Title

Habitat Partitioning by Three Species of Dolphins in Santa Monica Bay, California

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HABITAT PARTITIONING BY THREE SPECIES OF DOLPHINS IN SANTA MONICA BAY, CALIFORNIA

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ABSTRACT

Spatial distribution of and habitat partitioning by three species of dolphins, bottlenose dolphins (*Tursiops truncatus*), short-beaked common dolphins (*Delphinus delphis*), and long-beaked common dolphins (*Delphinus capensis*), were investigated in Santa Monica Bay, CA. Inshore surveys (*n*=40), offshore surveys (*n*=35), and combined inshore/offshore surveys (*n*=81), conducted in 1997-2000, documented that all three species inhabit the bay year-round. Bottlenose dolphins were found in shallow waters within 0.5 km from shore 80% of the time (*n*=137), clearly separated from the distribution of both common dolphin species, but some of the same individuals were also found in deeper waters over the continental shelf off Palos Verdes and pelagic waters outside the bay. Short-beaked common dolphins and long-beaked common dolphins were observed year-round (*n*=87) mostly far from shore in pelagic waters. Both species of common dolphins were found near escarpments, changes in bottom reliefs and submarine canyons. Although long-beaked and short-beaked common dolphins were observed in similar locations of the bay, confirming their sympatric distribution, these two species were never seen in mixed schools. In Santa Monica Bay, bottlenose and common dolphins inhabit different geographic ranges, suggesting that resource partitioning probably occurs.

Key words: bottlenose dolphin, *Tursiops truncatus*, short-beaked common dolphin, *Delphinus delphis*, long-beaked common dolphin, *Delphinus capensis*, habitat partitioning, resource partitioning, Southern California Bight.

INTRODUCTION

Detailed interspecific investigations of odontocetes are rare worldwide (Polacheck 1987, Selzer and Payne 1988, Gowans and Whitehead 1995), and no such studies have been conducted in the Southern California Bight. Within the Bight, the study area of Santa Monica Bay is characterized by a continental shelf indented by three submarine canyons and is inhabited year-round by three relatively abundant cetaceans (the bottlenose dolphin, *Tursiops truncatus*, the short-beaked common dolphin, *Delphinus delphis*, and the long-beaked common dolphin, *D. capensis*), and five less common species (Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, Risso's dolphin, *Grampus griseus*, Dall's porpoise, *Phocoenoides dalli*, gray whale, *Eschrichtius robustus*, and minke whale, *Balaenoptera acutorostrata*; M. Bearzi, unpublished data). This study examines spatial distribution and habitat partitioning of the three commonly observed species in the bay, bottlenose dolphins, short-beaked common dolphins and long-beaked common dolphins, during the years 1997-2000.

Similar species that co-occur are thought to compete for resources unless they occupy different physical locations, and/or feed on different prey (Roughgarden 1976). Along the California coast, short-beaked and long-beaked common dolphins are seldom seen close to shore, whereas some population units of bottlenose dolphins occur inshore year-round (Carretta *et al.* 1998, Forney and Barlow 1998, Hansen 1990, Defran *et al.* 1999). The genus *Delphinus* has been observed elsewhere associated with characteristic offshore bathymetric features such as sea floor reliefs, escarpments and submarine canyons (Hui 1979, Polacheck 1987, Selzer and Payne 1988, Gaskin 1992, Gowans and Whitehead 1995). This study is a comparative investigation that correlates the distribution of these three dolphin species in relation to the environmental features of Santa Monica Bay to identify habitat use and/or geographical separation of the species. The paper also investigates if short-beaked and long-beaked common dolphins are present in distinct inshore and offshore populations, if they ever form mixed groups and if one species is more frequently observed than the other.

The Three Species

The genus *Tursiops* is found widely in temperate and tropical waters. Offshore and inshore populations of bottlenose dolphins are known to inhabit pelagic waters as well as coastal areas, including bays and tidal creeks (Leatherwood *et al.* 1983). These populations also show morphological, osteological, and molecular variations (Walker 1981, LeDuc and Curry 1998, Rossbach and Herzing 1999). Despite their popularity, wide distribution and abundance, the taxonomy of bottlenose dolphins is still unresolved (Rice 1998). Coastal populations usually live within 1 km of shore (Defran and Weller 1999), in small schools, sometimes residing in a specific area, while offshore populations are found in larger groups ranging widely in the open ocean (Connor *et al.* 2000). The frequent presence of bottlenose dolphins along the coastline has also made this dolphin one of the best-known cetaceans. Studies on bottlenose dolphins (*T. truncatus*) in the Southern California Bight have been focused mostly on inshore populations present along the San Diego coastline (Defran *et al.* 1999).

Common dolphins (*Delphinus* spp.) are also characterized by a wide distribution in tropical and temperate waters, but far less is known about this genus. In the Eastern North Pacific, there are two separate species, the short-beaked common dolphin and the long-beaked common dolphin, distinguished by Heyning and Perrin (1994) morphometrically and by Rosel *et al.* (1994) using molecular genetics. These two species have subtle differences in color patterns, different total and rostral length, and other distinctive features. There is no gene flow between *D. delphis* and *D. capensis* in the Southern California Bight, although they occur sympatrically elsewhere in tropical and temperate waters (Heyning and Perrin 1994, Rice 1998). These dolphins usually live in large schools that can reach hundreds of individuals. Evans (1994), however, suggested that the basic social unit for common dolphins contains less than 30 individuals.

Inshore populations of *Delphinus delphis* have been described for the Southern California Bight (Evans 1975) whereas the ecology of offshore populations is still unknown (Rice 1998). Although sporadic information on occurrence, distribution, and abundance have been collected for this genus in central and southern California (Evans 1975, Hui 1979, Dohl *et al.* 1986, Forney and Barlow 1998), no information on these animals was previously available for Santa Monica Bay.

MATERIALS AND METHODS

Study Area

The Santa Monica Bay study area (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 continental shelf to the west. The bay is characterized by three submarine canyons: Dume and Redondo canyons head in shallow waters whereas Santa Monica Canyon begins at a depth of about 100 m at the edge of the continental shelf. A shallow shelf between Santa Monica Canyon and Redondo Canyon extends as a plateau from the 50 m contour (Dartnell 2000). This location has patchy areas of exposed bedrock, rock pinnacles, gravel, and mixed sediments (Terry *et al.* 1956). The bottom habitat includes sandy soft sediments inshore and silts along slopes and canyons. Physiography, currents, wind, and anthropogenic inputs of organic material contribute to the richness of the bay (Hood 1993). The typical depth is 60-70 m and the maximum depth 400-500 m. Surface temperatures range from 11 to 22 °C (July through December: 16-22; January through June: 11-17). Mild temperatures, short wet winters and long, dry summers are usual conditions for the bay.

Field Data Collection

A total of 178 boat-based surveys were carried out from a 7-m powerboat, including 22 long-range surveys in Channel Islands waters (Table 1). Surveys were uniformly distributed during a year-period with an average of 3.5 surveys per month, and conducted from January 1997 to

December 2000, excluding December 1999 and October 2000. Inshore (distance from shore <500 m) and offshore (>500 m) surveys were carried out in the morning and early afternoon, with wind below 2 Beaufort. Boat surveys, averaging a speed of 18 km/h, did not follow predetermined tracks, but an even distribution of inshore and offshore surveys was attempted in order to cover all part of the study area each month. To determine the evenness in the coverage for canyons, sea floor reliefs and escarpments versus flat areas and plateaus, a comparison between the kilometers spent in these two different bathymetric locations was made. The total effort was computed by dividing the bay into a grid comprised of 3.7x3.7 km cells and calculating the total number of kilometers spent into each cell. No significant difference was observed in surveying canyons, sea floor reliefs and escarpments versus flat areas and plateaus (t=1.92, DF=28, P>0.05). Surveys outside the bay were excluded from this calculation.

Data were collected with laptop computers and/or tape recorders, mostly following Bearzi *et al.* (1999). When cetaceans were spotted, number of animals and group formation were recorded at the end of 5-min intervals throughout the sighting. The cetaceans' position (± 30 m from the boat) was approximated to the boat's position using a GPS. Boat surveys were conducted alternating between a) remaining with a dolphin school for a minimum of 30 min and, b) covering a vast area of the bay staying with the groups enough to establish their activities, as suggested by Shane (1990). To distinguish between short-beaked and long-beaked common dolphins, researchers took close-up photographs of the animals' lateral foresection. Color photos were taken with 35 mm cameras equipped with 75-300 mm lens using 64-100 ASA slide films. During the sighting, researchers also videotaped the animals' lateral foresection and recorded their behavior with a Hi8 mm Video Camcorder. Photos and videos were cataloged and reviewed for the species identification based on body features described by Heyning and Perrin (1994).

Following Weller (1991), a *dolphin school* was defined as all dolphins in continuous association with each other and within visual range of the survey team. An *association* referred to distances between one or more individuals of two different species being less than 100 m, and *interaction* as instances when the distance between one or more individuals of two different species was about 1 m.

Data analysis was performed using Filemaker Pro 5, Excel 2000, Statview 5.0.1, Arcview GIS 3.2, and Surfer 6.02.

RESULTS

Field Effort

Data were collected during 40 inshore surveys, 35 offshore surveys, and 81 combined inshore/offshore surveys in the years 1997-2000. A total of 446 h were spent searching for cetaceans in good weather conditions (Beaufort scale <2) and 35 h navigating in "unfavorable" conditions (Beaufort scale >2) in 1997-2000. During this period, a total of 214 h were spent observing 278 groups of cetaceans encountered during 269 sightings lasting on average 47 min (range 2-262 min). The distances covered in the bay and during long-range surveys were 9526 and 5067 km respectively. The average of kilometers spent in each cell was 120.27 km. A total of 63 h (29.4% of total sighting time) were spent with short-beaked and long-beaked common dolphins during 83 sightings, lasting on average 51 min (range 5-185 min), and a total of 137 h (64 % of total sighting time) were spent with bottlenose dolphins during 137 sightings, lasting on average 64 min (range 3-262 min; Table 2). Over 5,000 animals belonging to *D. delphis* and *D. capensis*, and about 1,330 animals of *T. truncatus* were cumulatively counted in the field.

Occurrence, Sighting Frequencies and Distribution of the Three Species

In terms of number of schools observed year-round in the study area, bottlenose dolphins were the most frequently sighted species, followed by the two species of common dolphins. The number of sightings for the three species in the year 1997-2000 and during different seasons for the bay is illustrated in Figure 2*a,b,c*. Bottlenose dolphins were observed 49.3% of the time (n=278), mostly inshore (81.25 %). Both species of common dolphins were spotted 26.3% of the time (n=278), but only 8 times (9.6%) in inshore waters. Long-beaked common dolphins were slightly more abundant than short-beaked common dolphins in the years 1998-2000, although the difference in sighting number was not significant among the four years (*D. capensis* 59%, *D. delphis* 41%, n=61; χ^2=1.328, DF=1, P>0.05; Fig. 2*a*). Sighting frequencies for the three species are presented in Table 3.

The distribution of the three species under study in relation to the bathymetry of the bay is presented in Figure 3. Differences in distribution among species were evaluated comparing their positions among 8 different isobaths from 0 to 600 m. Species distribution differed significantly according to depth (χ^2=92.09, DF=7, P<0.001), with bottlenose dolphins inhabiting mostly inshore waters (0-50 m) and the two species of common dolphins being more frequent in deep waters (>50 m). The distribution of short-beaked common dolphins versus long-beaked common dolphins also differed significantly with depth (χ^2=21.19, DF=7, P<0.001), with short-beaked common dolphins showing a broader distribution, mostly along and between the 50-100 m isobaths. A significant difference between sightings of the three species near canyons, escarpments, slopes and bottom reliefs in comparison to flat areas and plateaus was observed (χ^2=22.41, DF=5, P<0.001), with all species showing a preference for canyons, escarpments, slopes and bottom reliefs. No significant difference was observed between short-beaked common dolphins and long-beaked common dolphins in terms of their proximity to canyons (Dume, Santa Monica, Redondo) and escarpments/slopes (continental slope, west of Los Angeles slope, south of Malibu mountain slope; χ^2=1.95, DF=5, P>0.05).

Presence of Delphinus *spp. in Inter-specific Schools*

Short-beaked common dolphins and long-beaked common dolphins were found exclusively in distinct schools. In offshore waters, common dolphins were observed twice in mixed schools with other cetacean species (*n*=83); once with Pacific white-sided dolphins, *Lagenorhynchus obliquidens*, and once with minke whales, *Balaenoptera acutorostrata*. In inshore waters, both common dolphin species were observed 87.5% of the time (*n*=8) in mixed schools with inshore bottlenose dolphins.

DISCUSSION

In Santa Monica Bay, bottlenose dolphins were the most observed of all cetacean species, followed by long-beaked common dolphins and short-beaked common dolphins. Within the bay, coastal bottlenose dolphins were found mostly within 500 m of shore, in agreement with observations of bottlenose dolphins along the San Diego coastline (Defran and Weller 1999, Defran *et al.* 1999). The high occurrence of *Delphinus* spp. in Santa Monica Bay is also consistent with reports for other areas (Southern California Bight: Norris and Prescott 1961, Leatherwood *et al.*1988, Bonnell and Dailey 1993; California coast: Forney and Barlow 1998). Other authors have reported that elsewhere this genus consists of two species in the Eastern North Pacific: an offshore species (*D. delphis*) and a coastal species (*D. capensis*) (Heyning and Perrin 1994, Rosel *et al.* 1994, Rice 1998). In Santa Monica Bay, however, although both species were sighted year-round, no separation of *D. delphis* and *D. capensis* between inshore and offshore waters was ever observed.

Long-term studies on occurrence, distribution and range characteristics of inshore bottlenose dolphins suggests that dolphin distribution may be related to the distribution and abundance of nearshore prey within the highly dynamic coastal ecosystem of Southern California Bight (Defran and Weller 1999, Defran *et al.* 1999). The high year-round presence of bottlenose dolphins in Santa Monica Bay may be explained by a year-round presence of nearshore prey (Deets and Roney 1999, California Department of Fish and Game 2000, M. Bearzi pers. comm.). This conclusion is supported by the time spent in feeding or in diving activities by this species (38.8% of total time; M. Bearzi unpublished data).

The low number of sightings of short-beaked common dolphins and long-beaked common dolphins immediately next to the coast may be also correlated to prey preference and abundance as well as the year-round high occurrence here of bottlenose dolphins, which generally feed on different prey than *Delphinus* spp. in Southern California waters (Table 4). Stomach content analysis from inshore bottlenose dolphins along the California coast show that 74% of their prey were either surfperches (*Embiotocidae*) or croakers (*Scianidae*) (Norris and Prescott 1961, Walker 1981, Hanson and Defran 1993). These prey species are non-migratory and present year-round in shallow coastal waters of the Southern California Bight (Dailey *et al.* 1993). For *D. delphis*, Evans (1975) found that 62% of this species' prey in the Bight were anchovies (*Engraulis mordax*) whereas Fitch and Brownell (1968) and Schwartz *et al.* (1992) reported that squid (family *Gonatidae* and *Loligo opalescens*) and Pacific whiting (*Merluccius productus*) were primary food sources. These prey species are primarily pelagic inhabitants of the Bight (California Department of Fish and Game 2000). In Santa Monica Bay, therefore, bottlenose dolphins and the two species of common dolphins differ both in distribution and prey preference (Figure 3, Table 4). I suggest that the habitat partitioning of these species is a consequence of prey specialization and competition for resources in inshore waters.

High abundance, year-round occurrence, and habitat partitioning for bottlenose dolphins, long-beaked common dolphins and short-beaked common dolphins in the bay correlated also to the bathymetry of this region as reflected by prey distribution. The importance of prey distribution in relation to cetacean occurrence has been discussed for other localities around the world (Cockcroft and Peddemors 1990, Acevedo and Würsig 1991, Smith and Whitehead 1993, Gowans and

Whitehead 1995, Defran *et al.* 1999). In Santa Monica Bay, bottlenose dolphins usually did not overlap with the distribution of the two species of common dolphins except near Redondo Canyon and the continental slope south of Palos Verdes Peninsula. Corresponding to these bathymetric features, bottlenose dolphins were observed offshore in similar locations of the two species of common dolphins (Fig. 3). Presumably the high concentration and overlapping of dolphin species in proximity to Redondo Canyon and the continental slope is associated with the bathymetry of these regions in contrast to other areas of the bay. Compared to Santa Monica and Dume canyons, Redondo Canyon is the deepest canyon with the steepest incline and the continental slope south of Palos Verdes is also steeper than the other slopes in the bay (Dartnell 2000). Upwelling of highly oxygenated and nutrient-rich water was found over the San Pedro shelf and eddy-like features near the slopes in the southern half of Santa Monica shelf were also observed using satellite sea surface temperature data (Hickey 1992, 1993). These oceanographic features are optimal for mixing of nutrients and are consequently rich in prey providing advantageous feeding grounds for dolphins. Anchovies (*Engraulis mordax*), a common prey of *D. delphis* in the Bight (Evans 1975), are known to concentrate in submarine canyons and escarpments in areas of upwelling (Mais 1974, Hui 1979). An abundance of prey near Redondo Canyon and the continental slope south of Palos Verdes can explain the overlapping of the three species in the same areas. Considering that bottlenose dolphins and both species of common dolphins generally feed on different prey (Table 4), these species might co-occur at these locations without competition for resources.

Although Redondo Canyon and the continental slope have the highest concentration of sightings, other locations of the bay near canyons, escarpments and sea bottom reliefs show a significant difference in number of schools compared to flat areas and plateaus, indicating a preference for canyons, escarpments and sea floor reliefs by the two species of common dolphins and by bottlenose dolphins. These results show interesting parallels with white-sided dolphins (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) along the continental shelf of Northeastern United States (Selzer and Payne 1988), and various odontocetes near a submarine canyon on the Scotian Shelf (Gowans and Whitehead 1995). Other authors have also reported the presence of the genus *Delphinus* along sea floor reliefs, submarine canyons and escarpments (Hui 1979, Polacheck 1987, Selzer and Payne 1988, Gaskin 1992, Gowans and Whitehead 1995), showing that undersea topography, rather than water depth, is the most significant feature influencing the distribution of *Delphinus* spp. in the Southern California Bight.

In Santa Monica Bay, even if *D. delphis* and *D. capensis* have a remarkable preference for the same escarpments, sea floor reliefs and submarine canyons, *D. delphis* shows a less defined distribution, predominantly along and between the 50-100 m isobaths. Short-beaked common dolphins have flexible behavior and are opportunistic feeders that can vary their movements with availability of the most abundant and catchable prey (Evans 1975, Young and Cockcroft 1994, Neumann 2001*a*, *b*). In Santa Monica Bay, it is possible that *D. delphis* displays a more opportunistic behavior exploring broader areas. The year-round presence and co-occurrence of these species in the study area in space and time over four years, may be related to productive feeding grounds, rich enough in prey to support their feeding requirements. This is suggested by the great amount of time spent feeding or diving (about 30% of total time; M. Bearzi, unpublished data) in comparison to data reported by Neumann for the Bay of Plenty, New Zealand (2001*b*; 17% of total time).

Shifts in abundance of *D. capensis* and *D. delphis* were observed since the last century in southern California waters (Banks and Brownell 1969). From 1970 to 1990, Heyning and Perrin (1994) found gradual shifts in their abundance, with more *D. delphis* (84.4% presence, n=109) prior to 1982 and more *D. capensis* (88.2% presence, n=34) from 1983 to 1988, corresponding to the 1982-83 El Niño event. From 1989 to 1990 the pattern was less clear, with a 37% presence of *D. capensis* and 63% of *D. delphis*. In this study, *D. capensis* were the better represented in the bay starting from 1998, at the end of the 1997-1998 El Niño, showing a pattern similar to the one previously observed by Heyning and Perrin (1994). These authors suggested that environmental factors may be more advantageous to one or the other species at different times. However, differences in habitat use between *D. delphis* and *D. capensis* are complex, considering the similar diet of the two species (Fitch and Brownell 1968, Schwartz *et al.* 1992, Ohizumi 1998). In the Southern California waters, stomach content analyses showed that *D. delphis* feed more on squid, prey usually caught at depth during the day or at surface at night, than do *D. capensis* (Schwartz *et al.* 1992). Decreased squid abundance during the two last El Niño events (California Department of Fish and Game 2000) could partially explain the higher presence of *D. delphis* before both El Niño events and the decrease in number after these events. The slight difference in diet could also indicate a separation of ecological niches reducing the occurrence of direct competition for food resources when the dolphins are sympatric. Different preferences in prey for sympatric dolphins were observed by other authors (Ferretti *et al.* 1998, Das *et al.* 2000, Hale *et al.* 2000). Gowans and Whitehead (1995) explained the co-occurrence of species either by a superabundance of food or by a slightly different diet that may eliminate a competitive pressure between the species. Similar hypotheses can be drawn for the two species of common dolphins in Santa Monica Bay. Further data on common dolphin diet for the two species would help understand differences in habitat use for the study area.

Presence of Delphinus *spp. in Inter-specific Schools*

Although short-beaked common dolphins and long-beaked common dolphins were both sighted in similar locations of the bay, confirming a sympatric micro-range, no occurrence of the two species in mixed schools was ever observed, in agreement with information reported by Heyning and Perrin (1994). In addition, although mixed-schools of cetaceans are known around the world (Norris and Dohl 1980, Polacheck 1987, Selzer and Payne 1988, Gallo Reynoso 1991), mixed groups of short-beaked common dolphins and long-beaked common dolphins with other cetaceans were rarely observed in the study area.

SUMMARY

Spatial habitat partitioning by different dolphin species is frequently discussed but has rarely been described in detail (Selzer and Payne 1988, Gowans and Whitehead 1995). This study provides a description of habitat partitioning by *T. truncatus*, *D. delphis* and *D. capensis* in Santa Monica Bay. Bottlenose dolphins were found year-round in shallow waters, clearly separated from the distribution of the two common dolphin species, but they were also observed occasionally in deeper waters over the continental shelf and pelagic waters outside the bay. *D. delphis* and *D. capensis* were also found year-round in the bay but mostly far from shore. Both common dolphin species were sighted near escarpments, bottom reliefs and submarine canyons. Although they were observed in similar locations of the bay, confirming their sympatric range, these two species were never seen in mixed schools. This study offers the basis for further investigations on the ecology of prey consumed by the three species of odontocetes as well as the important role played by oceanographic features.

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FIGURE LEGENDS

Figure 1.

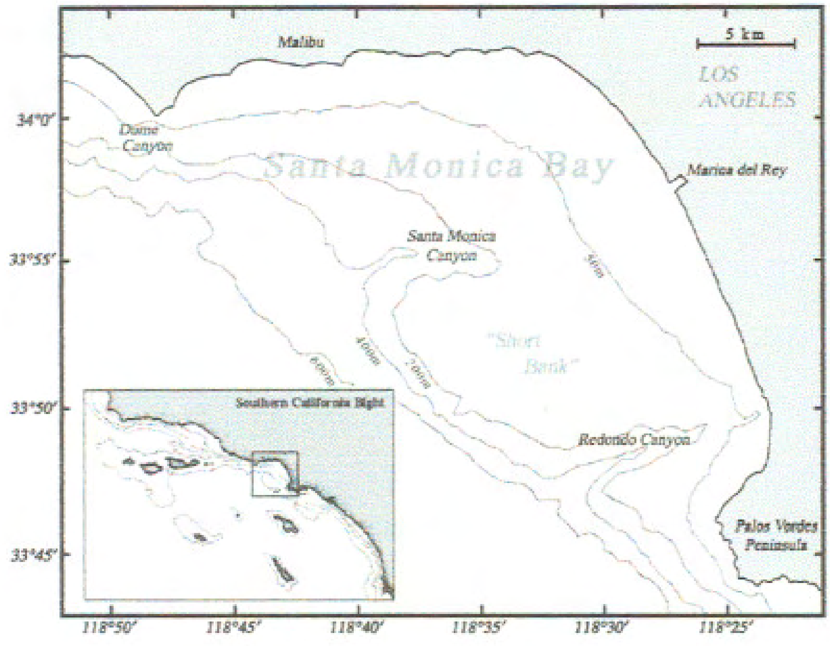
Study area.

Figure 2a,b,c.

(a) Number of sightings for the three species in the years 1997-2000, (b) number of *D. capensis*, *D. delphis*, and *Delphinus* spp. sightings, and (c) number of *T. truncatus* sightings observed during inshore and offshore surveys for Santa Monica Bay. Sightings in Figure 2*b,c* were divided into four seasonal categories: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November). Surveys were carried out evenly during the years except for December 1999* and October 2000* where no data collection was conducted.

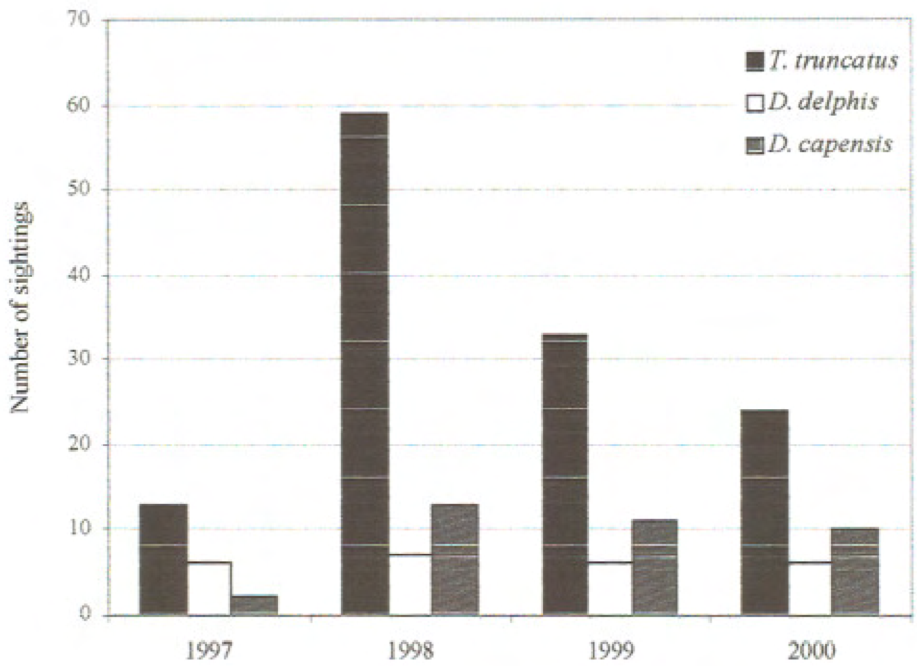
Figure 3.

Distribution of bottlenose dolphins (X), short-beaked common dolphins (●), and long-beaked common dolphins (❑) in the bay. Each symbol represents initial GPS coordinates of sightings. Sightings outside the bay and sightings of *Delphinus* spp. not recognized at the species level were excluded from this map. Submarine canyons (Dume, Santa Monica, Redondo), bottom reliefs and escarpments/slopes (Palos Verdes continental slope, west of Los Angeles slope, south of Malibu montain slope) include respectively sightings located no farther than ¼ of mile from each side of the canyons and the isobaths, and 1 mile from the centers of the slopes. Flat areas and plateaus include all the sightings observed in these locations.



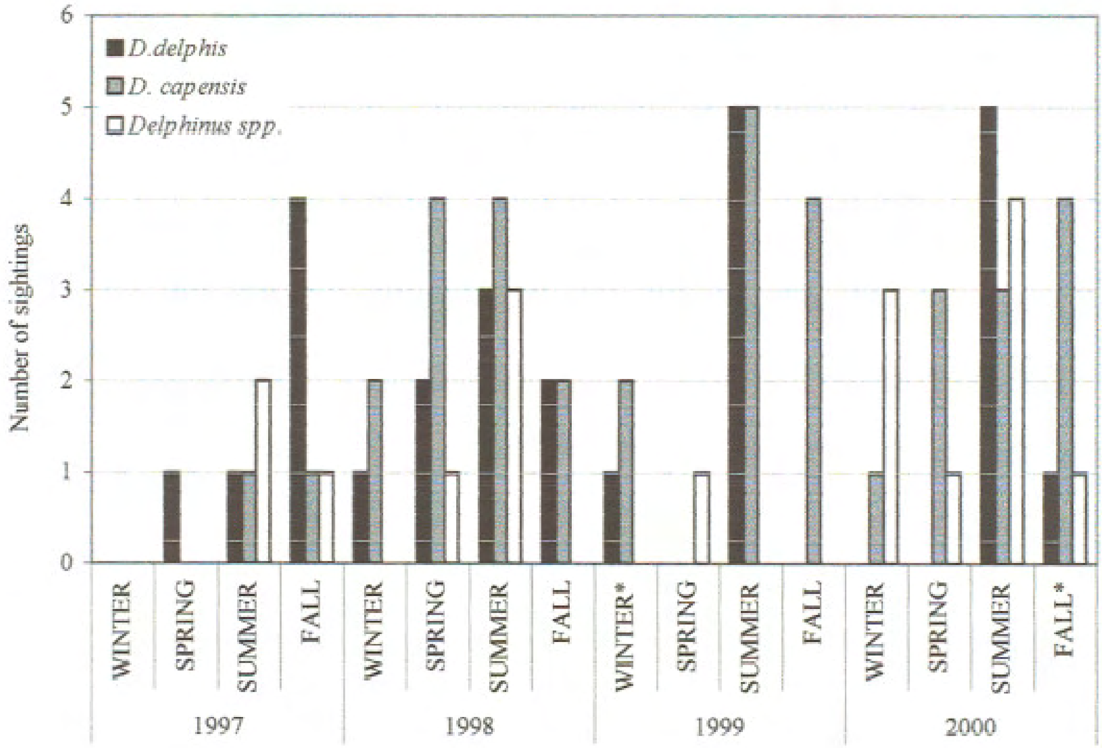
Malibu
5 km
LOS ANGELES
34°0'
Dume Canyon
Santa Monica Bay
Marina del Rey
Santa Monica Canyon
33°55'
"Short Bank"
33°50'
Southern California Bight
Redondo Canyon
Palos Verdes Peninsula
33°45'
118°50'
118°45'
118°40'
118°35'
118°30'
118°25'

Figure 1.



70
60
50
40
30
20
10
0
Number of sightings
T. truncatus
D. delphis
D. capensis
1997
1998
1999
2000

Figure 2a.



D.delphis
D. capensis
Delphinus spp.
Number of sightings
0
1
2
3
4
5
6
WINTER
SPRING
SUMMER
FALL
WINTER
SPRING
SUMMER
FALL
WINTER*
SPRING
SUMMER
FALL
WINTER
SPRING
SUMMER
FALL*
1997
1998
1999
2000

Figure 2b.

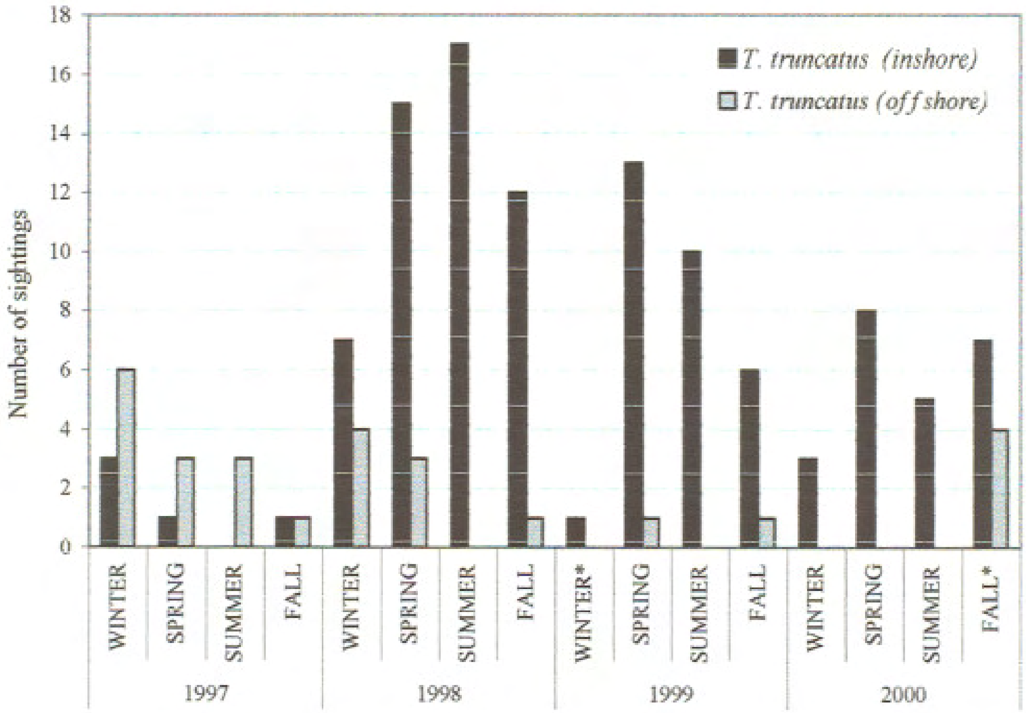

T. truncatus (inshore)
T. truncatus (off shore)
Number of sightings
0
2
4
6
8
10
12
14
16
18
WINTER
SPRING
SUMMER
FALL
WINTER
SPRING
SUMMER
FALL
WINTER*
SPRING
SUMMER
FALL
WINTER
SPRING
SUMMER
FALL*
1997
1998
1999
2000

Figure 2c.

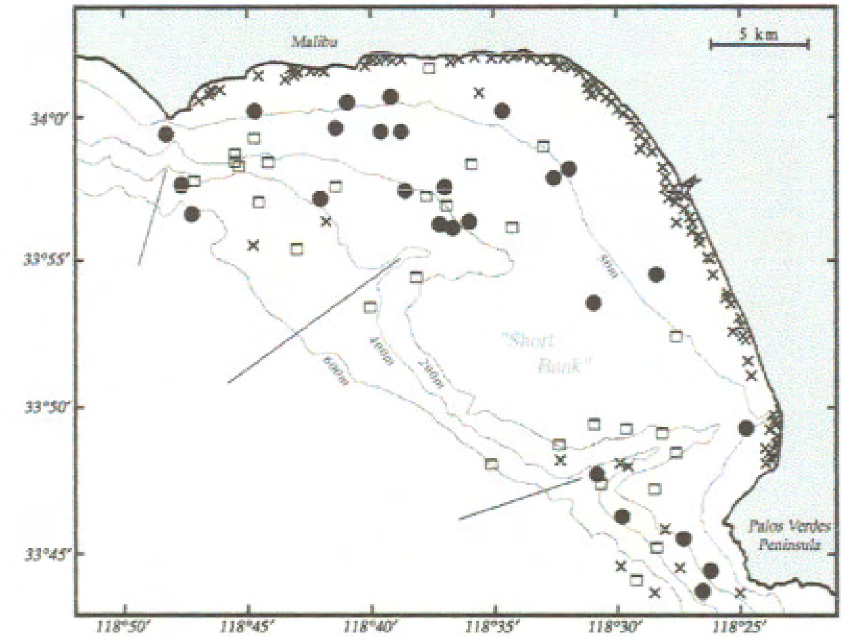

Malibu
5 km
34°0′
33°55′
33°50′
33°45′
"Short
Bank"
600m
400m
200m
50m
Palos Verdes
Peninsula
118°50′
118°45′
118°40′
118°35′
118°30′
118°25′

Figure 3.

TABLES

Table 1. Number of inshore, offshore, and combined inshore/offshore surveys in Santa Monica Bay, and number of long-range surveys in the Channel Islands waters (Catalina Island, Santa Barbara Island and Santa Cruz).

Year	Inshore	Offshore	Inshore/Offshore	Long-range	Total
1997	5	23	8	3	39
1998	17	3	31	7	58
1999	12	5	23	4	44
2000	6	4	19	8	37
Total	40	35	81	22	178

Table 2. Summary of research effort in the field for the years 1997-2000.

	1997	1998	1999	2000	Total
Hours spent in the field	144	224	178	149	695
Hours spent searching for cetaceans	110	136	130	105	481
Hours spent with cetaceans	34	88	48	44	214
Hours spent with *Delphinus* spp.	9	17	18	19	63
Hours spent with *T. truncatus*	17	63	35	22	137
N of sightings*	41	108	66	54	269
N of *Delphinus* spp. sightings*	10	26	24	23	83
N of *T. truncatus* sightings*	19	61	33	24	137
N of 5-min samples	295	1065	698	525	2583

* one mixed school is counted as 1 sighting

Table 3. Sighting frequencies of the three most observed cetacean species in the bay.

	1997	1998	1999	2000	Total
Tursiops truncatus					
Number of sightings	19	61	33	24	137
Sighting frequency (sightings/hour)	0.13	0.27	0.19	0.16	0.20
*Delphinus spp.**					
Number of sightings	10	26	24	22	82
Sighting frequency (sightings/hour)	0.07	0.12	0.14	0.15	0.12
Delphinus delphis					
Number of sightings	6	7	6	6	25
Sighting frequency (sightings/hour)	0.04	0.03	0.03	0.04	0.04
Delphinus capensis					
Number of sightings	2	13	11	10	36
Sighting frequency (sightings/hour)	0.01	0.06	0.06	0.07	0.05

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

Table 4. Diet of *T. truncatus* and *Delphinus* spp. in Southern California waters. N=nearshore prey, O=offshore prey, B= prey present in both, inshore and offshore waters (*e.g.,* different seasons, different life stages, etc.)

Prey	**Habitat**	***T. truncatus*[1]**	***Delphinus* spp.**
Walleye surfperch *(Hyperprosopon argenteum)*	N	X	
Pile surfperch (*Damalichthys vacca*)	N	X	
Black surfperch (*Embiotoca jacksoni*)	N	X	
Shiner surfperch (*Cymatogaster aggregatus*)	N	X	
White surfperch (*Phanerodon furcatus*)	N	X	
Barred surfperch (*Amphistichus argenteus*)	N	X	
Blacksmith (*Chromis punctipinnis*)	N	X	
Spotfin croaker (*Rancador stearnsi*)	N	X	
Kelp bass (*Paralabrax clathratus*)	N	X	
Smelts (Osmeridae)	N	X	X
Queenfish *(Seriphus politus)*	N	X	X
California halibut (*Paralichthys californicus*)	B	X	
Yellowfin croaker (*Umbrina rancador*)	B	X	
White croaker *(Genyonemus lineatus)*	B	X	
California corbina *(Menticirrhus undulates)*	B	X	
Specklefin midshipman (*Porychthys myriaster*)	B	X	
Octopoteuthidae	B	X	
Plainfin midshipman *(Porychthys notatus)*	B	X	X
Cusk eel (Ophidiidae)	B	X	X
Jack mackerel (*Trachurus symmetricus*)	B	X	X
Northern anchovy *(Engrualis mordax)*	B	X	X

Market squid *(Loligo opalescens)*	B	X	X
Sardine *(Sardinops coerulea)*	B		X
Pacific mackerel (*Scomber japonicus*)	B		X
Pacific whiting *(Merluccius productus*)	O		X
Northern lampfish *(Stenobrachius leucopsarus)*	O		X
Bonito (*Sarda chiliensis*)	O		X
California Smoothtongue (*Bathylagus stilbius*)	O		X
Pacific pompano (*Peprilus simillimus*)	O		X
Lanternfish (Myctophidae)	O		X
Medusafish *(Icichthys lockingtoni)*	O		X
Onychoteuthidae	O		X
Gonatus sp.	O		X

[1] Walker 1981, Hanson and Defran 1993 (for coastal populations)

[2] Norris and Prescott 1961, Fitch and Brownell 1968, Evans 1975, 1994, Schwartz *et al.* 1992, Bonnell and Dailey 1993, M. Bearzi pers. comm.