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Pinniped ecology in Santa Monica Bay，California *

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Abstract We investigated pinniped ecology at sea in Santa Monica Bay，California. Animals were studied during 277 boat-based surveys conducted in 1997 – 2007 documenting that California sea lion *Zalophus californianus* was the most observed species (89%，*n* sightings = 1393)，followed by harbor seal (*Phoca vitulina richardsi*；8%，*n* sightings = 131)，and northern elephant seal (*Mirounga angustirostris*；1%，*n* sightings = 15). Sea lions，and occasionally harbor seals，were found in aggregations with bottlenose dolphins *Tursiops truncatus* in 29% of the sightings (*n* bottlenose dolphin sightings = 205)，short-beaked common dolphins *Delphinus delphis* and long-beaked common dolphins *D. capensis* in 53% of the sightings (*n* common dolphins = 155). Sea lions and harbor seals were regularly observed in coastal waters (< 500 m from shore) but also in the entire bay，with both species showing a preference for submarine canyons. Northern elephant seals were only seen in offshore waters and mostly in proximity of the canyons. The three species were frequently observed traveling (50%，*n* = 728)，thermoregulating (14%，*n* = 205)，and feeding (3.2%，*n* = 47) but rarely socializing (0.21%，*n* = 3). This is the first long-term study on at-sea distribution，occurrence，frequency and behavior of pinnipeds in Santa Monica Bay [*Acta Zoologica Sinica* 54 (1)：1 – 11，2008].

Key words California sea lion，Harbor seal，Northern elephant seal，Distribution，Occurrence，Ecology

加州 Santa Monica 海湾鳍足类的生态学 *

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摘 要 研究了加州 Santa Monica 海湾鳍足类的生态学。从 1997 – 2007 年乘船调查了 277 次，发现海狮 (*Zalophus californianus*) 是最常见的动物 (89%，见到的次数为 1393 次)，其次是港海豹 (*Phoca vitulina richardsi*，8%，*n* = 131) 和北象海豹 (*Mirounga angustirostris*，1%，*n* = 15)。在 29% 的遇见次数 (观察到瓶海豚 205 次) 中，发现海狮 (偶尔也发现港海豹) 与瓶鼻海豚集群 (*Tursiops truncatus*)；短喙真海豚 (*Delphinus delphis*) 与长喙真海豚 (*D. capensis*) 在 53% 的遇见次数 (遇见真海豚次数 *n* = 155) 中，发现短喙真海豚 (*Delphinus delphis*) 与长喙真海豚 (*D. capensis*) 集群；一般在沿岸水域 (离岸边距离 < 500 m) 见到海狮和港海豹，但在整个海湾也能见到，表现出这两个物种对海底峡谷的偏爱。北象海豹仅见于近海，主要在海底峡谷附近。经常看到海狮、港海豹和北象海豹游动 (50%，*n* = 728)、进行热调节 (14%，*n* = 205)、以及取食 (3.2%，*n* = 47)，但几乎见不到有社会性活动 (0.21%，*n* = 3) [动物学报 54 (1)：1 – 11，2008]。

关键词 加州海狮 港海豹 北象海豹 分布 出现 生态学

Distribution，occurrence and foraging ecology of California sea lions *Zalophus californianus*，harbor seals *Phoca vitulina richardsi* and northern elephant seals *Mirounga angustirostris* are well documented along the Southern California Bight shoreline (Bartholomew and Boolootian，1960；Bonnell et al.，1979①；Condit and Le Boeuf，1984；Stewart and Yochem，1984；Antonelis et al.，1987；Yochem et al.，1987；Le Boeuf，2002；Lowry，2002②). In the Bight，the Channel Islands are breeding grounds for the three pinniped species (Odell，

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① Bonnell ML，Le Boeuf BJ，Pierson DH，Dettman DH，Farrens，GD，1979. Summary Report 1975 – 1978. Marine Mammal and Seabird Surveys of the Southern California Bight Area. Vol. Ⅲ. Pinnipeds. Bureau of Land Management，Department of the Interior，Contract AA550-CT7-36.
② Lowry MS，2002. Counts of northern elephant seals at rookeries in the Southern California Bight：1981 – 2001. NOAA Technical Memorandum NMFS：NOAA-TM-NMFS-SWFSC-345. 63 pp.

1971; Stewart and Yochem, 1986; Lowry and Perryman, 1992[①]) and ecological studies have been focused at these rookeries (Yochem and Stewart, 1998; Lowry and Carretta, 1999[②]; Melin et al., 2000). Few investigations, however, have involved pinniped distribution (Bonnell and Ford, 1987), abundance (Lowry and Forney, 2005) or behavioral ecology research at sea (Haaker et al., 1984).

Within the Bight, Santa Monica Bay hosts all three above-mentioned pinnipeds (Bearzi, 2003, 2006) but long-term studies at sea have never been conducted in this area. The goal of this investigation is to determine occurrence, seasonal frequency, distribution and behavior of pinnipeds at sea to better understand their ecology and the potential need for protection and management of these species in the study area.

California sea lions are the most commonly observed pinnipeds in the Bight and their range extends from Acapulco, Mexico, to British Columbia, Canada (Odell, 1971; Bonnell and Dailey, 1993). In the Bight, breeding occurs primarily on the offshore Channel Islands during June and July (Odell, 1981; Reeves et al., 1992). On the islands, adult males establish breeding territories; births on rookeries are mostly in late June and lactating females travel up to 100 km from land in search of food. Adult males leave rookeries in August and September, migrate north during autumn and winter, and return south in March – May (Bonnell and Ford, 1987; Riedman, 1990, Reeves et al., 1992). At sea, California sea lions are usually solitary but may form small groups, sometimes with cetaceans, when foraging (Reidman, 1990; Bearzi, 2006); the group size diminishes as the abundance of prey decreases (Antonelis and Fiscus, 1980).

Harbor seals range between Baja California and northward into Alaska (Reeves et al., 1992). This species aggregates on land and its distribution on the southern Channel Islands varies seasonally with the greatest numbers observed in May and June (Stewart and Yochem, 1984; Reeves et al., 1992). The breeding season of the different colonies are progressively later (between February and October) with rookeries from Baja California to Washington (Reeves et al., 1992). At sea, harbor seals are usually solitary, and are capable of diving to great depths (500 m +) to find prey (Burns, 2000).

Northern elephant seal breeding colonies range between Baja California and Point Reyes, California, including the Channel Islands (Reeves et al., 1992; Lowry, 2002). Of the Channel Island rookeries, the smallest number of elephant seals is found on San Clemente Island and the largest colony on San Miguel Island (Lowry, 2002). Northern elephant seals return to the Channel Islands twice a year to breed and molt after migrating to offshore locations in the North Pacific and Gulf of Alaska to forage (Stewart and DeLong, 1995). At sea, where they spend most of their annual cycle (Le Boeuf et al., 2000), northern elephant seals are usually solitary and dive continually during their foraging migrations (Le Boeuf, 1994).

1 Materials and methods

1.1 Study area

Santa Monica Bay (approximately 460 km^2; Fig.1) is 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 escarpment to the west. The bay contains three submarine canyons: Dume and Redondo canyons, which head in shallow waters (50 m), and Santa Monica Canyon, which heads at a depth of approximately 100 m. A shallow shelf between Santa Monica Canyon and Redondo Canyon extends as a plateau from the 50-m contour. The typical depth is 60 – 70 m and the maximum depth is 400 – 500 m. Surface temperatures range from 11℃ to 22℃ (July – December: 16℃ – 22℃; January – June: 11℃ – 17℃). During the 1997 – 1998 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℃ above the norm (Nezlin et al., 2003).

1.2 Data collection and analyses

We conducted surveys from February 1997 to June 2002 and from August 2005 to June 2007 with an average of 3.5 days on the water per month (n = 277; Table 1); no data was collected: Dec. 1999, Oct. 2000, July 2001, Sep. 2001, Dec. 2005, May 2006, Feb. – Apr. 2007. We generally followed inshore (distance from shore < 500 m) and offshore (distance from shore > 500 m) routes in the morning and early afternoon, usually with sea condition < 2 on the Beaufort wind-force scale. Routes were planned to provide an even coverage of the bay throughout the study period (Fig.2), and were covered from 7-m (1997 – 2000) and 10-m power boats (2001 – 2002, 2006 – 2007), and a 17-m sailboat (2005), at an average speed of 18 km/h.

① Lowry MS, Perryman LM, 1992. Aerial photographic census for California sea lion *Zalophus californianus* pups at San Miguel Island, California for 1987 – 1990 and San Nicolas Island, California for 1990. National Marine Fisheries Service, Southwest Fisheries Science Center, Administrative Report LJ-92-19. 19 pp.

② Lowry MS, Carretta JV, 1999. Market squid *Loligo opalescens* in the diet of California sea lions *Zalophus californianus* in Southern California (1981 – 1995). CalCOFI Report 40: 196 – 207.

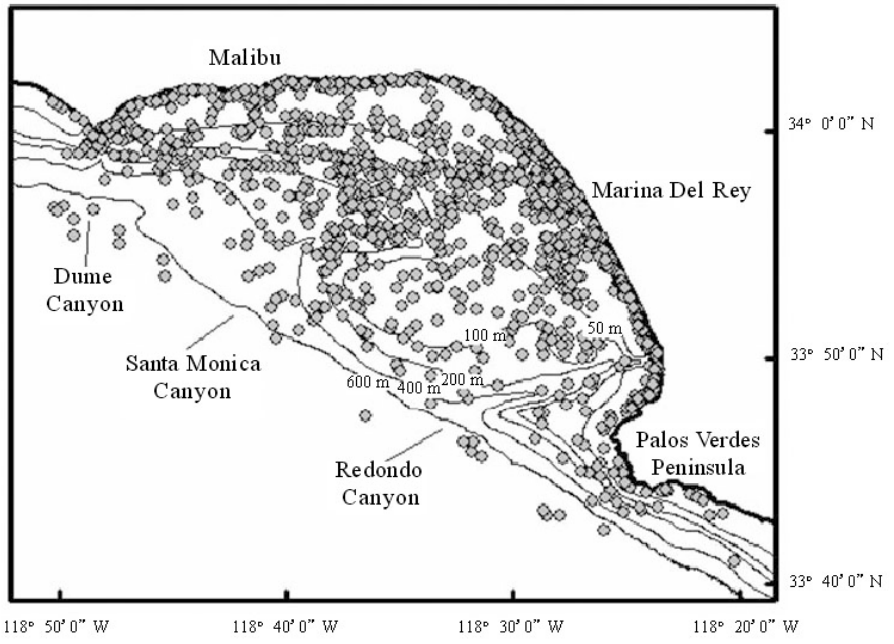

Fig.1 The study area—Santa Monica Bay
Each mark represents the initial GPS coordinates of California sea lion sightings.

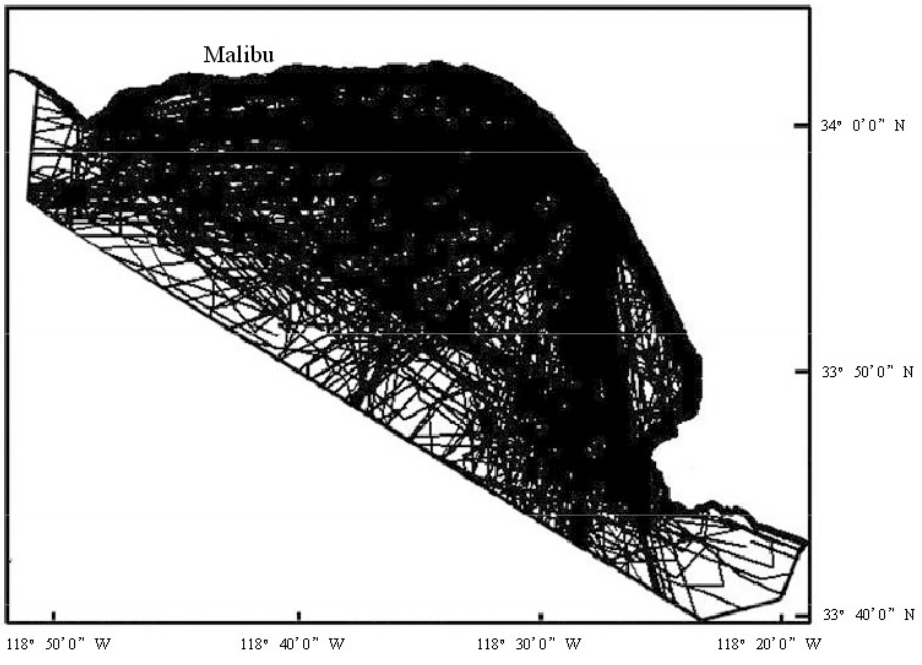

Fig.2 Effort in the field for the years 1997 – 2007 in Santa Monica Bay

We collected data with laptop computers and occasionally with tape recorders. When we spotted pinnipeds alone or in intraspecific groups along survey routes, we recorded species, number of animals, and data on behavioral states (Table 2). When they were observed in associations and/or aggregations with dolphins, we studied these mixed-species groups using a group following protocol with scan sampling (Altmann, 1974; Mann, 1999) and monitored them for at least 25 min at 5-min periods throughout the dolphin sighting (Bearzi, 2006). We estimated the number of animals, behavior, and group formation when the boat was < 50 m from a dolphin school. An *aggregation* was defined as a continuous association between sea lions and dolphins for ≥10 min, with the 2 groups displaying similar activities during at least part of the sighting. An *association* was defined as a grouping in which pinnipeds and dolphins were < 100 m apart in a 5-min sampling period; when the individuals were about 1 m apart, it was categorized as a *close association*. In mixed-group sightings, the protocol included a decision rule to always stay with the larger dolphin group when 1 or more animals left the

initial focal group.

Table 1 Number of surveys and summary of research effort during 1997 – 2002 and 2005 – 2007

	1997	1998	1999	2000	2001	2002	2005	2006	2007	Total
Boat surveys:										
Inshore (< 500 m from shore)	5	17	12	6	6	5	4	3	1	59
Offshore (> 500 m from shore)	23	3	5	4	10	9	5	17	2	78
Combined inshore and offshore	11	38	27	27	17	4	0	11	5	140
Total number of boat surveys	39	58	44	37	33	18	9	31	8	277
Research effort:										
Hours spent with pinniped and cetacean associations	0.2	1	0.3	0.3	0.5	0.1	0	1	1	4
Tot *n* of 5-min. behavioral samples during pinniped/dolphin associations	2	10	4	4	6	1	0	13	11	51
Hours spent with pinniped and cetacean aggregations	5	16	7	9	22	14	3	13	2	91
Tot *n* of 5-min. behavioral samples during pinniped/cetacean aggregations	58	186	80	111	258	172	31	150	27	1 073
Tot hours conducting surveys	144	224	178	148	161	73	75	204	84	1 291

Table 2 Definitions of the most important pinniped behavioral states and events, group formation, and boat disturbance

Behavior	Description
Behavioral states	
Travel	Moving steadily in one direction
Swimming	Moving without a precise direction at any speed and without leaping
Diving	No steady directional movement; dives longer than 30 s
Surface-feeding	Obvious feeding activities performed close to water surface
Socializing	Some or all group members in almost constant physical contact with one another and often displaying surface behaviors
Playing	Any activity that incorporates use of a foreign object
Resting	Nostrils at or close to the surface; body sloping downward at an angle, rising to surface to breathe
Thermoregulating	Hind and foreflippers extend above surface or any other hind- or foreflipper position extend above surface but not as in jugging
Porpoising	Leaping from water in a shallow arch, reentering headfirst (Peterson and Bartholomew, 1967)
Jugging	Both hind flippers and one foreflipper extend above surface (Riedman, 1990)
Following fishing boat	Following fishing boat while trawling at 0 – 300 m from stern
On buoys, on rocks	Thermoregulation, resting, or other behavior displayed on buoys
Behavioral events	
Head up	Exposure of foresection of body at surface in a near-vertical or vertical position, remaining briefly stationary
Leap	Airborne forward progress of at least one body length while in dorsal position (but repetitive instances of leaping are referred to as porpoising)
Spyhop	Brief vertical or near-vertical elevation of the body with head-up exposure of foresection
Group formation	
Tight	Animals generally one body length apart
Loose	Animals generally 1 – 5 body lengths apart
Dispersed	Animals generally > 5 body lengths apart
Variable	Animals irregularly spread; or a group that meet > 1 one of above criteria
Convergent	Joining of > 1 subgroups to the focal group
Boat disturbance	
Avoidance	Animals move away from vessel or appear to dive in response to vessel
No response	Animals show no apparent response relative to approach or pass-by of vessel
Approach	Animals move toward vessel during at least part of observation period
Bowride	Special case of an approach response (animals swim near bow of the boat)

Table 3 Pinniped sightings and counts for 1997 – 2002 and 2005 – 2007

	1997	1998	1999	2000	2001	2002	2005	2006	2007	Total
Number of pinniped sightings										
Searching for cetaceans										
California sea lion	150	299	114	109	105	63	56	201	94	1191
Harbor seal	10	22	14	18	0	5	4	22	13	105
Northern elephant seal	0	3	0	2	2	1	0	5	0	13
Generic pinniped*	7	8	6	2	0	0	0	0	0	23
Total sightings	167	332	134	131	107	69	60	228	107	1332
In association with cetaceans**										
California sea lion	2	7	1	4	6	0	0	11	8	39
Harbor seal	0	4	3	1	0	1	0	2	2	13
Northern elephant seal	0	0	0	0	0	0	0	0	1	1
Generic pinniped*	0	0	0	0	0	0	0	0	0	0
Total sightings	2	11	4	5	6	1	0	13	11	53
In aggregation with cetaceans**										
California sea lion	12	34	17	16	20	15	3	24	8	149
Harbor seal	0	3	2	1	2	1	1	1	0	11
Northern elephant seal	0	0	0	0	0	0	0	0	0	0
Generic pinniped*	0	0	0	0	0	0	0	0	0	0
Total sightings	12	37	19	17	22	16	4	25	8	160
Total number of pinniped sightings***	181	383	158	157	136	85	65	272	128	1562
Number of pinniped counted										
During search for cetaceans										
California sea lion	305	705	211	206	175	115	75	300	206	2298
Harbor seal	13	35	29	24	0	5	4	27	23	160
Northern elephant seal	0	3	0	2	2	1	0	5	0	13
Generic pinniped*	7	8	6	2	0	0	0	0	0	23
Total pinnipeds	325	751	246	234	177	121	79	332	249	2494
During cetacean sightings****										
California sea lion	18	68	50	31	68	77	4	95	41	452
Harbor seal	0	7	4	3	2	1	2	7	2	28
Northern elephant seal	0	0	0	0	0	0	0	1	1	2
Generic pinniped**	0	0	0	0	0	0	0	0	0	0
Total pinnipeds	18	75	54	34	70	78	6	103	44	482
Total number of pinniped counted	343	826	300	268	247	199	84	435	293	2976
Pinniped sighting frequency (sightings/hr)										
Searching for cetaceans										
California sea lion	1.04	1.33	0.65	0.74	0.65	0.86	0.75	0.99	1.12	0.92
Harbor seal	0.07	0.10	0.08	0.12	0.00	0.07	0.05	0.11	0.15	0.08
Northern elephant seal	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.02	0.00	0.01
Generic pinniped*	0.05	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Total pinnipeds	1.16	1.48	0.76	0.88	0.66	0.94	0.80	1.12	1.27	1.03
During cetacean sightings****										
California sea lion	0.10	0.26	0.11	0.16	0.17	0.19	0.05	0.19	0.21	0.16
Harbor seal	0.00	0.04	0.02	0.02	0.02	0.03	0.01	0.02	0.02	0.02
Northern elephant seal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Generic pinniped*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total pinnipeds	0.10	0.30	0.13	0.18	0.19	0.21	0.06	0.21	0.23	0.19
Total pinniped sighting frequency	1.26	1.71	0.89	1.06	0.85	1.15	0.86	1.33	1.51	1.22

* Pinniped not recognized at species level.

** Pinnipeds were sighted in association with bottlenose dolphins *Tursiops truncatus*, short-beaked *Delphinus delphis* and long-beaked common dolphins *D. capensis*, gray whale *Eschrichtius robustus*, blue whale *Balaenoptera musculus* and humpback whale *Megaptera noveaengliae*. They also aggregated with Pacific white-sided dolphins *Lagenorhynchus obliquidens*, Risso's dolphins *Grampus griseus*, minke whales *Balaenoptera acutorostrata*, gray whales, and Dall's porpoises *Phocoenoides dalli*.

*** This data includes pinnipeds observed > 100 m from cetaceans.

**** This data represents associations, aggregations, and pinnipeds observed > 100 m from cetaceans.

We took color photographs with 35-mm Canon EOS1N and A2 cameras equipped with 75 – 300 mm lenses, and Digital Canon 5D equipped with 400 mm lens. During the sighting, researchers also videotaped the animals' behavior with Canon Hi 8 mm Video Camcorder or Canon GL1 Digital Camcorder. We cataloged photos and videos and reviewed them for species identification and to determine the nature and length of associations. 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).

We also considered responses to potential disturbance involving research boat and pinnipeds. Pinnipeds in absence of cetaceans were never observed approaching, avoiding or bowriding our research boat. On a total of 213 associations and aggregations with cetaceans, boat disturbance was observed in 3.8% of the sightings (n = 8); approach and bowriding were observed, respectively, in 0.94% (n = 2) and 2.8% (n = 6) of the sightings, and avoidance was never recorded.

We performed data analyses using Statview 5.0 and Statistica 8.0; data on species distribution were plotted with ArcGIS 9.2. Only one sighting per aggregation was considered to avoid pseudo-replication during analysis of pinniped behavior, counts and distribution in mixed-species schools. We used predetermined transects to ensure that routes were not repeated in a single survey and each encounter was likely of being recorded only once.

2 Results

2.1 Field effort and number of sightings

Field effort for the entire study period is illustrated in Table 1. Of a total of 1562 pinniped sightings (data includes pinniped sightings in associations, aggregations and at > 100 m from cetaceans), California sea lions were the most observed species (89%, n = 1393), followed by Pacific harbor seals (8.4%, n = 131) and Northern elephant seals (0.96%, n = 15). Pinnipeds were not recognized at species level on a total of 23 sightings.

On a total of 408 cetacean sightings, we found that sea lions were the most often observed pinniped found in associations with dolphins (9.6%, n = 39), followed by harbor seals (3.2%, n = 13) and Northern elephant seals (0.25%, n = 1), and in close association with cetaceans (2.2%, n = 9). Further, sea lions also aggregated with cetaceans (37%, n = 149) whereas harbor seals were found in aggregations only during 11 sightings (1.7%). Northern elephant seals were never found in aggregations with cetaceans.

We counted a total of 2976 individual pinnipeds at sea during the search for cetaceans (n = 2494) and during cetacean sightings (n = 482) (Table 3).

2.2 Sighting frequency, occurrence and distribution

Sighting frequencies for the three species are illustrated in Table 3. California sea lions were most frequently sighted in 1998-in absence of cetaceans-and 2007-during associations with cetaceans. Overall, sea lions were observed with cetaceans during the entire study period. Harbor seal sighting frequency was highest in 2000 and 2007 in absence of cetaceans, and in 1998, 1999, and 2000 during associations with cetaceans. A significant difference in the overall sighting numbers for the three pinniped species among the entire study period was observed (t = 5.31, df = 8, P < 0.001), with more sightings found during 1998 in comparison to other years.

We frequently observed sea lions and harbor seals in

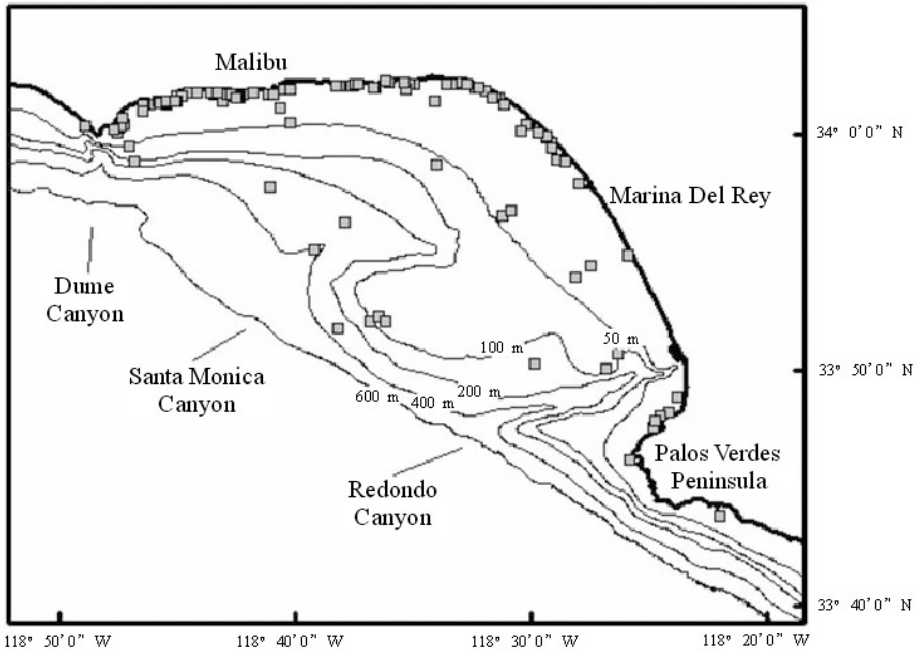

Fig.3 The study area and the initial GPS coordinates of harbor seal sightings

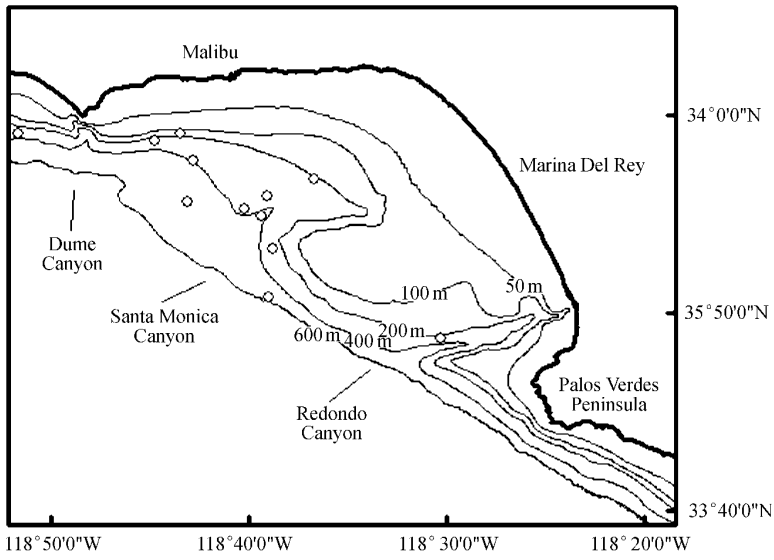

Fig.4　The study area and the initial GPS coordinates of Northern elephant seal sightings

coastal waters (< 500 m from shore) but also in the entire bay (Figs.1, 3), with both species showing a high number of sightings near submarine canyons, particularly the Santa Monica Canyon. Northern elephant seals were only seen in offshore waters and mostly in proximity of the Santa Monica Canyon (Fig.4).

Seasonal distribution of sea lions and harbor seals shows a regular year-round presence, with a significant high number of sea lion sightings in Summer 2002 (Fig.5). A significant difference in the overall sighting numbers for the three species was observed within the four month period categories (Winter, Spring, Summer, and Fall) in 1997 ($t = 3.53$, $df = 3$, $P < 0.05$), 1998 ($t = 4.67$, $df = 3$, $P < 0.05$), 1999 ($t = 4.99$, $df = 3$, $P < 0.05$), 2000 ($t = 11.6$, $df = 3$, $P < 0.001$), 2001 ($t = 4.33$, $df = 3$, $P < 0.05$), and 2006 ($t = 3.67$, $df = 3$, $P < 0.05$). No sufficient data for seasonal comparison was collected in 2002 and 2005. Northern elephant seal were observed only in 1998, 2001, 2005 and 2006, with a majority of sightings in recent years (Fig.5).

2.3　Behavior and group size

We found a total of nine behaviors exhibited by the three species of pinnipeds (Fig.6). On a total of 14555-min behavioral samples examined, all three species were most often observed traveling (50%, n sightings = 728), followed by thermoregulating/jugging (14%, $n = 205$), and feeding (3.2%, $n = 47$). Only sea lions wer Head up was also often observed (18%, $n = 259$).

On a total of 13125-min behavioral samples examined, we sighted California sea lions most often traveling (54%, $n = 703$), thermoregulating/jugging (15%, $n = 192$), and head up (14%, $n = 185$); they were also the only species of pinniped observed socializing (0.23%, $n = 3$). In contrast, harbor seals were most often seen head up (55%, $n = 58$ on a total of 105 behavioral samples), followed by traveling (13%, $n = 14$) and thermoregulating/jugging (12%, $n = 13$). Northern elephant seals were mostly observed head up (93%, $n = 13$ on a total of 14 behavioral samples).

We often sighted California sea lions in groups of two or more animals (mean = 1.97, range 1 – 50, $n = 1393$). Harbor seals, although observed in groups of two or more, were most often sighted alone (mean = 1.44, range 1 – 12, $n = 131$). Northern elephant seals were only sighted alone ($n = 15$).

3　Discussion

3.1　Sighting frequency, occurrence and distribution

We found California sea lions to be the most observed species of pinnipeds in Santa Monica Bay. This data is consistent with previous studies conducted in the Southern California Bight (Bonnell and Dailey, 1993; Carretta et al., 2000①; Forney et al., 2002②, Lowry and Forney, 2005). Harbor seals and northern elephant

① Carretta JV, Lowry MS, Stinchcomb CE, Lynn MS, Cosgrove RE, 2000. Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999. National Marine Fisheries Service, Southwest Fisheries Science Center, Administrative Report LJ-00-02. 45 pp.

② Forney KA, Barlow J, Muto MM, Lowry M, Baker J, Cameron G, Mobley J, Stinchcomb C, Carretta JV, 2002. U. S. Pacific marine mammal stock assessments: 2000. U. S. Department of Commerce. NOAA Technical Memorandum NOAA-TMNMFS-SWFSC-300, December 2000.

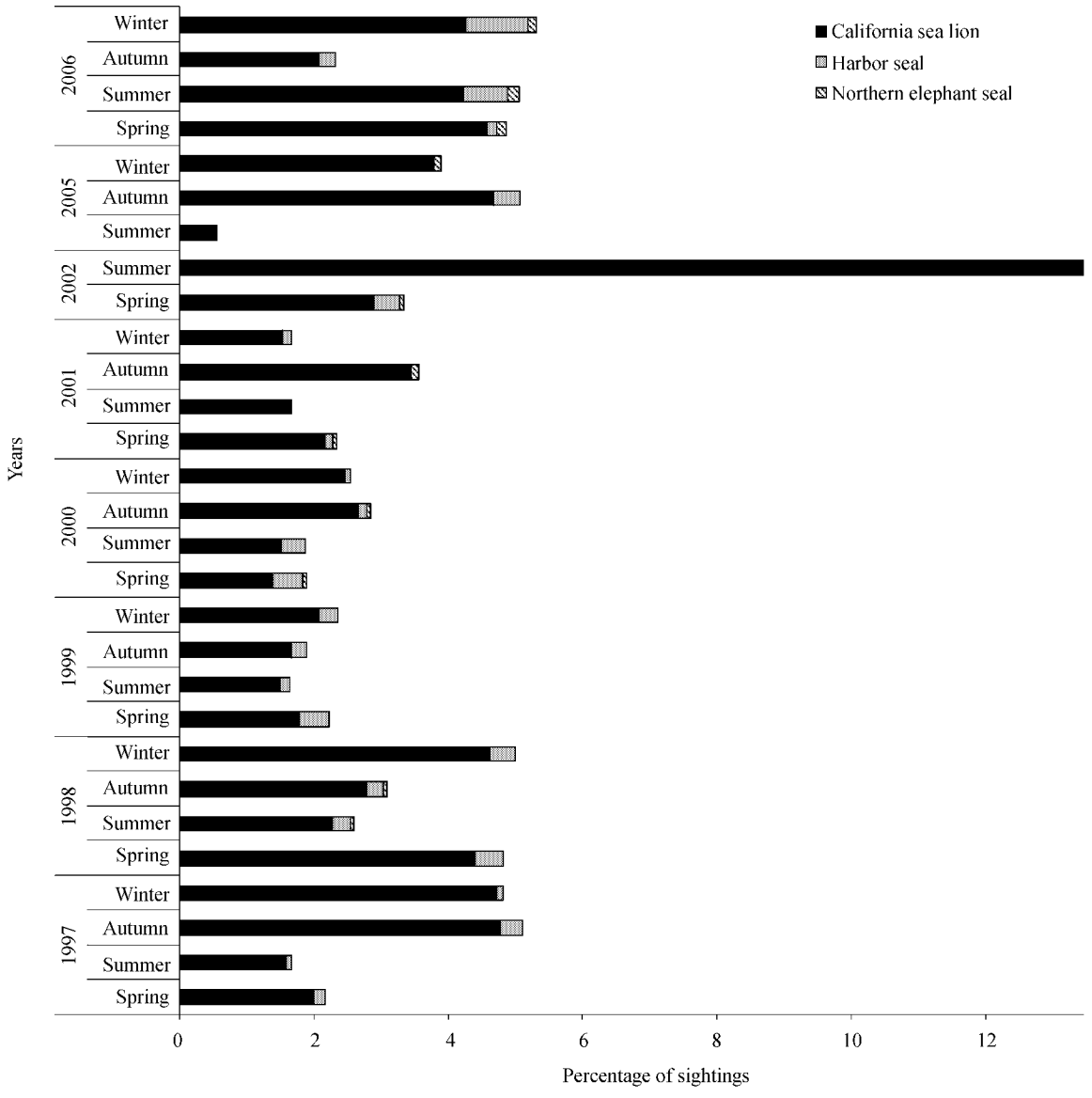

Fig.5 Seasonal distribution of pinnipeds (California sea lions, harbor seals, and elephant seals) during 1997 – 2002 and 2005 – 2006 (2007 is not included because of lack of data for the Winter – Spring months)

Percentages of sightings were divided into four seasonal categories: winter (December – February), spring (March – May), summer (June – August), and autumn (September – November), and divided by number of surveys for each season.

seals were observed less frequently, as also reported by Bonnell and Dailey (1993) and Forney et al. (2002).

The frequency of California sea lion sightings during search for cetaceans in 1999 was lower than in 1997 – 1998, possibly as an effect of the 1997 – 1998 El Niño. Similarly, after the 1983 El Niño, Shane (1994) recorded that populations of California sea lions near Santa Catalina Island were much lower in 1984.

The lowest percentage of sea lion sightings occurred during the summers of the study period, possibly indicating that they remained in rookeries during the months of June – July (Odell, 1981; Reeves et al., 1992), except when traveling offshore to forage. Unlike previous studies on seasonal distribution stating that sea lions were found at sea in the Bight more often in spring and winter (Bonnell and Ford, 1987; Carretta et al., 2000), a clear trend was not observed in the bay. The peak of sightings in summer 2002 doesn't seem to have any specific correlation to prey occurrence or other oceanographic factors. Harbor seals were less sighted than sea lions, with a peak frequency in 2007 when searching for cetaceans. Elephant seals were infrequently observed, with no sightings in 1997 and 1999 and a few more sightings in recent years. The low sightings during El Niño were perhaps a response to the decrease in market squid *Loligo opalescens*, important prey for this species in the Bight (Sinclair, 1994).

Most of our sea lion sightings occurred between the 50 m isobath and the coastline, as also recorded by Lowry and Forney (2005) for their distribution in central and

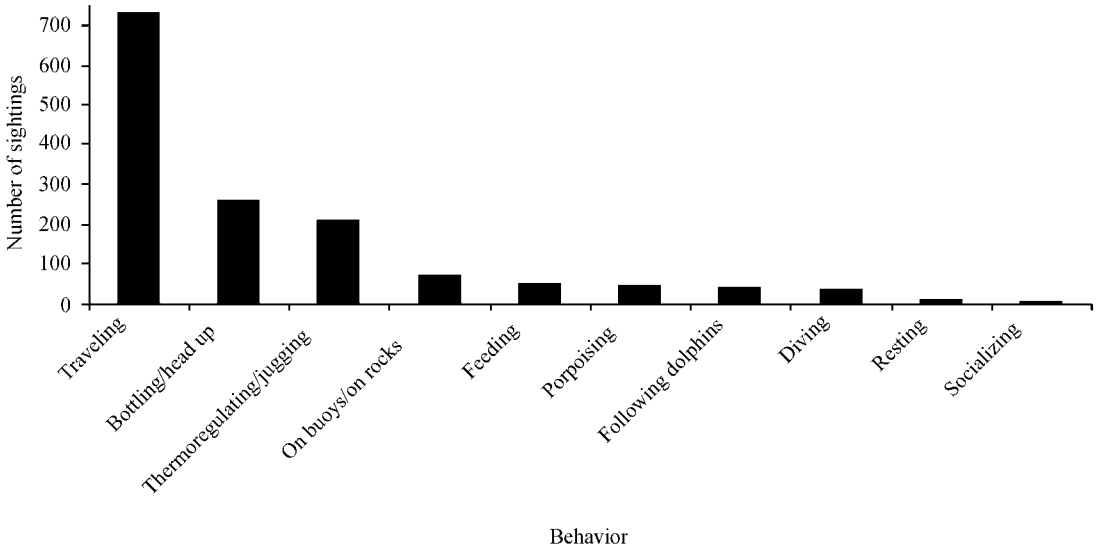

Fig.6 Behaviors of pinnipeds, both in search of cetaceans as well as in association with cetaceans
During aggregations with cetaceans, only the first time a behavior was sighted is included in this figure.

northern California. In the bay, sea lions were also observed often near submarine canyons—especially Santa Monica Canyon. Some marine mammals exhibit preferences toward certain oceanographic features like escarpments and submarine canyons when traveling or foraging (Compagna, 1995; Keiper et al., 2005, Sinclair et al., 2005). In the study area, short-beaked and long-beaked common dolphins showed a striking preference for the Redondo and Santa Monica canyons, possibly due to high productivity presence at these bathymetric features (Bearzi, 2006). Bearzi (2006) also recorded how sea lions use the superior echolocating ability of dolphins to locate food, and aggregate with them to feed near the canyons.

We found harbor seal sightings to be widely distributed, but the majority of observations were recorded in the northern coastal area and the southernmost part of the bay. These areas, characterized by rocks and beaches, represent favorite resting spots for this species (Burns, 2000) and have extensive kelp beds used by harbor seals for foraging and feeding activities (Bearzi pers. obs.). Their high presence in inshore waters is also in accordance with Antonelis and Fiscus (1980), which report this species to be regularly found in waters not deeper than 90 meters.

Northern elephant seals were only observed offshore in the bay and near Santa Monica Canyon, mostly beyond the 200 m isobath, as also recorded by Campagna (1995) for females of southern elephant seals *Mirounga leonina* in Patagonia waters. Northern elephant seals are known to spend a large amount of time in deep waters where they can prey on squid and fish, reaching depths up to 1500 m (Le Beouf et al., 2000). Between breeding and molting at rookeries, northern elephant seals remain in deep waters throughout the entire foraging migrations (Stewart and DeLong, 1994, 1995).

3.2 Behavior and group size

California sea lions were regularly observed traveling. As previously reported by Bearzi (2006) for the study area, traveling by this species was often associated with search for food in association with cetaceans. In Santa Monica Bay, sea lions may take advantage of the prey-detection ability of dolphins and use visual clues to locate dolphins in the open ocean—which explains the frequent "head up" behavior often observed while following common dolphins. California sea lions were also often observed thermoregulating and jugging; in the waters off Southern California, raised flippers out of the water is commonly observed to maintain the internal temperature (Riedman, 1990).

Harbor seals were most often sighted with their head out of the water. These results differ from Sullivan (1981) who states that harbor seals rarely exhibited behaviors other than swimming (or traveling).

Northern elephant seals were also mostly observed with their head out of the water. Considering that this species spends as much as 90% of their time submerged-hunting for food, traveling and even resting at depth of about 200 m (Hindell et al., 1991; Le Boeuf, 1994; Le Boeuf et al., 1996, 2000; Slip et al., 1994; Stewart and DeLong, 1994), it is not surprising that no other behaviors were recorded.

California sea lions are often solitary animals (Reidman, 1990) but they were found in larger groups while traveling and foraging, in accordance to previous data collected in the study area (Bearzi, 2006). Harbor seals were usually aggregated with other seals on rocks, but they were mostly alone at sea, as also observed for elephant seals, known as solitary animals that forage independently at depths (Hindell, 2000).

Sea lions were often found with cetaceans. They were observed in association with baleen whales (e.g.

gray whales, *Eschrichtius robustus*, and blue whales, *Balaenoptera musculus*), but usually they were recorded with bottlenose dolphins and the two species of common dolphins, likely due to the similar dietary requirements (Bearzi, 2006).

Harbor seals were less frequently sighted with cetaceans than California sea lions and the majority of associations occurred with coastal bottlenose dolphins, also present in waters < 50 m from shore (Bearzi, 2005). Northern elephant seals were rarely sighted in association with cetaceans, and most likely the nature of these associations was accidental.

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