Stercorarius longicaudus*
GULL	Unidentified gull, L*arus sp.*
GUHE	Heermann's Gull, *Larus heermanni*
GURB	Ring-Billed Gull, *Larus delawarensis*
GUHR	Herring Gull, *Larus argentatus*
GUCA	California Gull, *Larus californicus*
GUWE	Western Gull, *Larus occidentalis*
GUGW	Glaucous-Winged Gull, *Larus glaucescens*
GUBO	Bonaparte's Gull, *Chroicocephalus philadelphia*
KIBL	Black-Legged Kittiwake, *Rissa tridactyla*
GUSA	Sabine's Gull, *Xema sabini*
TERN	Unidentified tern, *Sterna/Hydroprogne/Thalasseus*
TECA	Caspian Tern, *Hydroprogne caspia*
TEBL	Black Tern, *Chlidonias niger*
TECO	Common Tern, *Sterna hirundo*
TEAR	Arctic Tern, *Sterna paradisaea*
TEAC	Arctic/Common Tern, *Sterna paradisaea/hirundo*
TEFO	Forster's Tern, *Sterna forsteri*
TELE	Least Tern, *Sternula antillarum*
TERO	Royal Tern, *Thalasseus maxima*
TEEL	Elegant Tern, *Thalasseus elegans*
ALCD	Unidentified alcid, *Alcidae sp.*
MUCO	Common Murre, *Uria aalge*
GUPI	Pigeon Guillemot, *Cepphus colomba*
MUXA	Xantus's Murrelet, *Synthliboramphus hypoleuca*
MUCR	Craveri's Murrelet, *Synthliboramphus craveri*
MUXC	Xantus'/Craveri's Murrelet. S*ynthliboramphus hypoleuca/craveri*
MUAN	Ancient Murrelet, S*ynthliboramphus antiquus*
AUCA	Cassin's Auklet, *Ptychoramphus aleuticus*
AURH	Rhinoceros Auklet, *Cerorhinca monocerata*

Miscellaneous Species

LORT	Red-Throated Loon, *Gavia stellata*
LOCO	Common Loon, *Gavia immer*
LOPA	Pacific Loon, *Gavia pacifica*
GREB	Unidentified grebe, *Podicipedidae*
DUCK	Unidentified duck
SHOR	Unidentified shorebird
RAPT	Unidentified raptor
NPSS	Unidentified non-passerine
PASS	Unidentified passerine

Table A2-3 (continued)

Pinnipeds

ARTO	Guadalupe Fur Seal, *Arctocephalus townsendi*
CAUR	Northern Fur Seal, *Callorhinus ursinus*
EUJU	Steller Sea Lion, *Eumetopias jubatus*
ZACA	California Sea Lion, *Zalophus californicus*
OTSP	Unidentified otariid
MIAN	Northern Elephant Seal, *Mirounga angustirostris*
PINN	Unidentified Pinniped

Sea Turtles

TULO	Loggerhead Sea Turtle, *Caretta caretta*
TUOR	Olive Ridley Sea Turtle, *Lepidochelys olivacea*
TURT	Unidentified Sea Turtle

Fish

FFUN	Unidentified flyingfish
FFFW	Unidentified four-wing flyingfish
FISH	Unidentified fish
TUNA	Unidentified tuna
MAHI	Mahi mahi, *Corypaena spp*.
WAHO	Wahoo, *Acanthocybium solandri*
MOLA	Ocean Sunfish, *Mola mola*
SRHH	Hammerhead shark
SRSP	Unidentified shark

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K.A. FORNEY
(October 2010)

463 Spawning biomass of Pacific sardine *(Sardinops sagax)* off the U.S. in 2010.
N.C.H. LO, B.J. MACEWICZ, and D.A. GRIFFITH
(October 2010)