USING AERIAL PHOTOGRAPHY OF HARBOR SEALS TO COMPARE TIMING OF PUPPING AND WEANING AT TWO GLACIAL FJORDS

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Icy Bay

Disenchantment Bay

Yakutat Bay

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Summary The timing of pupping and lactation are related to a species' life-history traits, and to maternal strategies to maximize energy transfer to offspring while minimizing other threats. Shifts in timing can signal environmental and demographic changes with implications for survival. Though individual-based studies are most informative, they are logistically complicated and disruptive and recently-tested proxies for timing of breeding from cross-sectional sampling have shown to be useful. Using aerial photographs, we developed a non-invasive method for classifying harbor seal (*Phoca vitulina richardii*) pups at glacial fjords in Alaska with the goal of estimating the timing of pupping and weaning. Using body length measurements from scaled images to distinguish pups (using actual growth rates and size ranges of known pups/yearlings) in conjunction with pup coloration and nursing behavior, we constructed a time series of pup occurrence with and without attendant mothers. Despite sites being outwardly similar and in close proximity (115 km), we found unusual differences in the timing of pupping and weaning. Icy Bay, which hosts about 3-fold more seals than Disenchantment Bay, had an advanced phenology of up to 7-13 days (using dates of 50% maximum pup count and maximum pup count), a pattern observed in both years. In conjunction with earlier pupping, mothers at Icy Bay left pups unattended at about half the frequency compared to Disenchantment Bay. Consistent with life-history theory and past findings on maternal strategies in phocid seals, our findings suggest that the population at Icy Bay is composed of a higher proportion of mothers in better condition which are able to pup earlier and nurse pups longer with less supplemental foraging. Our method provides an alternative to methods at terrestrial sites that involve repeated captures and tagging of animals, and represents the only practical means of studying ice-associated seals. This new technique has the potential to detect changes in maternal life-history traits and point to potential causes of changes in abundance. It also stands to increase our understanding of distributional patterns of harbor seals in Alaska especially adjacent to tidewater glaciers where floating ice attracts unusually large aggregations with seemingly disproportionate numbers of pups.

2 Background

a Harbor seals (*Phoca vitulina*) haul out in fjords on ice calved from glaciers. Mothers nurse their precocial pups on the ice for 2-4 weeks, though estimates to date are based on studies at terrestrial sites only.

b The glacial ice fields of Icy and Disenchantment Bays, near Yakutat, Alaska, host some of the largest aggregations of harbor seals in the world. Disenchantment Bay is visited by over 150 cruise ships during pupping and molting; only a few tour ships visit Icy Bay annually.

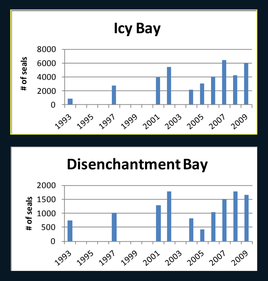


Fig. 1 Maximum count of seals during August surveys flown 1200-1700 h (ex. 1993). Counts are derived from visual estimates (1993, 1997), photogrammetry (2001,2002), and statistical sampling (2004-2009).

c Despite outward similarity in the natural habitat of these adjacent fjords, observations point to some striking differences with respect to the seals and the enviroment:

During the annual molt, Icy Bay hosts about 3X the number of seals as Disenchantment Bay; patterns in estimated abundance across 16 years at the two sites are similar (Fig. 1, left);

During pupping, high-altitude photo counts suggest similar numbers of seals use the two sites but estimates of productivity seem to be dramatically lower at Disenchantment Bay; and

Despite similar glacial cycles of seasonal advance and retreat, glaciers in Icy Bay are rapidly thinning and retreating (causing increased calving) while the Hubbard Glacier in Disenchantment is advancing (causing reduced calving).

3 Importance, Foundation, and Goals

a For most habitats, population-level studies of harbor seals via aerial surveys provide the most reliable (sometimes only) means of monitoring seal abundance over time. Such surveys, however, are limited in their usefulness in discerning any causes of change thus leaving managers minimal recourse to respond - especially proactively - to population declines or other conservation issues.

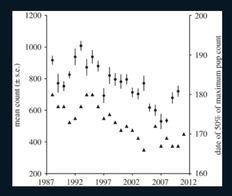


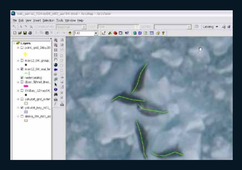
Fig. 3 (from Cordes & Thompson 2013) Trend in counts of harbour seals within the Inner Moray Firth (dots with error bars) and the timing of pupping (triangles) as inferred by the proxy of 50% of maximum pup count from 1988 to 2011.

b Previous seal studies show that dramatic shifts in timing of breeding over short periods (up to 25 days over 15-35 years; Fig. 3) coincide with changes in the environment and/or population thus highlighting seasonal timing as a useful measure for detecting natural and anthropogenic changes. Newly-tested proxies for timing of breeding from longitudinal studies allow for reliable tracking of phenology using cross-sectional surveys.

c In our study, we mapped seals on floating ice and developed methods to classify pups (both attended and not) in order to estimate the timing of breeding and weaning to compare across two similar/nearby glacial sites that differ dramatically in use by seals. To our knowledge, this study is the first to estimate weaning in seals from a time series of remotely-sensed imagery.

4 Methods and Data

a A GPS-linked, Digital SLR camera mounted in a DHC-Beaver captured non-overlapping images (4cm/px) every ~ 2 sec representing 80m X 120m ground coverage with a total ground coverage of 10-20%.



b About 30K seals (9970 pups) were mapped and measured over 49 surveys from May to July 2004 and 2005(15 @ Icy Bay, 34 @ Disenchantment Bay); 1,712 pups were photographed suckling; 37 newborn pups were observed. Standard lengths were estimated by superimposing polylines over seals using 5 standard body anchor points (photo, left). Pups were first classified based on size (see below), and then confirmed by color and nursing behavior; mothers were classified based on relative size and association with pups.

c Length estimates of known pups (observed suckling) and yearlings (teeth aging; ADFG) were modeled to derive a probabilty of a seal being a pup or yearling. Classification was improved by modeling growth in pups. Due to potential measurement errors (e.g., due to changing altitude and seal posture), pelage color was used to confirm pups that were classified based on size alone (pups are gray; yearlings are brown).

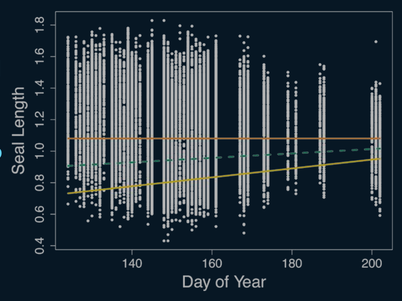


Fig. 2 Mean length of pups (yellow line; linear growth model) and yearlings (orange line) by day of year (pups: May to June; yearlings: April to May). The green dotted line marks the classification line, which is the halfway point between pups (trending) and yearlings (non-trending).

5 The Findings

a We found that the the timing of pupping was earlier at Icy Bay (up to 7-13 days) compared to Disenchantment Bay (Figs. 4 and 5).

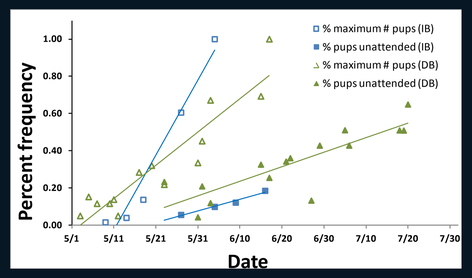


Fig. 4 Percent of maximum number of pups counted (hollow symbol), and pups left unattended (solid symbol), by date (only 2004 shown) at Icy (IB: blue squares) and Disenchantment Bays (DB: green triangles), Alaska.

b Our measure for progression of weaning (% pups unattended) points to mothers weaning pups more gradually at Icy Bay with pups expected to become independent later than Disenchantment Bay (Fig. 4).

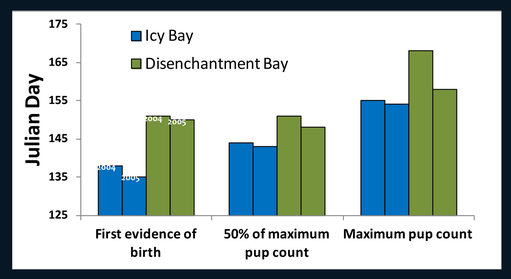


Fig. 5 Estimates of three phenological proxies: 1) first birth (evidenced by blood on ice near mother-pup pair), 2) 50% of the maximum pup count, and 3) the maximum pup count, at Icy (blue) and Disenchantment (green) Bays in 2004 (first bar) and 2005 (second bar).

6 The Take Home

a It was surprising to find evidence that seals at seemingly similar and nearby glacial fjords differ in timing of breeding and weaning. The differences persisted across two years and were most consistent using 50% of maximum pups, thus supporting the reliability of this proxy from longitudinal studies. Further models will be explored to examine the potential errors caused by differences in sampling frequencies across sites and years.

b Given that Icy Bay hosts 3X more seals, a pattern also reflected in differences in pup production, our findings support hypotheses that these two glacial habitats differ in quality, which could have led to differences in breeding success (i.e., pregnant females in better condition > earlier breeding/longer lactation > higher pup survival). Such variation over the long term likely would lead to differences in habitat use and abundance.

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Acknowledgments This research was supported financially and/or logistically by the Yakutat Tlingit Tribe, The NorthWest Cruise Ship Association, Cruiselines Agencies of Alaska, and the U.S. National Park, Forest, Weather, and Marine Fisheries Services.

Citation: Cordes LS and Thompson PM. 2013 Variation in breeding phenology provides insights into drivers of long-term population change in harbour seals. Proc R Soc B 280: 20130847

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