Estimating Disturbance of Harbor Seals by Cruise Ships

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Background

Tidewater glacial fjords in Alaska host the largest aggregations of harbor seals (*Phoca vitulina*) in the world. During seal pupping, ice calved from glaciers serves as a platform on which mothers whelp and nurse their young. These sites have experienced a ten-fold increase in cruise ship traffic since the 1980s, leading to concern over possible impacts on harbor seal populations. Research shows that seals on ice flush into the water when cruise ships approach closer than 400m, a reaction that can disrupt the seals' energy balance for thermoregulation. Immediate reactions to ships by individual seals can be readily observed, but estimating the cumulative effects on a given population during ship encounters requires a larger-scale approach. We examined the spatial relationship between seals on ice and a cruise ship in Disenchantment Bay, Alaska, a glacial fjord where vessel traffic is unregulated and where as many as 150 vessels visit during the spring and summer. Our goal was to estimate the number of seals disturbed into the water during a single visit by a cruise ship.

Methods

An aerial strip-transect survey of seals was completed as a cruise ship entered the haul-out area. Digital images from the survey were georectified and locations of photographed seals were mapped. An 'intensity surface' for seal densities in the areas outside the photographs was fitted for the observed seal locations using an interpolator based on radial basis functions in an inhomogeneous Poisson process. A GPS track of the cruise ship's transit into and out of the bay was overlaid on seal locations and closest ship-to-seal approach distances were calculated (see Fig. 1). Probabilities of observed seals flushing into the water were determined for those approached closer than 400 m by applying the proportion of seals flushed at each of four 100 m distance bins, as determined from separate behavioral studies (see Fig. 2). The same proportions were applied to each grid point in the interpolated intensity surface within 400m of the track to arrive at seals flushed per square meter, and the average was multiplied by the unsampled haul-out area within 400 meters of the track to give an estimate of number of seals flushed in areas that were not sampled. The probabilities of flushing for observed seals and for those interpolated in the intensity surface were combined as an estimate of total disturbance (e.g., two seals with a 50% chance of flushing = one seal predicted to flush). In order to estimate the proportion of all seals on ice that were disturbed, total haul-out abundance was estimated by adding the total count of photographed seals to the average (modeled) density multiplied by the haul-out area not photographed. We estimated disturbance on the inbound and outbound portions separately because of the potential for ice movements to cause greater displacement of seals in the longer time interval between the survey and the outbound portion. We also calculated a separate estimate for pup disturbance, as studies have suggested that pups may be especially vulnerable to the thermoregulatory stress of this disturbance.

Figure 1. Detail shows a mother and pup pair 270 m from the ship's track. Both seals were assigned a 44% chance of flushing into the water.

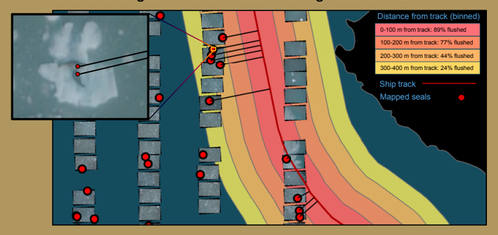
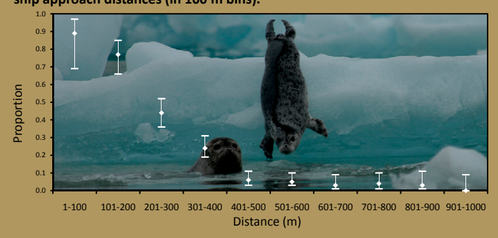
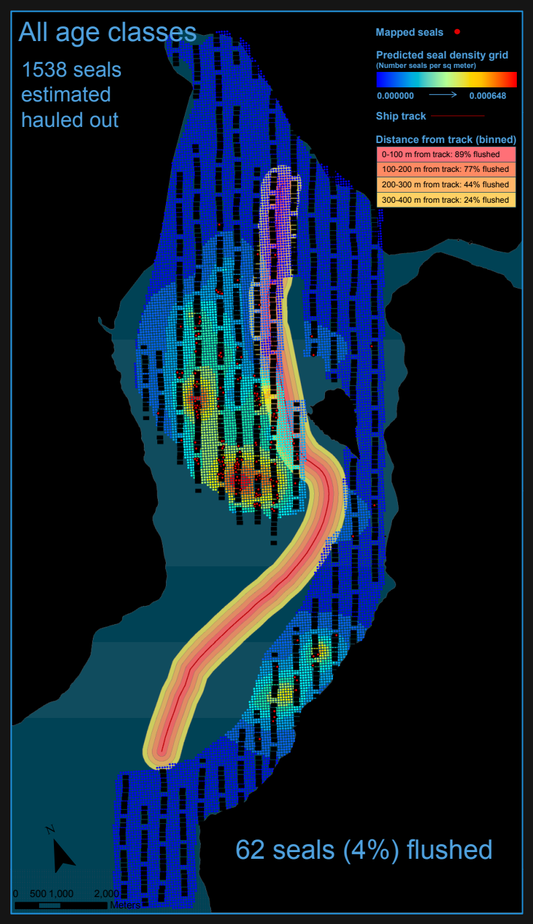


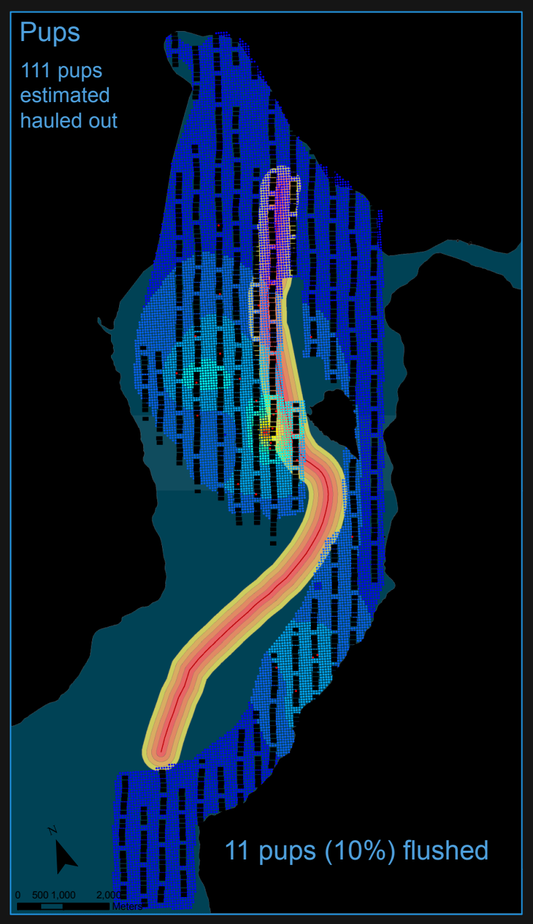
Figure 2. Proportion of harbor seals entering the water in response to varying ship approach distances (in 100 m bins).



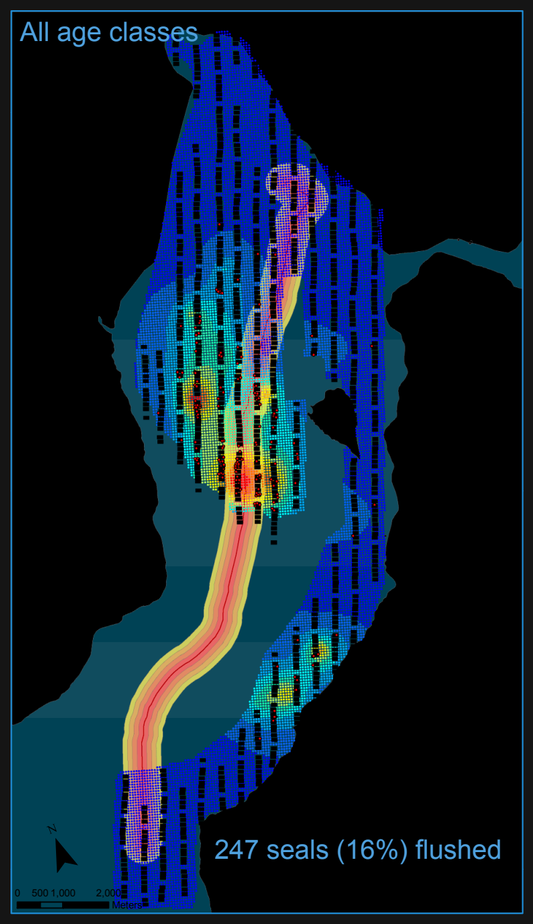
Results

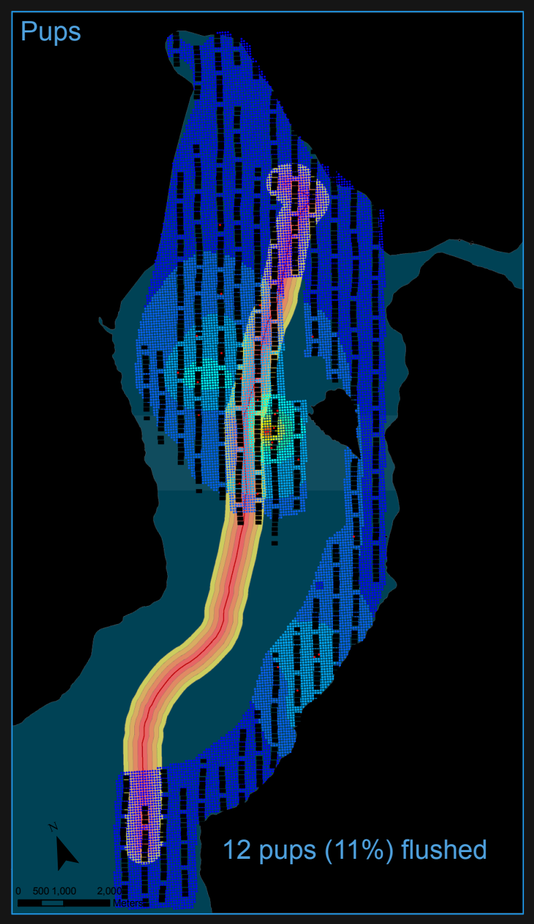
Vessel Inbound





Vessel Outbound





Conclusions

This analysis represents only a first attempt to estimate cruise ship disturbance of a seal population, but our results indicate that the scale of this disturbance may be significant. Winds, currents, and ice movements are common in the study area, and seal positions may have changed in the interval between the aerial survey and the ship's transit out of the bay, introducing greater uncertainty into the outbound portion of the estimated disturbance. However, even the 4% disturbance estimate from the inbound segment is potentially significant, particularly as it is common for up to three vessels to enter the bay on a given day. It is also noteworthy that the proportion of pups disturbed during the same segment was considerably larger. A 10% disturbance of pups, which may be subject to especially high energetic costs when forced into the water, is particularly significant.

We hope to gain a better understanding of the true costs of the disturbance due to a single ship's visit by integrating data on behavioral and physiological responses (e.g. how long seals spend in the water after flushing before hauling out again, and energetic costs of increased time spent in the water).

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