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HERD SEGREGATION IN HARBOR SEALS AT POINT REYES, CALIFORNIA [1]

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A mixed class aggregation of harbor seals resides at Double Point, California. Seals are present year round but are more abundant during the March through June breeding season. Seals were segregated by sex and age class within the herd, and patterns changed during the season. Early in the 1984 and 1985 breeding seasons the herd was equally composed of males, females, and immatures, but mid-way was composed of mostly females and pups. Late in the season more males and immatures were present. We hypothesize that changes in segregation patterns are related to intolerance of males and immatures by pregnant females and females with pups.

INTRODUCTION

The harbor seal, *Phoca vitulina,* is gregarious when hauled out on shore. Scheffer and Slipp's (1944) contention that harbor seal aggregations are composed of mixed ages and sexes, has been modified by observations that groups can be composed almost exclusively of one class; for example, nursery (Knudtson 1977, Naito and Konno 1979, Brown and Mate 1983, and Slater and Markowitz 1983), bachelor (Knudtson 1977), and juvenile aggregations (Payne and Schneider 1984). These variations in group structure have been correlated to availability of haul-out space and reproductive and feeding strategies.

Little is known about spatial segregation within mixed aggregations. We studied such segregation during the breeding season with two objectives: (i) to identify herd composition; (ii) and to determine whether the relative space-use pattern of various age/sex categories changed as the season progressed.

METHODS

Double Point is a coastal habitat named for its concave, steep, cliff-backed beach enclosed by two jagged promontories and is located in Marin County, California (lat 37° 56′ N, long 122° 46′ W). We censused a mixed sex/age group of seals at south Bolsa Beach, a pocket beach at Double Point, nine times during the 1984 and 12 times during the 1985 breeding seasons. Observations were conducted during midday, low to medium low tides when maximum numbers of seals were assumed to be present (Stewart 1984, Allen et al. 1985). South

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Bolsa Beach contained 75–100% of the total seals present at Double Point. We divided the breeding season into Early (March to mid-April), Middle (mid-April to mid-May), and Late (mid-May to mid-June) periods. These periods were based on the reproductive status of the majority of females and on the age of the pups (early = mostly pregnant females and few pups, middle = majority of females with pups, late = older and weaned pups). We censused each period three times in 1984 and four times in 1985. Censuses were done a week apart and were conducted by one observer from the cliff 30 m above the haul-out.

We classified seals as adult male, adult female, immature, and pup. Immature seals were distinguished from adults based on relative size. Seals mature at ages 3–5 (Boulva and McLaren 1979) so some overlap would be expected between the immature and other categories. Pups were easily distinguished by their small size and bright silver pelage at a time when adults and immatures are in their pre-molt condition. Females were further categorized as pregnant, non-pregnant, or with pup. Males were distinguished from females by the penal opening on the ventrum. Because adult male and female seals are almost identical in size and seals often lay on their ventrum, we were not able to sex all adult animals but were able to classify an average of 71% of the herd. We assumed that males and females were equally likely to lay on their ventrum.

We calculated the average percent representation of each sex/age category and standard deviation for each period. To determine relative spatial position, we divided the herd into quadrants from the south to the north end of the herd (A south, B, C, D north). Each quadrant equaled one quarter of the total number of seals hauled out on south Bolsa Beach on a given day; throughout the season, quadrant A was bordered by tide pools and B,C,D by deep water. We tested the null hypothesis for independence of position with sex and age class for each breeding period for each season with a Chi-square test of independence and analysis of residuals (Bishop, Fienberg and Holland 1975, Fienberg 1980).

RESULTS

The prevalence of each sex/age class changed as the breeding season progressed in both 1984 and 1985 (Table 1). During the early period, males, females, and immatures were equally abundant, and pups began to appear; during the middle period the herd was composed primarily of females and pups; and during the late period females and pups still were most abundant, although in 1985 the percentage of males began to increase then.

The level of spatial sex/age segregation also changed over the course of the season. The null hypothesis, independence of position in the herd with respect to sex and age class, was rejected for all three periods for both years (Table 2). Analysis of residuals indicated that in the early period most females hauled out in quadrant D, most immatures were in quadrant A, and males tended to be in quadrants B and C. In the middle period females and pups were uniformly present in all quadrants, fewer males were in quadrant D and immatures tended to be absent from quadrant D. In the late period most females were present in quadrant D, more males were present in quadrant B or C, and immatures and

weaned pups tended to be in quadrant A or B. For all three periods except late 1984 there was a strong tendency for immatures to be in the extreme opposite quadrant (A) of the herd from females (D).

TABLE 1. Percent Composition by Sex and Age Class at Double Point, California.

	1984		*1985*	
	$\bar{x}$*	*SD*	$\bar{x}$	*SD*
	n = 3		*n = 4*	
Early				
Male	31	2	22	9
Female	32	2	33	9
pregnant	(61)	–	(50)	–
with pup	(19)	–	(39)	–
non-preg	(20)	–	(11)	–
Immature	31	4	27	15
Pup	7	5	16	18
Count	170	90	249	65
Middle				
Male	12	5	8	3
Female	40	3	44	3
pregnant	(15)	–	(3)	–
with pup	(83)	–	(91)	–
non-preg	(2)	–	(6)	–
Immature	10	2	5	1
Pup	38	8	44	2
Count	296	103	299	46
Late				
Male	13	5	21	11
Female	38	7	44	10
pregnant	(1)	–	(0.2)	–
with pup	(62)	–	(51)	–
non-preg	(37)	–	(49)	–
Immature	17	11	10	5
Pup	32	8	25	7
Count	267	56	294	101

* $\bar{x}$ is the average for each period, SD is the standard deviation, and n is the number of censuses.
Percentages of pregnant females, females with pups, and non-pregnant females are taken with respect to total females.

Females of different reproductive status (pregnant or with pup) also tended to segregate within the herd (Table 1). Pregnant females seen primarily in the early period were mostly present in quadrant D whereas those with pups were present uniformly. During the middle and late periods, females with pups were still seen evenly distributed throughout all quadrants, and females that were neither pregnant nor with pup were primarily counted in quadrant C or D.

TABLE 2. Numbers of Seals by Sex and Age Class at Double Point, for Each Quadrant and Period Within the 1984 and 1985 Breeding Seasons.

		1984 Quadrant				*1985 Quadrant*			
Period	*Sex/Age Class*	*A*	*B*	*C*	*D*	*A*	*B*	*C*	*D*
Early.....	Male/adult	33 *	49	42	32	62	66	61	33 *
	Female/adult	35	41	33	50 *	48 *	65	103	141 *
	Immature	75 *	36	32	21 *	118 *	59	56	32 *
	Pup	13	9	5	5	22	29	47	52
		$X^2 = 42$	$p < 0.005$			$X^2 = 140$	$p < 0.005$		
Middle.....	Male/adult	22	33	31	13 *	26	28	35	9 *
	Female/adult	87	83	86	98	105	125	128	163
	Immature	37 *	16	18	13	32 *	10	10	3 *
	Pup	97	90	80	83	126	125	126	144
		$X^2 = 29$	$p < 0.005$			$X^2 = 62$	$p < 0.005$		
Late	Male/adult	26	13 *	28 *	18	54 *	103 *	50	34
	Female/adult	66	56	54	77 *	140	101	112	126 *
	Immature	37	26	36 *	23	110 *	19 *	24	20
	Pup	76	61	37 *	46	129	64	47	41
		$X^2 = 24$	$p < 0.005$			$X^2 = 141$	$p < 0.005$		

* The standardized residuals and Freeman-Tukey deviates for these cells are significant at $\alpha = 0.05$.

DISCUSSION

Segregation by haul-out location has been observed by others; however, these observations often occurred in estuaries or bays where ample haul-out space is available. On a rugged coastal site such as Double Point, haul-out space is limited, and seals form a mixed aggregation in one location. During the breeding season, the mixed aggregation of seals at Double Point is not random, but instead is structured by sex, age, and female reproductive status. We hypothesize that segregation on land is in part related to intolerance of males and immatures by females. The degree of segregation, which changed over the season, may be related to changes in the biological condition of females (parturition, weaning, and estrous). Segregation appeared most pronounced during the middle period when the majority of females were with pups; such females are particularly aggressive and will threaten nearby seals. The numbers of males and immatures were greatly reduced in all quadrants at that time, and females with pups were evenly distributed throughout all quadrants.

Many advantages exist for females to form sub-clusters within a herd while on shore. They are able to form and maintain tighter bonds with their offspring and to rest and nurse without interference from sexually active males. At the same time, they are able to retain the benefits of gregariousness (i.e. protection from predators, and proximity to males during the mating period). For segregation to persist into the late breeding period is not unexpected because mating occurs primarily in the water. While on shore, females in estrous rest and generally rebuff males (Allen 1985).

Some researchers have stated that topography and/or male social interactions dictate the spacing patterns of harbor seals on shore (Sullivan 1982, Slater

and Markowitz 1983). At Double Point, topography may have partially influenced herd segregation. Ample haul-out space was available at all but the highest of tides; however, ready access to deep water was limited to quadrants B, C, and D. Our observations indicated that in the early breeding period, females, the majority of which are pregnant, may choose quadrant D over the others because there is more space for birthing. Later, females nursing pups shift to quadrants A and B because of proximity to tide pools which are ideal "nursery pens" providing warm, calm water. During very low tides we consistently observed females with pups in these pools. In the late period, immatures and weaned pups may have been relegated to quadrant A because females, most probably in estrous, would be intolerant to them. Most males were in quadrant B with ready access to deep water and departing females.

Our observations provided no evidence for or against a male dominance hierarchy. A few males were present in quadrant D which could be interpreted as active exclusion of other males; these males, however, were often clustered rather than dispersed within the quadrant.

In conclusion, our results indicate that spatial segregation occurs within a mixed aggregation of harbor seals and that the relative space-use pattern of the different age/sex categories changed over the course of the breeding season as the reproductive status of females changed. We hypothesize that segregation is related to female intolerance of males and immatures. Proof that females are actively excluding other categories would require quantification of interactions between females of different reproductive status and males and immatures.

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