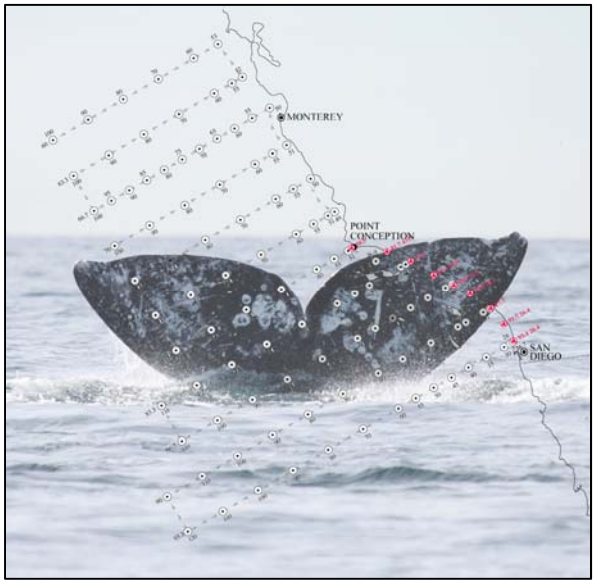
Marine Mammal Monitoring on California Cooperative Oceanic Fisheries Investigation (CalCOFI) Cruises: Summary of Results 2012-2016

Amanda J. Debich, Bruce Thayre, and John A. Hildebrand
Marine Physical Laboratory
Scripps Institution of Oceanography
University of California San Diego
La Jolla, CA 92037



Gray whale, photo by Amanda J. Debich

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Amanda J. Debich
Bruce Thayre
John A. Hildebrand

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14. ABSTRACT

Cetacean distribution, density and abundance in the Southern California Bight were assessed through visual and acoustic surveys during eighteen California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from February 2012-April 2016. Visual monitoring incorporated standard line-transect protocol during all daylight transits while acoustic monitoring employed a towed hydrophone array during transits and sonobuoys deployed at oceanographic sampling stations. Visual effort included 2,031 observation hours covering 31,807 kilometers. A total of 1,914 sightings were made, which included 18 different cetacean species. Acoustic effort included 1m027 sonobuoy deployments and 478 towed array deployments.

Blue whales (Balaenoptera musculus), fin whales (Balaenoptera physalus) and humpback whales (Megaptera novaeangliae) were the most frequently sighted baleen whales. Blue whales were primarily observed during summer and fall while fin and humpback whales were observed year-round with peaks in abundance during summer and spring respectively.

Short-beaked common dolphins (Delphinus delphis), Pacific white-sided dolphins (Lagenorhynchus obliquidens) and Dall's porpoise (Phocoenoides dalli) were the most frequently encountered small cetaceans. Seasonally, short-beaked common dolphins were most abundant in summer whereas Pacific white-sided dolphins and Dall's porpoise were most abundant during spring.

The CalCOFI marine mammal monitoring program examines seasonal and inter-annual patterns in density, abundance and distribution on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast, particularly for the winter and spring periods, for which there are currently few data available.

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Table of Contents

List of Tables

List of Figures

Executive Summary

Cetacean distribution, density and abundance in the Southern California Bight (SCB) were assessed through visual and acoustic surveys during eighteen California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from February 2012 through April 2016. Visual monitoring incorporated standard line-transect protocol during all daylight transits while acoustic monitoring employed a towed hydrophone array during transits and sonobuoys deployed at oceanographic sampling stations. Visual effort included 2,031 observation hours covering 31,807 kilometers. A total of 1,914 sightings were made, which included 17 different cetacean species. Acoustic effort included 1,027 sonobuoy deployments and 478 towed array deployments.

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The CalCOFI marine mammal monitoring program examines seasonal and inter-annual patterns in density, abundance and distribution on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast, particularly for the winter and spring periods, for which there are currently few data available.

The work presented in this report builds upon previous technical reports including Campbell *et al*., 2010, Campbell *et al*., 2011, Campbell *et al*., 2012, and Campbell *et al*, 2014.

A major portion of this project's data deliverable included the submission of all sighting data to NOAA's Southwest Fisheries Science Center for cetacean habitat-based density modeling. The results of this collaboration were submitted in a manuscript to *Frontiers* (Becker *et al.*, In review). Other published results from earlier CalCOFI cruises can be found in Campbell *et al*., 2015, and Douglas *et al*., 2014.

Project Background

Long-term assessments of abundance, density and distribution are central to evaluating potential effects of anthropogenic activities and ecosystem variability on cetacean populations (Carretta *et al.*, 2016). The California Current Ecosystem (CCE) is a productive and dynamic habitat (Hayward and Venrick, 1998; Chhak and Di Lorenzo, 2007) that supports a diverse community of cetacean species as well as an array of human activities including commercial fishing, shipping and naval exercises. The intersection between cetacean and human use of the CCE has resulted in entanglements in fishing gear (Carretta *et al.*, 2013) and various marine debris, ship strikes (Berman-Kowalewski *et al.*, 2010), and disturbances from anthropogenic sound (McDonald *et al.*, 2006; Goldbogen *et al.*, 2013).

CalCOFI cruises, conducted in the SCB four times per year, provide a unique and valuable platform to document spatial and temporal variations in cetacean abundance, density, distribution and habitat use patterns. Cetacean surveys have been integrated into CalCOFI quarterly cruises off southern California since 2004 using both visual and acoustic detection methods (Soldevilla *et al.*, 2006). The objectives of the cetacean monitoring program are to make seasonal, annual and long-term estimates of cetacean density and abundance within the study area, to determine the temporal and spatial patterns of cetacean distribution, to conduct habitat-based density modeling, to quantify differences in vocalizations between cetacean species, and to compare visual and acoustic survey methods and results.

The marine mammal research component of CalCOFI cruises contributes to the US Navy's efforts to better understand how cetaceans use the waters off Southern California. These long-term visual and acoustic surveys in Navy operating areas such as the SCORE (Southern California Offshore Range) range allow us to document trends and changes in marine mammal presence and contribute to the Navy's monitoring requirements.

Methodology

Marine mammal surveys were initiated as part of the CalCOFI cruises beginning in 2004. Visual monitoring incorporated standard line-transect survey protocol (Buckland *et al.*, 1993; Barlow, 1995; Barlow and Forney, 2007) that includes two experienced observers on the flying bridge scanning for marine mammals during transits between CalCOFI stations (Figure 1). Information on all cetacean sightings was logged systematically, including species, group size, reticle of cetacean position relative to the horizon, relative angle from the bow, latitude, longitude, ship's heading, behavior, and environmental data. Survey methods are described in detail in Campbell *et al.*, 2015.

Species diversity was calculated by dividing the number of species sighted by the total number of hours on visual effort per cruise. Only the southern 75 stations were included in this analysis because every cruise includes the southern stations, but not all cruises include the northern stations. Limiting the analysis to the southern stations allowed us to standardize effort hours for the analysis. It is worth mentioning that the winter 2014 cruise (1402SH) was incomplete due to ship repairs. Species diversity values reported for this cruise are therefore likely overestimated based on the fact that there were fewer hours on effort.

Acoustic monitoring for cetaceans during transits was conducted using a 6-element towed hydrophone array. The array is located approximately 300m meters behind the ship. This distance varies by a few meters each cruise, based on where the winch is placed on the ship. The exact distance is recorded for each cruise. Each pre-amplified element was band-pass filtered to decrease flow noise at low frequencies and to protect from signal aliasing at high frequencies. The multi-channel array data were sampled using both a Steinberg UR44 sound card (https://www.steinberg.net/en/products/audio_interfaces/ur_series/models/ur44.html) sampling at 192 kHz and a National Instruments NI-9223 sound card (http://www.ni.com/en-us/support/model.ni-9223.html) sampling at 300 kHz. This allowed for effective recoding bandwidths at 96 kHz and 150 kHz respectively. PAMGuard (https://www.pamguard.org/) was used to record the towed array data. During most cruises, the array was not monitored real-time because the acoustician also filled a visual observer role due to shortage of bunk space. Acoustic monitoring at CalCOFI oceanographic sampling stations was also conducted with passive SSQ-53F DIFAR sonobuoys. Sonobuoys were deployed one nm before each CalCOFI station and recorded for 2-4 hours while oceanographic sampling was underway during daylight hours. This deployment location is a compromise between signal range between the sonobuoy and antenna, and ship noise. The sonobuoys transmitted the signal to an antenna mounted on the ship which was connected to radio receivers. The analog signals were then converted to digital by external Audigy Sound Blaster sound cards (http://us.creative.com/p/sound-blaster/sound-blaster-audigy-se) sampling at 48 kHz. The sound cards were connected to a laptop and recordings were made via Ishmael (http://www.bioacoustics.us/ishmael.html).

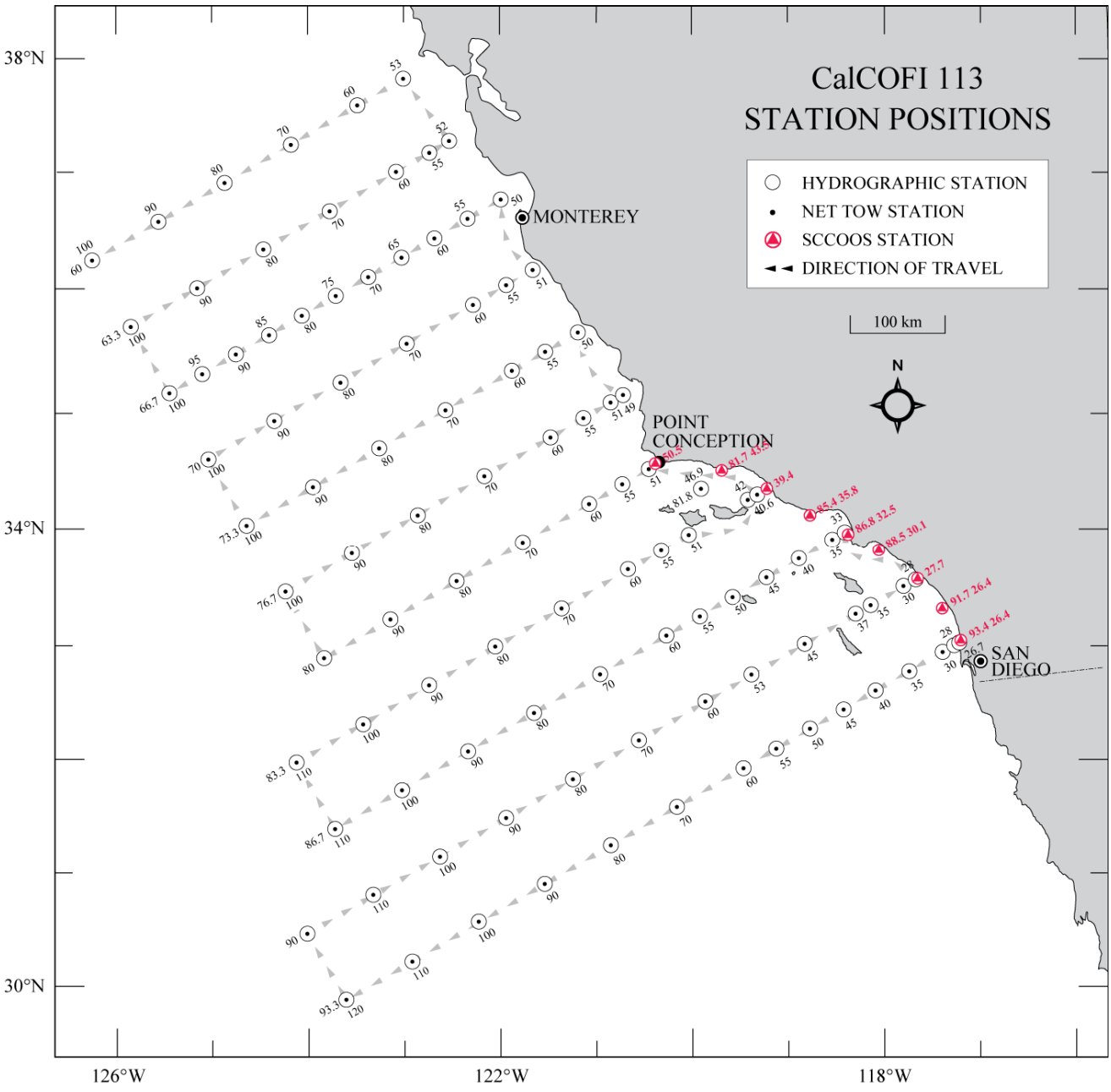

Figure 1. CalCOFI station pattern.
Each open circle represent a hydrographic station. Each black dot represents a net tow station. Each red triangle represents a Southern California Coastal Ocean Observing System (SCOOS) station. Gray arrows represent the direction of travel.

Results

Visual Effort

Eighteen CalCOFI cruises were conducted from January 2012 to April 2016. This included 334 days at sea and 2,031 hours on visual observation effort. Visual observation effort included 31,807 kilometers yielding 1,914 sightings of 18 identified cetacean species (Table 1). More detailed sighting information for each cruise can be found at: http://oceaninformatics.ucsd.edu/datazoo/catalogs/ccelter/datasets/262.

Table 1. Summary of CalCOFI cruise dates and visual effort between January 2012 and April 2016.

Cruise	Cruise Dates	Survey Effort (hours)	Distance Surveyed (km)	# of Sightings (on effort)	# of Species Sighted
1202NH	01/27/12 - 02/13/12	58.8	803.5	48	9
1203SH	03/23/12 - 04/07/12	59.9	999.7	97	9
1207NH	07/10/12 - 07/27/12	136.5	2031.6	137.0	8
1210NH	10/17/12 - 11/05/12	81.2	1335.4	100	7
1301SH	01/10/13 - 02/02/13	143.8	2058.6	115	12
1304SH	04/06/13 - 04/30/13	120.4	2002.1	140	9
1307NH	07/06/13 - 07/22/13	149.4	2170.2	123	10
1311NH	11/07/13 - 11/25/13	119.0	1661.5	73	8
1402SH	01/29/14 - 02/07/14	68.8	852.8	51	8
1404OS	03/28/14 - 04/18/14	99.3	1456.8	104	8
1407NH	07/06/14 - 07/22/14	134.5	2142.3	139	9
1411NH	11/08/14 - 11/23/14	102.2	1622.2	62	12
1501NH	01/15/15 - 02/07/15	185.2	2597.1	136	11
1504NH	04/04/15 - 04/20/15	132.5	1937.9	80	11
1507OC	07/08/15 - 07/24/15	96.3	1934.6	141	11
1511OC	10/25/15 - 11/13/15	113.1	2159.2	73	6
1601RL	01/07/16 - 01/29/16	79.4	1425.7	109	8
1604SH	03/29/16 - 04/22/16	151.1	2615.4	186	14
Total		**2031.2**	**31806.6**	**1914**	**Max: 12**

Baleen whale sightings

Five different species of baleen whale were identified on winter 2012 through spring 2016 cruises: blue, fin, gray (*Eschrichtius robustus*), humpback, and minke (*Balaenoptera acutorostrata*) whales. Large whales that could not be identified to species were logged as "unidentified large whale (ULW)." A total of 96 blue whales, 228 fin whales. 230 gray whales, 538 humpback whales, and 8 minke whales were sighted between 2012 and spring 2016. 494 additional whales were logged as ULW. Total number of on-effort groups and individuals sighted for each baleen whale species per cruise are found in Table 2. On-effort visual detections of baleen whales for 2012 through 2016 are shown in Figure 2 through Figure 6. A summary figure of all maps on one page can be found in the appendix (Figure A- 1). Spatial and temporal trends were apparent for several species. Blue whale sightings were more prevalent during summer and fall (warm) cruises than during winter and spring (cool) cruises. Most blue whale sightings also occurred along the continental slope or in offshore waters during the warm cruises whereas sightings during the cool cruises occurred along the continental shelf and inshore waters. Fin whale sightings showed a similar spatial pattern as blue whales, though the difference in numbers of sightings between the cool and warm cruises was not as noticeable as for the blue whales. Gray whale sightings always occurred along the continental shelf and were made only during the cool cruises. This corresponds with what we would expect to see during their migration. More humpback whales were sighted than any other baleen whale. Sighting patterns for humpbacks were different from the blue and fin whale sightings in that more humpbacks were sighted along the continental shelf and nearshore waters during the cool cruises rather than in the warm cruises. There were too few minke whale sightings to discern much of a spatial or temporal pattern.

Table 2. On-effort baleen whale detections winter 2012 - spring 2016 CalCOFI cruises.

		Species	Minke	Blue	Fin	Gray	Humpback	Unid Large Whale
2012	winter	# Groups	0	1	4	8	1	9
		# Individuals	0	1	10	15	1	13
	spring	# Groups	0	0	12	2	2	16
		# Individuals	0	0	17	5	4	27
	summer	# Groups	0	9	4	0	1	19
		# Individuals	0	13	6	0	3	24
	fall	# Groups	0	8	21	0	2	21
		# Individuals	0	13	37	0	2	38
2013	winter	# Groups	0	0	13	14	7	10
		# Individuals	0	0	20	34	16	13
	spring	# Groups	0	0	6	1	55	30
		# Individuals	0	0	9	2	90	34
	summer	# Groups	1	4	11	0	7	35
		# Individuals	1	5	15	0	10	35
	fall	# Groups	0	1	4	0	1	14
		# Individuals	0	3	5	0	2	19
2014	winter	# Groups	0	0	2	6	0	5
		# Individuals	0	0	2	9	0	5
	spring	# Groups	2	0	5	1	15	17
		# Individuals	3	0	9	3	24	19
	summer	# Groups	1	8	21	0	15	29
		# Individuals	1	16	52	0	18	46
	fall	# Groups	1	1	1	0	8	7
		# Individuals	1	1	1	0	10	12
2015	winter	# Groups	0	0	0	27	8	20
		# Individuals	0	0	0	73	13	25
	spring	# Groups	0	0	2	1	12	15
		# Individuals	0	0	2	1	16	18
	summer	# Groups	1	18	16	0	16	25
		# Individuals	1	39	22	0	54	37
	fall	# Groups	0	0	1	0	20	23
		# Individuals	0	0	1	0	29	33
2016	winter	# Groups	0	0	1	31	5	22
		# Individuals	0	0	1	83	9	55
	spring	# Groups	1	4	11	4	55	27
		# Individuals	1	5	19	5	237	41
Total # Groups			**7**	**54**	**135**	**95**	**230**	**344**
Total # Individuals			**8**	**96**	**228**	**230**	**538**	**494**

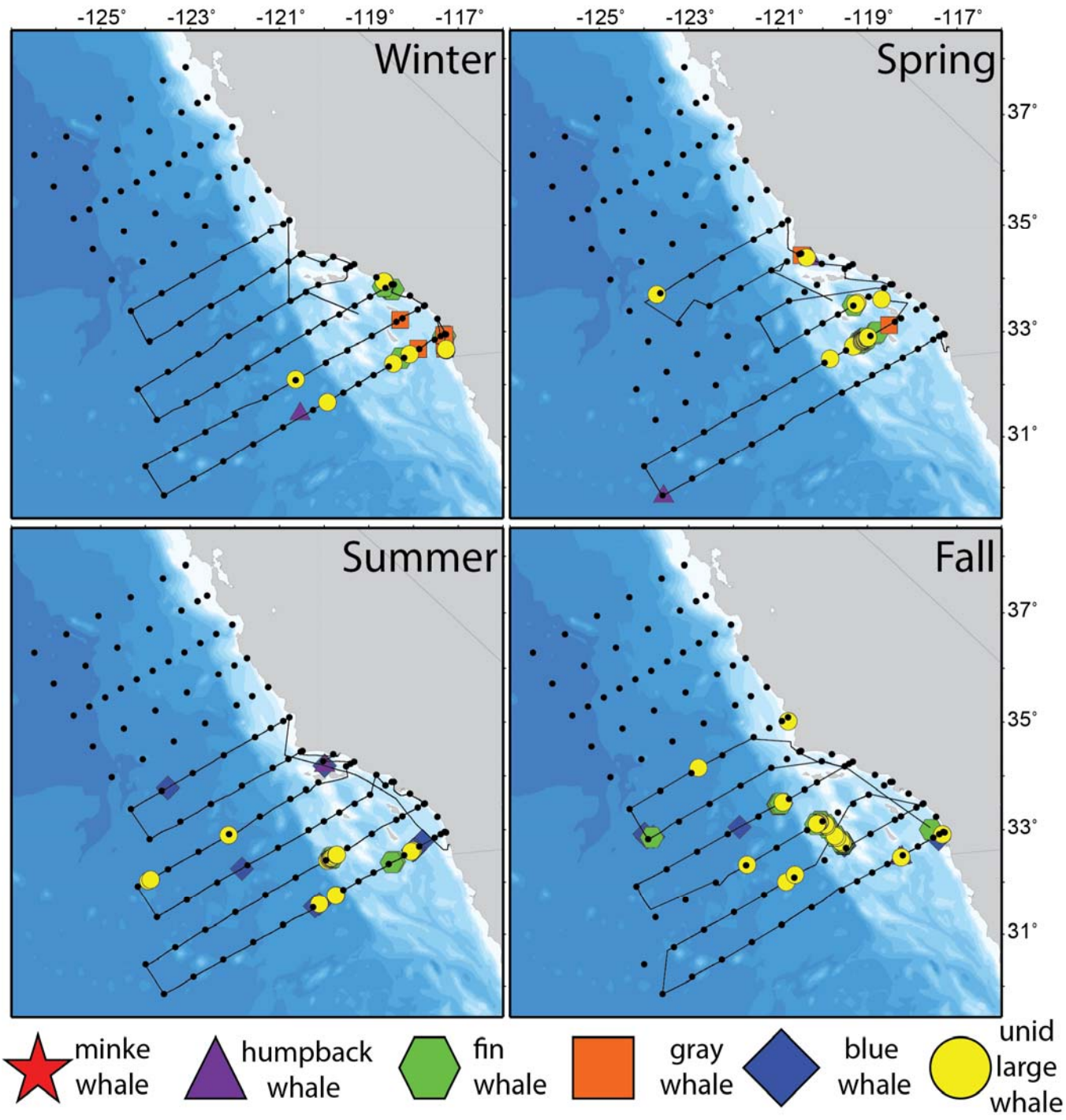

Figure 2. On-effort baleen whale sightings during 2012 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

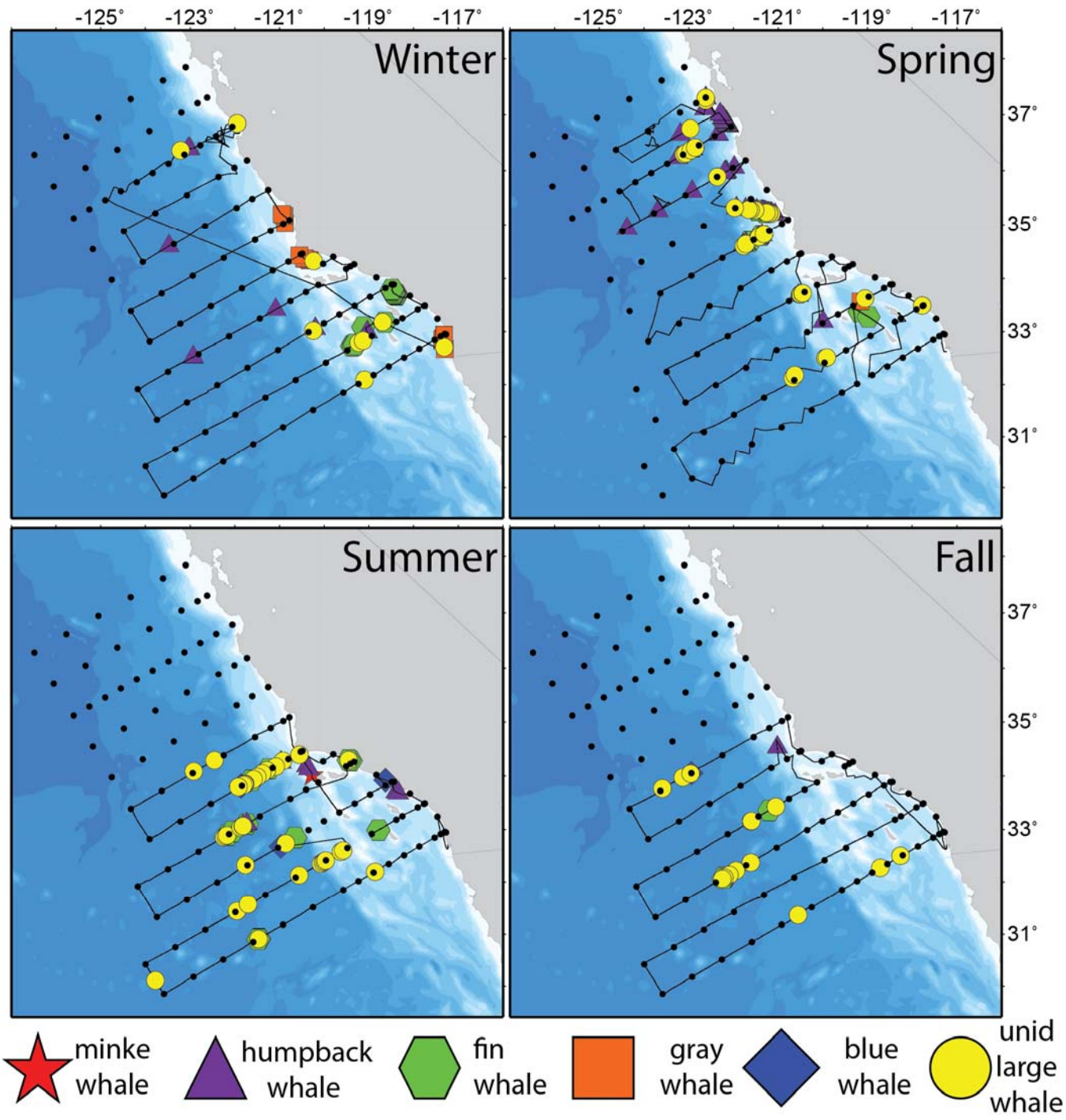

Figure 3. On-effort baleen whale sightings during 2013 CalCOFI cruises.
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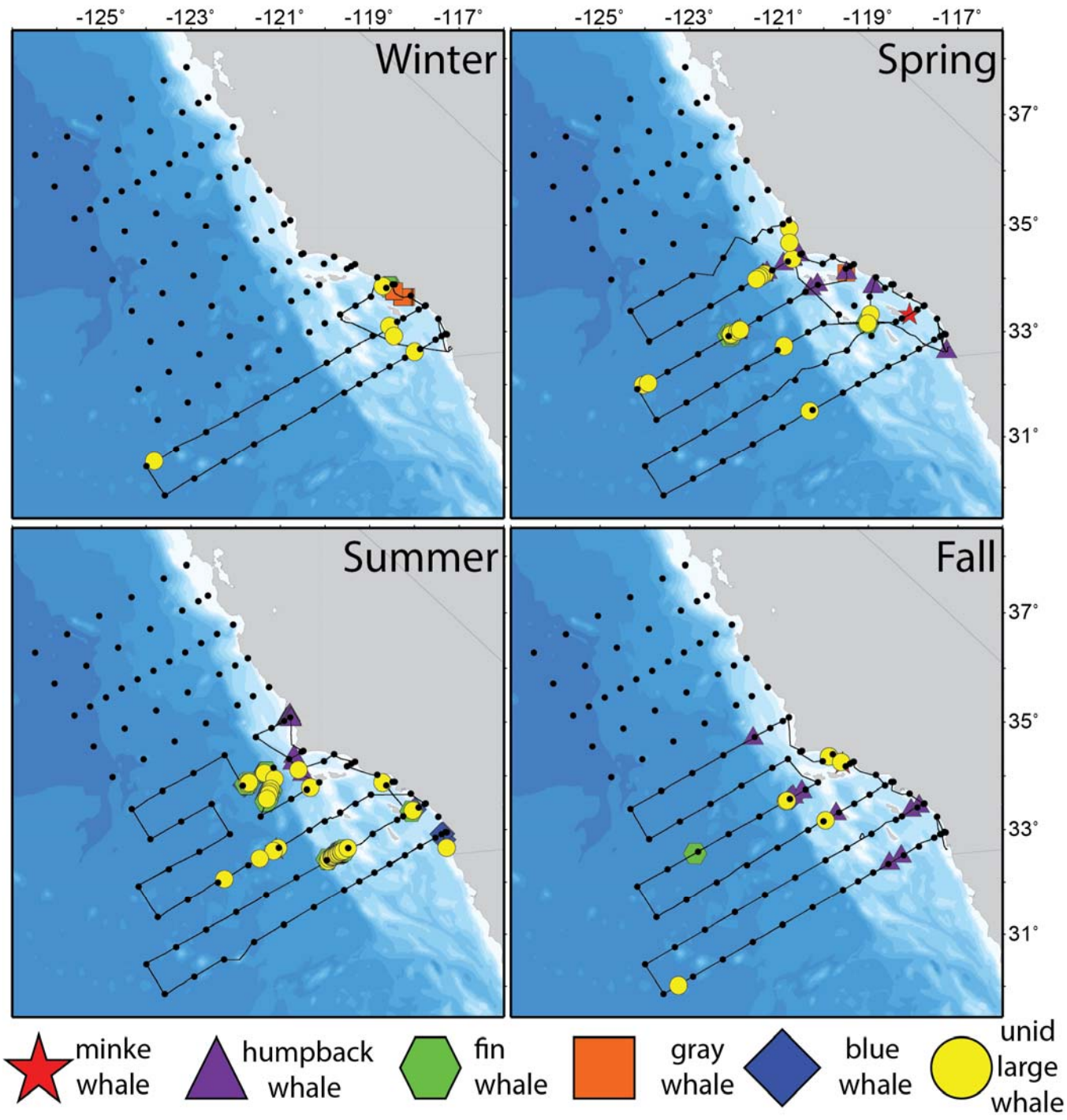

Figure 4. On-effort baleen whale sightings during 2014 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

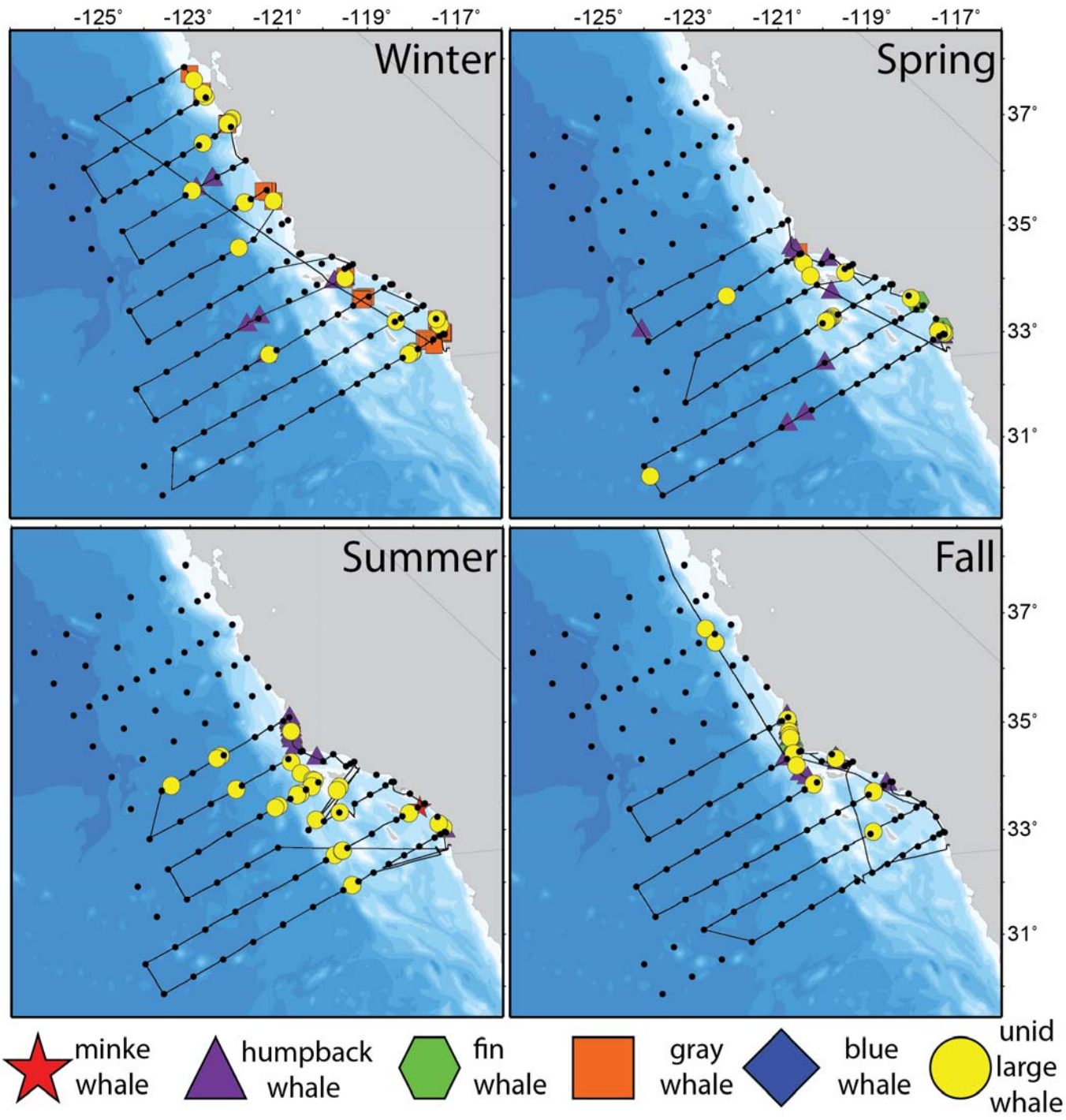

Figure 5. On-effort baleen whale sightings during 2015 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

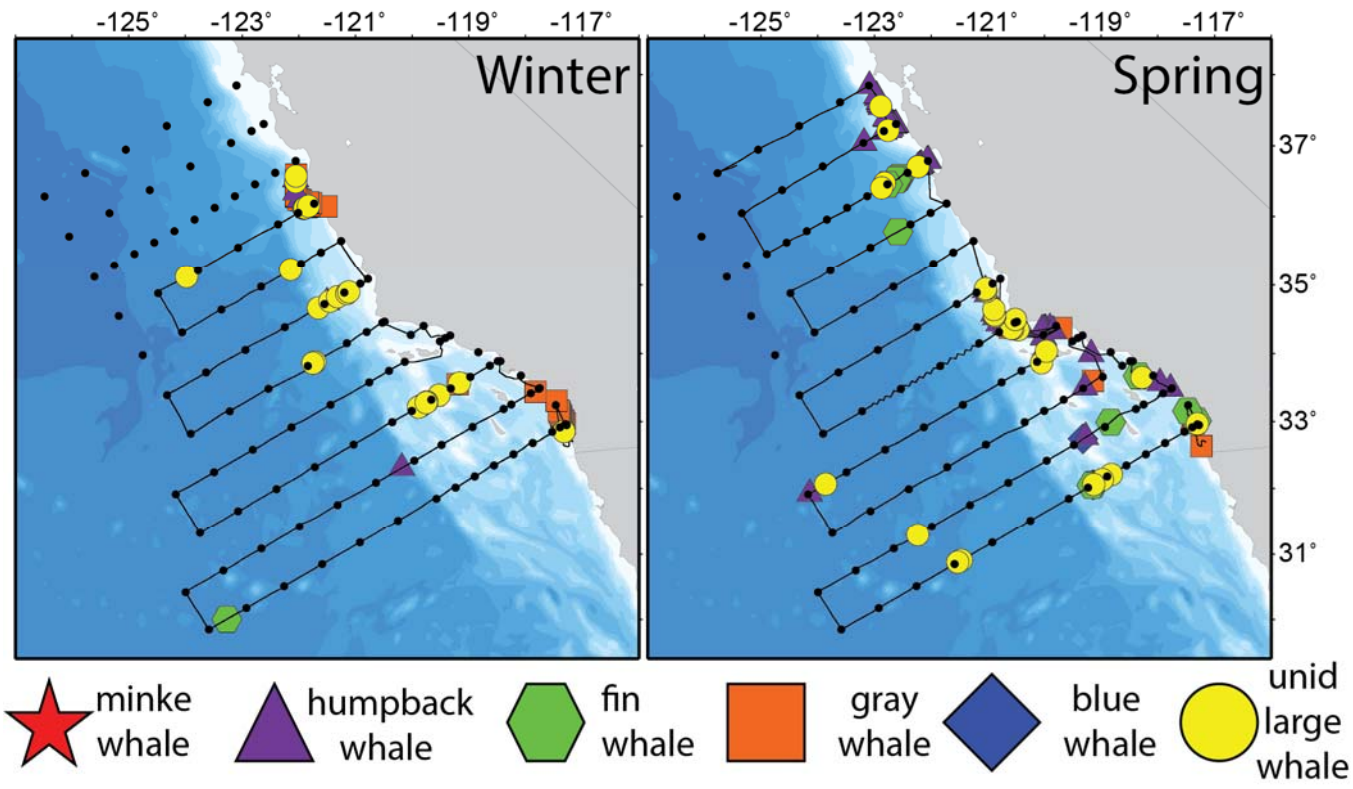

Figure 6. On-effort baleen whale sightings during winter and spring 2016 CalCOFI cruises. CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

Odontocete sightings

Twelve different species of odontocetes were identified on winter 2012 through spring 2016 cruises: long-beaked (*Delphinus capensis*) and short-beaked common dolphins, Risso's dolphins (*Grampus griseus*), short-finned pilot whales (*Globicephala macrorhynchus*), northern right whale dolphins (*Lissodelphis borealis*), Pacific white-sided dolphins , killer whales (*Orcinus orca*), Dall's porpoises , sperm whales (*Physeter macrocephalus*), striped dolphins (*Stenella coeruleoalba*), bottlenose dolphins (*Tursiops truncatus*), and Cuvier's beaked whales (*Ziphius cavirostris*). Common dolphins that could not be identified to species were logged as Delphinus species (Dsp). Any other dolphin that could not be identified to species was logged as unidentified dolphin (UD). A total of 24,573 long-beaked dolphins, 20,537 short-beaked dolphins, 1,017 Risso's dolphins, 27 pilot whales, 2,140 northern right whale dolphins, 1,888 Pacific white-sided dolphins, 30 killer whales, 368 Dall's porpoises, 63 sperm whales, 2 striped dolphins, 825 bottlenose dolphins, and 35 Cuvier's beaked whales were sighted between 2012 and spring 2016. Total number of on-effort groups and individuals sighted for each odontocete species are found in Table 3. Odontocete detections for 2012 through spring 2016 also revealed spatial and temporal trends (Figure 7 through Figure 11). A summary figure of all maps on one page can be found in the appendix (Figure A- 7). Common dolphins were the most commonly detected odontocete species and were sighted on every cruise. Though there were more groups of short-beaked common dolphins sighted, there were more individual long-beaked common dolphins. Striped dolphins were the least commonly sighted species. Short-beaked common dolphins were detected offshore more frequently than inshore; in contrast, long-beaked common dolphins were more frequently detected in inshore waters. During the summer and fall 2015 cruises, however, sightings of short-beaked common dolphins were more inshore. There were also fewer sightings of odontocetes during the fall 2015 cruise overall. The decrease in odontocete sightings is likely an effect from El Niño.

Table 3. On-effort odontocete detections winter 2012 - spring 2016 CalCOFI cruises.

		Species	long-beaked common dolphins	short-beaked common dolphins	Delphinus spp.	Risso's dolphins	pilot whales	northern right whale dolhins	Pacific white-sided dolhins	killer whales	Dall's porpoises	sperm whales	striped dolphins	bottlenose dolphins	unidentified dolphins	Cuvier's beaked whale
2012	winter	# Groups	3	2	2	5	0	0	0	0	0	1	0	2	3	0
		# Individuals	618	346	136	96	0	0	0	0	0	3	0	22	84	0
	spring	# Groups	2	3	12	2	0	1	0	0	8	0	0	4	4	0
		# Individuals	410	485	805	19	0	5	0	0	73	0	0	34	48	0
	summer	# Groups	16	16	35	0	0	2	0	1	0	0	0	10	9	0
		# Individuals	2718	1472	1508	0	0	92	0	7	0	0	0	286	156	0
	fall	# Groups	5	8	20	0	0	0	0	0	1	0	0	1	7	0
		# Individuals	341	383	1102	0	0	0	0	0	3	0	0	2	201	0
2013	winter	# Groups	2	13	16	4	0	2	5	3	9	1	1	0	0	0
		# Individuals	171	1075	1839	41	0	16	37	14	80	2	2	0	0	0
	spring	# Groups	0	5	5	1	0	4	4	0	12	0	0	1	4	0
		# Individuals	0	479	201	8	0	1600	1060	0	79	0	0	5	786	0
	summer	# Groups	6	13	19	2	0	1	2	0	0	0	0	5	2	0
		# Individuals	212	1389	1711	25	0	20	320	0	0	0	0	114	225	0
	fall	# Groups	6	10	18	2	0	0	0	0	0	1	0	4	8	0
		# Individuals	2264	758	1560	37	0	0	0	0	0	9	0	41	190	0
2014	winter	# Groups	1	19	4	2	0	0	1	0	1	0	0	4	1	0
		# Individuals	685	1060	155	177	0	0	1	0	2	0	0	151	24	0
	spring	# Groups	0	17	5	1	0	0	3	0	3	0	0	0	2	0
		# Individuals	0	1471	183	30	0	0	45	0	9	0	0	0	165	0
	summer	# Groups	11	8	24	6	0	0	0	0	0	1	0	3	7	0
		# Individuals	1420	272	2310	73	0	0	0	0	0	7	0	48	179	0
	fall	# Groups	5	8	12	1	0	0	2	1	1	1	0	0	6	1
		# Individuals	792	1159	888	5	0	0	12	2	7	7	0	0	172	5
2015	winter	# Groups	9	25	14	2	0	4	1	1	1	1	0	2	10	0
		# Individuals	6608	6210	269	9	0	25	55	7	3	5	0	6	500	0
	spring	# Groups	6	12	19	1	1	0	1	0	2	1	0	0	6	0
		# Individuals	818	534	922	370	27	0	125	0	24	9	0	0	541	0
	summer	# Groups	4	12	6	5	0	0	1	0	0	1	0	4	9	1
		# Individuals	496	1800	936	54	0	0	9	0	0	10	0	109	597	8
	fall	# Groups	3	6	7	0	0	3	6	0	0	0	0	0	4	0
		# Individuals	268	520	1451	0	0	355	65	0	0	0	0	0	195	0
2016	winter	# Groups	6	22	4	1	0	0	1	0	2	0	0	0	5	0
		# Individuals	903	625	74	7	0	0	9	0	27	0	0	0	55	0
	spring	# Groups	13	11	15	5	0	1	6	0	8	3	0	1	5	4
		# Individuals	5849	499	1321	66	0	27	150	0	61	11	0	7	184	22
Total # Groups			**98**	**210**	**237**	**40**	**1**	**18**	**33**	**6**	**48**	**11**	**1**	**41**	**92**	**6**
Total # Individuals			**24573**	**20537**	**17371**	**1017**	**27**	**2140**	**1888**	**30**	**368**	**63**	**2**	**825**	**4302**	**35**

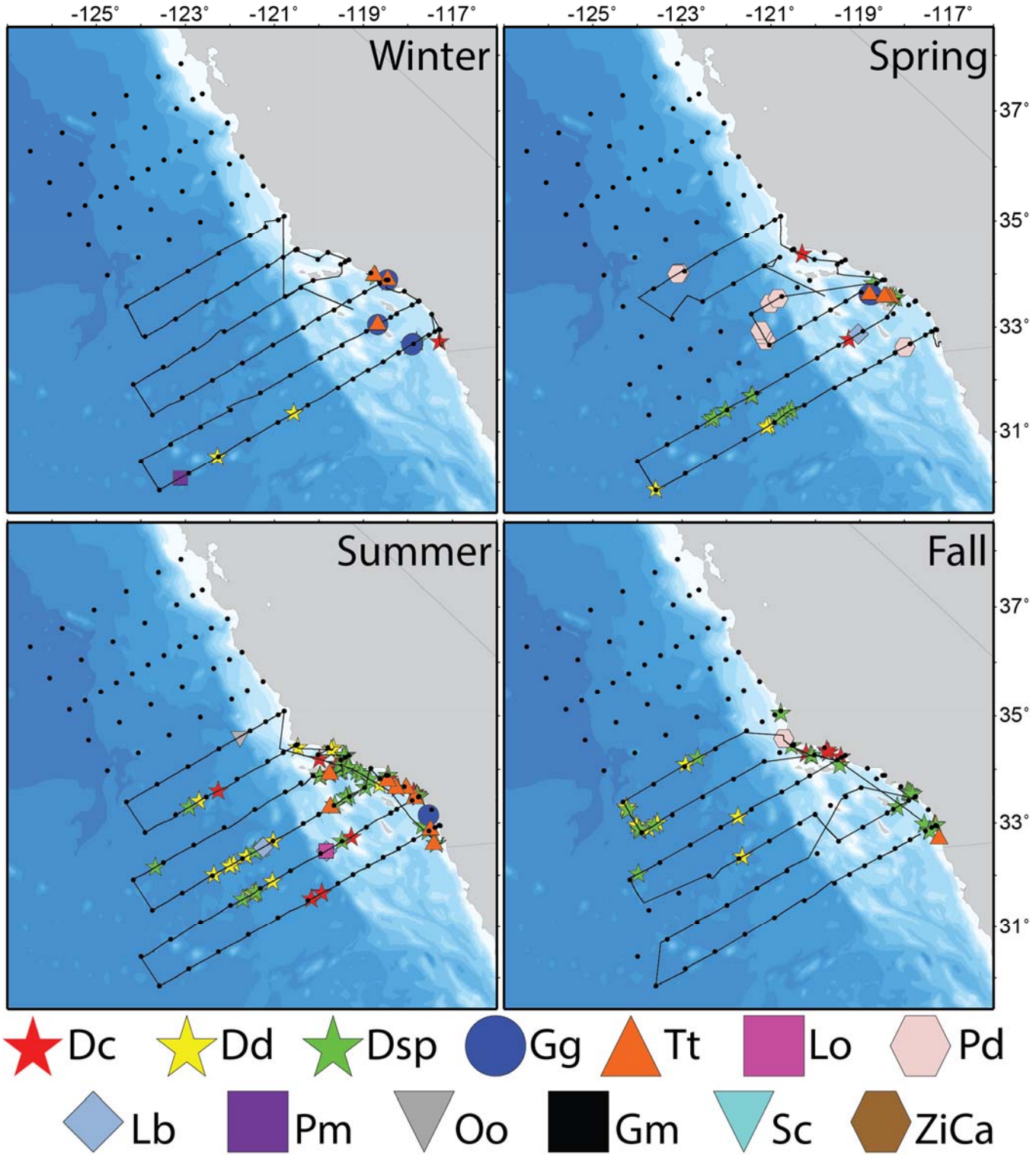

Figure 7. On-effort odontocete sightings during 2012 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

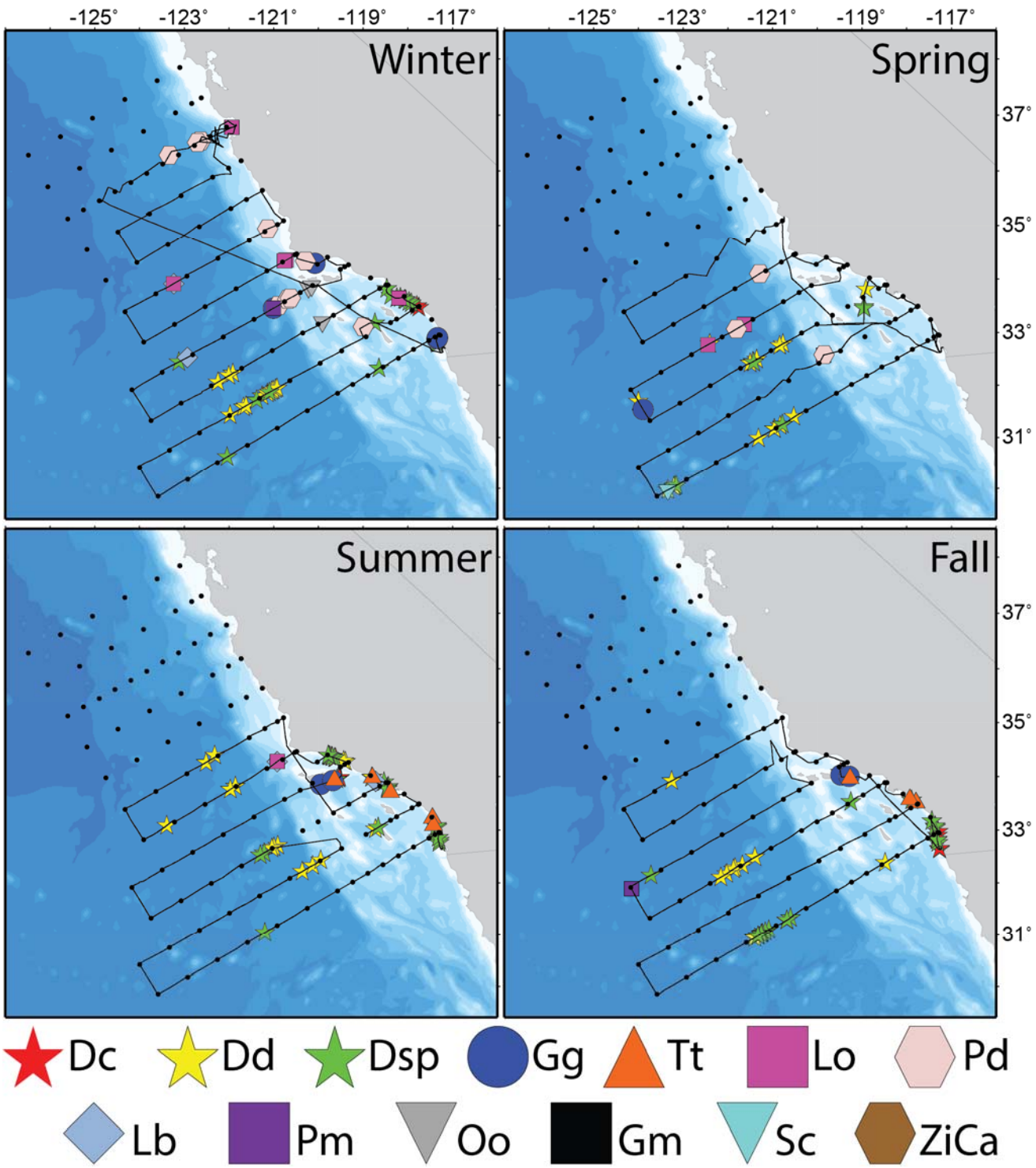

Figure 8. On-effort odontocete sightings during 2013 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

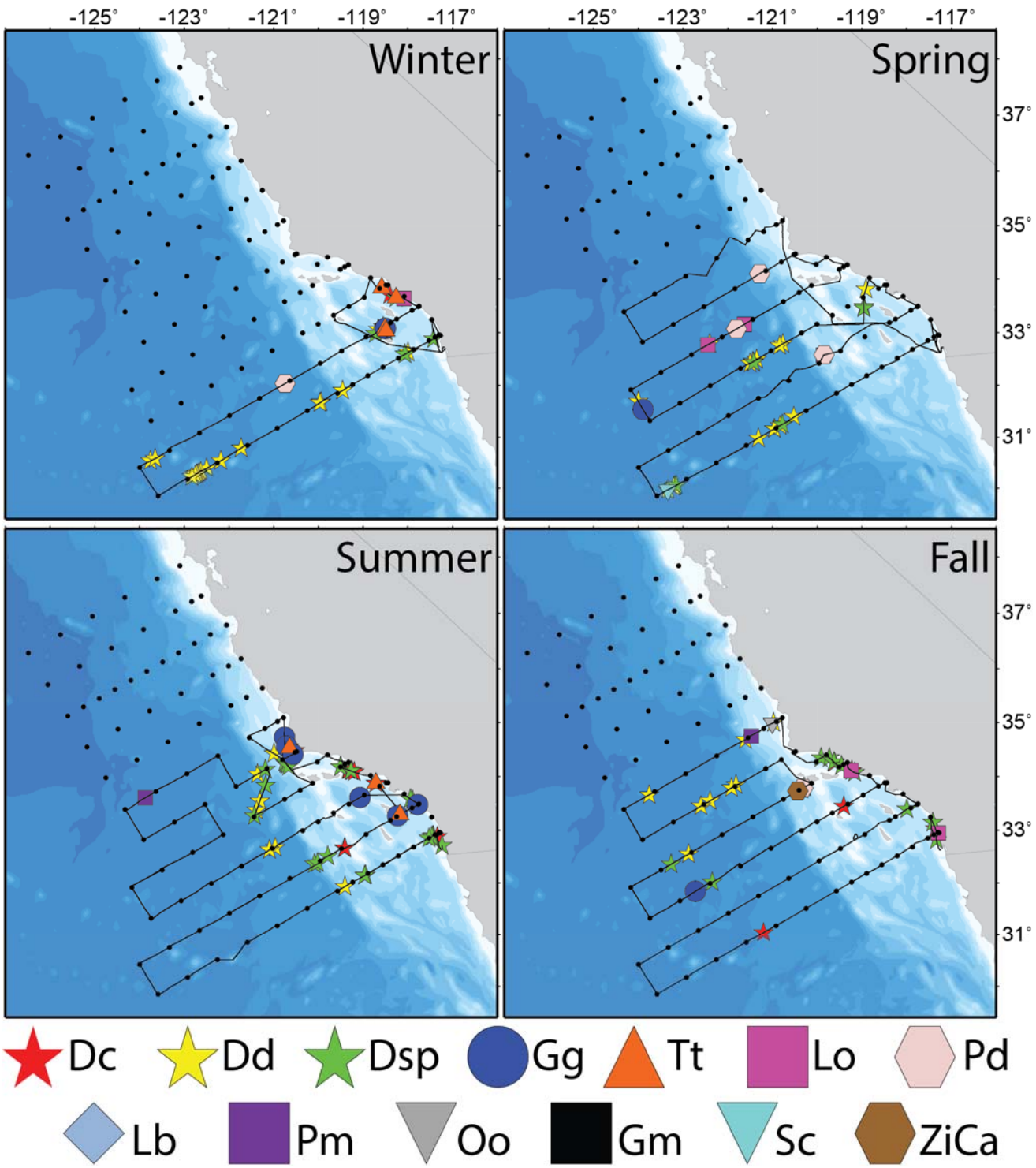

Figure 9. On-effort odontocete sightings during 2014 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

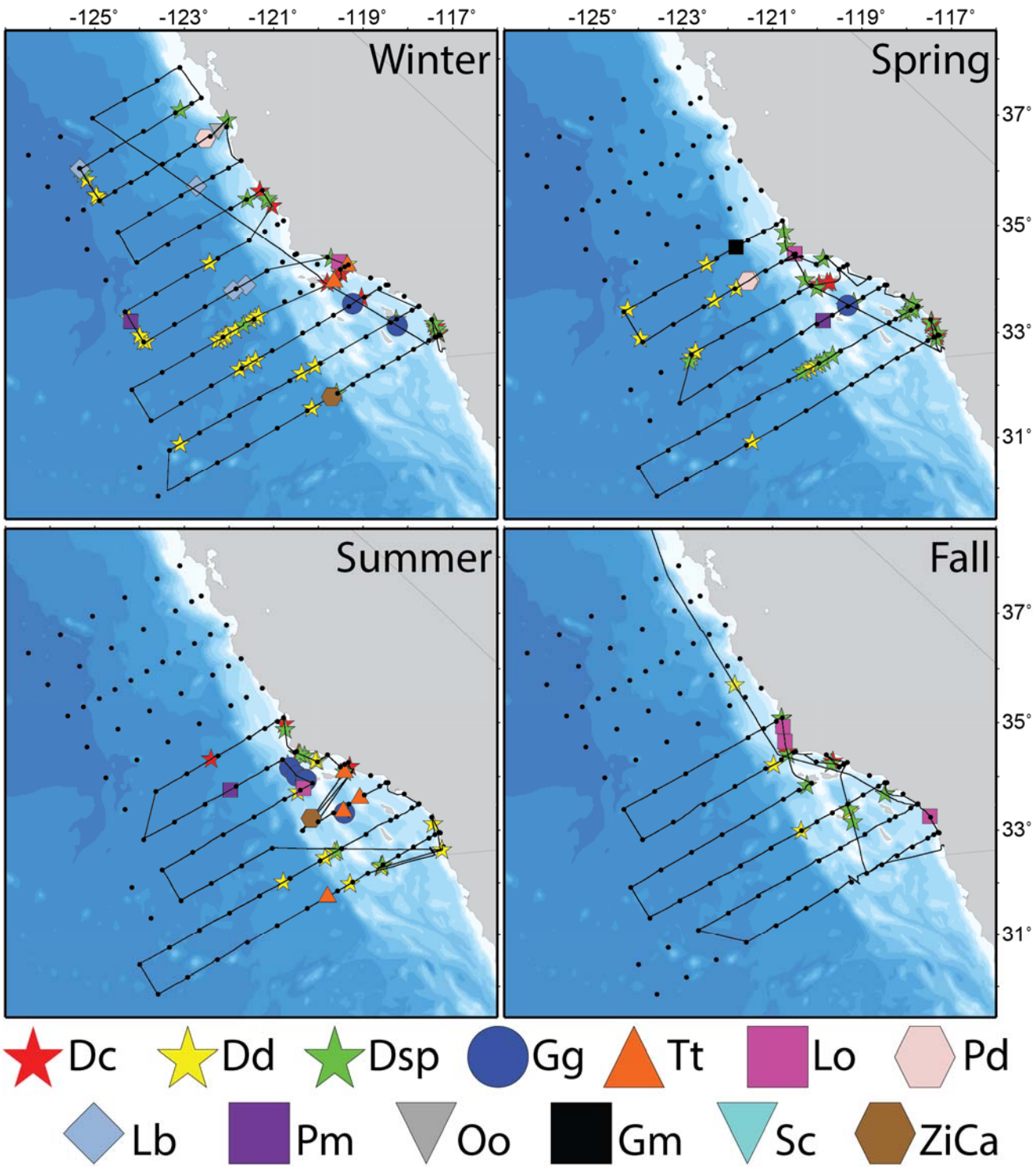

Figure 10. On-effort odontocete sightings during 2015 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

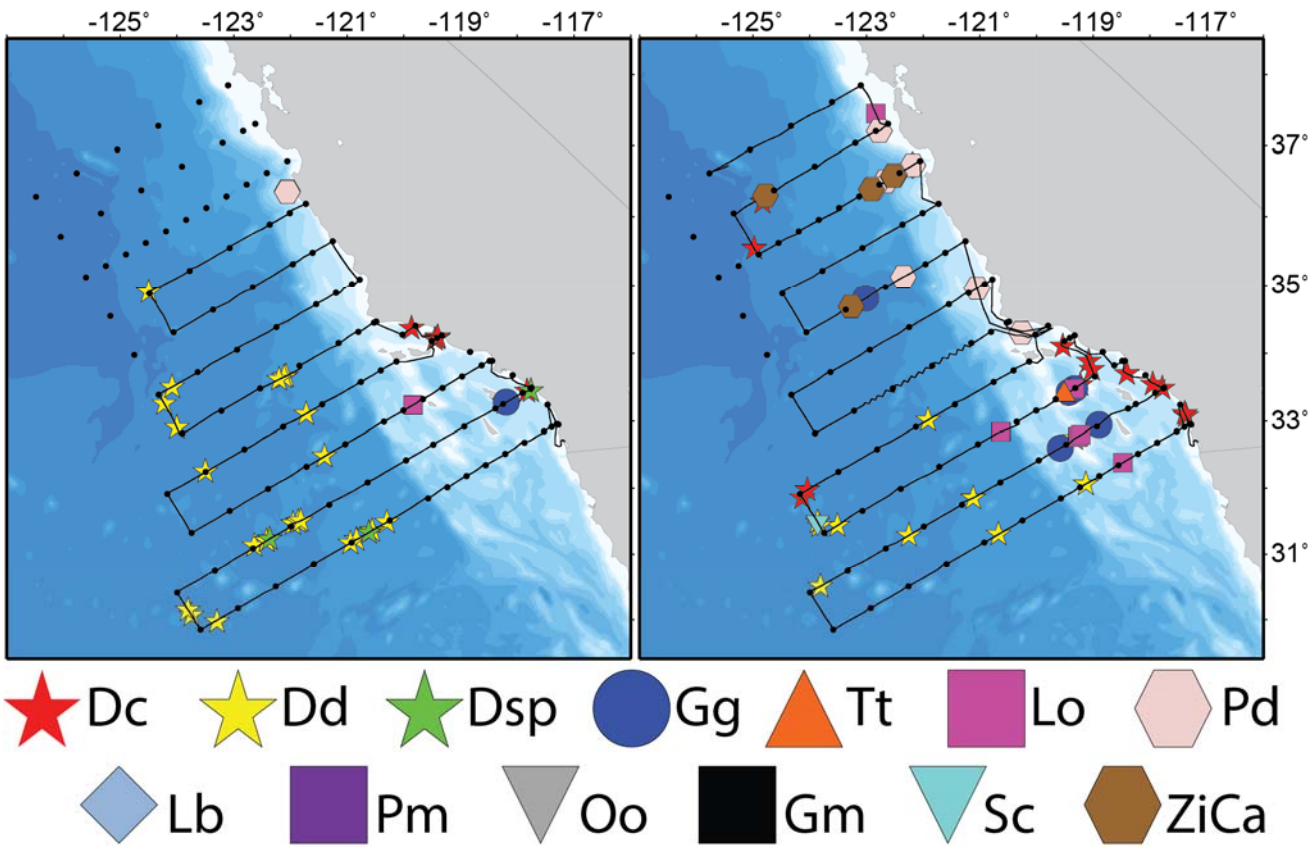

Figure 11. On-effort odontocete sightings during 2016 CalCOFI cruises.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

Species diversity

Cetacean species diversity varied by season. Overall, winter cruises had the highest species diversity for mysticetes (0.116 species per hour) (Figure 12) and odontocetes (0.144 species per hour) (Figure 13). Mysticete species diversity gradually declined across winter and spring cruises from 2012 to 2015 and then increased in 2016. The fall 2015 cruise (1511OC) had the lowest mysticete species diversity (0.017 species per hour) for all cruises 2012-2016. Variations of odontocete species diversity were somewhat similar to that of the mysticetes. Mysticete and odontocete diversity increased during fall cruises during 2012-2014 but there was a large decrease in species diversity during the fall cruise 2015.

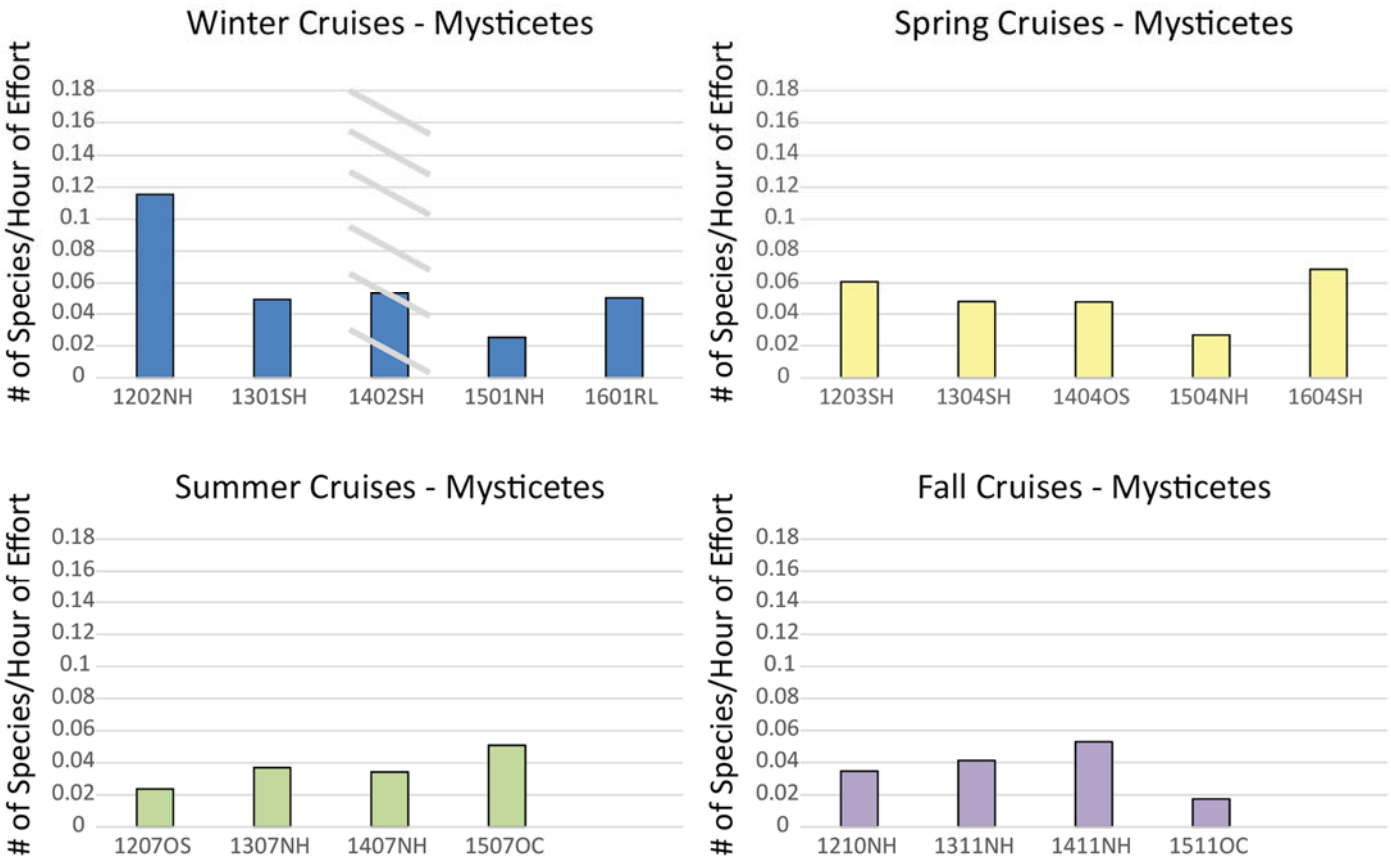

Figure 12. Number of mysticete species visually detected per hour of effort during CalCOFI cruises 2012-spring 2016.
Gray hash marks across the 1402SH cruise denotes incomplete cruise.

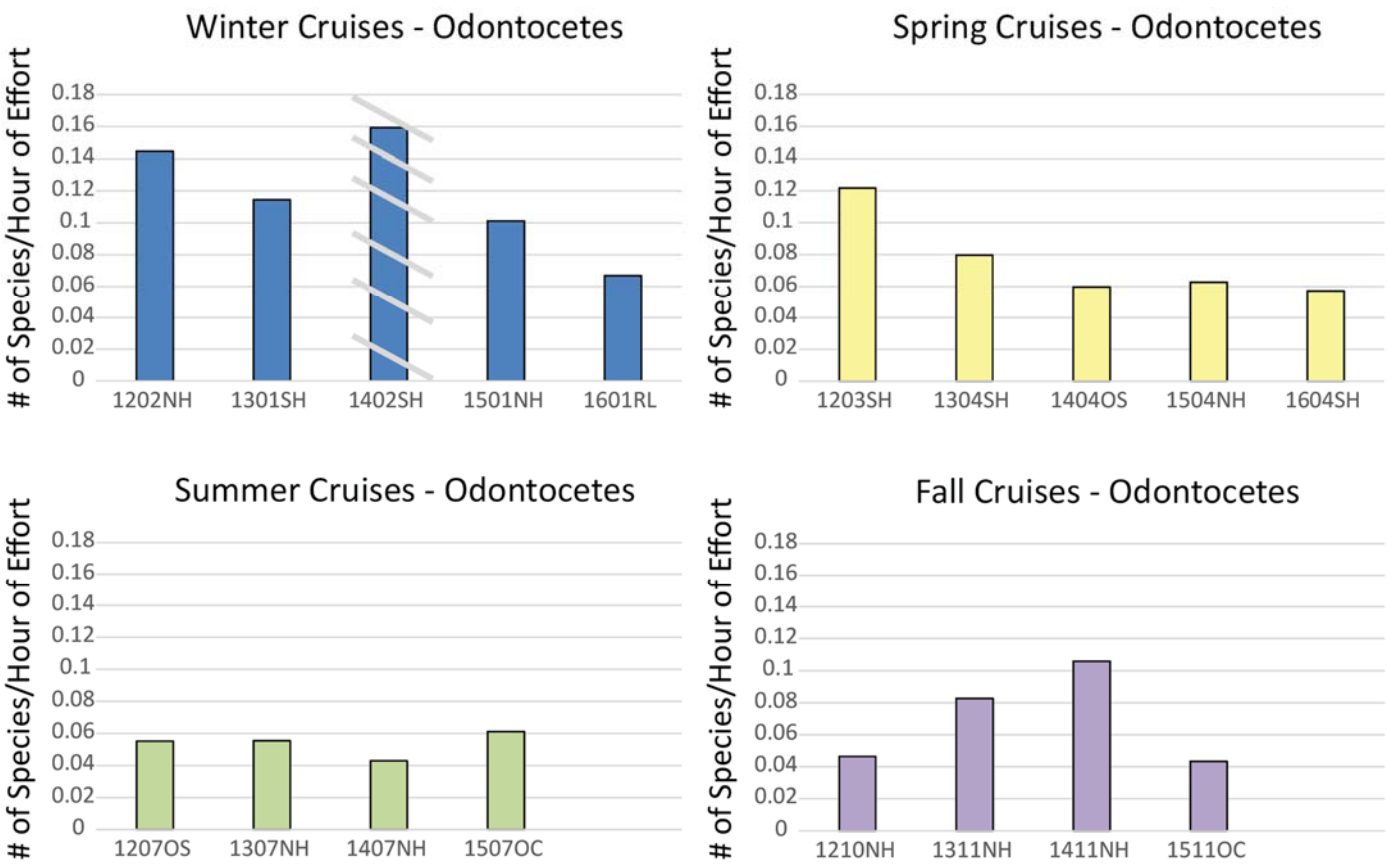

Figure 13. Number of mysticete species visually detected per hour of effort during CalCOFI cruises 2012-spring 2016.
Gray hash marks across the 1402SH cruise denotes incomplete cruise.

Acoustic effort

Acoustic effort on winter 2012 through spring 2016 cruises included 1,027 sonobuoy deployments and 478 towed array deployments (Table 4). This amounted to 1,277 hours of towed array recordings and 1,787 hours of sonobuoy recordings. Towed array and sonobuoy deployments are shown in Figure 14 through Figure 18.

Future analysis of these data will quantify differences in vocalizations between cetacean species, and compare visual and acoustic survey results.

Table 4. Acoustic deployments winter 2012 - spring 2016.

Cruise		# Towed Array Deployments	# Hours Recorded During Towed Array Deployments	# Sonobuoy Deployments	# Hours Recorded During Sonobuoy Deployments
2012	Winter	22	55.0	49	128.3
	Spring	20	52.7	52	47.9
	Summer	29	94.2	57	137.7
	Fall	24	83.2	52	63.0
2013	Winter	25	75.9	58	122.4
	Spring	29	100.8	61	123.4
	Summer	30	82.8	64	77.1
	Fall	23	50.6	55	91.2
2014	Winter	13	39.9	24	46.0
	Spring	25	70.5	54	153.9
	Summer	34	86.3	60	80.5
	Fall	16	29.6	54	89.3
2015	Winter	35	81.6	77	106.1
	Spring	23	57.7	58	77.8
	Summer	34	71.4	66	88.8
	Fall	28	90.9	54	108.7
2016	Winter	29	73.2	52	106.9
	Spring	39	81.2	80	138.1
Total		478	1277.4	1027	1787.1

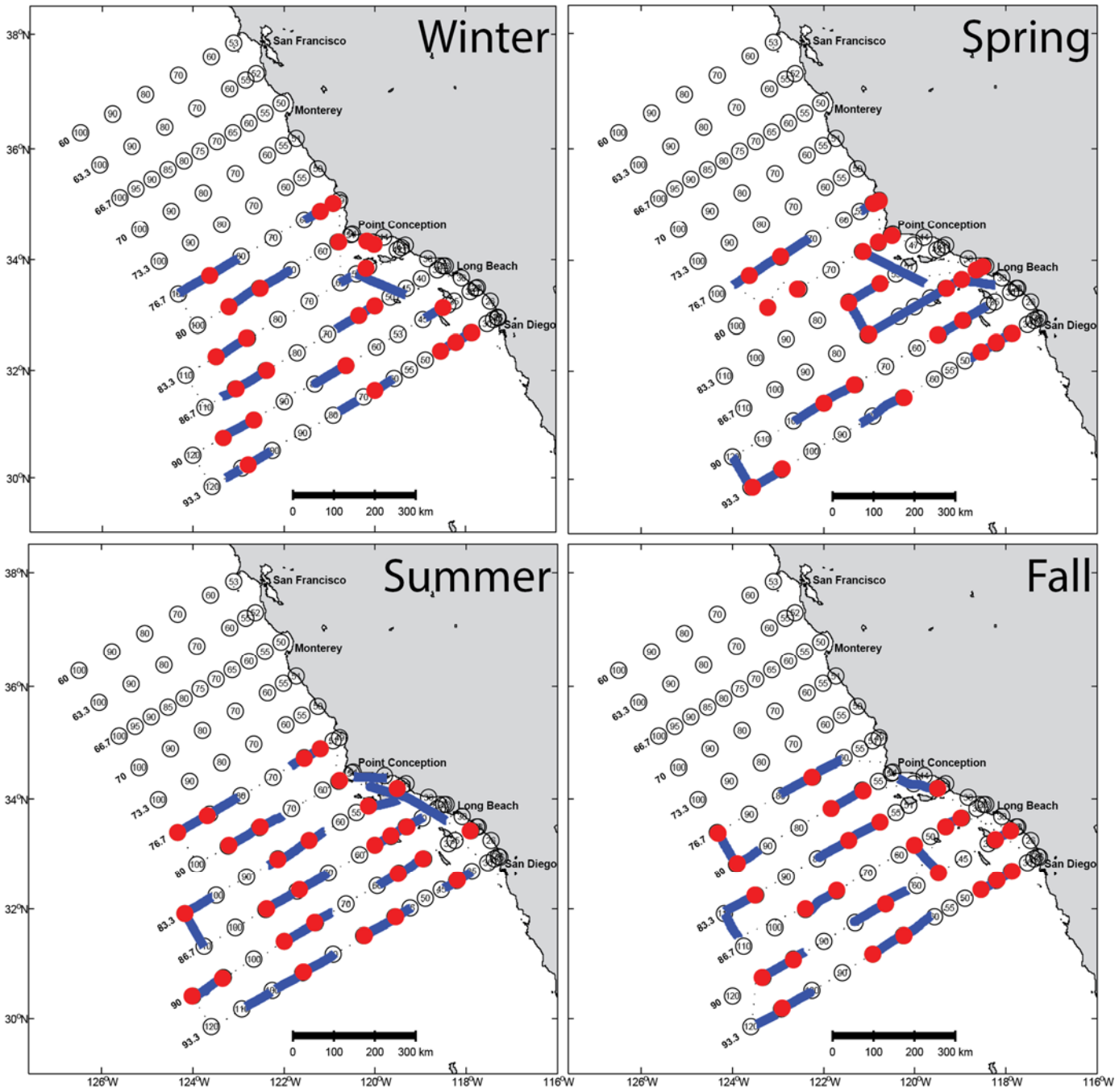

Figure 14. Acoustic effort during 2012 CalCOFI cruises.
Solid blue lines represent towed array deployments and red circles represent sonobuoy deployments. Dotted black line represents ship's track line.

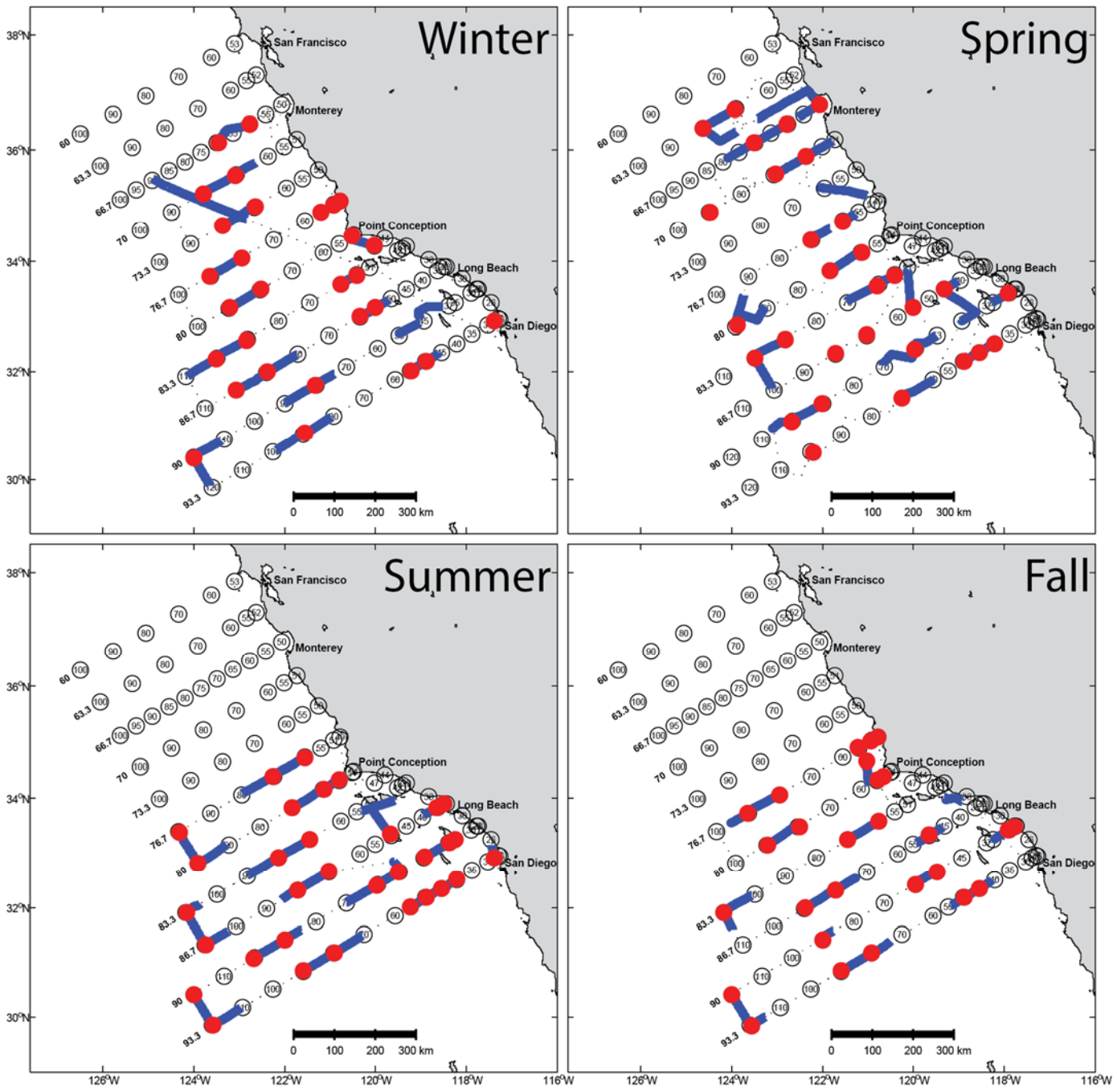

Figure 15. Acoustic effort during 2013 CalCOFI cruises.
Solid blue lines represent towed array deployments and red circles represent sonobuoy deployments. Dotted black line represents ship's track line.

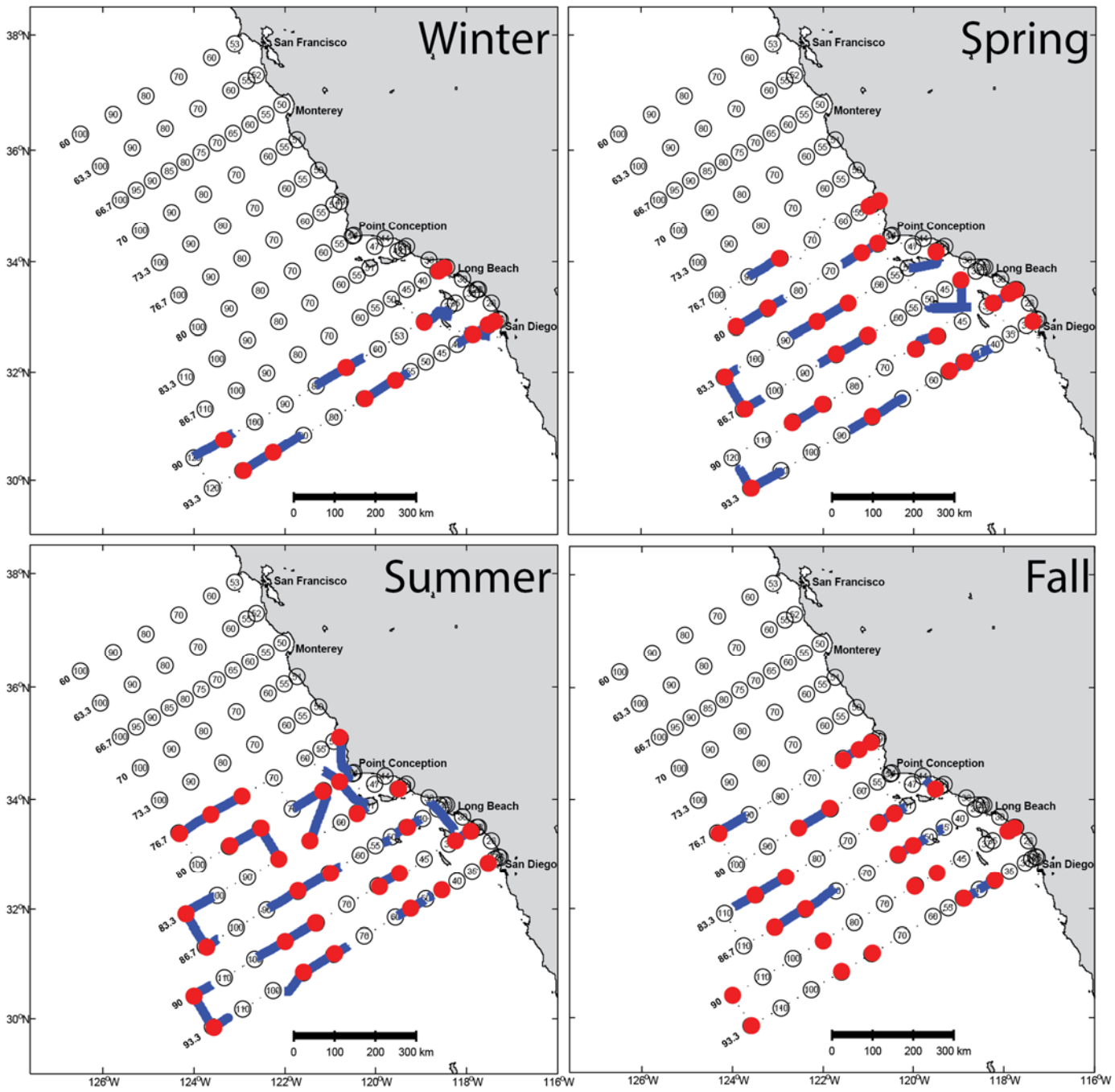

Figure 16. Acoustic effort during 2014 CalCOFI cruises.
Solid blue lines represent towed array deployments and red circles represent sonobuoy deployments. Dotted black line represents ship's track line.

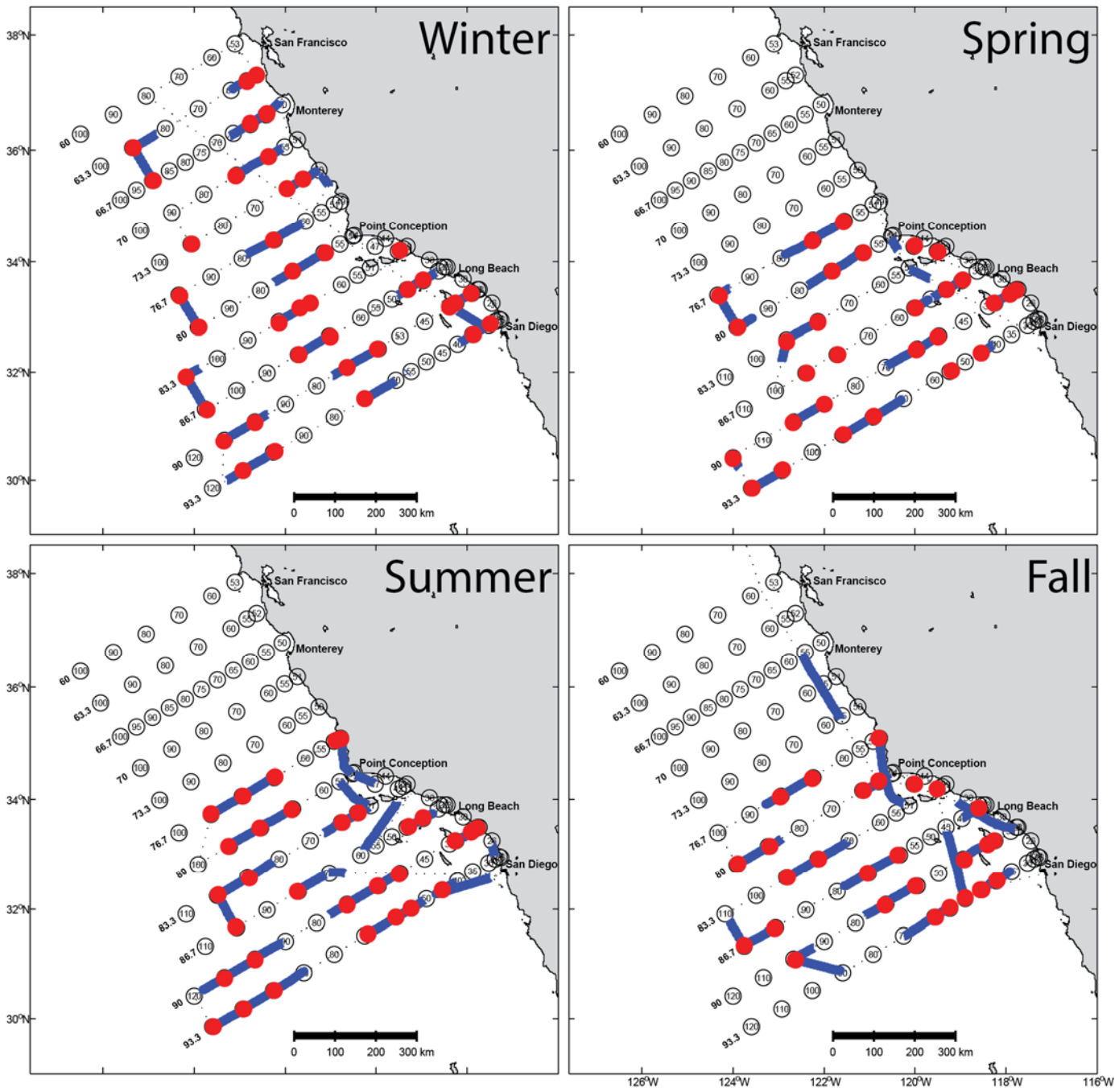

Figure 17. Acoustic effort during 2015 CalCOFI cruises.
Solid blue lines represent towed array deployments and red circles represent sonobuoy deployments. Dotted black line represents ship's track line.

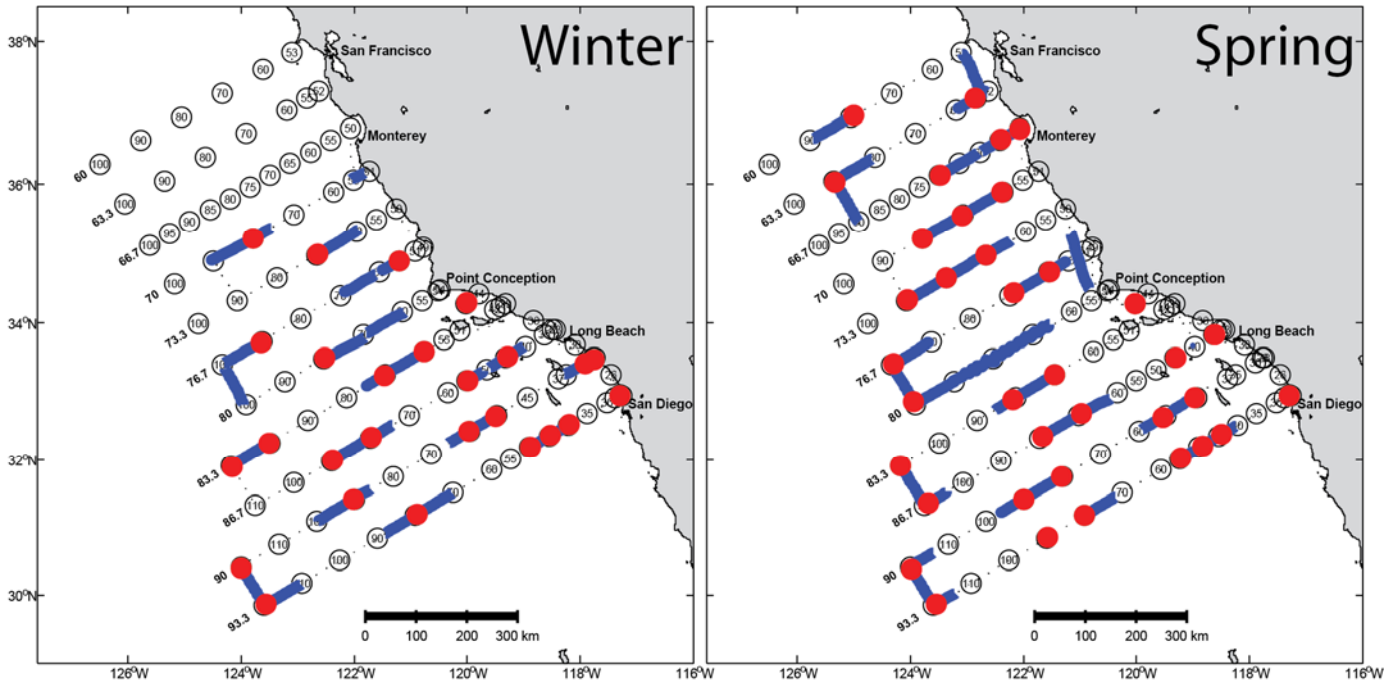

Figure 18. Acoustic effort during winter and spring 2016 CalCOFI cruises.
Solid blue lines represent towed array deployments and red circles represent sonobuoy deployments. Dotted black line represents ship's track line.

Conclusions

The results of our visual detections indicate spatial and temporal variability in the distribution patterns of cetaceans in the waters of the Southern California Bight, suggesting that different species have distinct habitat preferences. These data were used by Becker *et* al. (In review) to create habitat-based density models created for three species: (short-beaked common dolphin, Dall's porpoise, and humpback whale). This study showed that the cool seasons reveal distribution patterns that are markedly different from the warm seasons, thus providing insights into species ecology and quantitative data for the seasonal assessment of potential anthropogenic impacts. The CalCOFI surveys provide the data needed for these and future analyses for environmental assessments and ultimately management and policy.

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APPENDIX A- SUPPLEMENTAL GRAPHICS

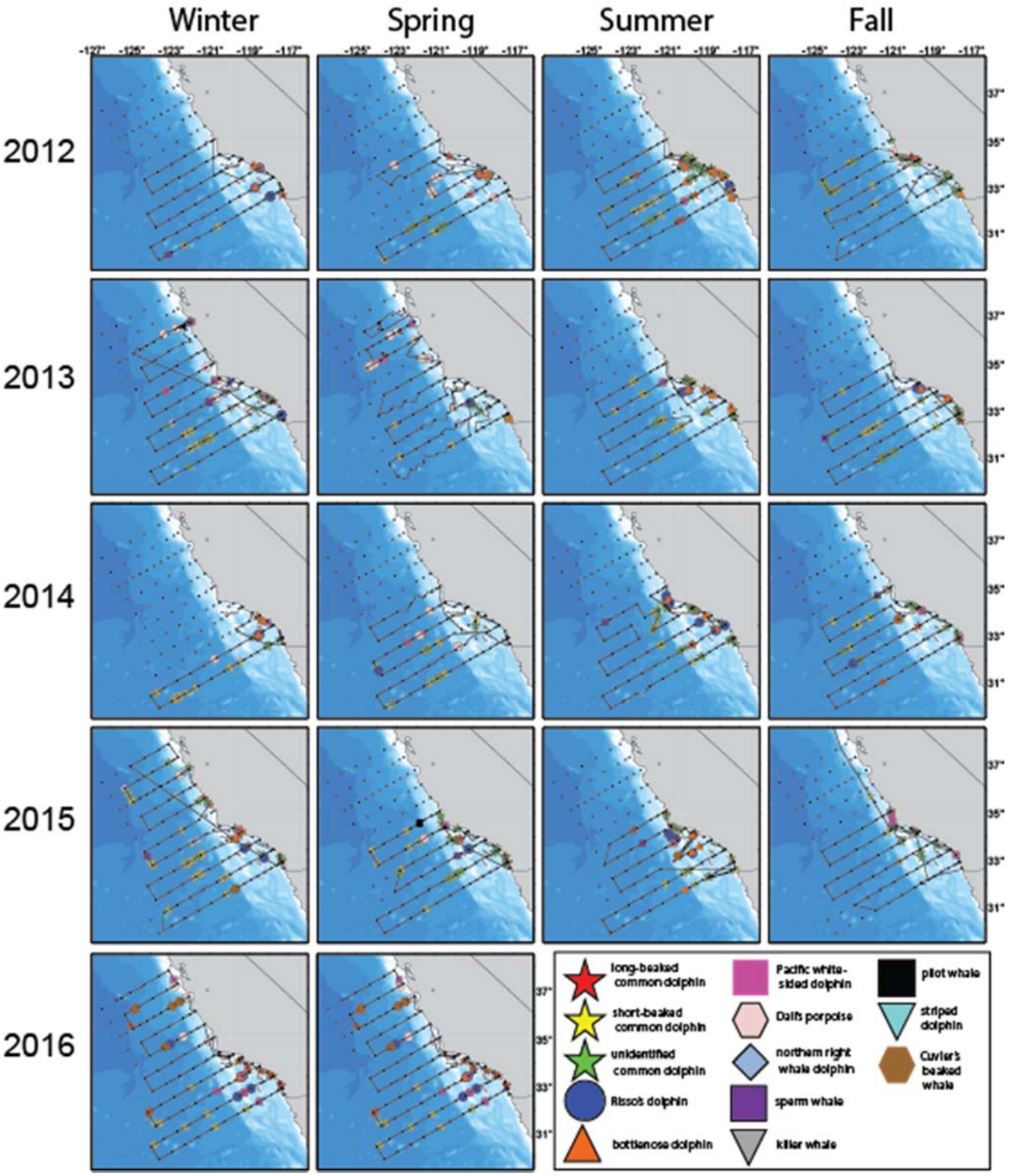

Figure A- 1. On-effort baleen whale sightings during CalCOFI cruises 2012-2016.
CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

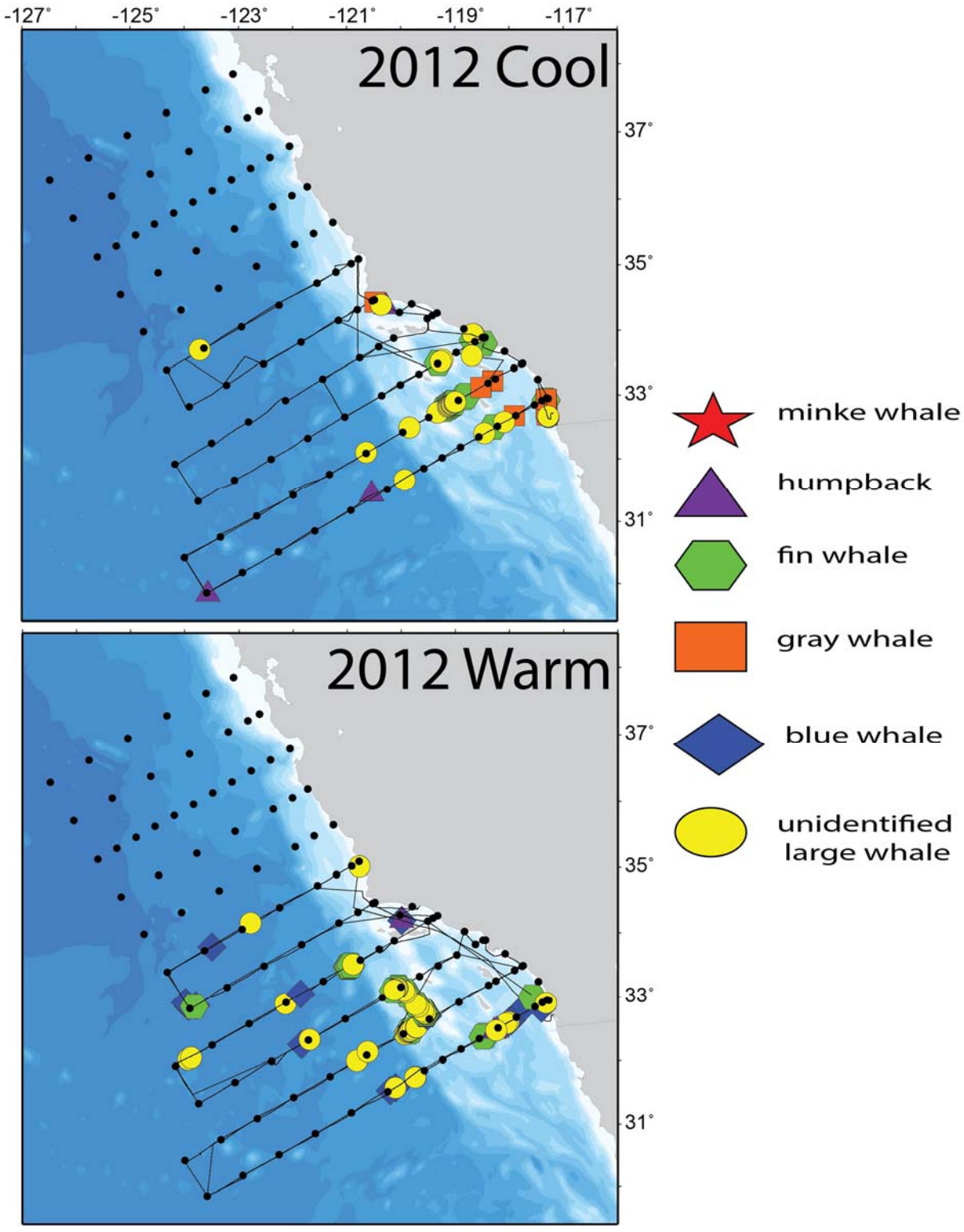

Figure A- 2. On-effort baleen whale sightings during 2012 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

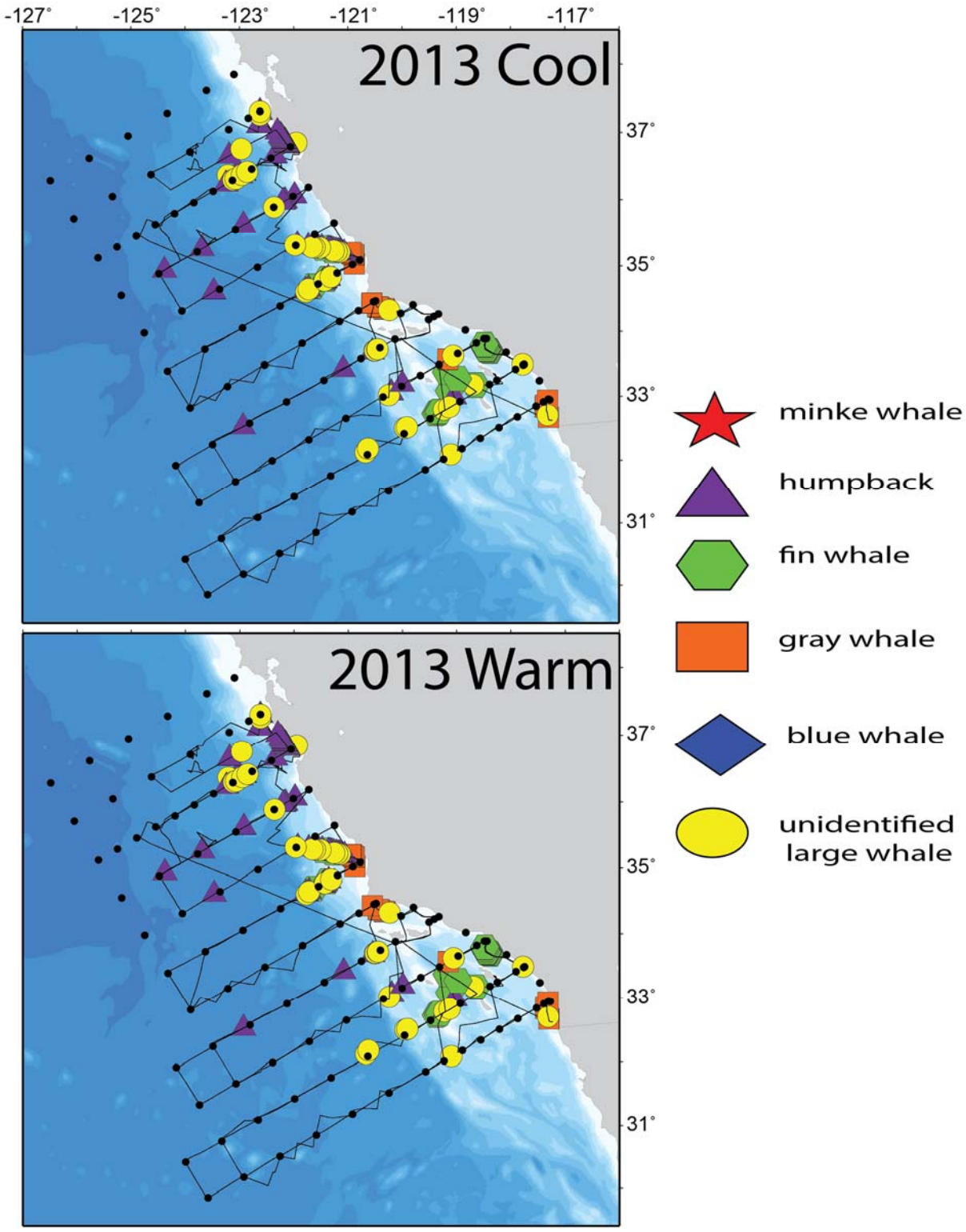

Figure A- 3. On-effort baleen whale sightings during 2013 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

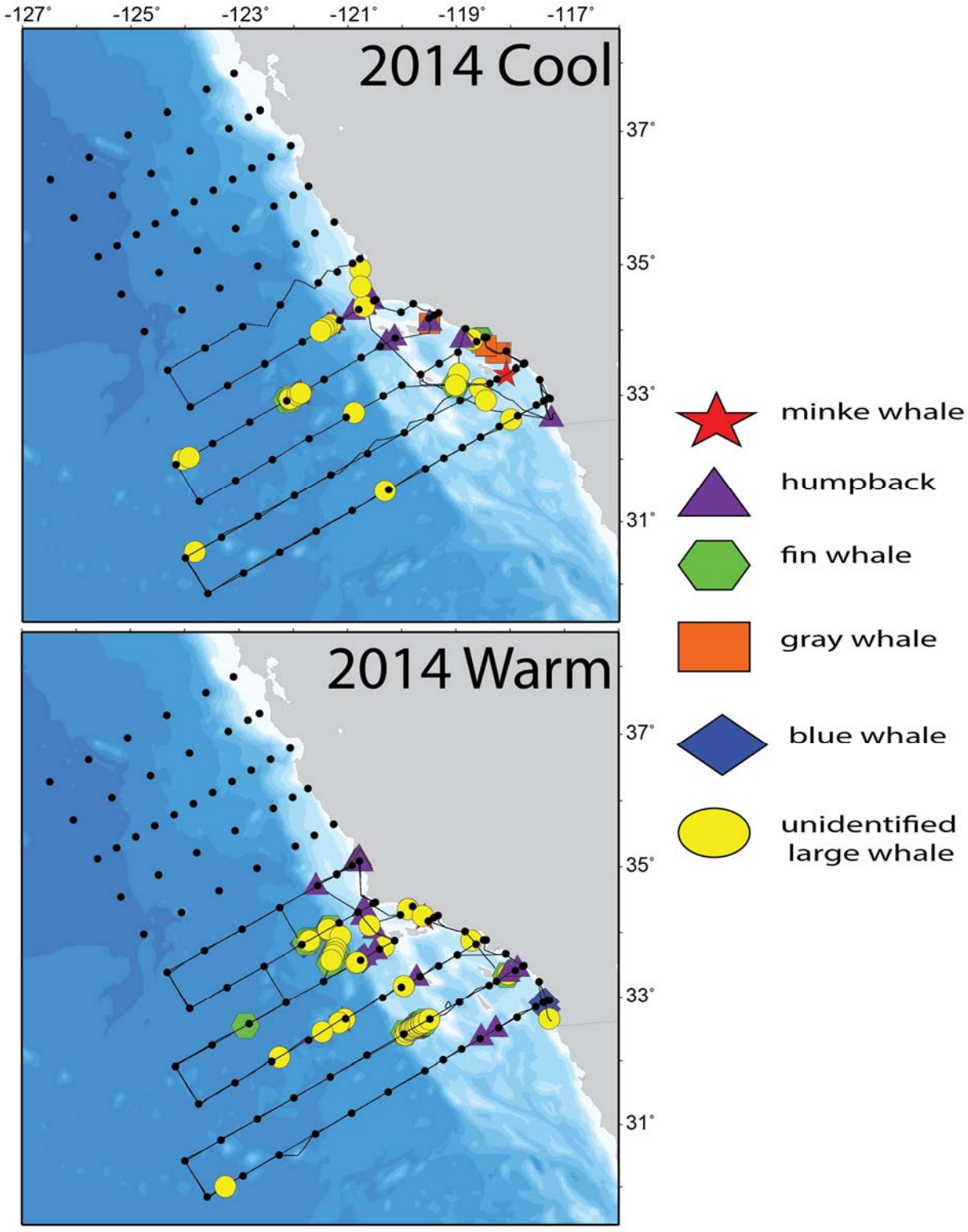

Figure A- 4. On-effort baleen whale sightings during 2014 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

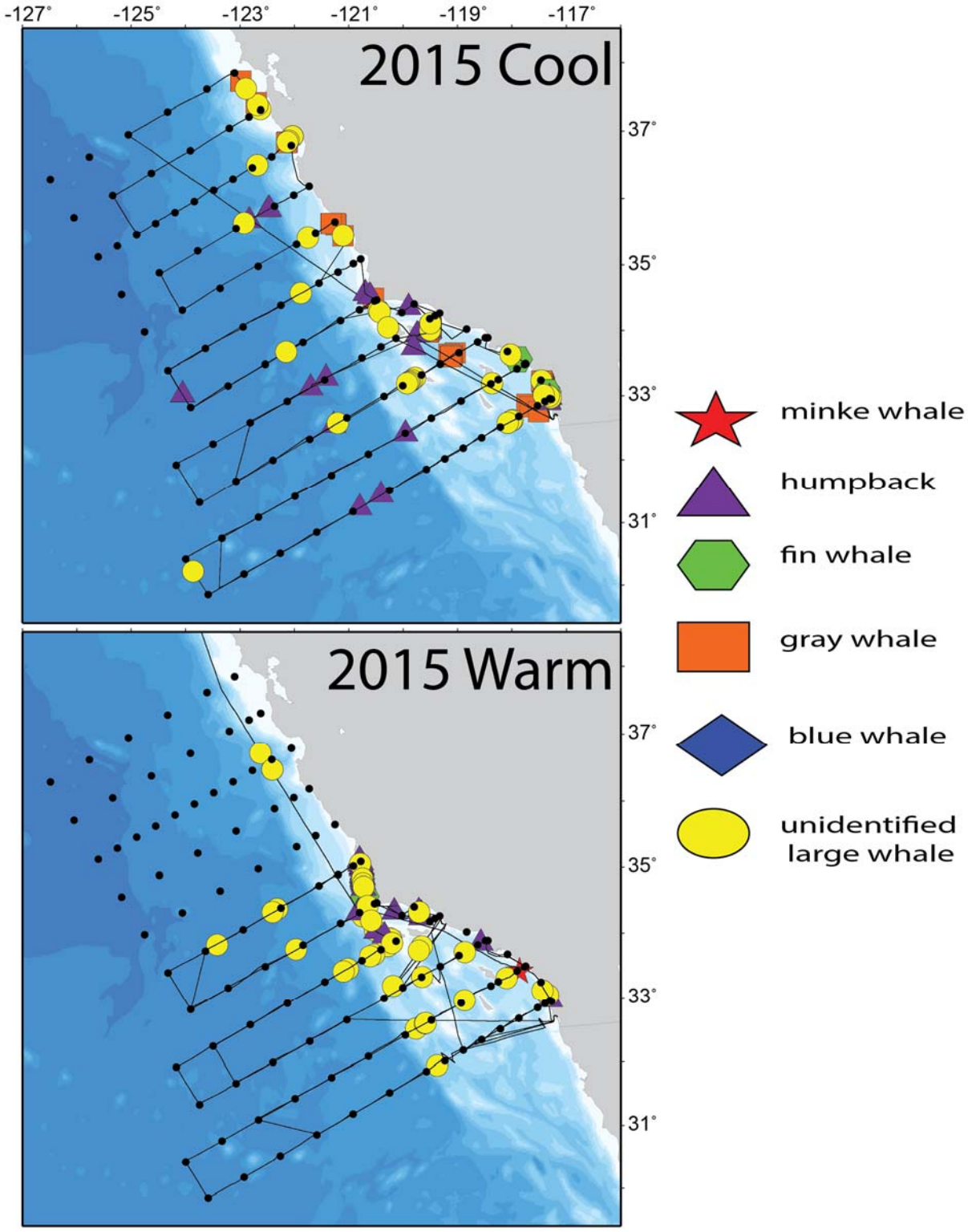

Figure A- 5. On-effort baleen whale sightings during 2015 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

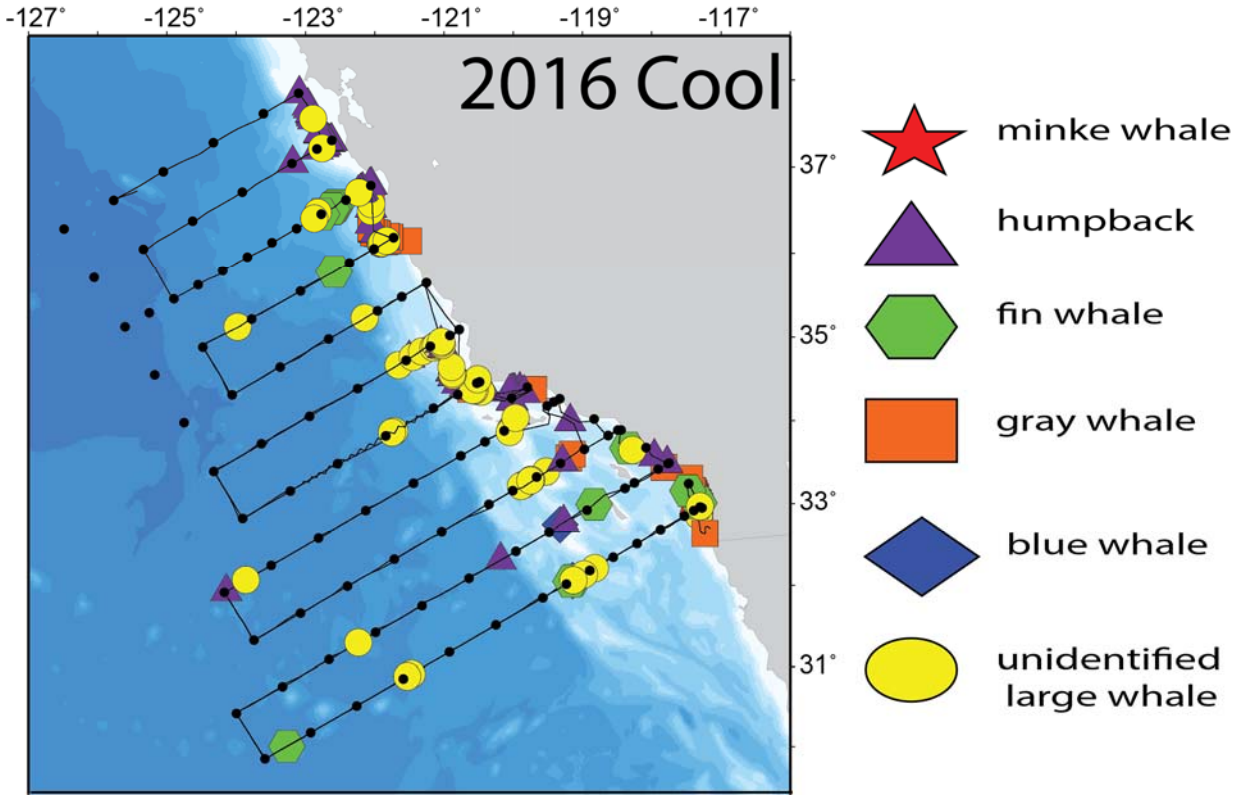

Figure A- 6. On-effort baleen whale sightings during 2016 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

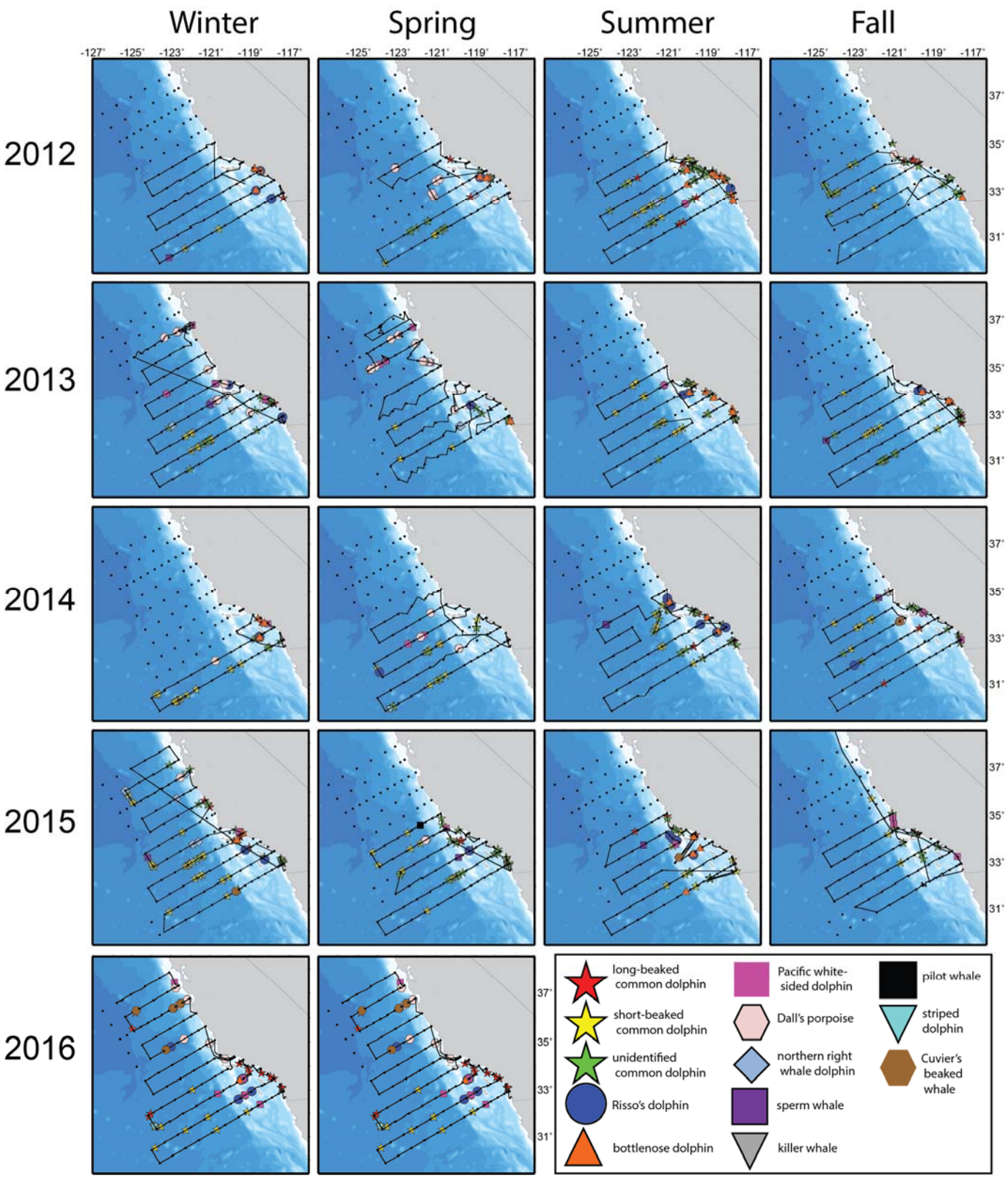

Figure A- 7. On-effort odontocete sightings during CalCOFI cruises 2012-2016. CalCOFI stations are represented by black dots and the ship's track line is represented as a solid black line between stations.

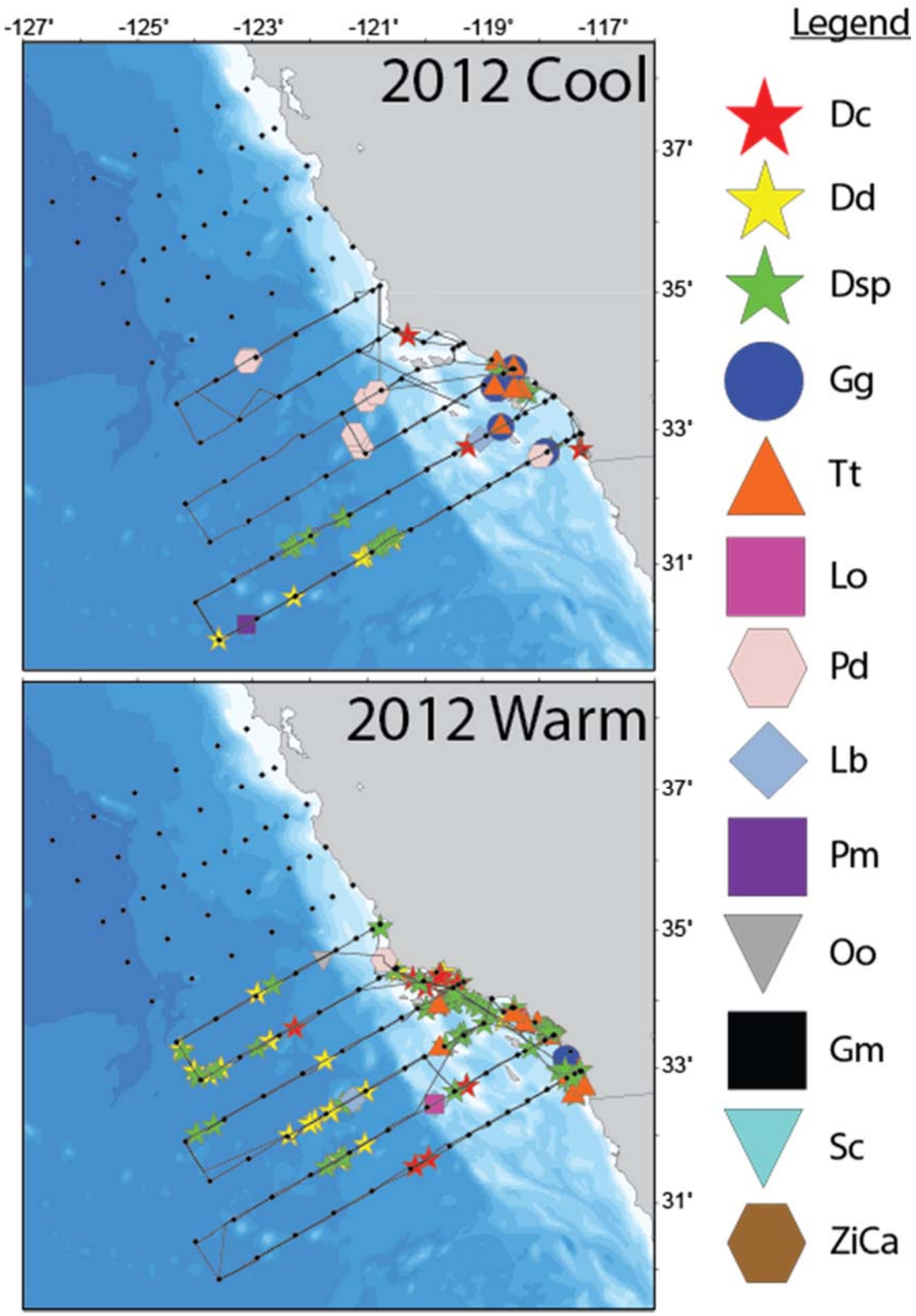

Figure A- 8. On-effort odontocete sightings during 2012 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

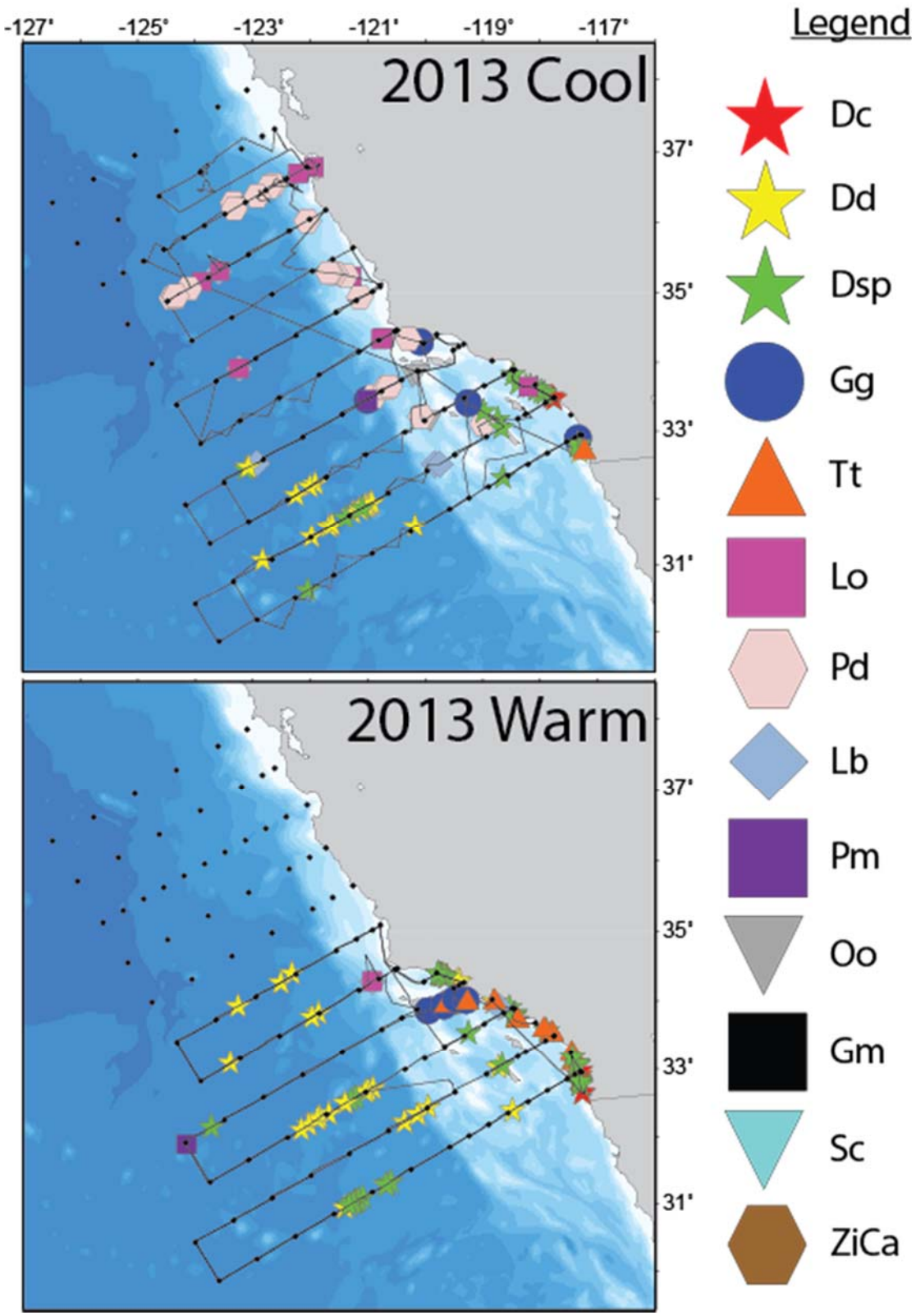

Figure A- 9. On-effort odontocete sightings during 2013 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

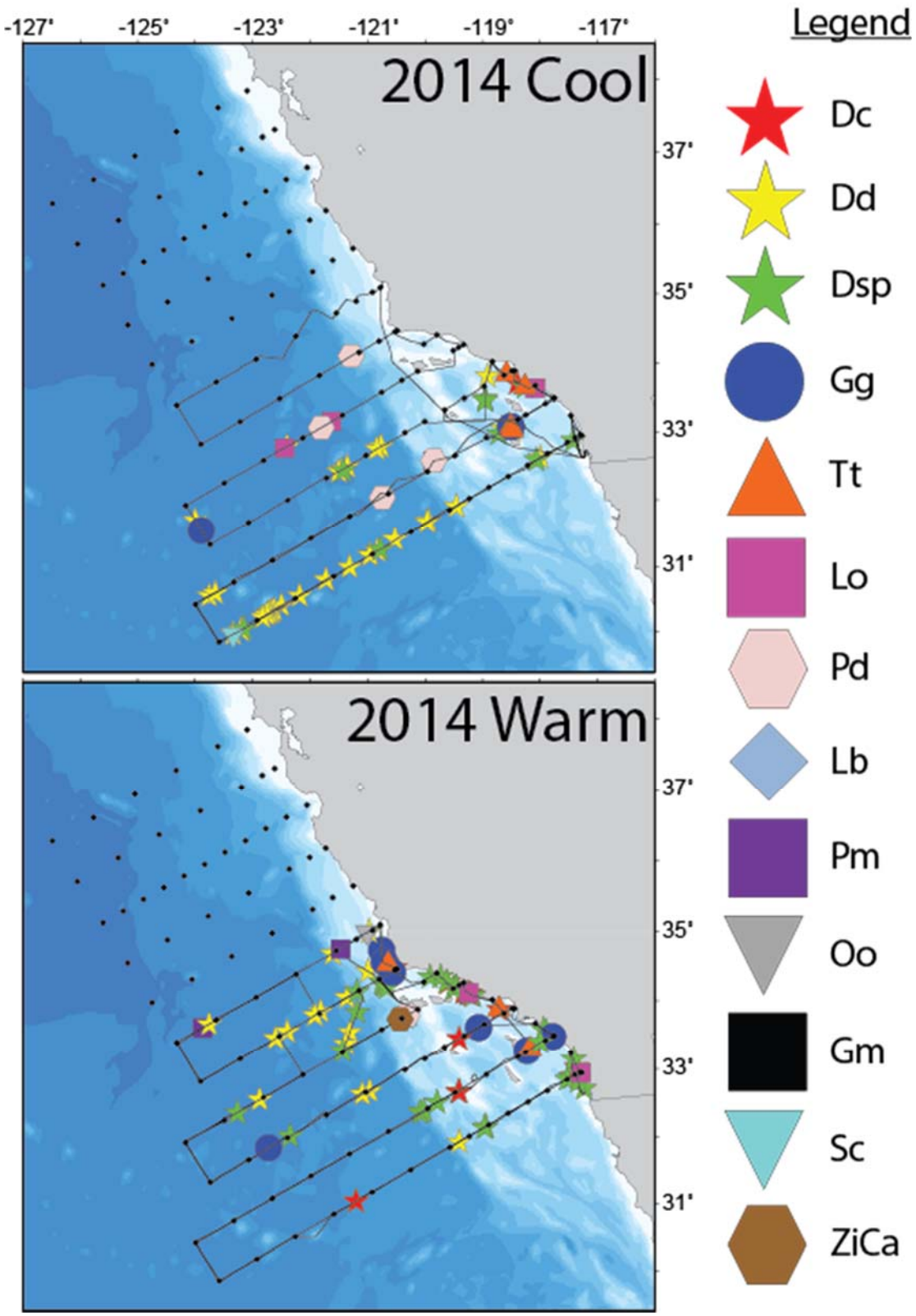

Figure A- 10. On-effort odontocete sightings during 2014 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

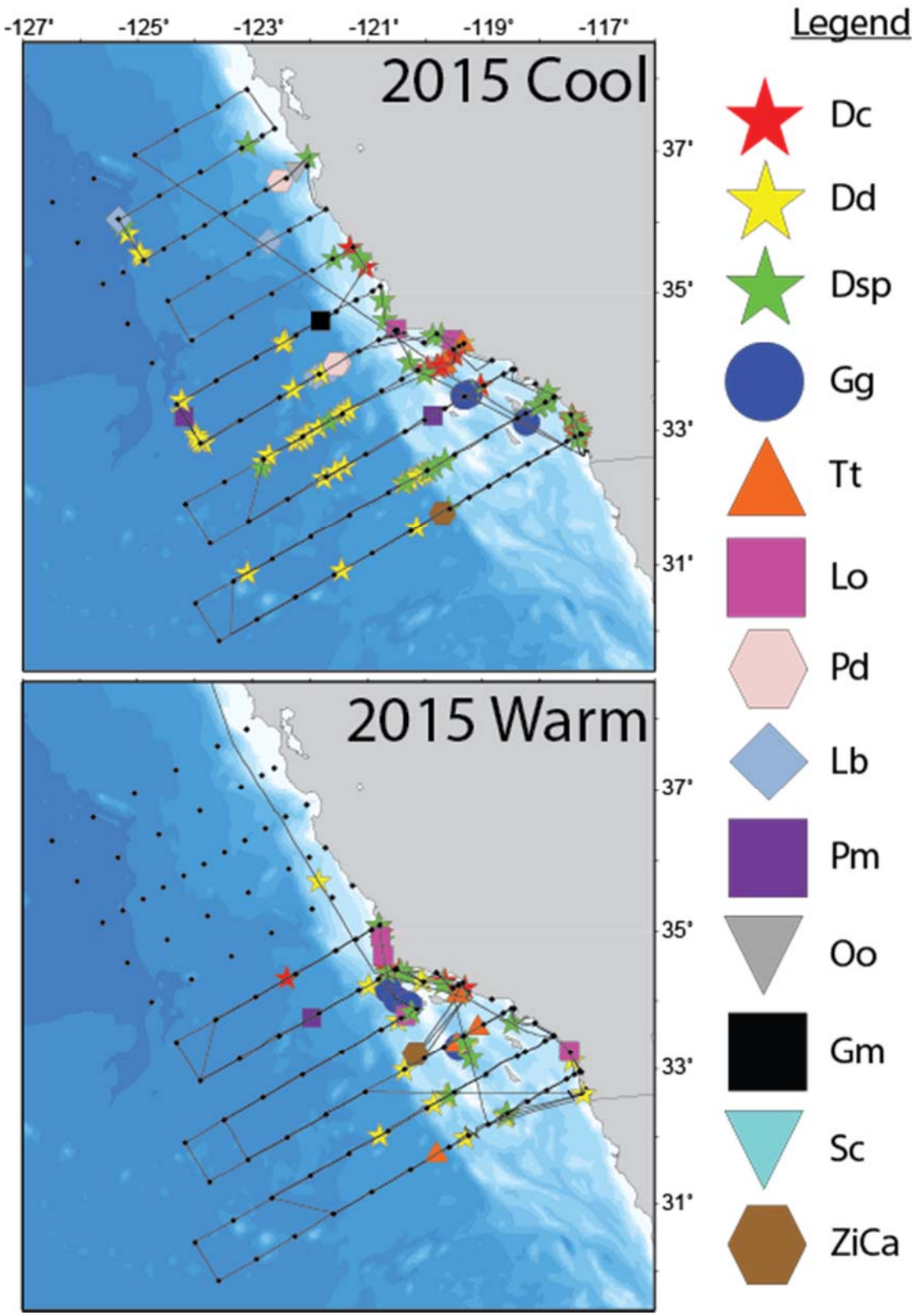

Figure A- 11. On-effort odontocete sightings during 2015 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.

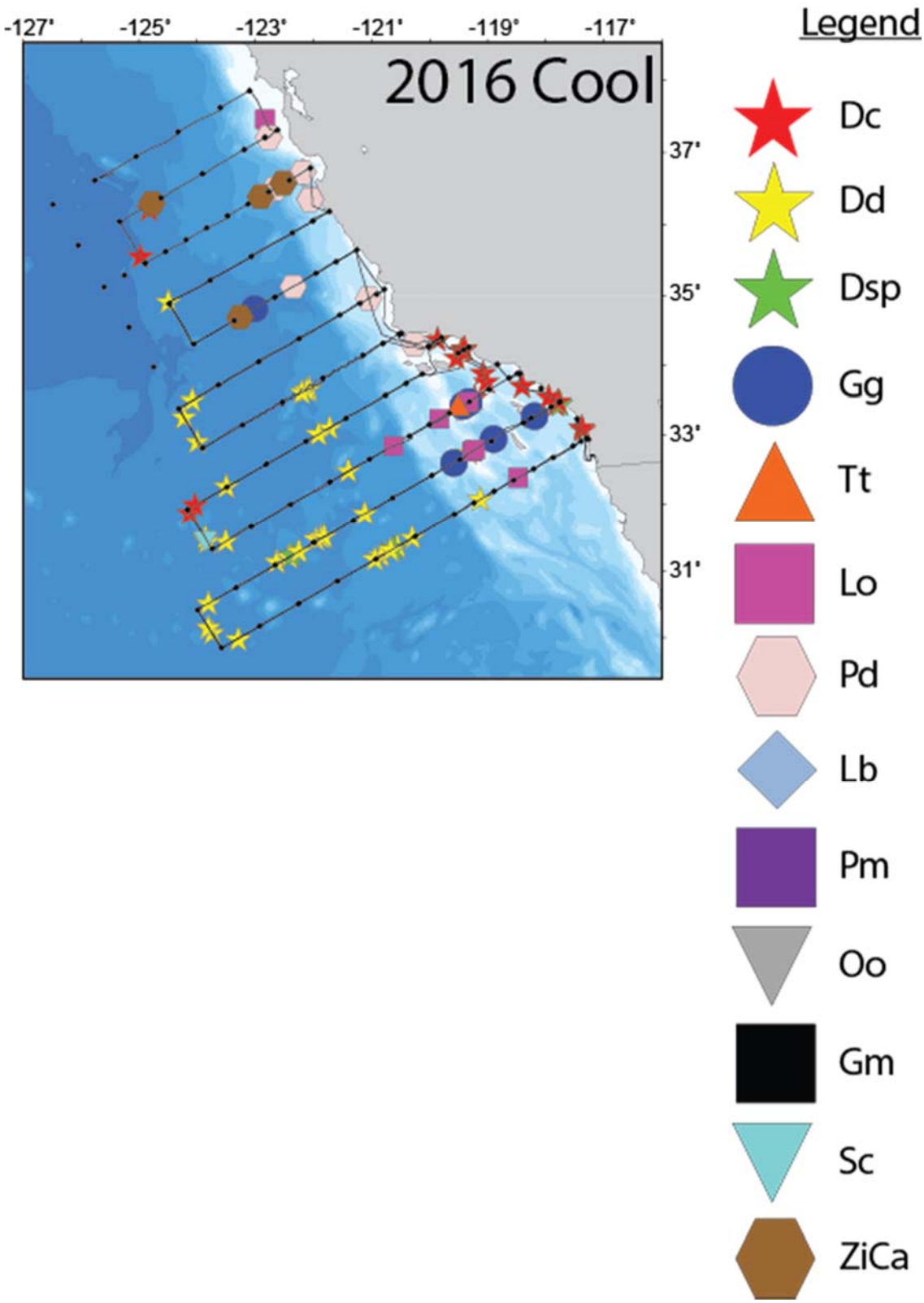

Figure A- 12. On-effort odontocete sightings during 2016 CalCOFI cruises.
Cool season represented by combined plots of winter and spring cruises. Warm season represented by combined plots of summer and fall cruises.