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EXTREME TEMPORAL VARIATION IN HARBOR SEAL (*PHOCA VITULINA RICHARDSI*) NUMBERS IN GLACIER BAY, A GLACIAL FJORD IN SOUTHEAST ALASKA

A three-week difference in survey dates resulted in an 85% reduction in the estimate of the number of harbor seals (*Phoca vitulina richardsi*) in Johns Hopkins Inlet, a glacial fjord in Glacier Bay, Alaska, and a similar underestimate for all of Glacier Bay (58°40′N, 136°W) (Fig. 1). Johns Hopkins Inlet seasonally contains one of the largest aggregations of harbor seals in Alaska, and it is one of 13 areas in which seals have been monitored for the past 10–25 yr (Sease 1992). As part of a four-year project to determine a minimal population estimate (sum of maximal counts) for harbor seals in Alaska, the National Marine Mammal Laboratory, National Marine Fisheries Service (NMFS) extensively surveyed southeast Alaska in September 1993. The NMFS will base management decisions on the minimal population estimate derived from that survey. During the September 1993 survey, only 500 seals were counted in Johns Hopkins Inlet and only 1,086 were found at haulouts throughout Glacier Bay; three weeks earlier 4,500 seals were counted in Johns Hopkins Inlet alone. A large underestimate of seals in Glacier Bay could bias the estimate of seal numbers throughout southeast Alaska, unless they were detected in adjacent areas. We documented the decrease in seals on haulouts between August and September 1993 by comparing the Johns Hopkins portion of the NMFS September 1993 survey to a survey conducted in the fjord in August of the same year, and by comparing results of the September 1993 surveys of all haulouts in Glacier Bay (including Johns Hopkins Inlet) to two baywide surveys completed in August 1992 and 1994 (Fig. 2). The data suggest that more than half of the 6,000 seals found in Glacier Bay in August were not detected in the bay, or within a 60-km radius of the bay, during the September 1993 survey.

During summer months the majority of harbor seals in Glacier Bay haul out to rest, pup, and molt on icebergs in Johns Hopkins Inlet (Streveler 1979, Calambokidis *et al.* 1987), a tidewater glacial fjord located 100 km north of the mouth of the bay (Fig. 1). Seals also use more than 20 land haulouts in Glacier Bay. During peak haulout periods in August, two different methods are used to survey seals throughout the bay. When there are several thousand seals in Johns Hopkins Inlet, land-based counts provide the best minimal population estimate, while aerial photographic surveys are ideal for censusing the smaller land haulouts scattered throughout the bay.

From 22–28 August 1992 and from 10–16 August 1994, we conducted baywide surveys of harbor seals at land and iceberg haulouts, including Johns Hopkins Inlet. Both surveys were timed to occur near monthly low-tide cycles. Seals at land haulouts were photographed from fixed-wing aircraft (Piper Su-

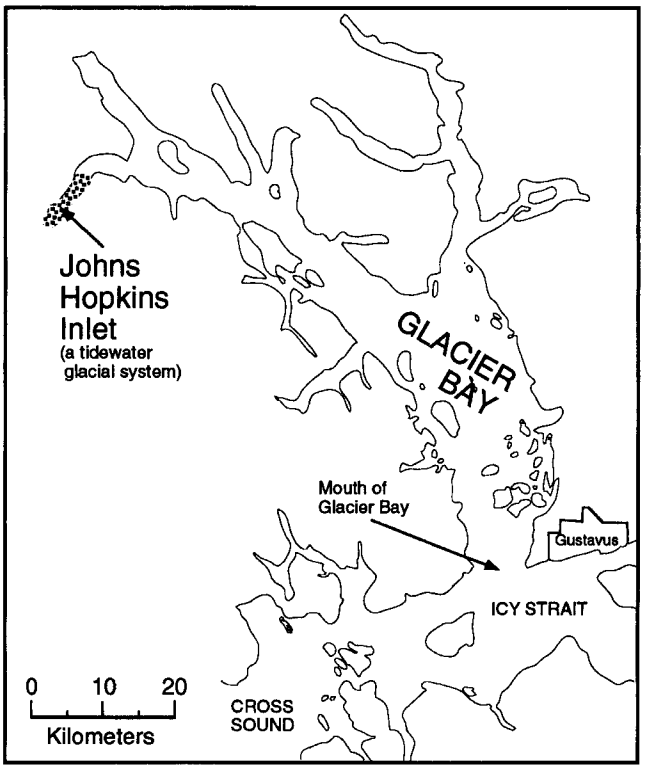

Figure 1. Map of Glacier Bay. During August the majority (> 60%) of harbor seals haul out on icebergs in Johns Hopkins Inlet. Over 20 other land haulouts are found throughout the lower Bay.

percub and Cessna 185) at altitudes of 215–330 m within three hours of low tide, and seals were then counted from color slide photographs. In Johns Hopkins Inlet thousands of seals occupied rapidly moving glacial icebergs which occasionally covered more than eight square kilometers. Consequently, animals in the fjord could not be counted from aircraft or aerial photographs during peak haulout periods. Instead, two observers simultaneously counted from the shore about 100 m above sea level with the aid of spotting scopes (1992 and 1993) or 20 × 60 binoculars (1994) mounted on tripods. Two to six paired counts per day were made from land on three to six days in August of each year from 1992 to 1994 (Mathews 1995). We observed, as did Streveler (1979) and Calambokidis *et al.*(1987), the highest numbers of seals in August.

During the two baywide surveys an average of 5,845 (95% CI = 3,221–8,469) seals were counted in Glacier Bay in 1992 and 5,560 (95% CI = 4,388–6,754) in 1994. These estimates were derived from the sum of the mean of daily high counts in Johns Hopkins Inlet and the mean from aerial photographic surveys of seals at land haulouts (Mathews 1995), so they represent conservative estimates of total numbers. While Johns Hopkins Inlet

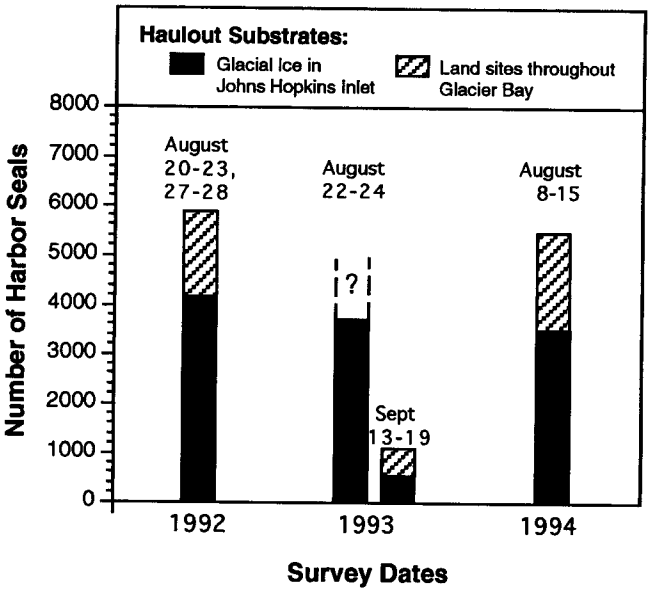

Figure 2. Harbor seal counts in Glacier Bay in August 1992, 1993, and 1994, and September 1993. August data are means of daily maximal counts, whereas the September 1993 count is a maximal count. In August 1993 there was no aerial survey of seals at land haulouts.

comprises less than 0.5% of Glacier Bay's inside waters (approximately 1,650 km^2), it accounted for 71% (4,277) and 62% (3,464) of the total number of harbor seals observed at haulouts in the bay during the August 1992 and 1994 surveys (Fig. 2). In both years more than 1,700 seals were also observed at up to 13 land haulouts elsewhere in the bay (Mathews 1995).

From 1992 to 1994 the means of daily maximal counts of seals in Johns Hopkins Inlet in August were 4,277 (SE = 588, n = 4), 3,672 (SE = 625, n = 3), and 3,464 (SE = 128, n = 6) (Fig. 2). Although mean numbers in the fjord declined from 1992 to 1994, this trend is not significant (Kruskal Wallis). The high count in Johns Hopkins Inlet in 1993 was 4,517 seals observed on 22 August.

In 1993, aerial surveys for harbor seals at land and ice haulouts were conducted in southeast Alaska by the National Marine Fisheries Service to determine a minimal population estimate for this region (Loughlin 1994). As part of that effort, we conducted four complete surveys of Glacier Bay from 14–19 September 1993. At that time, the density of icebergs in Johns Hopkins Inlet was one-third or less than it had been in August, and seals on the ice were easily counted from the air. A high count of approximately 500 seals was made in the Inlet on 14 September. Thus, seal counts in Johns Hopkins Inlet declined by more than 85% from a high of 4,517 animals on 22 August to 500 individuals just three weeks later (Fig. 2).

Based on a late afternoon count conducted on 13 September and completed

on the morning of the 14th, the maximal count for all of Glacier Bay during the mid-September 1993 aerial census was 1,086 seals (Fig. 2). We did not survey the entire bay in August 1993, yet over 5,500 seals were counted during both baywide surveys in August 1992 and 1994. This suggests that, in addition to the 85% decline documented in Johns Hopkins Inlet between August and September, seal numbers at haulouts throughout Glacier Bay also decreased substantially between August and September 1993 (Fig. 2).

The large change in seal numbers at ice and land haulouts in Glacier Bay between August and September may be due to one or more of the following factors: (1) seals on the ice in Johns Hopkins Inlet may have been underestimated in the September aerial survey; (2) seal numbers in Johns Hopkins Inlet tend to peak around 1300 (Calambokidis *et al.* 1987), so differences in census timing could have biased counts; (3) harbor seals may haul out less frequently or for shorter periods in September than in August; or (4) large numbers of seals may leave Glacier Bay between August and September.

We do not believe that either of the first two factors is sufficient to account for the observed discrepancy between counts in August and September 1993. Although counts from the air of large numbers of seals widely dispersed on ice are likely to be less accurate than systematic counts from elevated land sites, so few (50–500) seals were present on the ice during the September flights that they were quite easy to count from the air. Furthermore, the order of magnitude of difference in seal numbers from August to September renders any error introduced through differences in sightability trivial for this analysis.

Calambokidis *et al.* (1987) conducted counts of seals in Johns Hopkins Inlet every two hours from 0800 to 2000 on nine days between 10 June and 16 August. Morning counts were, on average, 32% less than peak counts at 1300, and a similar pattern was observed in Muir Inlet, a nearby glacial fjord. Thus, the earlier hour of the counts in September 1993 compared to those in August 1993 does not fully explain the magnitude (85%) of the decrease in seal numbers over the three-week period.

Several studies have indicated that harbor seals haul out less frequently and for shorter durations after molting (Johnson and Johnson 1979, Sullivan 1980, Thompson and Harwood 1990). Although the exact timing of the molt for harbor seals in Glacier Bay is not known, it probably extends at least from July through early September (Hoover-Miller 1994). Because many seals should be completing their molts in September, a decrease in the proportion of time spent at haulouts may be a contributing factor in the observed decline in numbers visible at land haulouts from August to September. In Scotland eight radio-tagged harbor seals were out of the water 36% of the time in summer (June–August) and 20% of the time in winter (September–March) (Thompson *et al.* 1989). Thus, some of the noted decline in Glacier Bay might be attributed to reduced haulout frequency or duration if seal behavior in the two study areas is comparable.

Differences in the August and September counts also may have resulted from movement of seals out of Glacier Bay. Hoover (1983) observed that by late summer virtually none of the postparturient female harbor seals were

observed on ice haulouts in another glacial fjord in central Alaska (Aialik Bay: 59°40′N, 149°34′W). Reproducing females comprised more than 30% of the seals in Johns Hopkins Inlet in 1993 (Mathews 1995) and 1994, and movements by them may have contributed to the lower counts. In the northwest Atlantic, Rosenfeld *et al.* (1988) provide evidence for a general southward movement of harbor seals from the Bay of Fundy (45°18′N, 66°20′W) to Massachusetts (42°37′N, 70°36′W) during autumn and early winter. From mid-October to mid-December they documented a decline of 76% (979 to 238) in seal numbers in the Bay of Fundy with a negatively-correlated increase in seal numbers at the southern extension of their survey area.

The reduced availability of icebergs in Johns Hopkins Inlet may also have precipitated a movement of seals out of the inlet. Furthermore, reduced glacial run-off may correspond to decreased upwelling at the face of the glacier. We have observed seals feeding in such upwelling zones and the reduced flow in these zones may contribute to the exodus of seals. A reduction in food availability could also explain the reduced number of seals at terrestrial haulout sites in Glacier Bay. Small scale (< 10 km, Thompson 1989) and longer distance (> 200 km) seasonal movements (Brown and Mate 1983) and shifts in distribution (Rosenfeld *at al.* 1988) of harbor seals have been documented elsewhere, and it is likely that such movements are related to changes in prey distribution or numbers (Thompson *et al.* 1991). Harbor seals in Oregon and British Columbia exhibited seasonal changes in distribution correlated with the timing of salmon runs (Brown and Mate 1983, Bigg *et al.* 1990). While little is known about the feeding habits of harbor seals in Glacier Bay, six of nine scat samples collected from a land haulout in August 1991 contained remains of salmon (*Onchorhynchus* spp.) (Paul Cottrell, personal communication), a seasonally abundant species in Glacier Bay.

The nine-fold decline in harbor seals observed in Johns Hopkins Inlet over a three-week period and the apparently comparable decline throughout Glacier Bay have not been documented previously. The NMFS's survey coverage of southeast Alaska in September 1993 was extensive, but more than half of the harbor seals observed in Glacier Bay in August may not have been included. During the nine-day survey in September only 1,086 seals were observed in the bay (Fig. 1), and only 1,756 (sum of maximal counts) seals were counted within a 60-km radius outside the south end of Glacier Bay (Loughlin 1994). Thus, approximately 3,000 seals were either missed in the regional survey, or they had moved more than 100–160 km between mid-August and mid-September. During the September survey 9,415 harbor seals were counted within a 180-km radius from the mouth of Glacier Bay (Loughlin 1994).

The NMFS count of seals in September 1993 in the Ketchikan area, one of the repeatedly surveyed sites in Southeast Alaska, was significantly lower (834) than the mean count for August 1988 (1,820) and for August 1994 (834 *vs.* 2,805) (J. Lewis, Alaska Department of Fish and Game, personal communication). The minimal population estimate derived from the September 1993 survey appears to have been biased low, not only for Glacier Bay but for other sections on the Southeast Alaska region as well.

The sum of the maximal counts for all of Southeast Alaska for 1993 was 22,447 seals (CV = 2.6%) (Loughlin 1994). The movement or change in behavior of more than 5,000 harbor seals may have strongly biased survey results for Southeast Alaska. Effects of the timing of harbor seal surveys need to be further clarified, and the distribution, haulout behavior, and movements of harbor seals in Glacier Bay between August and September need to be determined.

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