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Cetacean Ecology for Santa Monica Bay and Nearby Areas, California, in the Context of the Newly Established MPAs

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Abstract.—Cetacean occurrence, distribution and behavior were investigated in Santa Monica Bay and nearby areas, California (1997–2007). A total of 425 boat-based surveys documented three species inhabiting the study area year-round - the common bottlenose dolphin, *Tursiops truncatus*, the long-beaked common dolphin, *Delphinus capensis*, and the short-beaked common dolphin, *D. delphis*, and ten species occurring occasionally. Coastal bottlenose dolphins were mostly found traveling, diving and feeding in waters within 0.5km of shore in 81.4% of the sightings ($n = 221$), but were also observed occasionally in offshore waters. All other species were seen > 0.5 km of shore, often feeding near escarpments and submarine canyons. Endangered species, such as blue whales (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*), were also recorded in the study area. This paper provides new information as well as an update on data of the composition for the local cetacean community, and offers information that should be considered in the decision-making process associated with the newly established MPAs, and their use. The presence of a diverse cetacean fauna moving in and out the boundaries of these MPAs, also suggests the need for long-term and regular cetacean monitoring in the area.

Introduction

The waters of the Southern California Bight (SCB) support one of the largest and most diverse cetofauna in the world, including 30 cetacean species (Bonnell and Dailey, 1993; Forney et al., 1995; Forney et al., 1999; Schmitt and Bonnell, 2003; Carretta et al., 2006; Soldevilla et al., 2006). Long-term and detailed ecological studies for the SCB have been concentrated mostly on coastal common bottlenose dolphin (hereafter bottlenose dolphin), *Tursiops truncatus* (Defran and Weller, 1999; Defran et al., 1999; Lang, 2002; Bearzi, 2005a,b), whereas only general information is available for other offshore species (Forney et al., 1999; Appler et al., 2004; Barlow and Forney, 2007; Bearzi et al., 2009a).

Within the SCB, Santa Monica Bay and its nearby areas (Fig. 1a) represent a region with unique topographic and oceanographic features (Bonnell and Dailey, 1993), likely to affect the species inhabiting it. A better understanding of the ecology of the local cetacean community is essential to protect these animals, the species they feed upon, and the entire habitats in which they live (Yen et al., 2004; Fury and Harrison, 2008), as well as for making sound conservation and management decisions for Marine Protected Areas (MPAs; Hastie et al., 2003; Wilson et al., 2004).

This study, conducted between 1997–2007 (except for 2003–2004), aims to provide data on occurrence, frequency, distribution and behavior of cetacean species for Santa Monica

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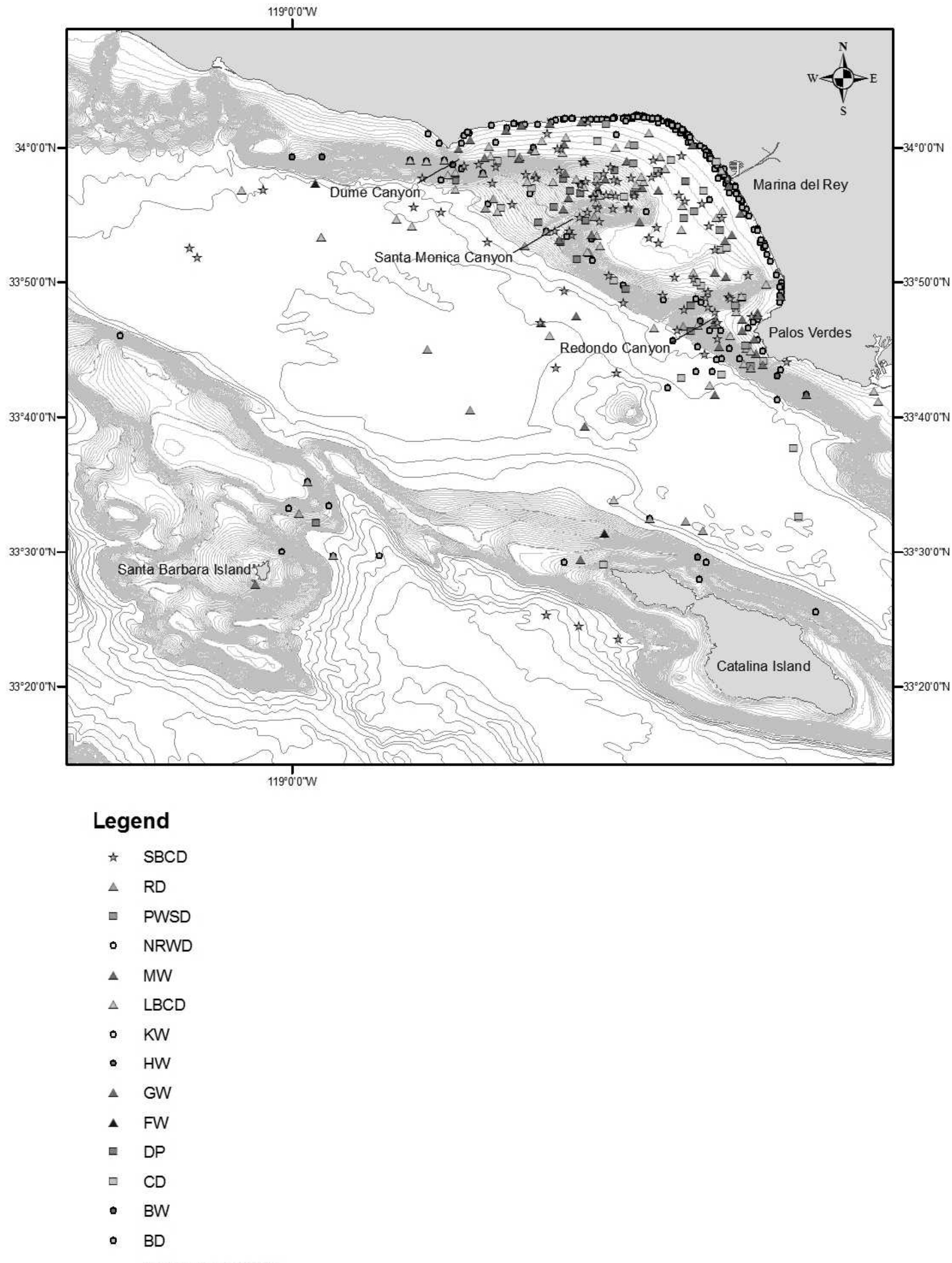


Fig. 1a. The study area and the distribution of cetacean species. Each symbol represents initial GPS coordinates of sightings.

Bay and adjacent areas. Further, considering that: a) several MPAs have recently been approved by the California Fish and Game Commission in the study area (http://www.dfg.ca.gov/mlpa/southcoast.asp), and b) the Monitoring Enterprise is now developing a South Coast MPA Monitoring Plan and it's leading toward the implementation of the

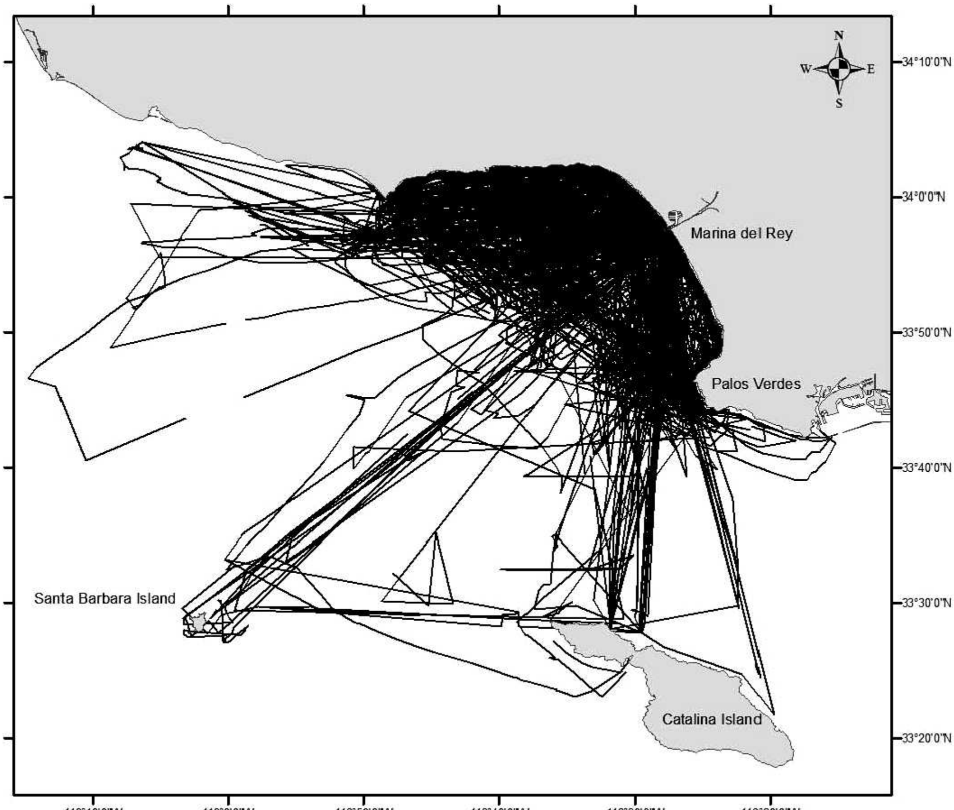


Fig. 1b. The total survey effort in the study area for the years 1997-2007.

South Coast MPA Baseline Program (http://monitoringenterprise.org/where/southcoast.php), the goal of this paper is also to offer information helping to ensure that cetaceans will be properly represented in any decision-making process regarding MPAs. Cetaceans are umbrella species (Mann et al., 2000; Prideaux, 2005) because conservation actions intended at mitigating threats to them can result in protection for entire communities of organisms, as well as the ecosystem itself. Since many cetaceans are now considered key species in conservation planning worldwide, as widely discussed at the last International Committee on Marine Mammal Protected Areas (http://icmmpa.org/) , this work hopes to emphasize to need to include these animals for conservation strategies toward the local MPAs.

Methods

Study Area

The Santa Monica Bay study area (approximately 460 km^2) is a shallow shelf, bounded by the Palos Verdes Peninsula to the south (33°45′N 118°24′W), Point Dume to the north (33°59′N 118°48′W) and the edge of the continental shelf to the west. The bay contains two shallow water submarine canyons (Dume and Redondo) and one deeper canyon, the Santa Monica Canyon. This begins at a depth of about 100 m, at the edge of the escarpment. The bay has a mean depth of about 55m and a maximum depth 450 m. A

Table 1. Number of surveys and summary of research effort in Santa Monica Bay for the years 1997–2007. No surveys were conducted on December 1999, October 2000, July 2001, September 2001, July 2005, December 2005, May 2006, and February–April 2007.

	1997	1998	1999	2000	2001	2002	2005	2006	2007	Total
Surveys*										
Inshore surveys	16	55	39	33	27	9	3	14	8	204
Offshore surveys	34	41	32	31	26	12	7	28	10	221
Total number of surveys	50	96	71	64	53	21	10	42	18	425
Research effort										
Hours spent in the field	144	224	178	149	137	73	68	194	56	1,223
Hours spent searching for cetac.	110	136	130	105	82	44	48	134	34	823
Hours spent with cetaceans	34	88	48	44	55	29	20	60	22	400
N of 5-min behavioral samples	295	1,065	698	525	675	396	265	638	234	4,791

* Inshore and offshore surveys conducted during the same day were considered as two separate surveys.

shallow shelf between the Santa Monica and Redondo Canyons extends as a plateau from the 50m contour. The study area also extended outside Santa Monica Bay, both along the coast (<500m from shore) to the south (33°43′N 118°15′W), and to the north (34°5′N 119°6′W), and in offshore waters around Catalina (33°23′N 118°41′W) and Santa Barbara Islands (33°27′N 119°3′W). The study area is shown in Figure 1a and a map of the recently established Marine Protected Areas is available at http://www.dfg.ca.gov/mlpa/pdfs/scmpas121510.pdf. The following protected locations are included in the study area: Point Dume State Marine Reserve, Point Dume State Marine Conservation Area, Point Vicente State Marine Conservation Area No-Take, Abalone Cove State Marine Conservation Area, Cat Harbor State Marine Conservation Area, Santa Barbara Island State Marine Reserve, Bird Rock State Marine Conservation Area, Blue Cavern State Marine Conservation Area No-Take, Long Point State Marine Reserve, Arrow Point to Lion Head Point State Marine Conservation Area.

Mild temperatures, short rainy winters and long, dry summers characterized the study area. Normal water surface temperatures range from 11 to 22°C. During the 1997–98 El Niño three peaks of sea surface temperature (SST) anomalies were evident: May–June 1997, September–October 1997 and August 1998, with an increase in temperature of + 2°C above the norm (Nezlin et al., 2003).

Data Collection and Analyses

Surveys were conducted from February 1997 to June 2002, and from June 2005 to July 2007 with an average of 5.2 days on the water per month ($n = 425$, Table 1). We followed routes, planned for even coverage of the entire bay throughout the study period (Fig. 1b). Inshore (distance from shore up to 1km) and offshore (distance from shore > 1km) routes were usually carried out with Beaufort scale 2 or less, sea state 0 and visibility >300m. Surveys were conducted from 7 m (1997–2000) and 10 m powerboats (2001–2002, 2006–2007), and a 17 m sailboat (2005–2006), at an average speed of 18 km h^{-1}. The dolphins' positions and speeds (± 30 m from the boat) were approximated to the boat's position using a GPS.

When cetaceans were spotted, data on the number of animals, size classes and behavior (for definitions see Bearzi, 2005a) and aggregation with other species were recorded on laptop computers at five-minute intervals and throughout the sighting. Boat speed was reduced in the presence of dolphins and sudden speed or directional changes were avoided. Behavioral data collected *ad libitum* from July to December 1996 (58 hours of field observations) provided a framework of information to design the behavioral sampling procedures systematically adopted from January 1997 (Bearzi, 2003).

Definitions of *aggregation, close aggregation, mixed group, dolphin school*, *focal group, behavioral state* and *mating* follow Bearzi (2005a); other cetacean groups spotted at distance and not belonging to the observed focal group were recorded, but excluded from group size calculations.

During the sightings, color photographs were taken with 35mm Canon EOS1N and A2 cameras equipped with 75–300mm lenses, and digital Canon 5D equipped with 400mm lens to photo-identify bottlenose dolphins. During the sighting, researchers also videotaped the animals' behavior with Canon Hi8mm or Canon GL1 Digital Video Camcorders. Videos and photos were reviewed in laboratory to validate field observations.

Data analyses were performed using Statview 5.01, Statistica 6.0 and Excel 2008; data on species distribution were plotted with Arcview GIS 9.2. For sighting frequency analysis, different sightings of the same individuals observed during the same day were considered only once.

Fieldwork was carried out under the current laws of California and the General Authorization for Scientific Research issued by the National Oceanic and Atmospheric Administration (files #856-1366 and #8561835).

Results

Field Effort

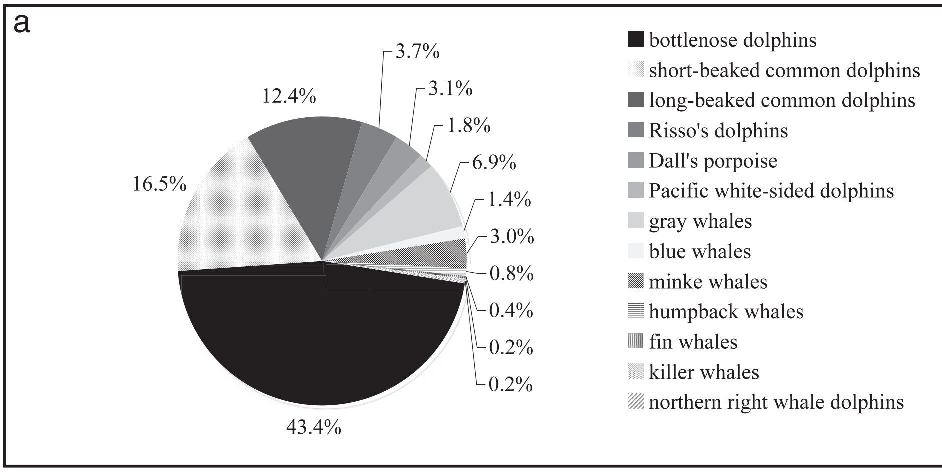
The majority of observations (94.1%, $n = 425$) were conducted in good conditions (Beaufort scale ≤ 2, sea state 0 and visibility > 300m) during 204 inshore and 221 offshore surveys. A total of 823 h were spent searching for cetaceans in good weather conditions; 400h were spent observing 509 cetacean groups encountered during sightings lasting on average 50 min (range 1-263 minutes; Table 1).

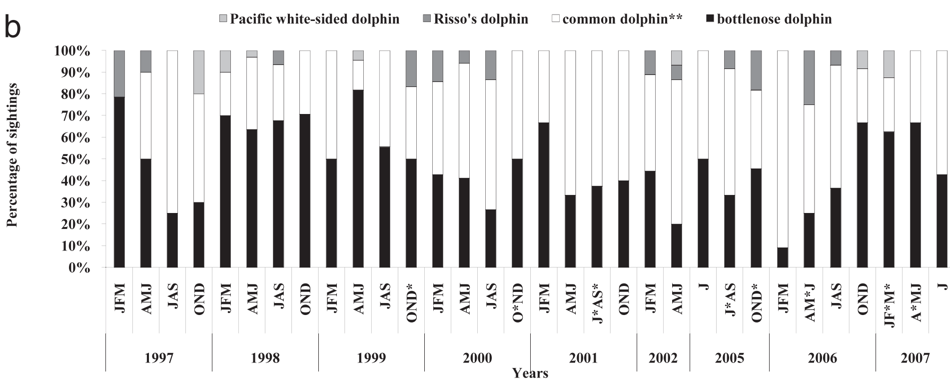
Occurrence, Frequency and Distribution

Percentage of sightings for all cetacean species and for the four most frequently observed species in the study area are presented in Figures 2a,b. Bottlenose dolphin was the species most frequently sighted (43.4%, *n schools* = 221), followed by short-beaked common dolphin (*Delphinus delphis*; 16.5%, n=84), and long-beaked common dolphin (*Delphinus capensis*; 12.4%, n=63; Table 2). Risso's dolphin (*Grampus griseus*), Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), gray whales (*Eschrichtius robustus*), blue whales (*Balaenoptera musculus*), minke (*Balaenoptera acutorostrata*), humpback (*Megaptera novaeangliae*) whales, fin whales (*Balaenoptera physalus*), northern right whale dolphins (*Lissodelphis borealis*) and killer whales (*Orcinus orca*) were sighted occasionally or during their migrations.

Although cetaceans were observed during the entire study period, a significant difference among the nine years of study was observed in the overall sighting numbers t = 6.20, df = 8, $P < 0.001$; Fig. 3).

Mixed groups were occasionally recorded in the bay (5.3% of total cetacean sightings, $n = 27$). The cetaceans found more often in inter-specific groups were offshore bottlenose dolphins associated with short-beaked and long-beaked common dolphins (44.4% of total mixed sightings, $n = 12$), followed by mixed groups of bottlenose dolphins and





* No data collection

** This calculation includes *Delphinus spp.* not recognized at the species level.

Fig. 2a, b. (a) Percentage of sightings for cetacean species observed in the study area, and (b) percentage of sightings for the four most frequently observed species recorded during 3-month periods in Santa Monica Bay for the years 1997–2007. No surveys were conducted December 1999, October 2000, July 2001, September 2001, July 2005, December 2005, May 2006, and February-April 2007.

Table 2. Sighting frequencies (sightings/hour) of the three most observed cetacean species in the bay.

	1997	1998	1999	2000	2001	2002	2005	2006	2007	Total
Tursiops truncatus										
Number of sightings	19	61	33	24	20	7	10	29	18	221
Sighting frequency (sights/hour)	0.13	0.27	0.19	0.16	0.14	0.10	0.15	0.15	0.32	0.18
*Delphinus delphis**										
Number of sightings	6	7	6	6	15	9	8	19	8	84
Sighting frequency (sights/hour)	0.04	0.03	0.03	0.04	0.01	0.12	0.12	0.10	0.14	0.07
*Delphinus capensis**										
Number of sightings	2	12	10	9	4	4	3	16	3	63
Sighting frequency (sights/hour)	0.01	0.05	0.06	0.06	0.03	0.05	0.04	0.08	0.05	0.05

* *This calculation does not include* Delphinus spp. *not recognized at the species level.*

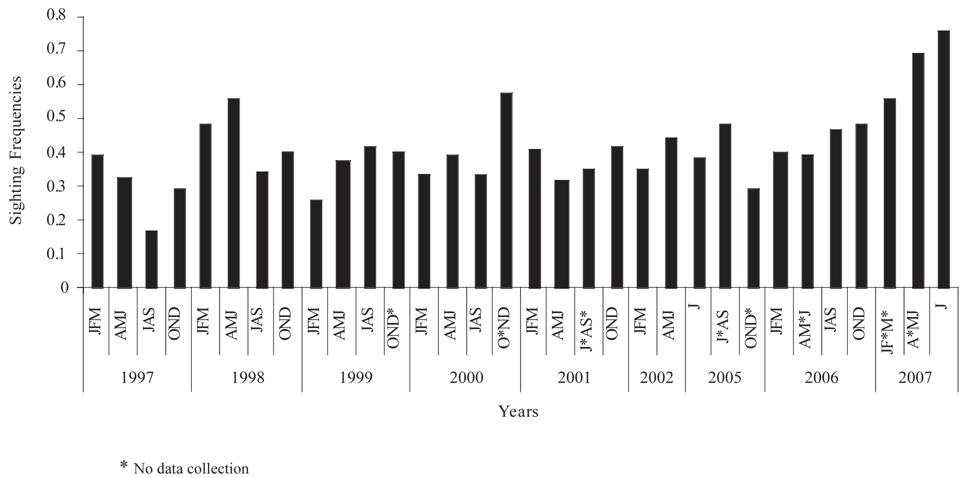


Fig. 3. Cumulative cetacean sighting frequencies (sightings/hour) recorded during 3-month periods in Santa Monica Bay.

Risso's dolphins (29.6% of total mixed sightings, n = 8) and bottlenose dolphins and gray whales (7.4% of total mixed sightings, n = 2).

Bottlenose dolphins were observed mostly in inshore waters (81.4%, n = 180), but offshore schools were also recorded (18.6%, n = 41) outside the bay and out to Santa Barbara Island. Short-beaked and long-beaked common dolphins were observed mostly in offshore waters (98.3%), usually above escarpments and submarine canyons (62.7%, n = 111). Bottlenose dolphins and the two common dolphin species were often recorded within and outside the boundaries of the four coastal designed MPAs (Point Dume SMR and SMCA, Point Vicente SMCA, and Abalone Cove SMCA); bottlenose dolphins were also found within Bird Rock and Blue Cavern SMCAs near Catalina Island (Fig. 1a).

Gray whales were often recorded in inshore waters (31.4% of gray whale sightings, n = 11), but also near Santa Monica Canyon (12.1%, n = 33) and the escarpment near Point Vicente (30.3%, n = 33). Gray whales were observed within the boundaries of three designed MPAs: Point Dume SMR, Point Vicente and Abalone Cove SMCAs (n = 5).

All other cetaceans were seen exclusively in offshore waters (Fig. 1a). Risso's dolphin sightings occurred either in the bay, near the escarpment or the Santa Monica Canyon (47.4%, n = 19), or at more than 15km from shore. Risso's dolphins were also recorded within the Point Vicente SMCA (n = 1). Dall's porpoises also occurred mostly in the bay (93.7%, n = 16) and, with the exclusion of one sighting, always near Santa Monica and Redondo canyons or along the escarpment. They were found inside the Point Dume SMR once. Of a total of nine sightings, Pacific white-sided dolphins were observed exclusively inside the bay with no distinctive preference for any bathymetric feature; they were recorded twice within the Point Vicente and Abalone Cove SMCAs. Northern right whale dolphins and killer whales were both recorded near Dume Canyon and within the boundaries of the Point Dume SMR/SMCA. Minke whales and humpback whales where both recorded in the bay (minke whale: 80.0%, n = 15; humpback whale: 75.0%, n = 4), with a preference for slopes and escarpments. Humpbacks were found in vicinity of the Point Vicente SMCA. Both of the fin whale sightings were seen in offshore waters outside the bay. Of the seven sightings of blue whales, all of them occurred inside the boundaries of the established MPAs and along escarpments near Dume Canyon (n = 3), off Point

Vicente (n = 1), north of Point Dume (n = 2), and within the Bird Rock SMCA near Catalina Island (n = 1).

Behavioral Patterns

The behavioral budget recorded for bottlenose dolphins showed a predominance of *travel* (42.2%; *n* 5-min samples = 2,381) and *travel-dive* (24.5%) activities. *Feeding* at surface was observed in 4.0% of the sightings, also in association with other activities such as *travel* (*travel-feeding*: 5.9%), *dive* (*dive-feeding*: 1.3%), and *socialize* (*feeding-socialize*: 0.9%; Table 3).

The budget for both common dolphin species, which are sympatric in the bay (Bearzi, 2005b), showed a large number of activities also characterized by *travel* (56.5%; *n* 5-min sample = 1,891). *Travel-dive* was recorded only during 4.4% of the sightings. *Feeding* was observed in 9.1% of the sightings, also in association with other activities such as *travel* (*travel-feeding:* 12.3%), and dive (*dive-feeding*: 0.8%; Table 3). Both species of common dolphins were regularly observed separating into smaller groups of about 25–30 individuals to feed near the surface on large schooling fish (M. Bearzi, pers. obs.).

Pacific white-sided dolphins and Risso's dolphins spent most of the time *travel*ing in the study area (respectively: 46.3%; *n* 5-min sample = 108; 62.5%, *n* = 112), but other behavioral states were also observed. Dall's porpoises were mostly *dive-traveling* (36.5%, *n* = 74). Gray whales were regularly observed *traveling* (75.8%; *n* = 128) from Point Dume to Point Vicente and *vice versa* during their winter migration, but some individuals were also seen in the inshore waters (< 0.5 km) of the bay. Minke whales were mostly sighted during *dive-travel* activities (48.0%, *n* = 50; Table 3).

Group Size

Group sizes for the most observed species are illustrated in Table 4. The mean group sizes of coastal and offshore bottlenose dolphin schools varied considerably (mean difference = 7.71, df = 40, t = 3.86, $P < 0.001$), with the largest groups observed offshore. Both species of common dolphins were usually observed in large schools (mean = 108.84, SD = 122.66, SE = 9.52, range = 1–600, *n* = 166), and the largest group sizes were in offshore waters (mean = 115.98, SD = 123.83, SE = 9.95, range = 1–600, *n* = 155). Inshore common dolphins were mostly observed alone in aggregation with bottlenose dolphins. Minke whales and gray whales were usually observed alone or in pairs.

Discussion

Occurrence and Distribution

Of the cetaceans inhabiting the study area, bottlenose dolphins were the most often observed, followed by long-beaked and short-beaked common dolphins, as previously recorded for the Southern California Bight (Bonnell and Dailey, 1993; Forney and Barlow, 1998; Carretta et al., 2006). Other cetaceans were occasional or rare inhabitants of the bay and their occurrence reflects, in general and at smaller scale, the occurrence of these species reported by other authors for the SCB (Bonnell and Dailey, 1993; Barlow et al., 1998; Schmitt and Bonnell, 2003; Appler et al., 2004; Carretta et al., 2006; Soldevilla et al., 2006).

Coastal bottlenose dolphins were regularly observed close to shore, in agreement with data off the San Diego coastline (Defran and Weller, 1999; Defran et al., 1999; Dudzik et al., 2005; Lang, 2002). Sightings of offshore bottlenose dolphin schools were recorded both along the canyons and out to Santa Barbara and Catalina islands. The presence of offshore bottlenose dolphins near these islands is in accordance with other authors (see Bonnell and Dailey, 1993).

The general occurrence of short-beaked and long-beaked common dolphins in offshore waters was consistent with Forney and Barlow (1998) for the California coast. In the bay, short beaked and long-beaked common dolphins showed a preference for submarine canyons, especially Santa Monica and Redondo canyons, in accordance with previous data collected in the area (Bearzi, 2005b). Dolphins are likely to aggregate in these areas of upwelling (Hickey, 1992, 1993), taking advantage of these nutrient-rich feeding grounds. Anchovies (*Engraulis mordax*), common preys of short-beaked common dolphins in the Bight (Evans, 1975), are known to be abundant around upwelling areas of submarine canyons and escarpments (Mais, 1974; Hui, 1979).

Prey abundance near these bathymetric features may also explain the presence of other cetacean species in the same areas. Competition for resources along canyons was probably avoided by: 1) different species of cetaceans feeding on different prey (Bearzi, 2005b), 2) the presence of species at different seasons at these locations, and, most likely, 3) productive feeding grounds rich enough in prey to support the feeding requirements of various species.

The most observed cetacean species occurred throughout the entire study period, including the strong 1997–98 El Niño (and following La Niña). The overall presence of cetaceans in the bay during El Niño years may have been related to prey abundance of some fish species, including Pacific sardine (*Sardinops sagax*), white seabass (*Atractoscion nobilis*) and splitnose rockfish (*Sebastes diploproa*), during this time of warmer water temperature (California Department of Fish and Game, 2000). Bottlenose and common dolphins are also known to be opportunistic feeders that change their diet based on availability and abundance (Heyning and Perrin, 1994; Bearzi et al., 1999).

The only exception to this trend was the Risso's dolphin that disappeared from the bay at the beginning of the 1997–98 El Niño and began to reappear in the area after the year 2000. This species was rarely observed before the 1982–83 El Niño event in southern California waters, but seemed to have increased above the continental shelf around Catalina Island after this event (Shane, 1995; S. Shane, pers. comm.). The disappearance of this species from the bay prior to and after the 1997–98 El Niño event may have been related to offshore movements of California market squid, *Loligo opalescens*, one of their common prey (Zeidberg et al., 2006).

In conclusion, the unique physical oceanography of the study area have shaped a suitable habitat for several species of prey and, consequently, for cetaceans. Santa Monica Bay could also act as an "oasis" during years of poor productivity, as has been documented for Monterey Bay during the 1997–1998 El Ninño (Benson et al., 2002).

Further studies on the relationships between oceanographic conditions, prey availability and the distribution and abundance of cetacean populations at different scales are needed to improve the understanding of the ecology of the local cetacean community.

Behavioral Patterns of the Most Observed Species

Behavioral data collected for bottlenose dolphins were comparable to those reported for the San Diego area (Hanson and Defran, 1993). Coastal bottlenose dolphins spent most of the time traveling (this study: 68.8% travel plus dive-travel; San Diego: 63.0%

Table 3. Overall behavioral state budget recorded for the most observed species. Behavioral state data at less than 0.5% level were not included in the table. A hyphen between two behavioral states refers to activities performed simultaneously by different focal group individuals during 5-min sample (e.g., Dive-Travel).

Species	Behavioral states	N 5-min Samples	Frequency distribution of observed behavioral states (approx. %)	Tot 5-min samples
Bottlenose dolphin	Travel	1,004	42.17	2,381
	Travel-Dive[a]	583	24.49	
	Travel-Socialize	199	8.36	
	Travel-Feeding	140	5.88	
	Feeding	96	4.03	
	Dive	44	1.85	
	Travel-Dive-Socialize	38	1.60	
	Socialize	37	1.55	
	Dive-Feeding	32	1.34	
	Travel-Milling	23	0.97	
	Travel-Dive-Milling	23	0.97	
	Feeding-Socialize	21	0.88	
	Travel-Dive-Feeding	17	0.71	
	Dive-Socialize	17	0.71	
	Travel-Dive-Socialize-Milling	15	0.63	
	Travel-Socialize-Milling	14	0.59	
	Dive-Socialize-Milling	7	0.29	
	Milling	4	0.17	
	Dive-Milling	3	0.13	
	Travel-Dive-Feeding-Socialize-Milling	3	0.13	
	Travel-Dive-Play-Socialize[b]	2	0.08	
	Socialize-Milling	2	0.08	
	Travel-Feeding-Milling	2	0.08	
	Dive-Feeding-Socialize	2	0.08	
	Travel-Dive-Feeding-Socialize	2	0.08	
	Travel-Dive-Feeding-Milling	2	0.08	
	Dive-Feeding-Milling	1	0.04	
	Feeding-Socialize-Milling	1	0.04	
	Dive-Feeding-Socialize-Milling	1	0.04	
	Travel-Feeding-Socialize-Milling	1	0.04	
Common dolphin[1]	Travel	1,069	56.53	1,891
	Travel-Feeding	232	12.27	
	Feeding	173	9.15	
	Travel-Socialize	135	7.14	
	Travel-Dive	84	4.44	
	Travel-Dive-Socialize	36	1.90	
	Dive	27	1.43	
	Travel-Feeding-Socialize	21	1.11	
	Travel-Dive-Feeding	20	1.06	
	Dive-Feeding	5	0.79	
	Socialize	8	0.42	
	Travel-Dive-Feeding-Socialize	8	0.42	
	Travel-Socialize-Milling	5	0.26	
	Travel-Milling	3	0.16	
	Travel-Dive-Milling	2	0.11	
	Travel-Dive-Milling-Feeding	2	0.11	
	Milling	1	0.05	

Table 3. Continued.

Species	Behavioral states	N 5-min Samples	Frequency distribution of observed behavioral states (approx. %)	Tot 5-min samples
	Travel-Milling-Feeding	1	0.05	
	Travel-Dive-Milling-Socialize	1	0.05	
Risso's dolphin	Travel	70	62.50	112
	Travel-Feeding	9	8.04	
	Travel-Dive	8	7.14	
	Travel-Socialize	6	5.36	
	Feeding	3	2.68	
	Dive-Feeding	2	1.79	
	Travel-Dive-Feeding	2	1.79	
	Milling	2	1.79	
	Dive-Milling-Feeding	1	0.89	
	Travel-Milling	1	0.89	
Dall's porpoise	Travel-Dive	27	36.49	74
	Dive	21	28.38	
	Dive-Feeding	15	20.27	
	Travel	10	13.51	
	Travel-Milling	1	1.35	
Pacific white-sided dolphin	Travel	50	46.30	108
	Travel-Socialize	20	18.52	
	Feeding	8	7.41	
	Travel-Feeding	7	6.48	
	Travel-Dive	4	3.70	
	Feeding-Socialize	4	3.70	
	Dive-Milling	4	.70	
	Dive	3	2.78	
	Milling	3	2.78	
	Travel-Play	3	2.78	
	Travel-Dive-Play	1	0.93	
	Travel-Dive-Feeding	1	0.93	
	Travel-Dive-Socialize	1	0.93	
Gray whale	Travel	97	75.78	128
	Travel-Dive	27	21.09	
	Dive	3	2.34	
	Feeding	1	0.78	
Minke whale	Travel-Dive	24	48.00	50
	Travel	12	24.00	
	Feeding	8	16.00	
	Dive	6	12.00	

[1] this data includes both species of short-beaked and long-beaked common dolphins.

[a] simultaneous behavior occurring during 5-min sample.

[b] the behavioral state *play* was only used in data collected during 2005–2007.

travel plus dive-travel), and feeding was observed 19.0% of the time along the San Diego coastline and 13.2% in the study area.

Data on behavioral patterns of free-ranging common dolphins (*Delphinus* spp.) are scarce worldwide (Neumann, 2001b). Data for short-beaked common dolphins in the study

Table 4. Group sizes for the nine most observed species and mean group sizes reported by other authors.

	Mean	SD	SE	Count	Min	Max
Bottlenose dolphin	9.94	7.59	0.53	203	1	57
Inshore	8.30	5.01	0.39	162	1	35
Offshore	16.41	11.66	1.82	41	1	57
Common dolphin[1]	108.84	122.66	9.52	166	1	600
Inshore	8.27	13.61	4.10	11	1	40
Offshore	115.98	123.83	9.95	155	1	600
Pacific white-sided dolphin	17.27	10.40	3.13	11	5	45
Dall's porpoise	6.67	4.56	1.32	12	2	15
Risso's dolphin	9.67	7.35	1.90	15	3	29
Gray whale	1.70	0.70	0.15	23	1	3
Minke whale	1.33	0.50	0.17	9	1	2

	Mean	Sources
Bottlenose dolphins	19.8	Defran and Weller (1999), San Diego, inshore dolphins
	18	Hansen (1990), Southern California, offshore dolphins
	15.7	Lang (2002), San Diego, inshore dolphins
	12.7	Lang (2002), Santa Barbara, inshore dolphins
	10	Scott and Chivers (1990), Eastern tropical Pacific Ocean, inshore dolphins
	9.1	Dudzik et al. (2005), San Diego, inshore dolphins
Common dolphin	67.1	Shane 1994, Catalina Island, California
	98	Au and Perryman 1985, Eastern Tropical Pac.
	77.6	Smith et al. 1986, California Current
	5.4–661.5	Barlow 1995, California waters
Pacific white-sided dolphin	10.3	Shane 1994, Catalina Island, California
	11.5–75.4.1	Barlow 1995, California waters
Dall's porpoise	4.7	Shane 1994, Catalina Island, California
	4.5	Smith et al. 1986, California Current
	3.3	Barlow 1995, California waters
Risso's dolphin	13.1	Shane 1994, Catalina Island, California
	8.3–25.2	Barlow 1995, California waters
Gray whale	2.1	Reilly et al. 1983, California shores
	3–5.3	Forney et al. 1995, California waters
Minke whale	1.1	Barlow 1995, California waters
	1.0	Forney et al. 1995, California waters
	1.8	Shane 1994, Catalina Island, California

[1] group sizes for *D. delphis* and *D. capensis* are cumulated for comparison with other authors.

area were consistent with observations for the same species in the north-western Bay of Plenty, in New Zealand, where dolphins were seen mostly traveling (55.0% Neumann, 2001b; 57.0% this study). In Santa Monica Bay, both species of common dolphins spent more time traveling, foraging and feeding at surface than bottlenose dolphins (Table 3). The large amount of time spent traveling by both species of common dolphins was probably related to the distribution and availability of prey in the pelagic environment of the bay that required movements between different foraging grounds (Bearzi, 2005b).

Group Sizes of the Most Observed Species

Mean group sizes for the most common cetaceans observed in Santa Monica Bay and adjacent areas were comparable to group sizes reported by other authors for the SCB

(Table 4). Coastal bottlenose dolphin groups observed in the bay ranged from 1 to 35 individuals and were typically composed of 2–15 individuals. Offshore bottlenose dolphin groups ranged from 1 to 57 individuals and were typically composed of 10–20 individuals. The results of this study are similar to Hansen (1990) and Scott and Chivers (1990). This species showed an increased group size from inshore to offshore waters, in agreement with Defran and Weller (1999), likely as a response to the patchily distributed food resources of the pelagic environment (Wells et al., 1980; Dailey et al., 1993).

Offshore bottlenose dolphins were also found in aggregations with other cetaceans (Bearzi, 2005a), possibly facilitating schooling behavior of prey and capture of food by these predators (Magurran, 1990; Similä and Ugarte, 1993; Norris and Johnson, 1994).

Both species of common dolphins were regularly observed in large schools, and often recorded in rank formation during food search, spreading out over a mile (M.Bearzi, pers. obs.). When a high concentration of prey was found, dolphins separated into smaller groups of 25–30 individuals, and exploited the resources present in different feeding grounds. The presence of these subgroups is in agreement with Evans (1994), suggesting a basic social unit for common dolphins of about 30 individuals.

Cetacean Community and the Newly Established MPAs

Recently, many investigations on dolphins and whales (*e.g*., Gregr and Trites, 2001; Harwood, 2001; Fury and Harrison, 2008) have helped to identify key areas for cetaceans and, in some cases, have contributed to the establishment or expansion of marine protected areas (Dawson and Slooten, 1993; Hooker *et al.*, 1999; Hoyt, 2005). Vice versa, some MPAs have helped to protect cetaceans and their habitats, as well as the species they feed upon (Hoyt, 2005).

Based on this study: 1) the presence of a rich and diverse cetacean fauna in the study area, that includes several threatened and endangered species, 2) the year-round and regular occurrence of three dolphin species, including the bottlenose dolphins frequenting coastal waters, 3) the use of this areas as foraging grounds by several cetaceans species, are all clear indications of the importance of these habitats for the local cetacean community.

Several of the MPAs located in the study area represent foraging hotspots and/or essential corridors for year-round species like bottlenose dolphins, short-beaked and long-beaked common dolphins (this study, Bearzi, 2005a,b; Bearzi, *et al.*, 2009a), as well as habitats in which endangered cetaceans like blue whales are found (this study). Protecting these critical habitats for cetaceans as well as the species they depend upon is the first step toward good management of MPAs (Hoyt, 2005).

Coastal bottlenose dolphins inhabiting the impacted waters off Los Angeles (Schiff, 2000) year-round and using the area as foraging ground (this study; Bearzi, et al., 2009a), are top predators susceptible to indirect threats like marine debris, chemical and acoustic pollution (Simmonds and Hutchinson, 1996; Nowacek et al. 2007, Weilgart 2007, Stavros et al. 2008). Anthropogenic effects on these animals are usually difficult to assess, but dolphins bioaccumulate toxins and suffer immunological and reproductive disorders as a consequence (Simmonds and Hutchinson, 1996; Bossart 2007; Blasius and Goodmanlowe, 2008). Over 80% of bottlenose dolphins in the study area were found carrying skin diseases and body malformations (Bearzi et al., 2009). These diseases are usually correlated to poor quality of water and presence of contaminants (Bossart, 2007). Bottlenose dolphins are now used worldwide as key indicators of the status and health of coastal habitats because they represent important marine ecosystem sentinels (Wells et al., 2004). Long-term population monitoring data on these dolphins are a powerful tool for tracking the progression of poorly understood diseases that may be relevant both to dolphin and human health.

In general, cetaceans are often viewed as flagship species (Mann et al., 2000; Prideaux, 2005). In the study area , and the established MPAs within, there is a substantial overlap in distribution between cetaceans and other apex and non-apex species (e.g. seabirds, fish, zooplankton; Bearzi, 2005). The overlap usually coincides with upwelling and nutrient-rich feeding areas. Conservation measures aimed at mitigating threats to cetaceans are expected to result in protection for other organisms as well.

Continuous monitoring is essential to identify not only the areas used preferentially by cetaceans within and outside the boundaries of the MPAs, but also the subset of critical habitats they use for different behavior, and the type of behaviors in which they are most vulnerable to human activities. Monitoring distribution, occurrence and behavior of these key species, as well as their threats, is essential in any decision-making process involving MPAs, as has also been suggested at the last International Committee on Marine Mammal Protected Areas (http://icmmpa.org/).

In conclusion, this paper provides new ecological baseline data on dolphins and whales, and offers preliminary information for better establishing goals for use of the newly established MPAs (e.g., control of human activities such as fishing, whale watching). The implication for MPA design and implementation in the study area is that a more flexible definition of MPAs for these cetaceans is needed. It also stresses the strong need of regular and long-term monitoring of cetaceans within and outside the boundaries of the MPAs. This will help to keep the definition of MPAs more adaptable, thereby facilitating the changes necessary to protect cetaceans, as well other species present in the areas.

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