Declines in a Harbor Seal Population in a Marine Reserve, Glacier Bay, Alaska, 1992–2002

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Abstract. Glacier Bay had one of the largest colonies of harbor seals in Alaska, yet numbers of seals declined by 63–75 percent from 1992–2002. We estimated seal population trends using models that controlled for environmental and observer-related factors. Numbers of non-pups in a glacial fjord declined by 6.8 percent/yr (-39 percent/8 yr) in June and in August by 9.6 percent/yr (-64 percent/11 yrs) and by 14.5 percent/yr (-75 percent/10 yrs) at terrestrial haulouts. The causes of the declines are not known; possible factors are discussed.

Introduction

From the mid-1970s to the mid-1990s, a tidewater glacial fjord (Johns Hopkins Inlet) in Glacier Bay had one of the largest breeding colonies of harbor seals *(Phoca vitulina)* in Alaska (Streveler, 1979; Calambokidis and others, 1987; Mathews, 1995). In 1997, harbor seals in Johns Hopkins Inlet comprised approximately 12 percent (3,989/32,926, maximal counts) of the seals in northern southeastern Alaska (from Kayak Island to Frederick Sound) (Mathews, University of Alaska Southeast, unpub. data; Withrow and Cesarone, 1998). Numbers of seals in Johns Hopkins Inlet and all other sites in Glacier Bay, however, have declined by 75 and 63 percent, respectively, in recent years (Mathews and Pendleton, 2006). Glacier Bay National Park is the only place in Alaska where commercial fishing is either prohibited or being phased out and where subsistence hunting of harbor seals has been prohibited by Federal regulations since 1974. In addition, there are seasonal quotas on the number and types of vessels and area closures to vessels and campers near breeding harbor seals. This suite of Federal protections make the marine waters of Glacier Bay (1,312 km^2) functionally the only marine protected area for harbor seals in Alaska. Understanding why harbor seals in Glacier Bay National Park are declining, despite multiple protections, may clarify their habitat needs and improve our ability to create effective marine reserves for this species.

Recent studies on the population genetics of harbor seals in Alaska, as well as other parts of their range, indicate that harbor seals are structured into smaller populations than previously predicted. Since 1995, the National Marine Fisheries Service has recognized 3 stocks of harbor seals in Alaska; however, genetic analysis of mitochondrial DNA indicates that there at least 12 demographically and genetically separate stocks of harbor seals, including one in Glacier Bay (O'Corry-Crowe and others, 2003). Harbor seals are a vital subsistence resource for Alaska Natives, as well as being high-level marine predators.

We report the population trends of harbor seals in Glacier Bay from 1992 to 2002 for both glacial ice and terrestrial haul-out sites. We used covariates to incorporate the effects of environmental and observer-related factors to improve the sensitivity of aerial and shore surveys to detect changes in numbers of seals. Such analyses reduce variation and the potential for spurious trend estimates resulting from factors not related to real changes in population abundance (Adkison and Quinn, 2003).

Methods

We conducted shore-based counts of harbor seals in Johns Hopkins Inlet, a tide-water glacial fjord in the northwest arm of Glacier Bay, during the pupping season (June, fig. 1) from 1992 to 1999 and during the annual molt (August) from 1992 to 2002. From 1992 to 2001 aerial photographic surveys of seals at terrestrial haulouts in August were also conducted. Environmental and observer-related covariates were recorded during each count and survey.

Figure 1. Harbor seal female and nursing pup. (Photograph by John Moran, Alaska Department of Fish and Game.)

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Aerial and shore-based surveys of seals at haulouts measure only the portion of the population out of the water and available to be counted. We used standardized survey methods and included covariates in trend analyses to reduce the variation caused by changes in the proportion of seals hauled out. If the covariates account for most of this variation, the resulting trend estimates will have small bias (Adkison and Quinn, 2003). Covariates included in both glacial and terrestrial analyses were year, date, and time relative to solar noon. Tide height and time from low tide were incorporated for each terrestrial site. Additional covariates used in the analyses of counts from shore were sky condition, precipitation, within-season observer experience, and long-term experience level. We also included quadratic (non-linear) effects for date and time. Trend was defined as the geometric mean rate of change over the interval of interest (Link and Sauer, 1997).

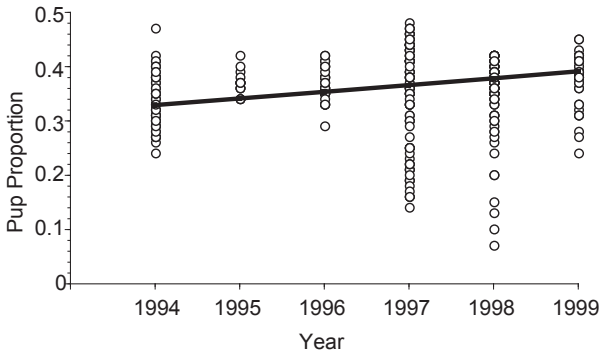

Figure 2. Proportion of harbor seal pups in Johns Hopkins Inlet counted in nearby subsections of 100 seals by year (=trend). Each circle represents one count of 100 seals; the line is the trend. The proportion of pups increased significantly by 5.4% per year (95% CI=3.9%-6.8%).

Results

The minimal population estimate during August surveys in Glacier Bay declined from 6,189 to 2,551 seals from 1992 to 2001 despite increased survey effort. On average, 72 percent (range=62–80 percent, n=9 yr) of all seals were found in tidewater glacial fjords, primarily Johns Hopkins Inlet. In Johns Hopkins Inlet, the number of non-pups declined during June as did counts of all seals during August surveys in this glacial fjord. Similarly, numbers of harbor seals at terrestrial sites surveyed during August declined (table 1). In contrast to the declines in non-pup numbers, there was no significant trend (i.e., 95 percent CI includes 0) in numbers of harbor seal pups in Johns Hopkins Inlet in June (table 1), and the proportion of pups increased by 5.4 percent per year (fig. 2).

Discussion

Between 1992 and 2002 harbor seals counted in Glacier Bay declined at annual rates and magnitudes exceeding any documented harbor seal decline in Alaska with the exception of that at Tugidak Island (Pitcher, 1990). The 14.5 percent/yr decline in harbor seals at terrestrial haulouts in Glacier Bay from 1992 to 2001 (table 1) exceeds the maximum theoretical and observed annual reproductive rate for harbor seals (12.5 percent) (Olesiuk and others, 1990), indicating that mortality or emigration of more than just young of the year is occurring. The declines in harbor seals in Glacier Bay suggest a localized decline, as they are in contrast to the only other areas within southeastern Alaska where longterm monitoring of harbor seals has occurred. From 1984 to 2001, harbor seal numbers were stable at 21 haulouts in Tenakee Inlet and Peril Strait (north of Sitka), and from 1983 to 1998, seal numbers increased by 7.4 percent/yr at 16 haulouts near Ketchikan (Small and others, 2003).

The potential causes of the observed declines can broadly be categorized as due to (1) redistribution or emigration out of Glacier Bay, (2) decreased reproductive output, or (3) increased mortality. Determining if the cause or causes of the declines in harbor seals in Glacier Bay are part of a natural cycle or due to human factors is an essential first step for preserving this important resource. Potential contributing factors that need to be studied include predation (by killer

Table 1. Population trend for harbor seals in Johns Hopkins Inlet (JHI), a glacial fjord, and at all other, primarily terrestrial (Terr), haulout sites in Glacier Bay.

[Influential covariates are listed in order of decreasing influence. All trends were significant except that for pups. No covariates met the importance threshold for the terrestrial sites. **Abbreviations:** trm, time relative to midday (solar noon); longterm exper, number of observer survey seasons; pcp, precipitation]

Year	Site	Month	Seals	Annual trend	95 percent CI	Cummulative change (percent)	Influential covariates
1992-99	JHI	June	non-pups	6.55	-8.45 to -4.65	-39	date, sky, pcp
1994-99	JHI	June	pups	3.56	-0.98 to 8.10	19	date, date, sky, pcp
1992-2002	JHI	August	all	-9.56	-10.3 to -8.8	-63	pcp, date, trm, longterm exper
1992-2001	Terr	August	all	-14.46	-17.1 to -11.85	-75	(none)

whales, Steller sea lions, and (or) Pacific sleeper sharks, *Somniosus pacificus*) (Taggart and others, 2005), changes in prey availability or quality, disease, contaminants, and subsistence hunting. Competition with Steller sea lions, whose numbers in Glacier Bay have increased rapidly from the early to late 1990s (Mathews, University of Alaska Southeast, unpub. data), also needs to be examined as a possible factor.

Large changes in the abundance of several marine vertebrates in Glacier Bay indicate that the underlying food web dynamics in Glacier Bay have changed (Mathews and Pendleton, 2006). During approximately the same time as the seal declines, the number of Kittlitz's *(Brachyramphus brevirostris)* and Marbled *(B. marmoratus)* murrelets in Glacier Bay also declined (Robards and others, , U.S. Geological Survey, written commun. 2003); these alcids both use glacial fjords during breeding and feed on some of the same small schooling fish species as harbor seals. In addition to the rapid increase in numbers of Steller sea lions in the last decade, sea otter numbers have increased (Bodkin and others, U.S. Geological Survey, written commun., 2002), as has the number of humpback whales *(Megaptera novaeangliae)* in Glacier Bay and Icy Strait (Doherty and Gabriele, Glacier Bay National Park, written commun., 2002). Information on Glacier Bay's marine ecosystem alone may not be adequate for determining the cause or causes of the declines in harbor seals. Seals most likely leave Glacier Bay to forage elsewhere in early fall (Mathews and Kelly, 1996); determining the movements and foraging behavior during fall and winter of seals that breed in Glacier Bay will be necessary for identifying factors outside of the Park that may be contributing to the declines.

Management Implications

Glacier Bay is the largest (1,312 km^2), highly protected marine reserve in North America and there are Federal protections specifically for protecting harbor seals during breeding. The effectiveness of Glacier Bay as a defacto reserve for harbor seals may be compromised if there are anthropogenic forces outside of the Park that now limit the population. Determining whether the declines in harbor seals in Glacier Bay National Park are driven by natural ecological cycles and (or) human factors and whether harbor seals in Glacier Bay are part of a local or a more regional decline is necessary for effective management of this important breeding habitat.

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Mount Fairweather and its neighbors, as viewed from the outer coast (west). (Photograph by Bill Eichenlaub, National Park Service.)