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Journal of Mammalogy, Vol. 64, No. 3. (Aug., 1983), pp. 518-520.

Stable URL:
http://links.jstor.org/sici?sici=0022-2372%28198308%2964%3A3%3C518%3AFAHOHS%3E2.0.CO%3B2-E

Journal of Mammalogy is currently published by American Society of Mammalogists.

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J. Mamm., 64(3):518–520, 1983

FACTORS AFFECTING HAUL-OUT OF HARBOR SEALS AT A SITE IN SOUTHEASTERN MASSACHUSETTS

Harbor seals (*Phoca vitulina*) haul out on a variety of substrates including beaches or intertidal ledges throughout the year. Factors influencing haul-out behavior have been suggested by Matthews (1952), Scheffer (1970), and Wipper (1975). Several proximate factors that influence the number of seals on land include tide (Venables and Venables, 1955; van Bemmel, 1956; Tickell, 1970; Sullivan, 1980), wave intensity (Venables and Venables, 1955; Lockley, 1966), disturbance (van Bemmel, 1956), and wind chill (Boulva and MacLaren, 1979). No single factor appears to be pre-eminent and it is likely that several factors operate simultaneously in determining haul-out behavior. We used multivariate analyses to describe the joint effects of several environmental variables on haul-out numbers during the winter at a site in southeastern Massachusetts.

The study was carried out at Stage Point (41°55′N, 70°32′W) Manomet, Massachusetts. Bluffs of glacial till rise 3 to 25 m above the shoreline and are fringed by sandy beaches, with rocks and cobbles scattered in the lower intertidal and immediate subtidal zones. Seals haul-out exclusively on the larger subtidal rocks that are exposed by semi-diurnal tides. The shoreline used by seals during 1978-1979 was divided into four areas that differeed in degree of exposure to northeast storms; Manomet Cove, Stage Point, Swale, and MBO. A count was made daily in each area within 1 h of low tide from November 1979 to May 1980. Counts also were made at hourly intervals throughout a 4–5 h portion of the tide cycle near the middle of each month. Seven environmental variables were recorded during each count: stage of tide, wind speed and direction, air temperature, sky cover, wave height, and disturbance. Counts were made with binoculars from the bluffs or from the beach.

We used canonical correlation to describe the relationship between seven environmental variables and the number of seals seen in each of three areas: MBO, Swale, and Stage Point. Counts at Manomet Cove were not included because few seals used this area. For this analysis we used the total number of seals seen from shore in each of the three areas. Environmental variables were treated as follows: tide (0 = low tide, 1 = 1 h before or after low tide, etc.), wind speed (0–40 knots), wind direction 0 = onshore, 1 = offshore), air temperature (°C), sky cover (10 categories, 0 = clear), wave height (to the nearest 0.3 m), and disturbance (0 = none, 1 = present).

We used multiple regression to examine the joint effects of tide and other factors on the percentage of seals hauled out at any one time. Percent of seals on land was determined by dividing the number of individuals hauled out by the total number of seals visible from shore (hauled out seals, bottling and swimming seals). Counts from MBO, Swale, and Stage Point were combined to compute each percentage. Percentages based on less than four seals were considered unreliable, and excluded from the analysis. Data were analyzed using routines from the SPSS package (Nie et al., 1975). A $P < 0.05$ was considered statistically significant.

Total number of seals visible from shore varied significantly ($F = 236.95$, $P < 0.0001$) among sites (Table 1). Maximum number of seals on land were at Swale, a section of shoreline with several large, flat rocks just offshore. Number of seals hauled out also varied significantly ($F = 39.65$, $P < 0.0001$) with month (Table 1). Tide also had a significant effect on total seal numbers ($F = 2.23$, $P = 0.013$), whereas wave height and disturbance had no significant effect on total numbers.

Canonical correlation was used to assess the contribution of particular variables in explaining the number

TABLE 1.—*Numbers of harbor seals visible from land at the Manomet study sites. Monthly totals are of MBO, Swale, and Stage Point. N = number of counts.*

Location/month	N	Average number of seals ± SE per count	Maximum number of seals
Manomet Bird Observatory	378	0.83 ± 0.14	24
Swale	380	25.73 ± 1.34	123
Stage Point	359	4.76 ± 0.49	60
Manomet Cove	225	0.33 ± 0.12	18
November	43	5.67 ± 1.08	38
December	45	47.84 ± 3.94	106
January	105	54.89 ± 3.39	135
February	47	19.94 ± 3.14	72
March	63	17.89 ± 1.32	37
April	57	19.95 ± 1.23	38
May	9	14.0 ± 2.03	23

of animals recorded in the 3 areas. The first canonical variate showed that tide, air temperature, and wave intensity exerted the greatest combined influence on the total number of seals in the areas ($r = 0.44$; $P < 0.0001$). Numbers of seals decreased with increasing time before and after low tide, with increasing temperature, and with increasing wave intensity. The negative relation with air temperature reflects the pattern of seasonal abundance, which reached a peak during the coldest months (Table 1). Examination of the second canonical variate shows total counts were correlated with wind direction, wind speed, disturbance, and sky cover ($r = 0.29$; $P < 0.04$) once tide stage, season, and wave action were controlled. The effects of wind, disturbance, and sky cover were significant, but of secondary importance relative to season, tide stage, and wave intensity.

A stepwise regression, introducing first tide, then a set of weather factors, and finally disturbance showed that tide explained 36% of the variation in haul-out percentage ($P < 0.0001$) and sky cover explained 16% ($P = 0.04$). The relation of haul-out percentage to tide is shown in Fig. 1. Subsequent addition of weather factors did not greatly improve the quality of the prediction at all sites (Table 2). Disturbance improved the prediction, after weather effects were controlled statistically.

Our analysis showed that several factors affected the number of seals appearing near shore at Manomet, but that only tide and disturbance had any significant effect on the percentage hauling out. Virtually all of the animals visible from shore at Manomet hauled out at the same time (Fig. 1). Synchronous haul-out appears to be true at other ledge sites used during the winter (Venables and Venables, 1955; van Bemmel, 1956). Harbor seals also haul-out on uninhabited beaches, but not in synchrony with each other or with the tide (Hewer, 1974; Boulva and MacLaren, 1979). One important implication of the synchronized haul-out that we observed at Manomet is that ledge counts may be a useful index for monitoring changes in the distribution and abundance of *P. vitulina* in eastern North America.

TABLE 2.—*Stepwise multiple regression of haul-out % (all sites) of harbor seals against tide, weather factors, and disturbance.*

Variable	Regression coefficient	Cumulative variation explained (R^2)	*f*-ratio	*P*
Tide (number of h before or after low tide)	−0.668	36.6%	184.09	<0.0001
Weather				
Increasing wave intensity	−0.157	38.6%	8.90	0.003
Increasing wind speed	−0.165	39.9%	10.04	0.003
Onshore (0) to offshore (1) wind	0.005	40.2%	0.019	0.92
Air temperature	−0.044	40.5%	0.69	0.41
Increasing sky cover	0.200	43.2%	16.40	0.001
Disturbance				
Absence (0) or presence (1)	−0.383	57.0%	61.31	0.001

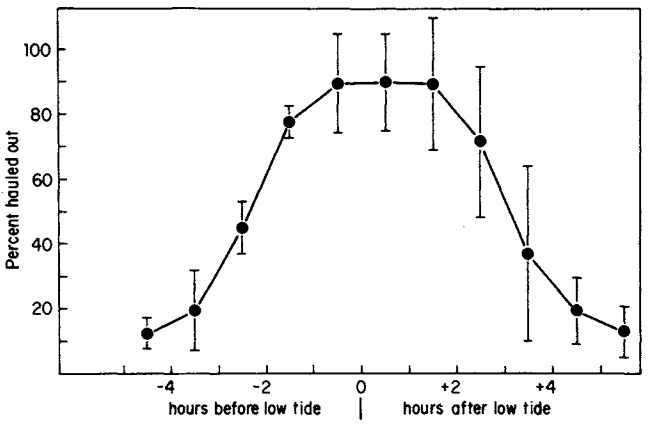

FIG. 1.—Percent (±SE) of the maximum daily numbers of seals hauled out relative to tide at Stage Point, November 1979 to May 1980.

Disturbance affected the percentage of seals hauled out at any one time. After a disturbance, seals hauled back out, usually on a new set of rocks because "preferred" rocks could not be regained at low tide, due to their steep sides. Occasional disturbance did not affect the total number of seals in the study area, but may nonetheless be important if the number of hours spent out of water is critical. Time spent out of water could be important because harbor seals rely on blubber and increased metabolism, rather than pelage for insulation (Irving and Hart, 1957; Harrison and Kooyman, 1968). Reduced metabolism out of the water (Irving and Hart, 1957) may increase the ability of a small endotherm to survive with minimum impact on blubber needed for insulation. Daily energy budgets need to be measured to determine whether the effect of disturbance on haul-out affects the energy balance of harbor seals.

We thank John Prescott for his advice at the outset of this project and the many people who made counts: Jeff Cherry, Ann Frothingham, Dottie Holcomb, Craig Kesselheim, Wally Kremers, Linda Leddy, Trevor Lloyd-Evans, Andrew MacLachlan, Barbara Mayer, Dorcas Miller, Susan Marcus, Chris Rimmer, Mary Rosenfeld, and Dave Twichell. This study was funded by a grant from the National Marine Fisheries Service at Woods Hole, Massachusetts (NA-80-FA-00005).

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Journal of Mammalogy, Vol. 61, No. 4. (Nov., 1980), pp. 754-760.
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