Long-term Trends in Abundance of Harbor Seals *(Phoca vitulina richardsi)* and Development of Monitoring Methods in Glacier Bay National Park, Southeast Alaska

by

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Abstract

Harbor seals in Glacier Bay National Park use more than 20 different land haulouts during summer months, and they are found in large numbers in a tidewater glacial fjord where they are widely dispersed on ice bergs. The use of two very different haulout substrates, and the large area over which seals may be found, have precluded parkwide counts of seals in the past. In 1992 counts of seals in a glacial fjord from land and counts of seals at land haulouts from aerial photographs were used to census harbor seals throughout Glacier Bay. The sum of mean daily high counts of seals in the Bay in August, 1992 was 5,982. At least 70% of the seals were found in Johns Hopkins Inlet, making this tidewater glacial system one of the largest documented breeding aggregations of harbor seals remaining in Alaska. Eighteen percent (1,090) were counted at the Spider Island reefs, the second largest haulout area in the Park and the largest land haulout. To assess the relative accuracy of aerial photographs compared to low-level counts, mean counts from land were compared to counts from aerial photographs of seals at Spider Island. Land-based counts from the low-level site were, on average, 51% (44%-61%) of counts from simultaneous photographs. To assess long-term trends in harbor seal abundance in Johns Hopkins Inlet, I compared the mean of daily high counts from the mid-1970s (Streveler 1979), from 1984 (Calambokidis, unpubl. data), and from my team's 1992/93 counts. The mean count from the early 1990s was significantly higher than that from the mid-1970s, however no change was detected between August 1984 and the early 1990s. These results indicate that the increase in seal numbers in Johns Hopkins Inlet occurred between the latter half of the 1970s and 1984. The proportions of mother/pup pairs in Johns Hopkins Inlet and Icy Bay (both glacial fjords) were higher than at the Spider Island land haulout and they appear to be higher than at land haulouts worldwide. Ice habitat generated in tidewater glacial fjords is important and ephemeral habitat for pupping and nursing harbor seals.

KEY WORDS: harbor seal, *Phoca vitulina,* censusing, pups, Glacier Bay, abundance, minimum population estimate (MPE), tidewater glacier.

Harbor seal *(Phoca vitulina richardsi)* numbers in parts of Alaska have declined by as much as 86% (Pitcher 1990), and this trend approximately parallels the unprecedented declines in northern sea lions *(Eumetopias jubatus)* in the central Gulf of Alaska and areas to the west (Braham, et al. 1980, Merrick, et al. 1987, Loughlin, et al. 1992). Similar declines are not evident for either pinniped species in Southeast Alaska (Hoover-Miller 1994) where there is some evidence of an increase in sea lion numbers (Loughlin, et al. 1992). However, census data for harbor seals in parts of Southeast Alaska have been considered inadequate for rigorous trend assessment (Hoover-Miller 1994). To address this limitation, I began working to standardize census methods in Glacier Bay National Park in 1992, and in 1991 the National Marine Mammal Lab (NMFS) initiated a three year study to determine minimal population estimates (MPE)

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for harbor seals throughout Alaska (Loughlin 1992, 1994).

Johns Hopkins Inlet in Glacier Bay has one of the largest documented breeding aggregations of harbor seals in Southeast Alaska (Calambokidis et al. 1987), and it may have one of the largest remaining groups of harbor seals in the State (Hoover-Miller 1994; Mathews 1992). However, between 1988 and 1991 harbor seal numbers in Johns Hopkins Inlet appeared to decline (Hoover-Miller 1994). I believe that this apparent trend was the result of non-standardized monitoring, rather than a real decline. Because harbor seal numbers have declined significantly in other parts of Alaska, the development and long-term use of standardized methodology to survey such a large group of harbor seals in a national park is of particular importance.

Harbor seals in Glacier Bay use more than 20 different land haulouts during summer months, and they are found in large numbers in Johns Hopkins Inlet, a tidewater glacial fjord where they haul out on ice bergs. The use of two very different haulout substrates, and the large area over which seals may be found, have precluded Parkwide counts of seals in the past.

In 1992 I received support from the National Marine Mammal Lab (NMFS, Seattle) and Glacier Bay National Park to conduct aerial surveys of land haulouts and land-based counts in Johns Hopkins Inlet for a Parkwide estimate of harbor seals. This paper summarizes the results of these surveys and the field work and describes other aspects of the development of harbor seal monitoring in Glacier Bay, including a comparison of the effectiveness of aerial photography of seals at land haulouts and counts from low-level sites on land.

Periodic studies of harbor seals in Glacier Bay spanning 20 years provide valuable information on numbers, reproductive timing, diurnal patterns, and other aspects of seal biology and behavior (Streveler 1979, Calambokidis et al. 1987, Mathews 1992, and unpublished NPS reports), including the effects of vessel traffic of seals resting on ice bergs (Calambokidis et al. 1983). To evaluate long-term trends in Johns Hopkins Inlet, where data from several years and from comparable studies were available, I compared census data collected during the mid-1970s (Streveler 1979), 1984 (Calambokidis, unpublished data), and my own work in 1992 and 1993 to determine if detectable changes in seal numbers had occurred.

As an index of the importance of an area as breeding habitat, proportions of pups in Johns Hopkins Inlet were determined using two different methods from land. In 1993 I also began developing a third method using aerial photographs to estimate pup proportions. An advantage of the aerial method is that the proportion of mother/pup pairs can be estimated even in areas where accurate counts cannot be made from land or air.

Methods

Study Areas

The two areas of focus for the work in Glacier Bay (58°N, 138°30'W) were Johns Hopkins Inlet and the Spider Island reefs (Fig. 1). Aerial surveys for seals at 40 previously-documented land haulouts in the Bay were conducted in 1992. In my summary of previous work on harbor seals I refer to counts conducted in Muir Inlet (Fig. 1). Located on the east side of Glacier Bay, Muir Inlet is a glacial fjord which was used by at least 1,300 harbor seals for pupping and molting during the 1970s (Streveler 1979). In the last decade Muir glacier has retreated, producing fewer and fewer icebergs. Pup proportions were estimated in both Johns Hopkins Inlet and in Icy Bay (50°N, 141°50'W), another tidewater glacial system located about 400 km northwest of Glacier Bay and adjacent to Wrangell-St. Elias National Park. Harbor seals are also found in Park waters along Icy Strait and the outer coast; however, these areas were not included in this study.

Censusing Methods: Counts from Land

In June and August 1992, a team of observers counted seals in Johns Hopkins Inlet and at the Spider Island reefs from land, but in 1993 only Hopkins Inlet was monitored. In the fjord we counted from an elevated site (~100 m), whereas the Spider Island teams counted from a site about 5 m above mean high tide on a small island located approximately one kilometer west of the haulouts (Fig. 1). In both areas, two observers simultaneously counted seals using 60 mm spotting scopes (Bausch and Lomb, 15X - 60X zoom; Swift, 20X) and three-digit counters.

The highest numbers of seals in Johns Hopkins Inlet are typically observed around midday (Calambokidis et al. 1987). Accordingly, two to four paired counts were made each day with at least one paired count within two hours of noon. For the June counts, seals were categorized as adults or pups. In August, no age class distinction was made, because older weaned pups are difficult to distinguish from adults at a distance. In 1992 we counted seals on June 16-18, July 18-20, and August 20-23, and in 1993 on June 13-17 and August 22-24. Only the June and August counts were used in this study, and only the August counts were used for the minimal population estimate, since this is when seals molt and spend more time out of the water (Calambokidis et al. 1983).

In Johns Hopkins Inlet, seals are typically dispersed over an area of more than four to six square kilometers, making systematic coverage with a spotting scope difficult. Beginning in 1992 I placed four vertical poles in a semi-

circle in front of our observation site so that they divided our field of view into five subsections (Fig. 2). As a subsection pole came into view, the scope was carefully lowered one field height, tightened, and moved back in the opposite direction. This approach reduced the average coefficient of variation between observers from 24% (N=4) to 17% (N=7) (Mathews 1992).

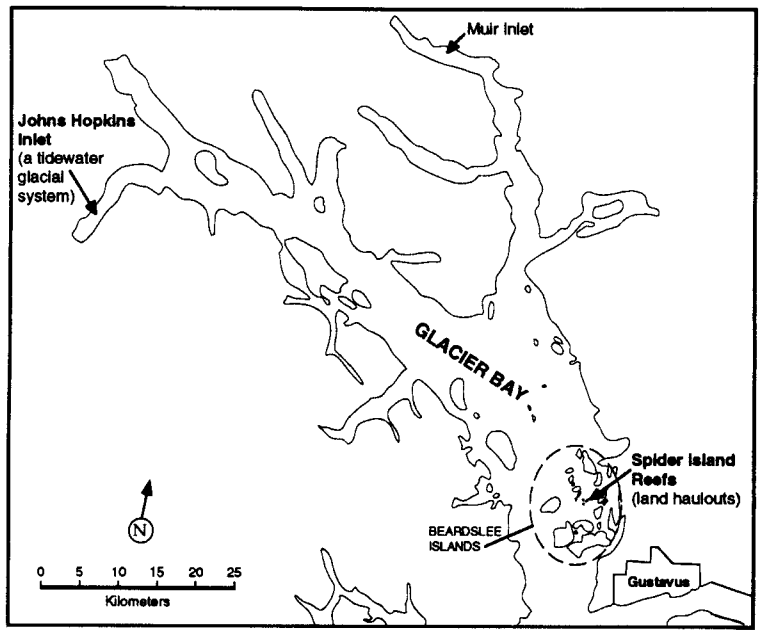

Fig. 1. Map of Glacier Bay, Southeast Alaska showing the two main study sites, Johns Hopkins Inlet and the Spider Island area in the Beardslee Islands.

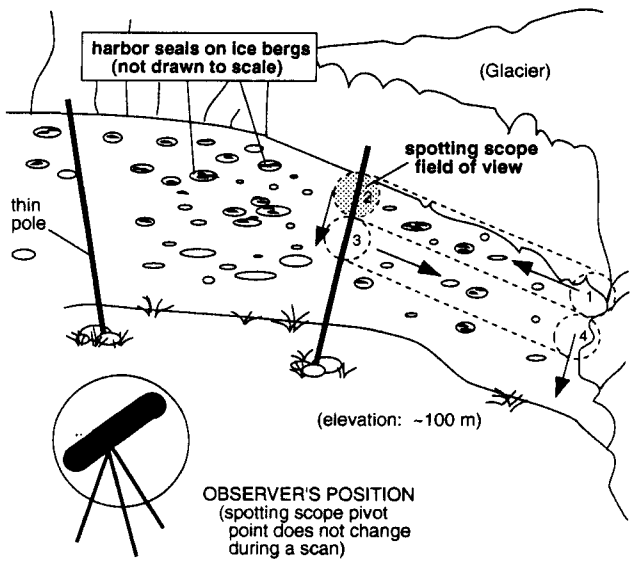

Fig. 2. Systematic scanning method using vertical poles for counting harbor seals on ice bergs in Johns Hopkins Inlet.

About 40 land haulouts have been documented in Glacier Bay since 1975 (Streveler unpublished data; Lentfer and Maier 1989; Mathews 1992). Currently about 20 haulouts are known to be regularly occupied in August (Mathews 1992 and *in* prep.), and over half of the seals observed at land haulouts during the August 1992 survey were found on the reefs and low islands to the south and west of Spider Island, in the Beardslee Island Wilderness area (Fig. 1). Aside from the counts in Johns Hopkins, all land-based counts were of seals in the Spider Island area. Because the observation site for Spider Island was not elevated, as it was in Johns Hopkins Inlet, the land-based method used in the Spider Island counts is considered different from, and inferior to, that used in Johns Hopkins Inlet. For the Spider Island censuses, two observers counted seals from an island approximately 1-2 km from haulouts. Beginning about two hours before low tide, paired counts were conducted until about two hours after low tide. Because counts took much less time (mean = 8 min) at the Spider Island site than in Johns Hopkins Inlet (mean = 73 min) more counts were conducted. In 1992 an average of 20 counts per day were made on 14 days.

Counts from Aerial Photographs

In 1992 two of six aerial surveys of Glacier Bay were flown in August during the molt, when highest numbers of seals at land haulouts are predicted (Calambokidis et al. 1983). No aerial surveys were conducted in 1993 due to a lack of funding. Counts from the August flights over land haulouts were used in conjunction with land-based counts in Johns Hopkins Inlet to determine a minimal population estimate (sum of high counts from all areas) for the Bay and to estimate a mean daily high count (Mathews 1992). During the flights, I attempted to photograph all known haulouts and to search for undocumented haulouts; however, heavy fog prevented surveys over several haulouts in the east arm of the Bay. The absence of seals at a known haulout was also noted.

When surveying the Beardslee Islands (Fig. 1), where the majority of the land haulouts including Spider Island are located, we flew a grid pattern at about 1000 feet. Once seals were spotted the pilot gradually dropped to 700 - 800 feet and began a wide loop around the haulout. Seals were photographed through an open window, using an Olympus OM 2S camera with an 80-200 mm zoom lens, motordrive and databack. Photographers used color slide film rated at 200 or 400 ASA and shot at shutter speeds between 1/250 and 1/1000 second. Location, time, altitude, and frame numbers were recorded for each occupied haulout, and we

also noted whether haulouts were unoccupied or not checked. Groups of seals at all haulouts were small enough to fit in one frame, except the Spider Island reefs where a series of overlapping photographs were taken. The two best slides (or series) for each haulout were projected onto white paper so that seals could be marked and counted. The slide with the higher count was used in the Baywide estimate (most slides differed by fewer than four seals).

During the three flights over Spider Island on August 27 and 28, two observers made one or two paired counts from land within 15 minutes of when I photographed the haulout from the air. The mean value of the paired counts from the land observers was used to determined what proportion of the seals were detected by land observers (= count from land/count from aerial photograph).

Methods: Proportions of Pups

The proportion of pups (= pups /(pups + adults)) during June was estimated for seals at the Spider Island reefs, in Johns Hopkins Inlet, and in Icy Bay using one or two of three different techniques. The first method was simply to count all visible seals from land and to categorize each animal as either an adult or a pup. One problem with this approach, especially in Johns Hopkins Inlet where animals might be more than a mile away, is that pups in the distance are more likely to be missed than pups close by. To determine if this might be a problem, I experimented with a second technique in 1992 (Mathews 1992) and 1993 in which we categorized seals which drifted close enough to our observation site that we could reliably see and distinguish pups if they were present.

From June 15-17, 1993 we categorized subsets of 100 seals approximately every two hours from 07:00 to 21:00. One of the new observers consistently overestimated pups compared to the most experienced observer, so these estimates were not used. For this analysis, I assumed that mother/pup pairs were randomly distributed across the ice. However, age/sex segregation of harbor seals has been documented at land haulouts (Kovacs et al. 1990) and on glacial ice (Hoover 1993), so some counts may have been biased high if they happened to occur in these 'nursery' areas. We conducted subset counts throughout the day, during which large tidal and wind-driven movements of the ice occurred. Our pup proportions were similar to those from other glacial fjords (Figure 3). Consequently, the effects of segregation of mother/pup pairs on the average pup proportion was assumed to be minimal, although it may increase variance. Tests of this assumption will be made by comparing land-based pup proportions with those derived from aerial photographs (described below).

A third method was developed to estimate pup proportions of large aggregations of harbor seals where access to elevated overlooks or funding for land-based surveys is limited. This technique was first used in Icy Bay. During the June 15, 1993 flight over Icy Bay, the observer took a series of 170 non-overlapping photographs. Five rolls of color slide film (ASA 200 or 400) were used. To evaluate pup proportions from the aerial photographs, seals resting on ice bergs were scored as adults, pups, or unknown by viewing the slides with a dissecting microscope. Due to low light levels, the overall quality of these slides was low. However, 112 to 250 animals per roll could be evaluated. To derive a minimum estimate of pup proportions for Icy Bay, pup percentages were determined for each of the five rolls of film. A mean proportion for the one survey day was then calculated by averaging these five values (Fig. 3). Further development and improvement of this technique is underway.

To assess the relative importance of glacial fjords as pupping and nursing areas, I also compiled information on pup proportions at land haulouts (listed in Olesiuk et al. 1990) and at Aialik Bay, another glacial fjord (Hoover 1983). Table 1 and Figure 3 summarize the proportions of pups observed in these studies.

Streveler (1979) used three different observation posts to accomplish his counts of seals in Johns Hopkins Inlet. Thus, I considered his method more similar to that of our counts of 100 nearby animals. Three comparisons of mean pup proportions were made: 1) Johns Hopkins counts of all seals and counts of subsets of 100 nearby seals, 2) the mean values of counts in Johns Hopkins by Streveler for 1975-78 and nearby subsets in 1993, and 3) Johns Hopkins counts of all seals and low-level counts of the Spider Island haulouts. Mann-Whitney U tests were used to analyze each of the three pairwise comparisons.

Harbor Seal Trends, 1975-1993

One of the problems with analyzing data from the 12 different years in Glacier Bay when seal counts were made is that the effort (number of counts and days), observer experience, and haulouts examined vary considerably from study to study. To partially control for this, I only compared data collected by experienced or trained observers who worked in Johns Hopkins Inlet, since this is the main site within Glacier Bay which was examined in multiple years. I compiled count data from Streveler (1979), Calambokidis and coworkers (1987 and unpubl. data) and my teams (1992 and 1993). Mean values of the daily high counts for each study (June 1975-1978; August 1984; June and August 1992 and 1993) were averaged for each month and 'decade' (Table 2). Pairwise comparisons of means (Mann-Whitney U test) were made for the following datasets:

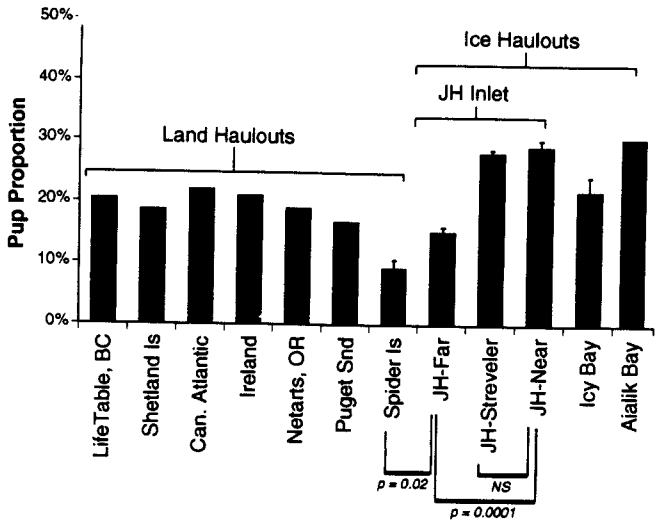

Fig. 3. Proportions of pups at haulouts in Glacier Bay and Icy Bay, Southeast Alaska (data from this report), at land haulouts worldwide (cited in Olesiuk et al. 1990), and at Aialik Bay, another glacial fjord in Alaska (Hoover 1983). Median values are plotted for published data presented as a range. (Mann-Whitney U tests; NS=not significantly different).

1) June 1970s to June 1992/93; and 2) August 1984 to August 1992/93 (Fig. 4). June counts occurred during the pupping season, whereas the August counts occurred during the molting period. Comparisons of counts from different months in different years were not made, although this would be feasible if appropriate correction factors were verified for this study site (Olesiuk et al. 1990)

Between 1973 and 1978, Streveler counted harbor seals in Muir Inlet in June. He also surveyed Johns Hopkins Inlet from 1975 to 1978 (Streveler 1979). To evaluate whether or not the increasing numbers of seals using Johns Hopkins Inlet might have come from Muir Inlet, I plotted data from Streveler's counts and analyzed for trends in years for which there were counts in both inlets (1975-78) (Spearmans Rank Correlation) (Fig. 5).

Table 1. Comparison of the proportion of pups at ice and land haulouts reported in this paper and from three other studies (Streveler 1979, Hoover 1983, and Olesiuk et al. 1990)

GLACIAL FJORDS				
Glacier Bay:	**Method Used (Researcher)**	**Mean %**	**SD**	**N**
Johns Hopkins Inlet	1) All Seals (Mathews)	15%	3.8	13
Johns Hopkins Inlet	2) 100 Nearby (Mathews)	29%	6.0	28
Johns Hopkins Inlet	1) All Seals (Streveler 1979)	28%	2.2	13
Icy Bay, Alaska	3) Aerial Photographs (Mathews)	23%	5.0	5
Aialik Bay, Alaska	1) All Seals (Hoover 1983)	22 - 39%		
LAND HAULOUTS				
Glacier Bay:		**Mean %**	**SD**	**N**
Spider Island Reefs	1) All Seals (Mathews)	9%	2.5	3
Cited in Olesiuk et al. 1990:				
Shetland Islands	(Venables and Venables 1955)	19%		
Atlantic Canada	(Boulva and Maclaren 1979)	20 - 24%		
Ireland	(Summers et al. 1980)	21%		
Tillamook Bay, OR	(Brown and Mate 1983)	14 -18%		
Puget Sound, WA	(Calambokidis et al. 1985)	17%		
	Data are rounded to the nearest percent.			

Table 2. Summary of daily high counts used to compare trends from the mid 1970s (Streveler 1979), 1984 (Calambokidis, unpubl. data) and 1992 and 1993 (Mathews)

	June 1975-78 (Streveler 1979)		August 1984 (Calambokidis unpubl.)		June 1992/93 (Mathews)		August 1992/93 (Mathews)	
	Jun 70s	Dates	Aug 84	Dates	Jun 92/93	Dates	Aug 92/93	Dates
	1089	6/19/75	3026	8/07/84	2185	6/15/92	3403	8/20/92
	1076	6/20/75	3549	8/08/84	3135	6/16/92	3714	8/21/92
	1475	6/19/76	3871	8/09/84	2713	6/17/92	5796	8/22/92
	1439	6/20/76	4314	8/10/84	2527	6/18/92	4147	8/23/92
	1319	6/21/76	5208	8/11/84	2539	6/13/93	4517	8/14/93
	1537	6/22/76	4736	8/12/84	2913	6/14/93	4049	8/15/93
	1616	6/15/77	3744	8/13/84	3477	6/15/93	2451	8/16/93
	1888	6/16/77	1722	8/14/84	4281	6/16/93		
	1456	6/17/77	2350	8/15/84	3212	6/17/93		
	1713	6/18/77	2123	8/16/84				
	2431	6/18/78						
	2313	6/19/78						
	2202	6/20/78						
Mean:	1658		3464		2998		4011	
N:	13		10		9		7	
SD:	420		1209		583		1088	
SE:	117		382		194		411	

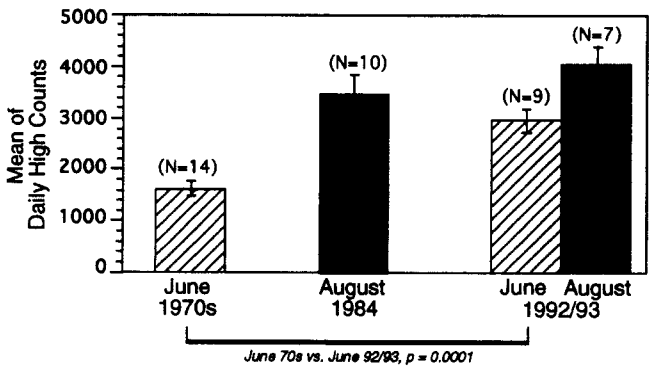

Fig. 4. Comparisons of mean values from daily high counts of harbor seals in Johns Hopkins Inlet for June 1975-1978 (Jun 1970s) from Streveler 1979, for August 1984 (Calambokidis, unpublished data), and for June 1992 and 1993, and August 1992 and 1993 (Mathews). The June 1992/93 mean was significantly higher than the June 1970s mean (Mann Whitney U test), whereas the 1984 and 1992/93 August counts were not significantly different.

Results

Harbor Seal Abundance Estimates

Based on the sum of counts from aerial photographs of land haulouts and the high count for Johns Hopkins Inlet, the high count (or MPE) for harbor seals in Glacier Bay in August 1992 was 7,620 (Mathews 1992). The sum of mean daily high counts in Johns Hopkins Inlet and the mean for the two aerial photographic surveys was 5,982 (95% CI = 4,715 to 7,248). In August 1992, an average of 71% (4,277) of the seals counted in the Bay were found in Johns Hopkins Inlet. The Spider Island reefs, a land haulout, supported the second largest aggregation of seals in the Park with 1,090 (18%) animals.

Comparison of Counting Methods at Land Haulouts

The mean count for the three, paired land-based counts of Seals on the Spider Island reefs was compared to the counts from corresponding aerial photographs. On average, observers at the low-level land site counted only 51% (range = 44%-61%) of the seals present.

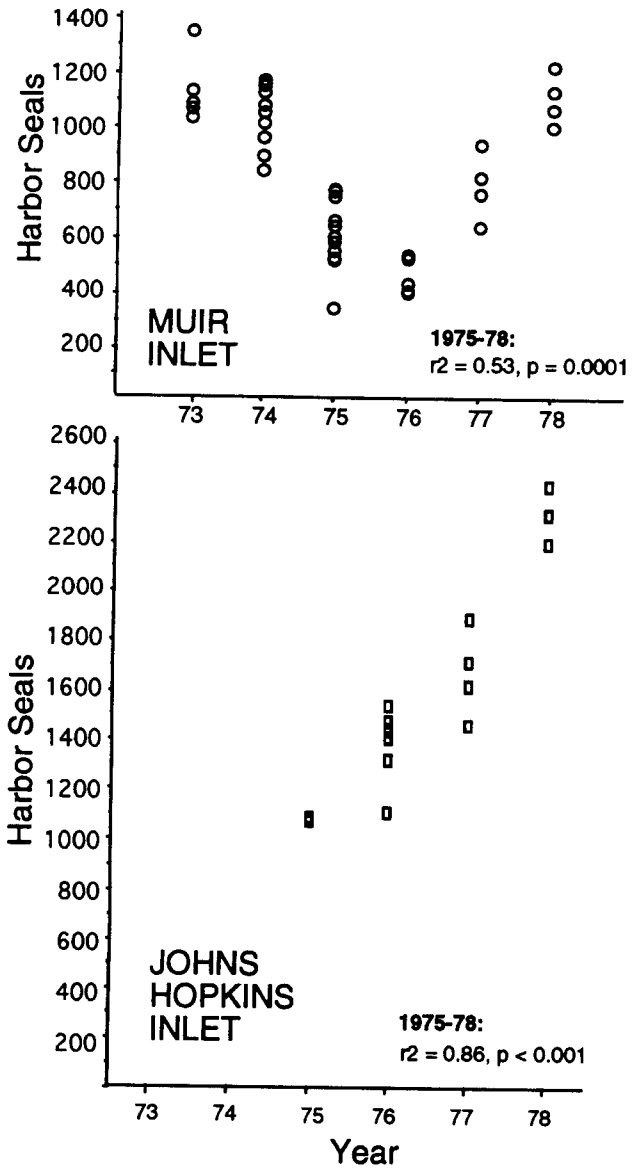

Fig. 5. Trends in harbor seal counts in Muir Inlet and Johns Hopkins Inlet from 1973 to 1978 (data are from Streveler 1979). Movement from Muir Inlet does not appear to account for the increase in Johns Hopkins Inlet.

Proportions of Pups

The proportions of pups estimated for all study areas using all methods are summarized in Table 2 and Fig. 3. Pup proportions from the counts of 100 nearby seals in Johns Hopkins Inlet in 1993 were significantly higher ($p = 0.0001$) than those from counts of all seals in the inlet. The estimate of pup proportion for Johns Hopkins from counts of all seals, both distant and far, was significantly higher than the pup proportions estimated using the same method at the Spider Island reefs ($p=0.02$). There was no statistical difference between the mean pup proportions recorded during Streveler's four summer counts (1979) and those from the nearby subset counts in 1993.

Trends in Johns Hopkins Inlet, 1975-1993

The mean of the daily high counts of adult harbor seals in June of 1992 and 1993 was significantly higher ($p = 0.001$) than the mean for 1975-1978. The mean number of seals counted in August 1984 was not different from the August 1992/93 counts (Fig. 4).

A review of Streveler's data from 1973 and 1978 indicates that there was a decline in seal numbers in Muir Inlet from 1973 to 1975, but that this was followed by an increase (Fig. 5). At the same time that seal numbers in Muir Inlet were increasing, numbers in Johns Hopkins Inlet increased significantly from 1975 to 1978 ($r2 = 0.86$, $p < 0.001$). Annual rates of increase ranged from 24-30% per year in Johns Hopkins Inlet.

Discussion

Harbor Seal Abundance Estimates

In August 1992 we observed more than 5,900 harbor seals in Glacier Bay, and an average of 4,277 seals were counted in Johns Hopkins Inlet, making this tidewater glacial system one of the largest documented breeding groups of harbor seals remaining in Alaska. In this study, no effort was made to correct for the proportion of seals in the water, so these counts clearly underestimate seal numbers. Correction factors derived from telemetry studies range from 1.5 to 1.8 (Huber et al. 1992), but I would predict that the correction factors for seals at land haulouts might differ from that of seals resting on ice bergs in glacial fjords.

Because harbor seals in Glacier Bay haul out on icebergs and at land sites, to estimate the number of seals found throughout the Park, different censusing methods are required depending upon haulout substrate. Results from this work demonstrate that, compared to counts from low-level land sites, counts from aerial photographs are superior for seals at land haulouts. This method also allows for surveys of the entire Park in only three hours and the photographic slides can be independently verified and archived.

Direct counts from photographs cannot currently be used to obtain total counts of seals on ice in Johns Hopkins Inlet or in Icy Bay during peak haulout periods. In summer months seals are dispersed on ice floes over such a large

area that it is not possible to spatially orient photographs taken of the ice, and thousands of photographs would be required for full coverage of the fjord. However, the development of a photographic or videographic system using film with extremely high resolution and multispectral sensitivity could allow higher altitude images of large areas while still detecting harbor seals. Until such a system is developed and tested, counts of harbor seals from elevated sites on land are recommended for Johns Hopkins Inlet, since its steep walls offer good vantage points for much of the area used by seals.

In 1992, we observed 1,090 seals at the Spider Island reefs in August. Between 1982 and 1984 researchers (Calambokidis et al. 1987) counted a maximum of 536 seals in the Spider Island area. However, because the counts in 1984 were from land and the 1992 count was from aerial photographs, it is not possible to determine if there has been a change in harbor seal use of the Spider Island area. Indeed, if the error in the land-based counts conducted in 1984 is at all comparable to that demonstrated in 1992, then it would appear that there had been little change in seal numbers at this haulout between the mid-1980s and 1992.

Proportions of Pups

The proportion of pups observed at the Spider Island reefs was significantly lower ($p = 0.002$) than that observed in Johns Hopkins Inlet. Yet, the Spider Island counts were conducted from more than a kilometer away, at a low observation angle, and seals at these reefs are more highly clumped than those on ice bergs. Consequently, the chances of missing pups at the Spider Island haulout were probably greater than they were in Johns Hopkins. Pups appear to aggregate closer to the water (pers. observ.) at land haulouts, possibly reducing the chances of underestimating their numbers. However, aerial photography of both haulout areas during pupping is recommended for a more rigorous comparison of pup proportions in these two habitats. The photographs of the Spider Island haulout in 1992 were inadequate for reliably distinguishing pups, although this should be possible if flights were conducted on days with excellent lighting conditions.

Two different methods were used to determine pup proportions in Johns Hopkins Inlet in mid-June (land-based counts of all seals; counts of 100 close seals), and in Icy Bay pup proportions were estimated from aerial photographs on only one day (June 15, 1993). Mean pup proportions from these two study sites, from a third glacial fjord (Hoover 1983), from Spider Island, and from six land haulouts (Olesiuk et al. 1990) are summarized in Table 1 and Figure 3. Although I could not compare my results statistically to those from the six land haulouts, it appears that proportionately more females give birth and nurse in glacial fjords than at land haulouts, and/or that nursing females in these areas spend more time hauled out than other seals (Godsell 1988) (Fig. 3). Hoover (1983) also observed a relatively high proportion (22-39%) of mother/pup pairs in Aialik Bay, a glacial fjord on the Kenai Peninsula. Calambokidis (1987) reported that 40% of the seals in Muir Inlet and 37% in Johns Hopkins Inlet in mid-June, 1984 were pups. Ice habitat generated in tidewater glacial fjords appears to be important habitat for pupping and nursing.

Trends in Johns Hopkins Inlet, 1975-1993

The comparison of three harbor seal studies spanning two decades indicates that seal numbers in Johns Hopkins Inlet have increased significantly since the mid-1970s. June counts increased from the mid-1970s to the early 1990s, whereas no change was detected between August 1984 and the early 1990s. These results indicate that the increase in seal numbers in Johns Hopkins occurred between the latter half of the 1970s and 1984 (Fig. 4).

There are four non-exclusive explanations for the observed increase in numbers of seals at Johns Hopkins Inlet from 1975 to 1978: 1) harbor seals may have moved from Muir Inlet to Johns Hopkins Inlet, 2) the increase may have been due to an increase in reproduction and survival or 3) a decrease in mortality, or 4) seals may have immigrated to Johns Hopkins from areas other than or in addition to Muir Inlet.

The increase in numbers of seals in Johns Hopkins from 1975 to 1978 cannot be explained by seals moving from Muir Inlet, since numbers in both inlets increased significantly during this time (Fig. 5). Streveler's 1973-1978 (1979) counts of harbor seals in Muir Inlet suggest a decline from 1973 to 1975, followed by a steady increase until at least 1978 (Fig. 5). Although the method for quantifying ice cover was not clarified, Streveler suggested that there was less ice in Muir Inlet in 1975, and that this might explain the low numbers for that year.

Although we might predict that seals habituated to using glacial ice might relocate to another glacial fjord if ice habitat in one location declined, it seems unlikely that seals moved from Muir to Johns Hopkins Inlet in large numbers. In 1984 Calambokidis et al. (1987) observed a maximum of 1,167 seals in Muir Inlet and suggested that ice suitable for hauling out might limit seal abundance. By 1992 only around 200 seals were observed in Muir Inlet (Mathews 1992), and by 1994 the receding glacier grounded and no seals were observed on icebergs in this area. The data suggest that seals which had pupped and mated in Muir Inlet in the mid 1980s did not relocate to Johns Hopkins Inlet, since an increase from 1984 to the early 1990s was not

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