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Short communication

Spotted seal haul-out patterns in a coastal lagoon on Sakhalin Island, Russia

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Spotted seals (*Phoca largha*) are pagophilic seals distributed mainly in the Okhotsk, Bering, and Chukchi Seas (Shaughnessy and Fay 1977), but use coastal haul-outs during ice-free months (Burns 1970). These hauling areas are common in bays, estuaries, and river mouths, where spotted seals congregate near seasonally available and abundant prey, primarily spawning fishes (e.g., Tikhomirov 1961; Gol'tsev 1971; Makhnyr and Perlov 1988). Although the presence of spotted seals at coastal haul-outs can be continuous throughout the open water season (Frost et al. 1993), individual seals tend to spend relatively little time in these areas between extended near-shore foraging trips (Lowry et al. 1998). While annual habitat use patterns of spotted seals at sea have been documented (Lowry et al. 2000), haul-out patterns of seals summering in coastal regions are not well described.

Spotted seals occur along the coast of Sakhalin Island, Russia, in the western Okhotsk Sea, during ice-free periods (Tikhomirov 1961; Kosygin et al. 1986; Lagarev 1988). Previous summer counts of spotted seals have suggested that nearly 10,000 seals use hauling areas on Sakhalin Island, which are found predominantly on the island's eastern coast (Kosygin et al. 1986). Results presented here provide information on habitat use, numbers, and haul-out patterns of spotted seals in a coastal lagoon located on northeastern Sakhalin Island.

Study area and methods

The present study was conducted at Piltun Lagoon, the largest lagoon system on Sakhalin Island, Russia (Fig. 1). Piltun Lagoon, 80 km long and 15 km across at its widest point, is connected to the western Okhotsk Sea at 52°50.2'N, 143°19.5'E by a single entrance bordered by barrier spits. The study area was focused on the lagoon entrance and encompassed all hauling locations and the majority of lagoon waters utilized by spotted seals.

Systematic shore-based counts of spotted seals were made from 24 July to 31 August 1998. Counts were conducted during daylight hours (i.e., between approximately 06:00 and 21:00) from a 35-m lighthouse located at 52°51.0'N, 143°18.6'E, approximately 1.5 km northwest of seal hauling areas (Fig. 1). The study area was divided into three sections: 1) Land — western beaches of the barrier spits; 2) Near-Shore — waters <5 m from land; and 3) Water — waters >5 m from shore. A 45× monocular spotting scope was used to count seals on land and near-shore, and 7 × 50 hand-held binoculars were used to count seals in the water.

Counts were performed by two observers, with one observer counting seals on land and near-shore while the second observer counted seals in the water. Thus, the possibility of recounting seals moving between sections during a count was minimized. However, in order to test for inter-observer reliability, counts were made in two successive 'rounds'. A round consisted of the simultaneous land/near-shore and water counts performed by the two observers. During the second round count, the observers switched sections. To avoid consistent biases to values obtained by each observer during a round from seal movement between rounds, the two observers alternated starting roles for round one of every count. To evaluate the reproducibility of the paired measurements between the two observers, a concordance correlation coefficient (r_c) was calculated (Lin 1989) for counts in each of the three sections.

All counts were spaced >1 h apart. Disturbance

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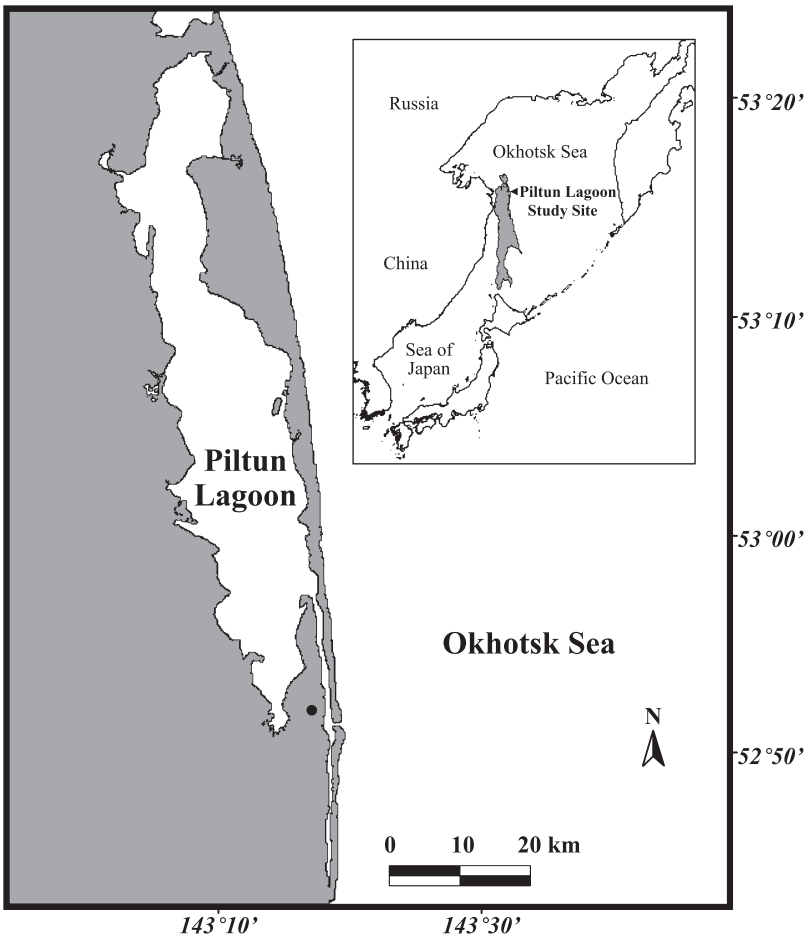

Fig. 1. Map of Piltun Lagoon study site on Sakhalin Island, Russia. Inset shows relative location of Sakhalin Island in the western Okhotsk Sea. ● = Lighthouse location.

sources (i.e., boats, helicopters, humans) and descriptive environmental parameters (e.g., time of day, Beaufort State, visibility) were noted during each count. Counts completed in Beaufort State ≥4 and poor visibility (i.e., fog, smoke, or sunglare in >10% of the study area) were not used. If a potential disturbance source occurred within 100 m of the study area during the first round of a count or 45 min before a count, the count was excluded from analysis. If >50% of hauled-out seals entered the water during round one of a count, even if the causal stimulus was unknown, the count was not used.

Counts were classified as occurring during falling or rising tide periods based on high and low water predictions in the Admiralty Tide Tables (Hydrographer of the Navy 1997). A two-sample *t* test and linear regression analysis, with a significance level of 0.05, were used to examine the influences of tidal condition, daylight period, and the interaction between tidal condition and daylight period on the proportion of seals hauled out in the study area. The proportion of seals hauled out for each count was determined by dividing the number of seals on land by the total number of seals on land, near-shore, and in the water.

Results and discussion

From 24 July to 31 August 1998, a total of 9,776 spotted seals were observed during 52 usable counts. The paired observer concordance correlation coefficients obtained in this study were r_c = 0.90 (land), r_c = 0.81 (near-shore), and r_c = 0.79 (water). Acceptable levels of inter-observer reliability usually exceed r = 0.70 (Martin and Bateson 1986). Based on the overall agreement between the two observers, only values collected during the first round of each count were used for the analyses reported here.

Seal hauling areas consisted of sandy beaches along the barrier spits at the lagoon entrance, and were acces-

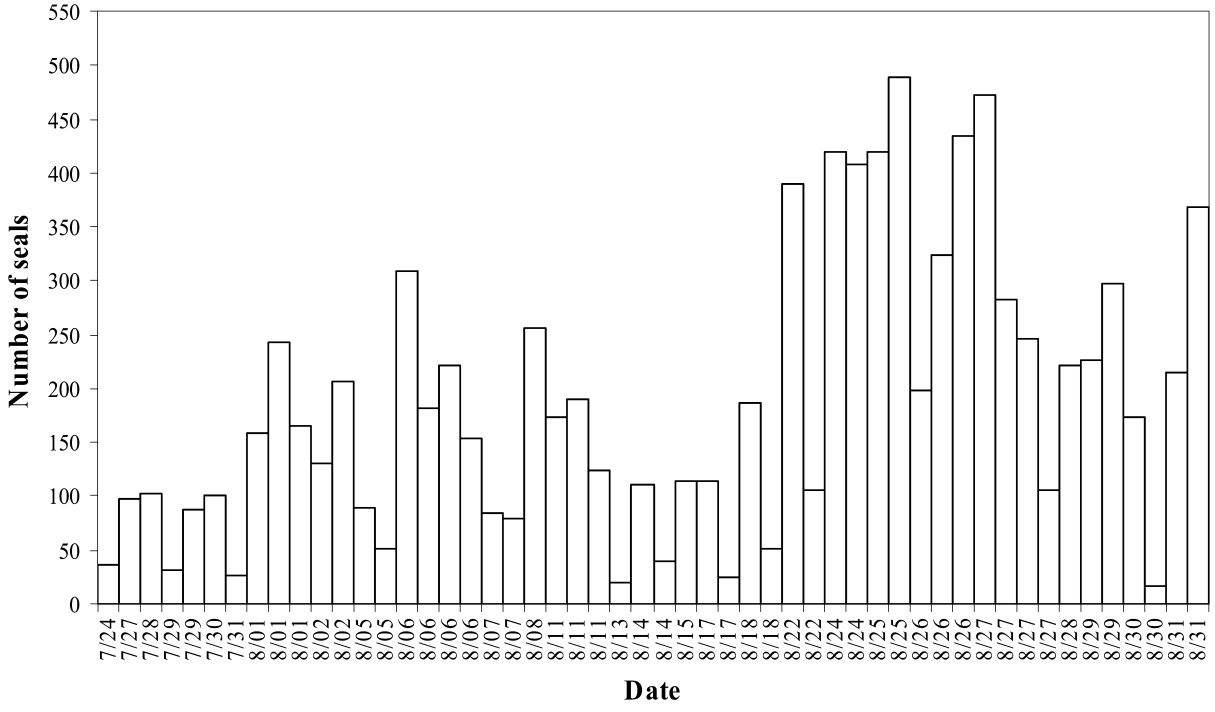

Fig. 2. Total number of spotted seals on land and in water per count (n = 52) at Piltun Lagoon in 1998. Days on which more than one count was conducted are represented by repeated dates on the x-axis.

sible to seals at all tidal heights. Seals were present in Piltun Lagoon throughout the study period, with higher total numbers occurring in late August (Fig. 2). The total number of seals on land and in water ranged from 16 to 489 (mean = 188.0 ± *SD* 129.51). The number of seals on land ranged from 0 to 421 (mean = 112.5 ± *SD* 101.43), and the proportion of seals hauled out ranged from 0 to 0.9 (mean = 0.5 ± *SD* 0.25).

The proportion of seals hauled out was significantly higher in falling tide conditions (t (2,50) = 3.951, P = 0.0002). The mean (±*SD*) proportion of seals hauled out by tidal stage was: Falling = 0.62 ± 0.192 (n = 29) and Rising = 0.37 ± 0.250 (n = 23). The proportion of seals hauled out showed a significant decrease during daylight hours (F (1,50) = 16.190, P = 0.0002), and diurnal influence accounted for 24% of the variance (r^2 = 0.24) (Fig. 3). However, adding tidal condition as a categorical predictor variable in the regression analysis significantly characterized the proportion of seals hauled out (F (2,49) = 11.102, P = 0.0001), explained an additional 4% of the variance (Adj. R^2 = 0.28), and was selected in a stepwise regression procedure.

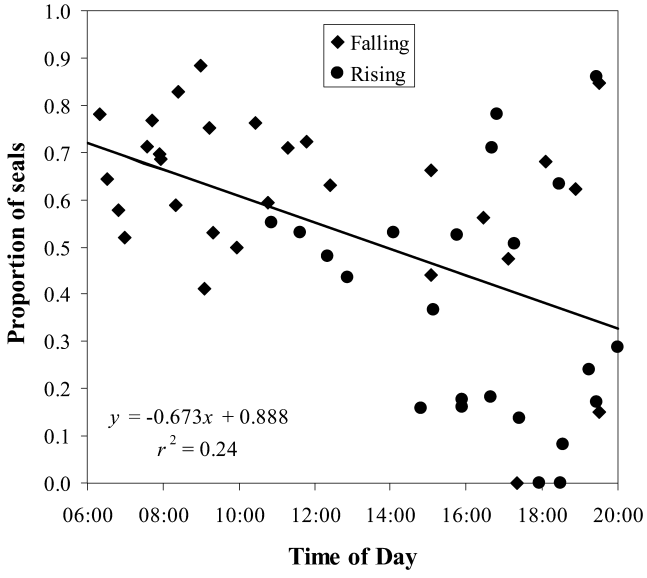

Fig. 3. Proportion of spotted seals hauled out during counts (n = 52) as a function of daylight period, with regression equation and coefficient of determination displayed. Multiple regression equation and adjusted coefficient of multiple determination from the inclusion of tidal condition as a predictor variable: $y = -0.442x_1 + 0.154x_2 + 0.671$, Adj. R^2 = 0.28.

The continuous use of Piltun Lagoon by spotted seals during this study suggests that this region is an important hauling and feeding area for the species. Numerous spawning fishes such as pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*), as well as locally abundant fishes including Arctic char (*Salvelinus leucomaenis*), redfin (*Leuciscus brandti*), and Pleuronectids

are present in Piltun Lagoon and are known prey of spotted seals (e.g., Gol'tsev 1971; Makhnyr and Perlov 1988). Although the total number of seals was highly variable throughout the study, a peak occurred in late August. This peak in seal abundance closely corresponds with the annual peak in pink salmon runs along the coast of Sakhalin Island (Makhnyr and Perlov 1988). Thus, as observed in other locations (see Rugh et al. 1997 for review), we hypothesize that spotted seals aggregate around the entrance to Piltun Lagoon, as do local fishers, to take advantage of the seasonal availability of abundant prey.

The proportion of spotted seals hauled out was higher during falling tides and earlier in the day. We suggest that tidal condition was the primary influence on the proportion of seals hauled out at any given time during the day. During falling tides, seals were more likely to be on land. However, as water entered the lagoon during rising tides, fewer seals remained hauled out despite the availability of suitable hauling habitat. Previous studies have qualitatively demonstrated that spawning fishes move along shorelines and through channels with incoming tidal currents (e.g., Stasko et al. 1976 for sockeye salmon, *O. nerka*, in British Columbia), and that seals do take advantage of these influxes of fish (e.g., Brown and Mate 1983 for harbor seals, *P. vitulina*, in Oregon). Further, Zamon (2001) quantitatively determined that harbor seal abundance in water, aggregation near a channel constriction, and captures of large fish (predominantly salmon) all increased during rising tides in the San Juan Islands, Washington. Thus, rising tides may help channel prey into the Piltun Lagoon system and offer seals increased foraging opportunities, a link corroborated by the tidal haul-out pattern observed in this study.

A possible explanation for the diurnal decrease of seals hauled out, even in falling tide conditions, is the impact of diurnal human activity in the lagoon. Spotted seals have been noted for their extreme sensitivity to anthropogenic disturbance (Frost et al. 1993; Rugh et al. 1997). When small motor boats (e.g., operated by local fishers and hunters) or helicopters (i.e., related to offshore oil and gas development activities) entered the present study area, a majority of hauled-out seals would quickly flee into the water. Generally, these types of human activities increased in frequency as the day progressed. Additionally, disturbed seals may not have returned to the hauling areas after the disturbance source was no longer present.

Future studies of spotted seals in Piltun Lagoon could focus on systematically assessing tidal influences on seal feeding behaviour, while investigating the impact of anthropogenic disturbance on seal hauling and foraging opportunities. As human activity and potential disturbance sources in the study area has greatly increased since the study period, mostly associated with expanding oil and gas development off the northeastern coast of Sakhalin Island, the latter research component would be particularly timely and useful.

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