November 5, 2010

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION (CALCOFI) CRUISES: 2009-2010

Greg Campbell, Karlina Merkens and John Hildebrand

Marine Physical Laboratory, Scripps Institution of Oceanography
University of California San Diego, LA Jolla, CA 92037-0205

ABSTRACT

Spatial and temporal distribution patterns, density and abundance of cetaceans in the southern California Bight were assessed through visual and acoustic surveys during four California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from July 2009 – April 2010. Visual monitoring incorporated standard line-transect protocol during all daylight transits while acoustic monitoring employed a towed hydrophone array during transits and sonobuoys at oceanographic sampling stations. Visual effort included 390 observation hours covering 4,030 kilometers yielding 339 sightings of 15 cetacean species. Humpback whales were the most frequently sighted baleen whale species, followed by grey, fin, and blue whales. Common dolphins were the most frequently sighted odontocete species, followed by Dall's porpoise, Risso's dolphin, Pacific white-sided dolphin, sperm whale, and bottlenose dolphin. Seasonal variations in encounter rates and distributions were evident for some species. Grey whales and Dall's porpoise were sighted primarily in winter and spring, whereas blue whales were visually and acoustically detected in summer and fall only. Spatial variations in visual detections as a function of species were also evident. Bottlenose, Risso's and long-beaked common dolphin detections were concentrated in coastal and shelf waters, whereas sperm whale detections occurred exclusively in pelagic waters. Short-beaked common dolphin, Pacific white-sided dolphin, Dall's porpoise, fin and humpback whales had a broader distribution with encounters occurring in coastal, shelf and pelagic waters.
Each species showed distinct spatial and temporal distribution patterns across the study area; indicative of species-specific habitat preferences within the California Current ecosystem. Current research is investigating the association between cetacean distribution with biological and physical oceanographic variables measured during CalCOFI surveys. Density and abundance estimates of cetaceans encountered in the study area are currently the focus of an extensive line-transect analysis and modeling effort. Modeling of cetacean habitat preferences in conjunction with density and abundance estimates, will provide data needed to evaluate potential impacts from anthropogenic activities and ultimately for the development of comprehensive management protocols.

INTRODUCTION

Cetacean surveys have been integrated into California Cooperative Oceanic Fisheries Investigation (CalCOFI) quarterly cruises off southern California since 2004. CalCOFI cruises have been conducted consistently on the same transect lines over the past 60 years and provide on of the longest and most extensive time series of physical and biological

oceanographic data in existence. Cetacean monitoring by Scripps Institution of Oceanography incorporates both visual and acoustic methods to assess cetacean populations occurring in the California current ecosystem. The objectives of the cetacean monitoring program are to determine the temporal and spatial patterns of cetacean distribution, to compare visual and acoustic survey methods and results, to quantify differences in vocalizations between cetacean species, and to make seasonal estimates of cetacean density and abundance within the study area. The greatest strength of CalCOFI cetacean surveys is the broad seasonal and geographic coverage within SOCAL. Sample sizes are comparable or greater than the total number of SWFSC sightings from the region. The weakness of CalCOFI cetacean surveys are that, due to time constraints, the vessel cannot alter course during the survey to better estimate group sizes and/or species identification. A comparison of visual and acoustic methods has demonstrated that most species are detected by both methods. CalCOFI cetacean surveys are planned to continue for at least the next two years. To date, estimates of cetacean density and abundance have been limited to blue, fin and humpback whales; however, extensive line-transect analysis encompassing all commonly sighted species is currently underway. Recent analysis of baleen whale density relative to habitat type and productivity levels has proven insightful for expanding the scope and complexity of our habitat modeling efforts.

METHODS

Visual monitoring for cetaceans on four quarterly CalCOFI cruises during 2009-2010 utilized standard line-transect marine mammal survey protocol. Visual observers searched during daylight hours under acceptable weather conditions during all transits between CalCOFI stations (Beaufort sea state 0-5 and visibility greater than 1 nm). Data on time, position, ship's heading/speed, and environmental conditions were recorded at regular intervals or when conditions changed. Information on all cetacean sightings was logged systematically, including distance and bearing from the ship, species identification, group composition, estimated group size and behavior. During all surveys, 18x power binoculars were used to improve species identification after an initial sighting using 7x binoculars.

Acoustic monitoring for cetaceans during line-transect surveys was conducted using a 6-element 300 m towed hydrophone array. Each pre-amplified element was band-pass filtered from 3 kHz to 200 kHz to decrease high intensity, low frequency flow noise and protection from signal aliasing at high frequencies. The multi-channel array data are sampled using both a MOTU 896 at 192 kHz and a National Instruments USB 6152 at 500 kHz to allow for a broad range of frequencies to be recorded. An acoustic technician monitored the incoming signals from the towed array using both a real-time scrolling spectrogram and headphones. Acoustic monitoring on CalCOFI stations is conducted with both broadband passive 57B omni-directional and 53F DIFAR sonobuoys. Sonobuoys were deployed 1 nm before each daylight station to a depth of 30 m and recorded for 2-3 hours while oceanographic sampling was underway. An acoustic technician monitored the sonobuoy signals for cetacean calls using a scrolling spectrogram display. Mysticete calls, sperm whale clicks as well as low frequency dolphin calls, including whistles, buzzes and the lower frequency components of clicks are recorded with this system.

RESULTS

Four surveys covering 4,030 kilometers of track-line with 390 hours of effort were conducted from July 2009 – April 2010. Surveys conducted in July, November and January utilized the standard 75 station CalCOFI pattern; efforts in April 2010 surveyed the trawling and northern transects (see Figure 1). Summary data on effort and sightings from the four CalCOFI surveys conducted from July 2009 – April 2010 are provided in Table 1.

Cetacean sightings across the four CalCOFI cruises included eleven odontocete and four mysticete species encompassing a total of 339 encounters (Table 2). Encounter rates of cetaceans in the study area varied by species. Humpback whales were the most frequently encountered mysticete, followed by grey whales, fin whales and blue whales. Short-beaked common dolphins were the most frequently encountered odontocete, followed by Dall's porpoise and Risso's dolphins. Killer whales, striped dolphins and Cuvier's beaked whales were the least frequently encountered cetaceans with only one sighting per species during the four survey period (Table 2).

The geographic distribution of cetacean species encountered in the CalCOFI study area was not uniform (Figures 2 and 3). Bottlenose, Risso's and long-beaked common dolphin as well as grey whale sightings were concentrated in coastal and shelf waters. Sperm whale sightings were concentrated in pelagic waters. Short-beaked common dolphins, Pacific white-sided dolphins, Dall's porpoise, fin whales and humpback whales had a broader distribution with encounters occurring in coastal, shelf and pelagic waters.

Encounter rates varied by season with greater numbers of encounters and higher encounter rates during the winter and summer, and fewer numbers of encounters and lower encounter rates during spring and fall (Table 2). Seasonal variations in encounter rates as a function of species were evident. Fin whales were the only mysticete species encountered during all four seasons, with the greatest number of encounters in summer. Humpback whales were encountered in all seasons except summer with the highest number of sightings in spring. Blue whales were primarily encountered during the summer with one sighting during the fall cruise. Grey whales were mainly encountered during winter with one sighting during spring (Table 2). Small cetacean species encountered during all seasons included short–beaked common, Risso's and bottlenose dolphins. Dall's porpoise, Pacific white-sided dolphins and northern right-whale dolphins were encountered in all seasons except summer while long-beaked common dolphins were sighted in all seasons except spring.

DISCUSSION

The results of our visual and acoustic detections indicate temporal and spatial variability in the distribution patterns of cetaceans inhabiting waters of the Southern California Bight, suggesting that different species have distinct habitat preferences. Modeling efforts incorporating cetacean distribution data with oceanographic variables sampled from CalCOFI cruises, satellite imagery, and autonomous gliders will provide new insights into the role of cetaceans in this dynamic marine ecosystem. The development

of comprehensive density and abundance estimates for all cetacean species across the 6 year study period across are currently underway. Cetacean surveys on CalCOFI cruises provide an avenue to examine seasonal and inter-annual patterns in distribution as well as density and abundance on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast. The insight gained from these analyses will provide needed data for environmental assessments and ultimately management protocols.

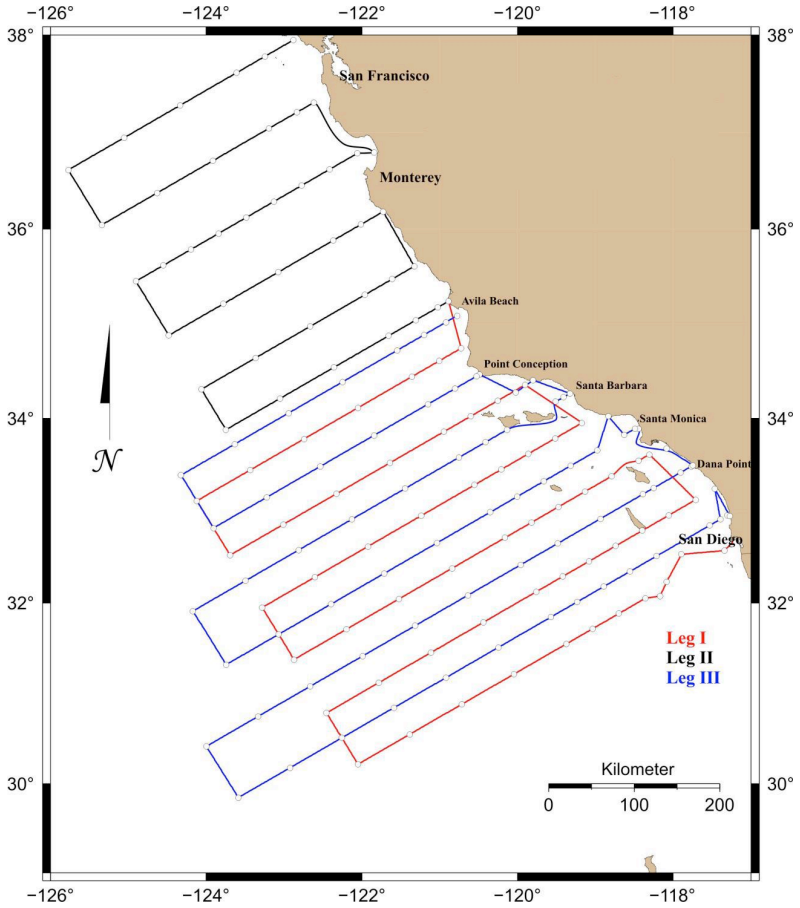

Figure 1. CalCOFI station positions for standard transect (blue), trawling transect (red), and northern transect (black). Image courtesy of CalCOFI program.

November 5, 2010

Table 1. Summary data from four CalCOFI cruises between July 2009 and April 2010.

CalCOFI Cruise Dates	Survey Effort (hrs)	Distance Surveyed (nm)	Number of Cetacean Sightings	Number of Individuals	Number of Digital Photos	Number of Acoustic Recordings	Total Hours of PAM	Number of Acoustic Detections/ Species	Number of Sonobuoys Deployed
14 Jul - 5 Aug 2009	102	965	110	2,050	7	62	123	129/8	36
6 -22 Nov 2009	96	842	49	3,364	29	55	212	53/7	29
12 Jan - 3 Feb 2010	97	898	105	8,998	5	71	196	126/8	36
4 - 24 Apr 2010	95	1325	75	3,220	217	65	216	*	65
Totals	390	4,030	339	17,632	258	253	747	308	166

Table 2. CalCOFI cetacean encounter rates by cruise from July 2009 – April 2010.
Ns = number of sightings; Enc/100km = encounter rate per 100km surveyed, Ni = number of individuals

	CC0907 (14 Jul - 5 Aug 2009)			**CC0911 (6 -22 Nov 2009)**			**CC1001 (12 Jan - 3 Feb 2010)**			**CC1004 (4 Apr - 24 Apr)**		
Species	**Ns**	**Enc/ 100km**	**Ni**	**Ns**	**Enc/ 100km**	**Ni**	**Ns**	**Enc/ 100km**	**Ni**	**Ns**	**Enc/ 100km**	**Ni**
Bm	17	0.95	21	1	0.06	1	-	-	-	-	-	-
Bp	12	0.67	14	3	0.19	10	3	0.18	6	1	0.04	14
Dc	5	0.28	351	2	0.13	953	5	0.30	237	-	-	-
Dd	27	1.51	1167	9	0.58	1532	8	0.48	3146	3	0.12	830
Dsp	14	0.78	284	8	0.51	712	12	0.72	3228	4	0.16	68
Er	-	-	-	-	-	-	22	1.32	47	1	0.04	1
Gg	4	0.22	45	2	0.13	18	8	0.48	84	5	0.20	337
Lb	-	-	-	1	0.06	5	2	0.12	720	1	0.04	650
Lo	-	-	-	2	0.13	22	2	0.12	84	6	0.24	871
Mn	-	-	-	7	0.45	11	4	0.24	6	22	0.90	106
Oo	-	-	-	-	-	-	-	-	-	1	0.04	6
Pd	-	-	-	2	0.13	11	7	0.42	63	17	0.69	87
Pm	6	0.34	9	-	-	-	3	0.18	25	1	0.04	5
Sc	1	0.06	58	-	-	-	-	-	-	-	-	-
Tt	7	0.39	82	1	0.06	3	1	0.06	7	-	-	-
UD	1	0.06	1	3	0.19	76	10	0.60	1307	2	0.08	232
ULW	13	0.89	18	7	0.45	9	18	1.08	38	11	0.45	13
Zcav	-	-	-	1	0.06	1	-	-	-	-	-	-
TOTALS	110	6.15	2050	49	3.14	3364	105	6.31	8998	75	3.06	3220

SPECIES CODE

Bm = *Balaenoptera musculus* (blue whale)
Bm = *Balaenoptera physalus* (fin whale)
Dc = *Delphinus capensis* (long-beaked common dolphin)
Dd = *Delphinus delphis* (short-beaked common dolphin)
Dsp = *Delphinus spp.* (unid. Common dolphin)
Er = *Eschrichtius robustus* (grey whale)
Gg = *Grampus griseus* (Risso's dolphin)
Lb = *Lissodelphis borrealis* (N. right-whale dolphin)
Lo = *Lagenorhynchus obliquidens* (Pacific whiste-sided dolphin)
Mn = *Megaptera noveangliae* (humpback whale)
Oo = *Orcinus orca* (killer whale)
Pd = *Phocoenoides dalli* (Dall's porpoise)
Pm = *Physter macrocephalus* (sperm whale)
Sc = *Stenella coeruleoalba* (striped dolphin)
Tt = *Tursiops truncatus* (bottlenose dolphin)
Zcav = *Ziphius cavirostris* (Cuvier's beaked whale)
UD = unidentified dolphin
ULW = unidentified large whale

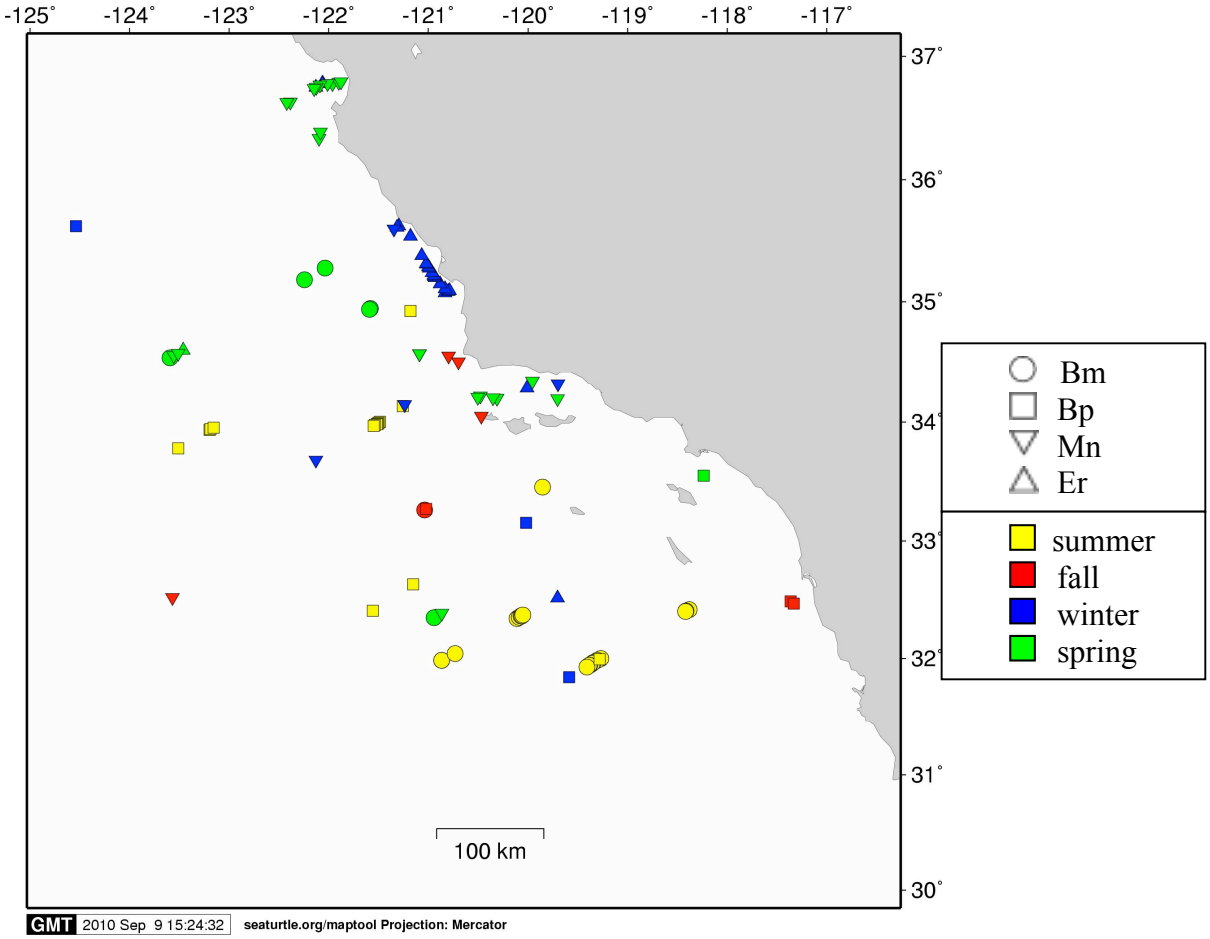

Figure 2. Baleen whale sightings during CalCOFI cruises between July 2009 and April 2010.

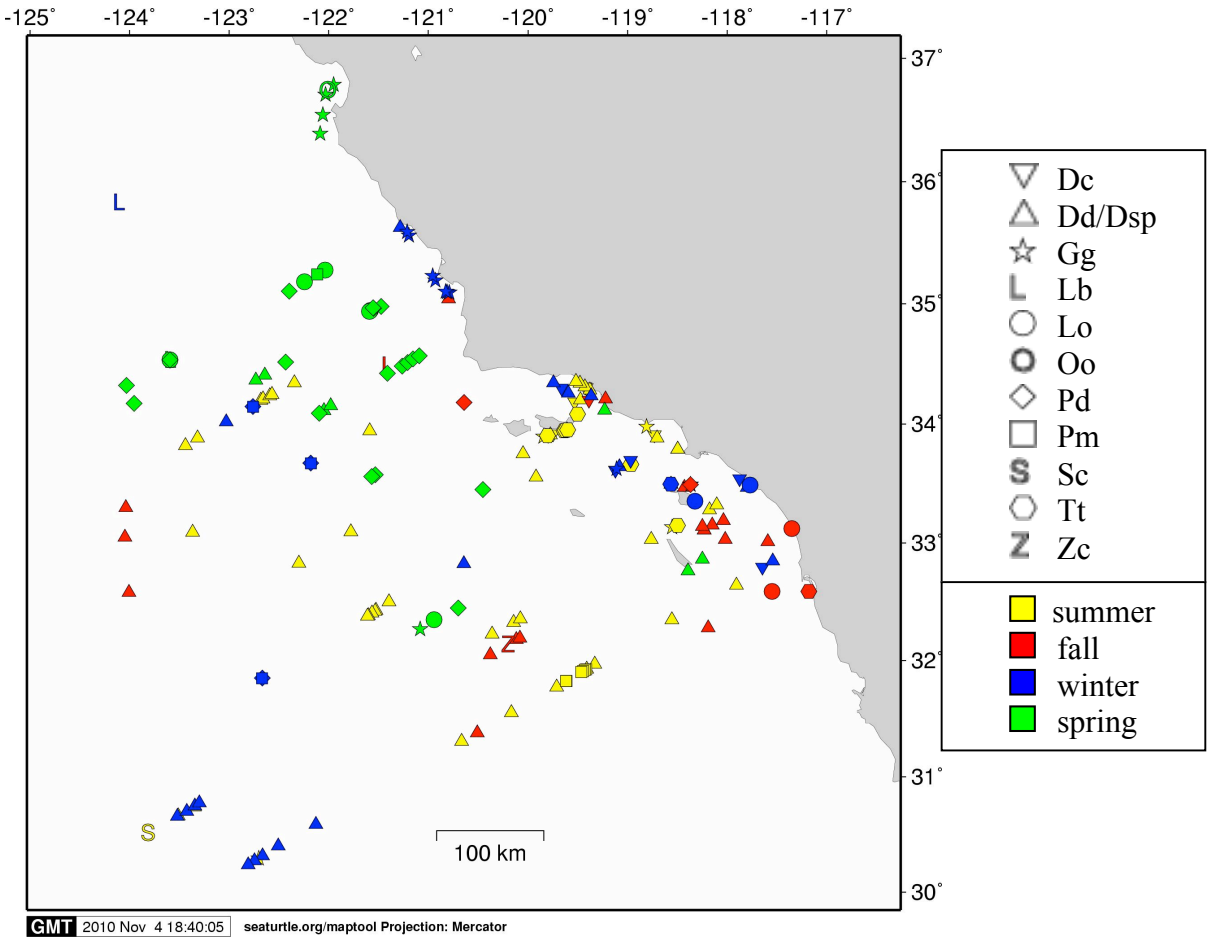

Figure 3. Toothed whale sightings during CalCOFI cruises between July 2009 and April 2010.