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MOVEMENT AND ACTIVITY PATTERNS OF HARBOR SEALS (PHOCA VITULINA) FROM THE DRAKES ESTERO POPULATION, CALIFORNIA, 1985-86

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NOTICE

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INTRODUCTION

Harbor seal colonies in the Point Reyes area, Marin County, contribute about 20% of the mainland California breeding population (Allen and Huber 1984, Hanan et al. 1986) and consequently deserve attention when devising regional management policies. Estimates for the size of the state and Point Reyes populations are based on direct ground and aerial counts, without corrections for the number of seals hauled out on a given day relative to the total number of seals present in the area. Consequently, estimates are rough, and are likely low. In addition, it is difficult to relate numbers among seasons. This problem is not unique to the Point Reyes population.

Several researchers have addressed the problem using marked animals and have derived correction factors with varying attendance patterns based on location, time of day, and season of year (Brown and Mate 1981, Pitcher and McAllister 1981, Stewart and Yochem 1983, and Sullivan 1979). Stewart and Yochem (1983) for the Channel Islands and Sullivan (1979) for Humboldt Bay, California, found that seals spent about 40% of each day hauled out. Stewart and Yochem (1983) determined that marked seals hauled out on 65% of the days in May, 58% in June, and 35% from October through December. Pitcher and McAllister (1981) estimated that seals in Alaska hauled out on 50% of the days in June and 41% in August, and Herder (1986) found that seals in the Klamath River area hauled out on average 56% of the days in April and 64% in May.

These researchers determined that the differences between total number hauled out and the estimated population were a function of variations in

daily haul-out patterns as well as movements to other areas. Brown and Mate (1983) determined that dispersal accounted for seasonal changes in the number of seals hauled out in Oregon. Movements appeared to be associated with seasonal changes in reproductive status and in response to feeding strategies (Brown and Mate 1983, Herder 1986). Seals at the Klamath River, California, moved locally to alternate haul out sites year round and dispersed long distances in winter months (Herder 1986). With the exception of one inter-island movement, Stewart and Yochem (1983) found seal movements were local, leading them to conclude that reduced hauling frequency accounted for the decline in seal numbers during the fall and winter months.

In the Point Reyes area we determined previously that seals displayed diurnal and seasonal variation in haul-out patterns (Allen and Huber 1983, 1984). Diurnal and tidal effects on seal haul-out behavior varied within an optimum range with most seal hauled out from mid-day to late afternoon at low to medium tides, depending on the physical attributes of each location. The diurnal pattern was similar to that of the southern Channel Islands (Stewart 1984), Mowry Slough in San Francisco Bay (Fancher 1979), Southeast Farallon Island (Ainley et al. 1977), and Bolinas Lagoon (Allen et al. 1985). Seals were seasonally most abundant during the spring and summer, coincident with the breeding and molt periods. Maximum numbers reached 2449 in May and 2502 in June 1983-84. During the fall and winter, the maximum number of seals was around 1000 animals. It appeared that seals were either moving to other haul-out sites outside of Point Reyes in the winter, or spending more time at sea.

Information on seasonal activity patterns and fall/winter movements would be invaluable for any long-term management program for seals in the Point Reyes area, and, in conjunction with results accumulated elsewhere (Stewart and Yochem 1983; Herder 1986), could provide more accurate estimates of the California harbor seal population.

In an effort to identify movement and seasonal activity patterns, we undertook a radio-tagging program of harbor seals in Point Reyes. We chose this method based on the successful results obtained from radio-telemetry studies by Brown and Mate (1983), Herder (1986), Pitcher and McAllister (1983), and Stewart and Yochem (1983). Our main objectives were to determine 1) if the apparent decline in seal numbers during the winter months was a function of dispersal and seasonal movements, or a reduction in the frequency of the haul-out pattern, 2) the destination of departing animals, 3) daily and seasonal variability in haul-out behavior, and 4) if gender accounted for variations in the above.

STUDY AREA AND METHODS

Drakes Estero is an estuary where seals haul out on tidal mud flats exposed at low, medium, and medium-high tides, as well as on the tip of Limantour Beach exposed at all tide levels. This location is one of the main breeding areas in the Point Reyes area (Figure 1). Significantly more seals were present during the spring and summer than during fall or winter; however, in contrast to the two other important areas, Tomales Point and Double Point, seals were present in substantial numbers year round (Allen and Huber 1983, 1984). A maximum of 122 pups was counted in May 1983, accounting for 19% (122/656) of the total numbers of seals present. Twenty-three percent (122/527) of all pups in the Point Reyes area occurred at Drakes Estero in 1983.

We chose to tag seals at Drakes Estero because of its significance to the Point Reyes population, because seals there exhibited the seasonal and diurnal activity patterns characteristic of seals elsewhere in the area, and because the capture technique we wished to use was only possible in an estuarine environment.

Over a two-day period (July 31 - August 1) in 1985, we successfully captured about 60 seals and affixed radio transmitters to 17 (nine males and eight females). Our intention was to obtain a sample size of 10 females and 10 males, rather than to randomly capture and tag whatever seals happened to be caught; therefore, we released unmolted and immature seals. Personnel from the Point Reyes National Seashore, the Point Reyes/Farallon Islands National Marine Sanctuary, the National Marine Fisheries Service, the California Department of Fish and Game, the Oregon

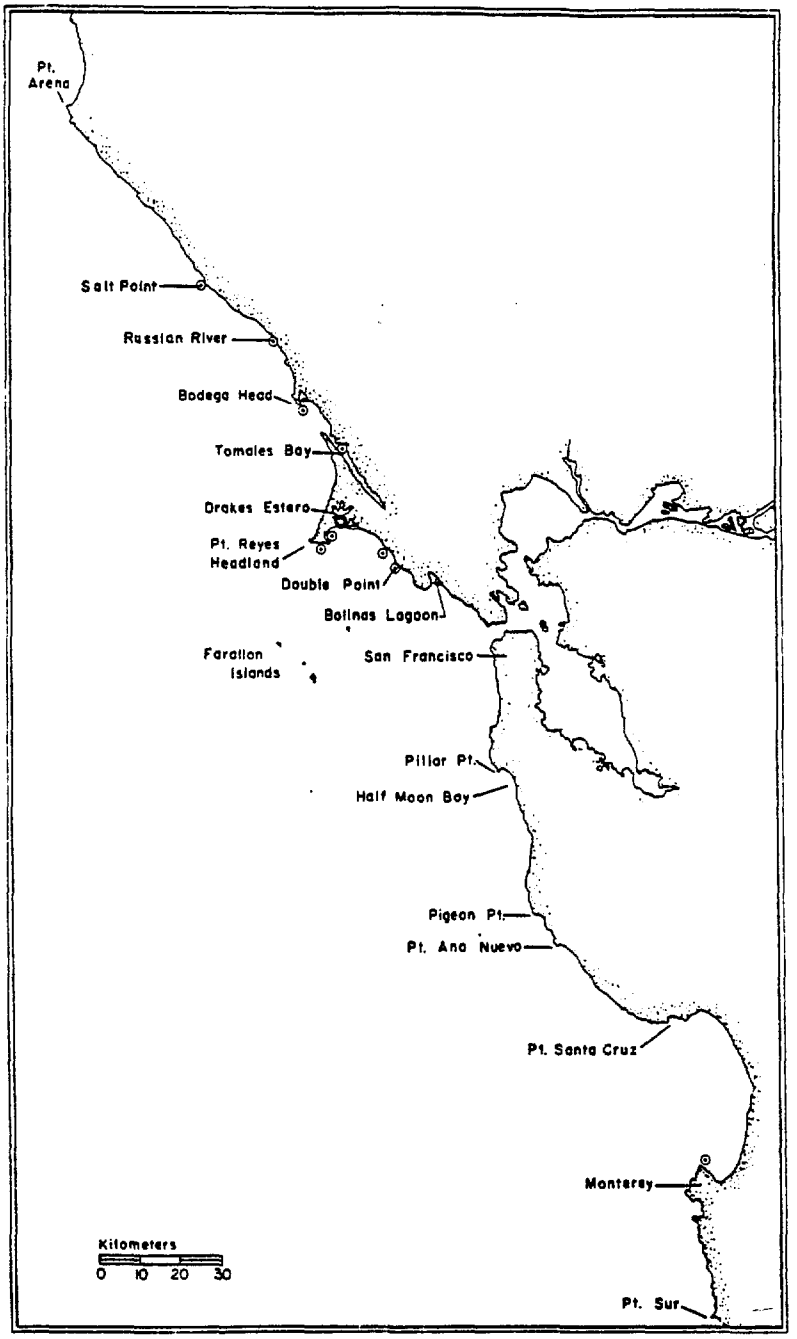

FIGURE 1. Capture site and locations of movement of harbor seals in California, 1985-1986.

Department of Fish and Wildlife, and the Point Reyes Bird Observatory assisted in the capture. We captured seals in a 60-fathom long gill net, with 8-inch mesh, set off the haul-out site and then pulled ashore. Two power boats were used to deploy the net adjacent to the haul-out site. The lead boat carried the net on a platform set above the transom. This boat approached the hauled out seals as rapidly as possible, set the net as the seals entered the water, and then landed on the far side of the haul-out beach. The second boat retrieved the other end of the net and landed. A third boat carried supplies and additional personnel for handling the seals. This method of capture was successfully developed and used in Washington and Oregon for capturing harbor seals in estuaries and enabled the researcher to capture a large number of seals over a short period of time, thereby minimizing the duration of disturbance days to the herd (Beach et al. 1985).

Captured seals were removed from the large net and individually placed in small hoop nets. This temporarily restrained the animals before they were tagged and reduced aggressive interactions between seals, thus reducing injury. Seventeen people were involved in handling the seals. One person recorded data, three weighed seals, two monitored the condition of seals retained in hoop nets, two marked seals with flipper-tags, two to three restrained seals being tagged, one attached the radio transmitter, and one supplied the equipment (tags, resin, etc.). All 17 people were needed to pull the net ashore and place seals in hoop nets.

Captured seals were weighed, measured (length and girth), sexed, flipper-tagged, dye-marked, and radio-tagged. The average time required to

accomplish this was 15-20 minutes per seal. When the tide level began to flood the haul-out site, any remaining seals were transferred by boat to the mainland for processing. Red Woolite sheep dye which lasts for about three months was used to mark each seal for easy visual resighting. Fourteen seals were flipper-tagged with lime green "Riese" cattle ear tags supplied by NMFS. Two neoprene patches with an individual number code and a color code for gender were glued with "Lock-tight" super glue to the fur between the shoulder blades to provide an additional visual mark. A radio transmitter manufactured by Advanced Telemetry Systems, Inc. (Bethel, Minnesota) was glued to the fur on the back of the seal's head with "Devcon" 5-minute epoxy (for attachment procedures see Beach et al. 1985). By attaching the radio tag to the head of the seal we were able to locate seals when they were in the water. Radio transmitters were 9 x 3 x 3 cm, weighed 60 gms, had a 13-inch flexible antenna, and a life expectancy of 300 days. Each transmitter had a frequency within the range of 164-165 Mhz, transmitting 55 pulses per minute.

We monitored seals with an automated recording station and aerial surveys. The automated recording station was established on a bluff overlooking Drakes Estero and consisted of an "Esterline Angus" 20-channel strip chart recorder, a programmable scanning receiver, a 12-volt marine battery, and a "Yagi" antenna. The station recorded seals within a two-mile radius on a 24-hour basis. Each frequency was monitored by the scanning receiver for 32 seconds and was scanned five to six times per hour. A seal was considered hauled out if it was recorded with two strong pen marks in a row within a half-hour period; a seal was considered in the

vicinity but in the water if a strong pen mark in conjunction with two weak marks within a half-hour was recorded. We manually checked frequencies to determine if radio interference from the nearby radio communication facilities (U. S. Coast Guard Station and RCA Gobal Communications Center) triggered pens and found that interference did not hinder distinguishing whether a seal was hauled out. Radio interference on one frequency prevented our distinguishing whether one animal was in the water but did not hinder our distinguishing when it was hauled out; interpretation was not impaired for the other frequencies. A test transmitter was placed near the remote station to verify that the receiving system was functioning properly. The remote receiving station was in operation from July 31 through September 5, and from October 25 through December 31, 1985; and from January 1 through February 16, and February 21 through April 30, 1986.

We checked and maintained the remote station almost daily in August and semi-weekly for the rest of the study period. During visits we scanned all frequencies and checked for signal drift. Each signal was checked for a period of five to ten minutes to detect seals in the water. We based this scan period from averaging dive times of tagged seals during the first month of the project ($\bar{x}$ = 3 min, range = 5 sec - 9 min 45 sec, SD = 2 min, n = 76). We made visual searches for marked animals to check for transmitter loss or failure.

We also conducted all-day censuses at Drakes Estero to compare the diurnal haul-out pattern of the herd with those of individually marked seals. For both summer and winter, individual patterns were similar to those of the herd (Table 1). Consequently, we were confident in making

Table 1. Diurnal haul-out pattern of the herd in comparison to that of radio-tagged seals at Drakes Estero during the summer and winter seasons; herd = total number of seals hauled out, tagged = total number of tagged seals hauled out, and proportion = the proportion of tagged seals hauled out to the total number of resident, tagged seals.

	TIME (PST)									
	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600
SUMMER										
Aug 6										
Herd	453	397	429	462	365	259	81	36	17	21
Tagged	8	8	8	9	7	7	3	3	0	0
Proportion	0.6	0.6	0.6	0.6	0.5	0.5	0.2	0.2	0	0
Aug 13										
Herd	387	378	325	94	24	106	89	173	192	70
Tagged	5	7	7	5	3	3	4	4	5	2
Proportion	0.5	0.7	0.7	0.5	0.3	0.3	0.4	0.4	0.5	0.2
Aug 20										
Herd	389	427	261	372	316	51	1	0	0	6
Tagged	8	8	5	9	8	4	0	0	0	0
Proportion	0.8	0.8	0.5	0.9	0.8	0.4	0	0	0	0
Aug 27										
Herd	257	241	174	56	60	72	211	248	265	157
Tagged	3	3	4	2	2	3	8	8	9	9
Proportion	0.3	0.3	0.4	0.2	0.2	0.3	0.8	0.8	0.9	0.9
Sep 3										
Total	100	230	355	252	210	48	0	0	3	24
Tagged	3	4	4	5	5	2	0	0	1	2
Proportion	0.3	0.4	0.4	0.6	0.6	0.2	0	0	0.1	0.2
WINTER										
Jan 1										
Herd	190	266	404	467	467	497	192	70	66	0
Tagged	4	4	7	8	8	8	3	1	1	0
Proportion	0.5	0.5	0.9	1.0	1.0	1.0	0.4	0.1	0.1	0
Jan 7										
Herd	0	0	0	0	157	329	419	497	498	506
Tagged	0	0	0	0	5	6	7	7	7	7
Proportion	0	0	0	0	0.7	0.9	1.0	1.0	1.0	1.0
Jan 15										
Herd	309	364	413	456	462	451	229	110	RAIN------	
Tagged	3	3	4	4	5	6	5	4	0	
Proportion	0.4	0.4	0.6	0.6	0.7	0.9	1.0	0.6	0	
Jan 20										
Herd	0	0	14	124	310	372	464	476	467	445
Tagged	0	0	0	2	4	4	5	5	4	4
Proportion	0	0	0	0.3	0.6	0.6	0.7	0.7	0.5	0.6
Jan 18										
Herd		212	210	165	79	64	100	100	110	110
Tagged		4	4	3	3	3	3	3	3	4
Proportion		0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.6

assumptions regarding herd behavior from data derived from monitoring individuals at Drakes Estero until the spring (after the month of March) when two transmitters that were still functioning were too few to make valuable comparisons. During the all-day censuses we also verified the accuracy of the equipment in distinguishing the presence or absence of seals and whether they were hauled out or in the water.

To locate dispersing seals we attempted to make weekly aerial surveys along the California coast from Monterey Bay to the California/Oregon border. Seals were monitored with a scanning receiver and two wing-mounted, two-element antennae from Telonics (Mesa, Arizona), and frequencies chosen were continuously scanned for three seconds each. When a seal was located, activity, time, and location were recorded. Most flights ranged from Point Arena south to Half Moon Bay and into San Francisco Bay. The flights varied depending on which animals we were trying to locate. We scheduled flights on days when tides were low to medium to maximize numbers of seals hauled out.

DATA ANALYSIS

We defined seals as "resident" if they remained at Drakes Estero for most or all of the study period, "breeders" as those which departed in the fall but returned during the following breeding season, and "transients" as those present at Drakes Estero during the capture but which resided away from Drakes Estero during the rest of the study period. Seal behavior at Drakes Estero was classified as either 1) hauled out, 2) in the water, or 3) absent. All information recorded on the Esterline Angus strip charts

was transferred to the "DBase III" database system. The "SPSS statistical program for micro-computers" was used for all analyses. Analyses presented here are exploratory and primarily descriptive since this is the first of a two-year study. Averages are expressed with $\pm$ standard error. We chose August and December data to illustrate some of the seasonal differences in haul-out behavior.

RESULTS

We captured and radio-tagged 17 seals (eight females, nine males) and flipper-tagged two additional males (Table 2). On average, males weighed 27.5 kg more, and were 10.2 cm longer than females. On the day after capture, all but two of the radio-tagged seals were hauled out again at Drakes Estero, and on the third day after capture all but one seal was hauled out. All but two transmitters (88%) remained attached to seals for a minimum of five months, nine (53%) for seven months, six (35%) for eight months, and one for nine months (Table 3). We were able to locate regularly, either visually or with a receiver, all but one animal through April 1986.

MOVEMENTS

All radio and flipper tagged seals were resighted at Drakes Estero at least once during the study period. Two seals with transmitters that ceased functioning within the first month of study were excluded from all analyses; the two animals involved remained at Drakes for the entire year. Radio-tagged seals moved both north and south of the capture site;

Table 2. Standard measurements of harbor seals tagged at Drakes Estero, August 1985. (RT = Radio Tag, FT = Flipper Tag.)

Radio Tag	Age	Sex	Length(cm)	Girth(cm)	Weight(kg)	Comments
RT024	AD	F	146	98	63.5	
RT033	AD	F	138	95	56.7	
RT092	AD	F	148	96	55.8	
RT234	AD	F	147	120	86.2	
RT313	AD	F	145	103	63.5	
RT415	AD	F	131	94	50.0	
RT491	AD	F	121	94	56.7	
RT710	AD	F	138	96	63.5	
RT047	AD	M	150	108	74.8	
RT084	AD	M	154	112	93.0	Old shark bite
RT124	AD	M	148	125	77.1	
RT176	AD	M	148	118	84.4	
RT256	AD	M	146	105	74.8	Old shark bite
RT272	AD	M	167	117	90.7	
RT435	AD	M	168	106	79.4	
RT753	AD	M	147	118	9[illegible].0	
RT974	AD	M	163	114	90.7	
FT212	AD	M	155	111	90.7	
FT222	AD	M	144	107	77.1	
FT220	AD	M	150	-	83.9	
--	AD	M	173	117	102.0	
Total Average			149 ± 3	108 ± 2	77 ± 3	
Average for Females			139 ± 3	100 ± 3	62 ± 4	
Average for Males			155 ± 3	113 ± 2	86 ± 2	

Table 3. Minimum estimated length of time transmitters were functional, and date/place seal last located visually or audibly with a receiver.

Seal	Date Last Recorded	Date Last Observed/Recorded	Location[a]	Minimum length of Attachment(days)
024	Nov/12/85	Apr/29/86	DE	101
033	Mar/3/86	Jul/10/86	DE	240
047	Mar/12/86	Jul/10/86	DE	221
084	Mar/27/86	Jul/10/86	DE	236
092	Mar/19/86	Jul/3/86	DE	228
124	Mar/6/86	Jul/ /86	DE	236
176	Jan/8/86	Jan/8/86	DE	158
234	Jan/24/86	Jul/10/86	DE	174
256	Aug/9/85	Jul/21/86	DE	7
272	Aug/28/85	Jul/10/86	DE	26
313	Dec/19/85	May/22/86	DE	138
415	Apr/18/86	Apr/18/86	RR	258
435	Jan/1/86	Jul/3/86	DE	151
491	Dec/19/85	May/10/86	DP	138
710	Mar/19/86	Jul/23/86	DE	228
753	May/3/86	Jul/10/86	DE	273
974	Apr/16/86	Jul/3/86	DE	256

[a] DE = Drakes Estero, DP = Double Point, RR = Russian River.

movements were within 0.8 km of the shoreline (Table 4, Figure 1). Five seals (33%) were recorded exclusively at Drakes Estero, six others (40%) on a total of two haul-out sites, and four (27%) on three haul-out sites (Table 5).

We classified eight radio-tagged seals (53%) as residents (five males, three females). Of these, three were located once in the water near another, nearby, haul-out site and one (a female) traveled greater than 25 km. We classified four seals (27%) as breeders (three females, one male); all of which traveled greater than 25 km away from Drakes Estero. We classified two females and one male as transients (20%), and these moved both locally and further than 25 km (Table 5).

Long-range movements of greater than 25 km were recorded for 6 of 15 seals. Although females traveled longer distances than males, both sexes moved about the same number of times (Table 5). One female moved north to the Klamath River (480 km) and one traveled south to Monterey Bay (210 km) for the winter months. Both were observed (without transmitter) at Drakes Estero in April 1986. The seal at Monterey Bay was observed on almost a weekly basis hauled out in front of Hopkins Marine Station from mid August to mid-March (Alan Baldridge, Hopkins Marine Station, CA; C. Deutsch, Univ. of Calif., Santa Cruz, CA, pers. comm.). Five seals traveled to nearby haul-out sites at Point Reyes; three to the Tomales Bay haul out site and two to the Double Point haul-out site. Seals were also recorded in the water near the Point Reyes Headland, Wildcat Beach, Bolinas Point, and Drakes Bay near the fish docks.

More movements both local and long distance (20) were recorded during

Table 4. Location and behavior of seals that traveled from Drakes Estero recorded during aerial surveys. Behavior is classified as A = active/swimming, I = inactive/hauled out.

FLIGHT DATE/PLAN		SEAL BY RADIO FREQUENCY NUMBER														
		024	033	047	084	092	124	176	234	313	415	435	491	710	753	974
1985																
Aug 9	1	DE/I				DE/I	PRH/A			DE/I			DE/I	DE/I		DE/I
15	1															TB/I
29	1								DL/I	TB/A						TB/I
Sep 12	1		DE/I	PRH/A			DP/I	DE/I	DE/I	TB/I		DE/I		DE/I		TB/I
13	2					MB/I										
19	1				DE/A								DP/I			
26	1		DE/I	DE/I	DE/I			DE/A	DE/I			DE/I	DP/A	DE/I	DE/I	TB/I
Oct 4	1				DE/I		DP/I			TB/A			PRH/A	TB/A		TB/I
10	3	KR/A	DB/A	DE/A	DE/I		DP/A	DB/A	DE/I	TB/I	SR/I		DP/A		DE/I	
22	1													DE/A		
23	2					MB/I										
28	1											DB/A			DE/A	TB/I
31	1			DE/A	DE/A					BH/A		BP/A			DB/A	BH/A
Nov 8	1		DE/I	DP/A	DE/I			DE/I		TB/A		DE/I		DE/I		TB/I
21	1		DE/I	DE/I	DE/I			DE/I				DE/I		DE/I	DE/I	TB/I
26	1				DE/I			DE/I		SP/I					DE/I	
Dec 10	equipment failure															
19	1						DP/I			SP/I	RR/I		DP/I			TB/I
Feb 7	1			PRH/A							RR/I					TB/A
27	1			PRH/A										DE/A	DE/I	TB/I
Mar 20	1		DE/I		DE/I						RR/I			DE/I	DE/I	
23	2		DE/I		DE/I	MB/I									DE/I	
25	1		DE/I								RR/I				DE/I	TB/I
Apr 2	1										RR/I				DE/I	TB/I
18	1										RR/I				DE/I	DE/I
May 9	1														DE/I	

Locations with distances (km) from capture site:

DE = Drakes Estero	0	BP = Bolinas Point	20
DB = Drakes Bay	<10	BH = Bodega Head	40
DP = Double Point	16	MB = Monterey Bay	210
KR = Klamath River	480	RR = Russian River	55
SP = Salt Point	65	TB = Tomales Bay	48
SR = Sea Ranch	85	PRH = Pt Reyes Head	12

Flight Plan:

Half Moon Bay to Pt. Arena = 1
Drakes Estero to Monterey Bay = 2
San Francisco to Klamath R. = 3

Table 5. Distance of movement and locations of individual seals.

Seal	No. of moves	Average distance (km)	Locations[a]	Number of Locations
Females:				
024	2	480 ± 0	KR DE	2
033	-0-	-	DE	1
092	2	210 ± 0	MB DE	2
234	-0-	-	DE	1
313	3	47 ± 11	TB SP DE	3
415	2	58 ± 28	SR RR	3
491	3	24 ± 4	DP PRH DP	3
710	2	48 ± 0	TB DE	2
Totals	14	128 ± 43		
Males:				
047	4	12 ± 0	PRH DE PRH DE	2
084	-0-	-	DE	1
124	4	18 ± 0	PRH DP DE DP	3
176	-0-	-	DE	1
435	2	20 ± 0	BP DE	2
753	-0-	-	DE	1
974	2	48 ± 0	TB DE	2
Totals	12	26 ± 4		

[a] BP = Bolinas Point, DE = Drakes Estero, DP = Double Point, KR = Klamath River, MB = Monterey Bay, PRH = Point Reyes Headlands, RR = Russian River, SP = Salt Point, SR = Sea Ranch, TB = Tomales Bay.

the fall (August-October) than during the winter (November-February) or the spring (March-April), i.e. eight versus six movements, respectively. Most long distance movements were made by breeders during the fall and the spring when seals were departing to wintering sites after the molt and returning for the breeding season (Table 6). One transient seal that traveled 85 km did not return to Drakes during the breeding season.

ACTIVITY PATTERNS

Resident seals exhibited distinct seasonal and circadian trends in haul-out behavior at Drakes Estero. Resident seals were hauled out an average of 0.92 ± 0.03 of the days from August through October but only 0.77 ± 0.04 of days from November through February (Tables 7, 8) ($p = .0081$, $n = 8$, Wilcoxon matched-pairs sign-rank test). The change in number of days that seals were hauled out in winter was more pronounced for females than males but sample sizes were too small to test for significance. If one looks at the individual patterns, there is variation, but the trends are similar. The proportion of tagged seals hauled out per day relative to the total number of tagged resident seals was also greater for August through November than from December through March (Table 9).

When resident seals were not hauled out, they were in the water in the vicinity of the haul out or they were absent from Drakes Estero. The length of absences averaged 1.4 to 1.9 consecutive days for over six months; the longest absence was 10 days (Table 10). Length of absences was similar for females and males.

When seals were present in Drakes Estero, the haul-out was strongly

Table 6. Movements of resident, breeding, and transient seals by season.[a]

	Resident	Breeder	Transient	Totals
Number of seals	8	4	3	15
Number moves <25 km	11	3	7	21
Number moves >25 km	2	9	2	13
Number of moves by season:				
Aug-Oct				
<25 km	6	2	5	13
>25 km	2	4	1	7
Nov-Feb				
<25 km	5	1	-0-	6
>25 km	-0-	1	1	2
March				
<25 km	-0-	-0-	2	2
>25 km	-0-	4	-0-	4

[a] Local movements not recorded after March because transmitters ceased functioning.

Table 7. Proportion of days resident seals were hauled out at Drakes Estero during the fall and winter and March, based on number of days monitored. Only resident seals included.

	SEAL BY RADIO FREQUENCY								AVERAGE		
SEASON	033	234	710	047	084	176	435	753	Female	Male	Total
Fall (Aug-Oct)	0.9	0.9	0.9	1.0	0.8	1.0	1.0	1.0	0.9±0.0	0.9±0.0	0.9±0.0
Winter (Nov-Feb)	0.7	0.6	0.7	0.7	0.8	0.9	0.8	0.9	0.7±0.1	0.8±0.0	0.8±0.0
Spring (March)	0.7	-	0.6	0.5	0.7	-	-	0.9	0.7±0.5	0.7±0.1	0.7±0.1

Table 8. Proportion of days per month each seal was hauled out at Drakes Estero.

	MONTH							
Seal	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Females:								
RT033	0.9	1.0	1.0	0.9	0.7	0.8	0.6	0.7
RT234	0.9	0.6	0.9	0.5	0.5	0.7	*	
RT491	0.5	0.4	**					
RT710	0.9	0.8	0.9	0.5	0.9	0.7	0.6	0.6
Males:								
RT047	0.9	1.0	1.0	0.9	0.8	0.7	0.3	0.5
RT084	0.8	0.8	0.6	0.8	0.9	0.8	0.7	0.6
RT176	1.0	1.0	1.0	0.8	0.9	**		
RT272	0.8	*						
RT435	0.9	1.0	1.0	0.9	0.8	*		
RT753	0.9	1.0	1.0	0.9	0.9	0.8	0.9	0.9
Total Average	0.9	0.8	0.9	0.8	0.8	0.7	0.6	0.7
SE	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
n	10	9	8	8	8	6	5	5
Female Average	0.8	0.7	0.9	0.6	0.7	0.7	0.6	0.7
SE	0.1	0.1	0.1	0.1	0.1	0.0	0.5	0.5
n	4	4	3	3	3	3	2	2
Male Average	0.9	0.9	0.9	0.8	0.9	0.8	0.6	0.7
SE	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.1
n	6	5	5	5	5	3	3	3

* Transmitter ceased functioning.
** Seal no longer present at Drakes Estero.

Table 9. Proportion of resident radio-tagged seals hauled out each day (seals with transmitters that are no longer functional, breeders, and transients are excluded).

	MONTH							
Date	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1		0.9		1.0	0.6	0.7	1.0	1.0
2	0.9	0.9		1.0	0.4	-	0.6	1.0
3	1.0	0.9		1.0	0.9	0.6	0.6	0.8
4	0.7	0.9		0.9	1.0	0.4	0.8	1.0
5	0.7	0.8		1.0	1.0	1.0	0.8	1.0
6	0.7			1.0	0.9	1.0	1.0	1.0
7	0.9			1.0	0.7	0.9	0.8	0.2
8	0.8			0.6	1.0	1.0	0.2	0.4
9	0.9			0.9	1.0	0.7	0.8	0
10	0.4			0.6	0.9	0.7	0.8	0
11	0.3			0.8	0.4	0.6	0.8	0
12	0.6			0.8	-	0.6	0	1.0
13	0.8			0.5	0.7	0.7	0.6	0.8
14	0.9			0.5	1.0	0.3	0.2	1.0
15	0.9			0.6	1.0	0.9	0.6	1.0
16	0.8			0.8	1.0	0.4	1.0	0.8
17	0.9			0.8	1.0	0.7		0.8
18	1.0			0.9	1.0	0.9		0.8
19	1.0			1.0	0.9	0.4		0.8
20	1.0			0.9	1.0	0.7		0.5
21	1.0				0.7	0.7	0.8	1.0
22	1.0				0.9	0.6	0.6	
23	1.0				1.0	0.7	0.4	
24	1.0				0.6	0.7	0.4	
25	1.0		0.9		0.6	0.3	0.6	
26	1.0		0.9		0.5	0.6	0.8	
27	0.8		0.9		0.2	0.6	0.6	
28	0.9		0.9		0.2	0.7	0.2	
29	0.9		0.9		0	-		
30	1.0		0.9	0.4	0.5	0.7		
$\bar{x}$	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.7
SE	0.0	0.0	0	0.0	0.1	0.0	0.1	0.1
Adjusted figures including breeders and transients:								
$\bar{x}$	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.3
SE	0.1	0.1	0.0	0.1	0.2	0.1	0.1	0.1

Table 10. Average length of time resident seals were absent from Drakes Estero, measured in consecutive days. Seals were neither in the vicinity in the water nor hauled out. Insufficient data were available for September and October. Averages and modes for days absent are presented for seal and for each month.

	AVERAGE BY MONTH						AVERAGE ALL MONTHS				
Seal	Aug	Nov	Dec	Jan	Feb	Mar	$\bar{x}$	SE	mode	range	n
033	1	1	2	1	2	1	1.4	0.2	1	1-3	19
234	1	2	3	0	*		2.6	0.8	1	1-10	10
710	2	1	0	1	0	2	1.4	0.3	1	1-3	6
047	1	1	2	1	2	*	1.5	0.3	1	1-4	13
084	2	0	1	1	2	1	1.3	0.2	1	1-3	14
176	0	0	1	*			1.0	0	1	1	2
435	1	0	1	*			1.0	0	1	1	5
Average days by month (all seals combined):											
$\bar{x}$	1.5	1.4	1.9	1.0	1.8	1.4					
SE	0.3	0.3	0.6	0.0	0.5	0.2					
mode	1	1	1	1	1	1					
range	1-3	1-4	1-10	1	1-4	1-2					
n	10	9	16	13	13	8					

* Transmitter ceased functioning.

diurnal in all months monitored, and most hauled out during mid-day regardless of season. The proportion of tagged seals hauled out over a 24-hr period was largest 0800 to 1400 hr in August, and 1000 to 1600 hr in December (Table 11). On average, seals hauled out for a total of seven hours per day; however, seals would often haul-out more than once per day. The duration of a single hauling bout averaged 4.8 to 5.6 hrs (Table 12). The averages for hours-per-day and length-of-hauling-bout were not significantly different between August and December (hour, $p = .88$; length, $p = .84$; Wilcoxon matched-pairs sign-ranks test, $m = 3$, $n = 5$). Our sample was too small to test for differences between males and females; however, in December two pregnant females (RT234 and RT710) that gave birth in April spent fewer hours on shore per day than males. Individuals hauled out for up to 34 hrs in August, but never more than 17 hrs in December. The average number of hauling bouts per day was similar in August ($\bar{x} = 1.6 \pm 0.05$) and December ($\bar{x} = 1.4 \pm = 0.05$) and for both sexes (females in August, $\bar{x} = 1.7 \pm = 0.08$, and December, $\bar{x} = 1.4 \pm 0.09$; males in August, $\bar{x} = 1.5 \pm 0.06$; and December, $\bar{x} = 1.4 \pm 0.07$) and ranged between one and four. Ninety-five percent of the 372 hauling bouts in August, and 96% of the 212 in December were 12 hrs or less; 20% of the hauling bouts were less than two hrs in both August and December.

The length of a hauling bout was affected by the time of initiation in August such that seals that first hauled out between 0500 and 0900 hr were on shore longer than seals that initiated a haul-out between 0900 and 2400 hr; in December, though, time of initiation did not appear to influence length of bout (Table 13). Though seals initiated a hauling bout

Table 11. The proportion of resident seals hauled out per day during two-hour intervals.

Hours	August $\bar{x}$	August SE	August n	December $\bar{x}$	December SE	December n
0000-2000	0.1	0.0	30	0.1	0.0	28
0200-0400	0.1	0.0	30	0.1	0.0	28
0400-0600	0.2	0.0	30	0.2	0.1	28
0600-0800	0.5	0.1	30	0.2	0.1	28
0800-1000	0.7	0.1	30	0.3	0.1	28
1000-1200	0.7	0.1	30	0.5	0.1	28
1200-1400	0.6	0.0	30	0.6	0.1	28
1400-1600	0.5	0.1	30	0.5	0.1	28
1600-1800	0.5	0.0	30	0.5	0.1	28
1800-2000	0.3	0.1	30	0.3	0.1	28
2000-2200	0.2	0.0	30	0.2	0.0	28
2200-2400	0.1	0.0	30	0.2	0.0	28

Table 12. Average number of hours per day and the average duration of haul-out bouts presented for individuals and by season.

	FEMALES			MALES					
	033	234	710	047	084	176	435	753	ALL SEALS
AUGUST:									
Hours/Day									
$\bar{x}$	6.7	8.0	7.1	7.2	7.8	7.6	7.6	7.8	7.5
SE	0.6	0.7	0.7	0.8	0.9	0.8	0.7	0.7	0.2
Median	6.5	8.2	6.5	6.3	8.0	7.5	7.5	7.0	7.0
Range	1-13	1-20	1-17	1-19	1-19	1-19	1-16	1-17	1-20
n	28	27	27	28	24	30	27	28	219
Length of Bout									
$\bar{x}$	4.7	5.4	4.6	6.5	6.3	6.9	6.0	5.5	4.8
SE	0.7	0.7	0.4	1.1	0.9	1.1	0.8	0.7	0.2
Median	4.2	5.0	4.0	4.8	5.0	7.0	5.0	5.0	0.4
Range	1-13	1-20	1-10	1-28	1-19	1-34	1-16	1-17	1-34
n	38	49	52	32	35	40	40	53	339
DECEMBER:									
Hours/Day									
$\bar{x}$	7.0	5.3	5.5	7.8	7.6	8.1	8.1	8.0	7.3
SE	0.8	1.2	0.8	0.6	0.5	0.6	0.6	0.7	0.3
Median	6.0	4.0	5.0	9.0	7.8	7.8	8.0	8.3	7.5
Range	1-15	1-16	1-14	1-13	1-13	1-13	1-16	1-15	1-16
n	19	11	21	26	22	22	23	26	170
Length of Bout									
$\bar{x}$	4.8	4.5	5.0	6.8	7.0	6.7	7.1	5.5	5.6
SE	0.6	1.3	0.8	0.8	0.6	0.9	0.6	0.7	0.2
Median	5.0	2.5	4.5	7.5	7.5	7.3	7.8	5.5	5.5
Range	1-8	1-16	1-14	1-17	1-13	1-13	1-13	1-12	1-17
n	19	11	24	28	27	30	29	40	208

[a] Season is represented by data from one month.

Table 13. Length of haul-out in relationship to time of initiation.

	August					December				
Hours	n	$\bar{x}$	SE	$\tilde{x}$	Range	n	$\bar{x}$	SE	$\tilde{x}$	Range
0100-0500	32	6.88	.89	5.25	1-19	12	5.38	1.14	3.75	1-13
0500-0700	74	7.09	.65	6.0	1-34	33	5.30	.58	5.5	1-13
0700-0900	86	5.63	.39	5.5	1-26	29	6.65	.76	7.0	1-16
0900-1100	47	3.39	.34	3.0	1-12	36	6.96	.49	7.5	1-13
1100-1300	33	3.39	.47	2.5	1-9	44	5.71	.42	6.0	1-13
1300-1500	44	3.74	.39	3.5	1-13	19	5.26	.79	5.0	1-13
1500-1700	28	3.41	.39	3.5	1-8	14	4.89	1.4	2.0	1-17
1700-1900	20	2.83	.77	1.5	1-16	5	5.0	1.49	4.0	1-10
1900-2400	25	1.94	.44	1.0	1-12	20	3.98	.71	2.75	1-12

at all hours of the day most initiations occurred during daylight hours between 0400 and 1600 hr for August and between 0600 and 1400 hr for December (Table 14). The pattern was similar for both males and females.

DISCUSSION

Results from one survey year indicate that the decline in seal numbers during the winter months is related to both a seasonal movement away from Drakes Estero and a reduction in the number of days spent hauled out for the remaining animals. Among radio-tagged animals, equal numbers remained in and moved away from Drakes Estero; departees were composed of more females than males. Similar to results in Alaska (Pitcher and McAllister 1981) and on San Nicolas Island (Stewart and Yochem 1983), we found a high level of site fidelity, with seals using no more than three sites. Exclusive use of one haul-out site has also been noted in other studies (Boulva and McLaren 1979, Herder 1986, Stewart and Yochem 1983). In contrast to seals at the Klamath River (Herder 1986), most movements of seals from Drakes Estero occurred from August to October; however, we have no data for the period from April to June when Klamath seals exhibited the greatest local movement. We found, as did Herder (1986), that females made more long distant moves than males. Immature seals may travel greater distances than adult animals, as suggested by Pitcher and McAllister (1981), but we have no information on this.

In general, we observed that if a seal moved to a location greater than

Table 14. Frequency of initiation of haul-out bouts in relationship to time of day by season for females, males, and all seals.

Time	August 1985 n = 28d Female	Male	Total	December 1985 n = 30d Female	Male	Total
0000-0200	2	5	7	4	6	10
0200-0400	3	7	10	4	1	5
0400-0600	24	17	41	8	10	18
0600-0800	35	72	107	8	21	29
0800-1000	24	36	60	7	23	30
1000-1200	10	1,	27	11	39	50
1200-1400	10	30	40	10	22	32
1400-1600	13	24	37	3	7	10
1600-1800	10	18	28	5	13	18
1800-2000	8	9	17	2	8	10
2000-2200	9	2	11	2	3	5
2200-2400	4	1	5	3	3	6

25 km away from the capture site, it remained there for an extended time rather than continuing to travel. The majority of these long-range movements occurred after the molt and prior to the breeding season. The movements were to well established haul-out sites in estuaries (Tomales Bay), at river mouths (Klamath and Russian rivers), and at coastal sites (Double Point, Hopkins Marine Station).

The localities at which seals relocated may be preferred winter foraging areas. However, because migrant seals were highly individual in the distance of their movement and their final destination, we suggest that seals were not responding to a single prey situation as was noted in winter movements of seals in Oregon and Washington. Instead, individuals may be expressing a preference for location based on past experience, including foraging success (Beach et al. 1985, Brown and Mate 1983).

The observed movements indicate that Drakes Estero is an important breeding area for seals between Monterey Bay and the Klamath River, an overall distance of 690 km. The three seals which did not return to Drakes Estero in the following breeding season may visit Drakes Estero only during the molt, or use it only as a secondary haul-out site as did one transient which visited Drakes Estero twice after capture but resided at Double Point through the breeding season. The movements also indicate that there is substantial mixing among harbor seal colonies along the central and northern California coast, and that seals in central and northern California may represent a subpopulation of harbor seals in California. Herder (1986) and Brown and Mate (1983) also found movement of seals between colonies in the Klamath River and Alsea Bay, Oregon,and between

seals in Oregon and Washington.

All recorded foraging activities and movements of seals in the Point Reyes area appeared to be limited to within 0.8 km of shore. Though pelagic movements of harbor seals have been recorded by others (Pitcher and McAllister 1981, Spaulding 1964, Stewart and Yochem 1983, Wahl 1977), our results suggest nearshore feeding and migration are more typical than offshore.

Seals that remained at Drakes Estero were hauled out on more days and in higher proportions of total animals in the fall than the winter months. Our figures on the proportion of days per month spent hauled out and on the proportion of radio-tagged seals hauled out per month were substantially higher than those derived by both Stewart and Yochem (1983) and Pitcher and MacAllister (1979); if we include in our analyses animals that departed from Drakes Estero, our figures would be similar (see Table 9 for adjusted figures). We eliminated these animals from analyses, though, since the location of the departed animals had been ascertained, thereby allowing for more accurate assessments of time spent ashore for seals in the immediate vicinity.

When hauled out, the number of hours per day that seals spent on shore was similar for fall and winter, as was the haul-out time interval. This suggests that despite high tides during the day in winter, with winter storms accentuating high tides, seals were regular in the length of time they hauled out, but not in the number of days hauled out. Both Sullivan (1979) and Stewart and Yochem (1983) observed a higher average time per day that seals were hauled out, 44% and 39%, respectively, than we found for

seals at Drakes Estero (29%). Differences may be attributed to stronger tidal influences at Drakes Estero or to exposure to disturbance from humans; though Limantour Spit is exposed at all tide levels, seals there are more frequently subjected to human distubance. Seals at Drakes Estero may, therefore, be forced to spend more time in the water. Females may haul-out for shorter periods both in number of days and number of hours per day than males in the winter (see also Stewart and Yochem 1983). The small differences between means coupled with the small sample of animals result in insignificant differences at this time. Pregnant females may require more time feeding than males.

The strong diurnal haul-out pattern documented at Drakes Estero previously (Allen and Huber 1983), and shown by innumerable other researchers (Boulva and McLaren 1979, Fancher 1979, and Stewart and Yochem 1983), was further confirmed in this study. Though seals hauled out at all hours of a day, peak abundance, based on the proportion of tagged animals, occurred mid-day. Stewart and Yochem (1983) determined that time of initiation of a haul-out bout did not influence the length of the bout; however, we found that in August, seals hauled out for longer periods when bouts were initiated between 0100 and 0900 hr than for other time periods during the day or night. In December, time of day did not appear to influence the length of bout during daylight hours but did during the night. Differences may be attributed to changes in day length, and/or frequency of human disturbance at Drakes Estero.

Absences of resident seals from Drakes Estero, averaged about one day suggesting that absentees were foraging fairly close by; the local movement

patterns observed during aerial surveys also support this conclusion.

SUMMARY

1. Evidence from movement patterns indicates that Drakes Estero is a focal breeding area for seals ranging as far south as Monterey Bay and as far north as the Klamath River, and therefore, that northern and central California may represent a subpopulation of harbor seals in California. It is also likely that some mixing between seals from Oregon and this subpopulation occurs (Herder 1986).

2. A larger proportion of tagged seals hauled out on a daily basis in August (92%) than in December (77%), and this difference appeared to be more pronounced for females than for males.

3. The largest proportion of seals were hauled out between 0400 and 1600 hr in August and this represented between 53% and 71% of the estimated number of seals in the area.

4. Seasonal changes in abundance are a function of the movement of seals away from Drakes Estero and of a decrease in the number of days that seals spent hauled out in the winter.

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