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Tidal and temporal interaction on harbour seal haul-out patterns

B. D. Pauli and J. M. Terhune*

Department of Biology, University of New Brunswick, P.O. Box 5050, Saint John, New Brunswick, E2L 4L5, Canada

The numbers of harbour seals (*Phoca vitulina concolor*) on a haul-out site, in an area of large tidal amplitude, were examined for 2 summers. Daily, pre- and post-pupping, and between year differences occurred in the numbers of seals present and their hauling patterns. When the numbers were analyzed as a proportion of the maximum daily count, a temporal variation superimposed on the tidal pattern was observed. In the morning, seals hauled-out close to, or after, low tide. They hauled-out earlier in the tidal cycle, and in greater numbers, when low tide occurred in the afternoon. Censuses for harbour seals on haul-out sites should be conducted during afternoon low tides.

Introduction

Harbour seals (*Phoca vitulina*) haul out onto offshore ledges, sand bars and isolated beaches. The numbers of seals hauling out on a daily basis can be influenced by weather factors and human disturbance (Boulva & McLaren, 1979; Renouf *et al*, 1981; Schneider & Payne, 1983; Terhune & Almon, 1983; Stewart, 1984; Pauli & Terhune, 1987). The number of seals in any area can be influenced by migrations for food or reproduction (Schneider & Payne, 1983; Brown & Mate, 1983). The most important influences on the number of seals that will haul out on any day are reported to be either the time of day (where haul-out sites are available at high tide; Boulva & McLaren, 1979; Stewart, 1984) or state of the tide (Schneider & Payne, 1983; Terhune & Almon, 1983). More seals haul out during afternoon low tides than for morning low tides when seals have continuous access to their hauling grounds (Wilson, 1978; Stewart, 1984) or where they haul out from shallow bays onto mudbanks (Rosenthal, 1968; Ling *et al*, 1974). We examined the diurnal haul-out patterns of harbour seals (*P. v. concolor*) in the Bay of Fundy, Canada, an area of large tidal amplitude where haul-out sites are accessible only near low tide.

Study Area and Methods

Passamaquoddy Bay, New Brunswick, Canada is subject to large amplitude (maximum range 9.1 m), semi-diurnal tides (Smith *et al.*, 1984). Seals have access to their hauling grounds (rocky, tidal ledges adjacent to islands) for approximately 6 hours during each low tide cycle. At Saint Croix Island (45°N, 67°W) observations were made of the numbers of harbour seals hauled-out onto 2 sets of ledges consisting of 3 rocks each. The ledges have a low, gently sloping profile. The seals hauled out onto the eastern (observer's) side of the ledges, possibly because the western sides were exposed to more boat traffic and areas of human habitation. We believe that virtually all seals that hauled out would have been visible to the observers. Counts were made at 10-minute intervals over a 4 to 6 hour observation period which was centred at low tide. Observations were made between dawn and dusk. Seals were observed from a distance of 1 km using a 20–45 X telescope. Observations were made from May 10–Sept. 1, 1983 and April 15–Sept. 1, 1984 (65 days in 1983 and 94 in 1984).

Human-related disturbances (18 in 1983, 16 in 1984) resulted in all seals abandoning the haul-out. These counts were deleted from the analysis. There was a great deal of variability in the number of seals counted on a daily basis (Pauli & Terhune, 1987). To reduce the influence of this variability, the numbers of seals on land on a 10 minute or half-hourly basis during each observation period, were converted to a percent of the maximum count for that day (Fig. 1). Count data were divided into 2 periods for each year. The period from the start of observations to June 14 (Figs 1B and 1E) was considered to be the 'pupping period' as harbour seals have their pups at this time in this area (Boulva & McLaren, 1979; Gilbert & Wynne, 1984). The period from June 15 to Sept. 1 (Figs 1C and 1F) is considered to be the 'post-pupping season'.

Results and Discussion

Examination of the haul-out sites revealed that more accessible ledge space was available than was used by the seals. The animals initially hauled-out onto a few steep-sided rocks when these were first exposed by the falling tide. The seals always moved to lower profile ledges more distant from the island as the water level dropped.

*Author to whom reprint requests should be addressed.

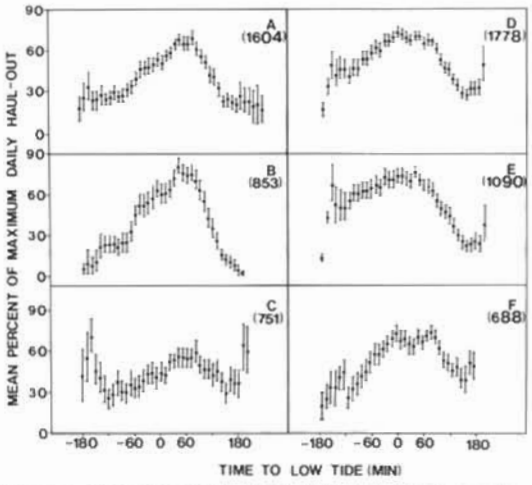

Figure 1. Mean percent (±SE) of the maximum number harbour seals hauled-out relative to tide, at Saint Croix Island. (A) all 1983 data; (B) 1983 pupping season; (C) 1983 post-pupping season; (D) all 1984 data; (E) 1984 pupping season; (F) 1984 post-pupping season. Sample sizes given in parentheses.

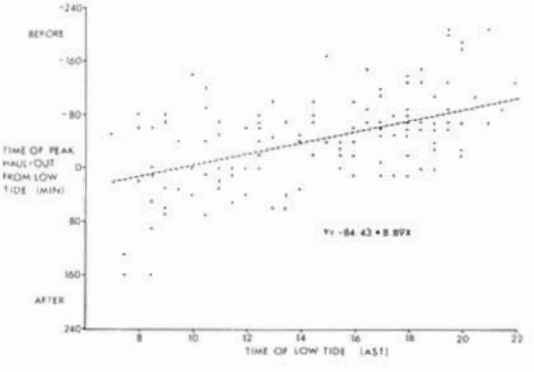

Figure 2. Time of maximum harbour seal haul-out from low tide by time of day, (Atlantic standard time) at Saint Croix Island; 1983 and 1984 pooled data.

The predominant factor influencing harbour seal haul-out was the tide. The seals hauled out only onto ledges which were exposed at low tide. The hauling pattern followed the tidal cycle during all periods except the 'post-pupping' period of 1983 (Fig. 1C). In 1984 the seals used a set of ledges about 200 m to the south of those used in 1983. The ledges used in 1984 were exposed earlier and thus for longer periods during the low tide cycle. This may account for the slightly different hauling pattern between the 2 years.

Time of day also influenced the seals' haul-out behaviour. The time of peak haul-out in the tidal cycle changed with the time of low water (Fig. 2). A

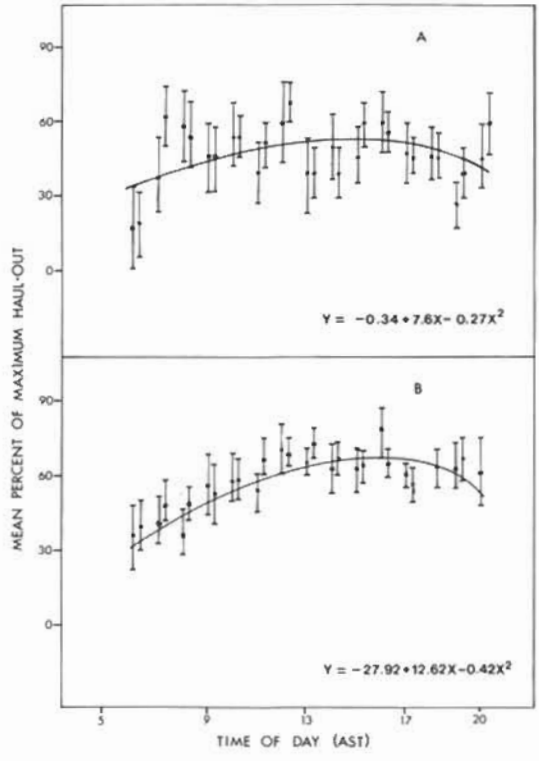

Figure 3. Mean percent (±SE) of maximum harbour seal haul-out numbers at half-hour intervals over the day, (Atlantic standard time) at Saint Croix Island; A = 1983, B = 1984.

regression analysis of these data ($F = 51.9$, $n = 131$, $R^2 = 0.29$, $P < 0.0001$) indicates that the seals delayed hauling out and would even haul out after low tide, when low water occurred early in the day but hauled out earlier in the tidal cycle when low tide occurred in the afternoon or evening.

We examined the mean percent of the daily maximum number of seals hauled out at half hour intervals (Fig. 3). A regression analysis of the 1983 data was non-significant ($n = 370$, $F = 2.97$, $R^2 = 0.18$, $P = 0.062$). The 1984 data yielded a significant regression ($n = 470$, $F = 45.82$, $R^2 = 0.77$, $P < 0.0001$). The ledges used during 1983 were exposed for shorter periods of time than those used during 1984. This may have meant that in 1983 the animals were confined to a haul-out pattern that followed the tidal cycle more closely than any diurnal rhythm. Yet, the 1984 data suggest that even within the confines of a strong tidal influence, more seals haul out in the afternoon.

Our data support an hypothesis that diurnal activity cycles influence harbour seal haul-out patterns in the presence (this study) or absence (Stewart, 1984) of a pronounced tidal cycle. Other

studies have shown that factors such as weather and season influence the numbers and timing of seals hauled-out at specific locations (Sullivan, 1980; Krieber & Barrette, 1984; Pauli & Terhune, 1987). The variability of harbour seal hauling patterns both daily (Terhune & Almon, 1983) and seasonally (Ling *et al.* 1974; this study) suggests that such patterns should be examined prior to a large scale harbour seal census. In addition, when conducting an aerial survey, as much ground-truthing as possible should accompany each flight. We recommend that censuses for harbour seals be conducted during afternoon low tides.

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