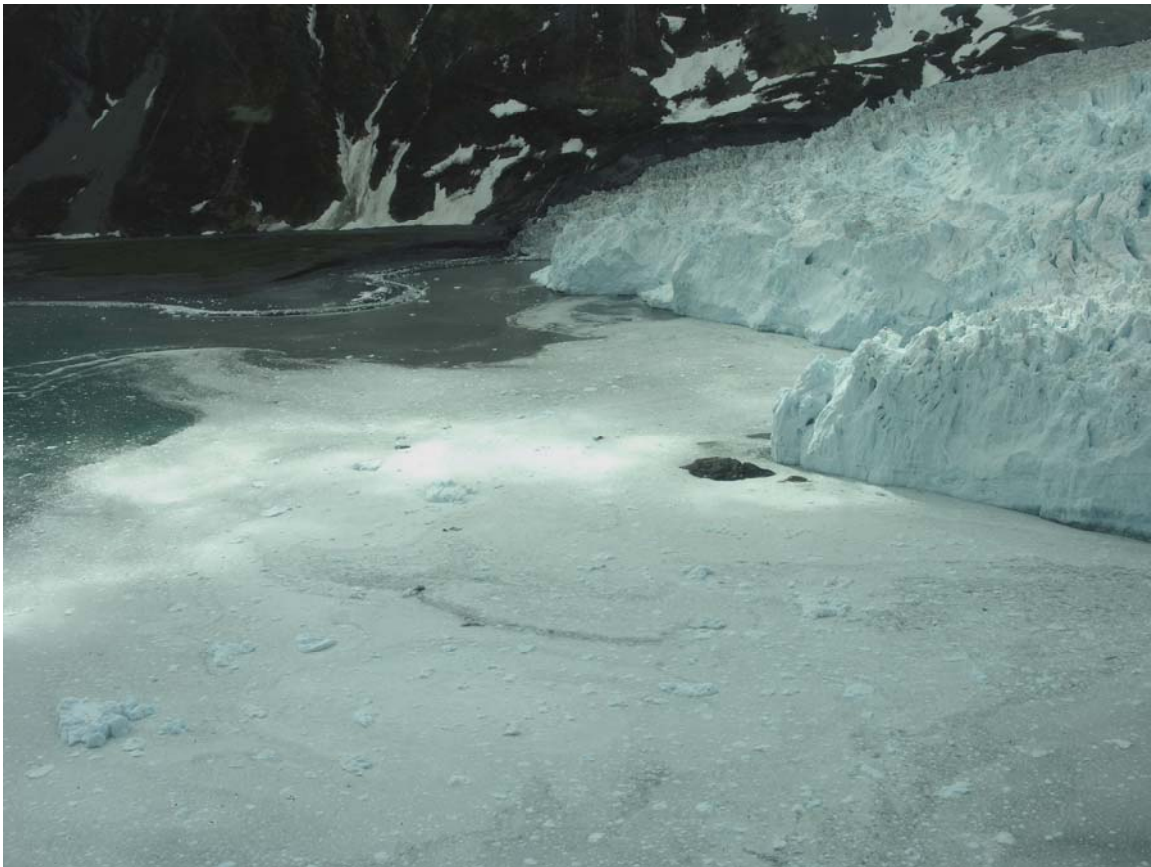




**HARBOR SEAL POPULATION DYNAMICS AND RESPONSES TO VISITORS IN
AIALIK BAY, ALASKA**

2009 Fall Report to the
Ocean Alaska Science and Learning Center and the
National Park Service



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INTRODUCTION

Harbor seals (*Phoca vitulina*), high-trophic, long-lived, coastal pinnipeds, once were ubiquitous along the shorelines of the Gulf of Alaska. From the mid 1970s through the mid-1990s, an extensive reduction in numbers of harbor seals was detected at Tugidak Island, near Kodiak Island (Pitcher 1980, Small et al. 2003). Reductions in numbers of seals also were observed at Aialik Bay and in Prince William Sound, since the early to mid-1980s. Although numbers of seals near Kodiak began recovering in the mid 1990s, numbers remained low in Aialik Bay and Prince William Sound through 2002 (Frost 1994, Hoover-Miller et al., 2001, Small et al. 2003).

Approximately 10% of harbor seals in Alaska haul out on glacial ice (Bengston et al. 2007). Why seals associate with glacial ice is not well understood (Hoover 1983). The association may be a remnant of times when glaciers were a predominant coastal feature. Research by the Alaska Department of Fish and Game (ADFG) and National Park Service (NPS) indicate that seals associated with ice in Glacier Bay travel more extensively to forage than those at land haulouts (e.g., Womble et al. 2006) suggesting that foraging opportunities associated with ice may not be a primary reasons seals use glacial ice. Ice does appear to provide a good haulout habitat with more options for haulout at suboptimal tide stages and potentially less crowding than at terrestrial haulouts. Thick ice conditions also may restrict access by killer whales and other predators during pupping. The presence of ice allows seals to haulout at all tides, a particular advantage for nursing pups and seals that need to conserve energy during the molt.

Tidewater glaciers calve ice directly into marine and lake environments (Figure 1, cover) creating unique habitats that vary in short and long time-scales and exhibit constant transitions as temperatures and precipitation change. Glacial fjords, carved by tidewater glaciers, are found only within belts north of 43 degrees north and south of 42 degrees south latitude. In Alaska, fjord coastlines extend more than 1,500 km from Cook Inlet through British Columbia and consist of at least 200 major Alaskan fjords, few of which have been studied in detail (Syvitski *et al.* 1986, Burrell 1986, Gay 2002, Hooke and Hooke 2002). Although roughly 20% of the Gulf of Alaska watershed is covered by glaciers (Royer 1982), only about 51 glaciers reach marine-influenced tidewater, and most of those glaciers are thinning and retreating with global climate change (Viens 1995, Molnia 2008).

Both harbor seals and tidewater glaciers have shown sensitivity to external forcing functions driven by multiple climatic cycles operating over time intervals ranging from tens to hundreds of years (Spies 2006, Wilson et al. 2007). Atmospheric and oceanographic cycles have affected glacial dynamics and have caused widespread ecological change in the Gulf of Alaska (Spies 2006). Glacial fjords provide the spatial transition from watersheds to the open oceans that produce strong physical and chemical gradients where fresh and salt waters mix (Syvitski *et al.* 1986). The presence of tidewater glaciers intensifies those gradients with the direct input of cold meltwater from glaciers and the melting of ice calved from the glacier. Low-density, sediment laden waters flow as surface plumes towards the mouth of fjords. The plume typically generates vertical gradients in temperature, salinity and turbidity often with a stratified circulation near the head of the bay (Syvitski *et al.* 1986, Burrell 1986, Gay and Armato 1998, Gay 2002, Hooke and Hooke 2002). While estuarine conditions common in glacial fjords during the summer promote productivity, low density, turbid waters can inhibit forage fish and lower trophic level diversity and abundance (Syvitski *et al.* 1986, Goering *et al.* 1973, Carpenter 1983, Piatt 2002). Nevertheless, tractable, mid to high trophic-level predators such as harbor seals, kittiwakes, sea otters, gulls and Kittlitz's Murrelets associate with ice at the heads of tidewater glacier fjords (Hoover 1983, Murphy *et al.* 1992, Duffy 1999, Day and Nigro 1999, Mathews and Pendleton 2000). As glacial ice habitats diminish, those species and others that occupy similar niches in the ecosystem are affected.

Figure 1. (Cover) Face of Aialik Glacier advancing on 'Little Rock' in June 2009. Harbor seals are hauled out on ice in the lower left hand corner.

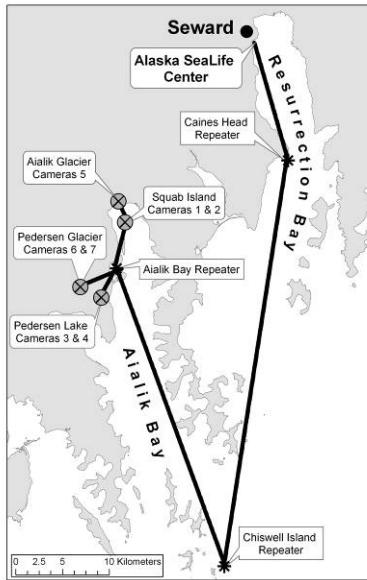


Figure 2 (Left) Location of camera monitoring sites and video transmission repeater stations in Aialik and Resurrection Bays. Figure 3 (above) Left: Aialik Glacier and upper Aialik Bay; Right: Pedersen Glacier and Lake, drains into Pedersen Lagoon, which empties into Aialik Bay, immediately south of a 13m deep glacial sill. Aialik Glacier has remained relatively stable since about 1900 whereas Pedersen Lake was completely covered by ice in 1961.

Study Area

This study uses remotely controlled video cameras, installed in 2002, to observe harbor seals and glacial ice habitats in Aialik Bay, southcentral Alaska. The study continues harbor seal research begun in 1979 (Hoover 1983, Murphy and Hoover 1981). Aialik Bay (Figure 2) is a 30-km-long fjord that opens directly to the Gulf of Alaska. Aialik Glacier (Figure 3, left), a relatively stable glacier since about 1900, calves ice into the head of Aialik Bay; Pedersen Glacier (Figure 3, right) has been steadily retreating and currently calves ice into a tidally influenced lake that was completely covered by the glacier in 1961. A shallow (13 m deep) sill east of Pedersen Glacier separates Aialik Bay's 9-km-long upper basin from the lower fjord. Harbor seals, recovering from a more than 80% population decline since 1980 (Hoover-Miller *et al.* 2007), haul out on ice calved from both Aialik and Pedersen glaciers. Harbor seal use of each habitat differs seasonally and between years.

Aialik Bay is located in the Kenai Fjords National Park and is within a focal region of research, immediately west of long-term oceanographic and weather monitoring operated by the National Oceanic and Atmospheric Administration (NOAA) and the University of Alaska, Fairbanks (UAF). Aialik Bay has been subject to a variety of research and monitoring studies conducted during the past century (e.g., Grant and Higgins 1913, Bishop 1967, Feder *et al.* 1979, Post 1980, Murphy and Hoover 1981, Carpenter 1983, Murphy *et al.* 1984, 1992; Hoover 1983, Tetreau 1998, Crowell *et al.* 1996, 1998, Gay and Armato 1998, Molnia 2001, NPS, unpublished, ADF&G unpublished, ASLC unpublished) that render a historical record from which ecological comparisons can be made. Data collected complement ongoing regional studies of the marine environment conducted by the UAF, NPS, ASLC, US Geologic Survey (USGS), US Fish and Wildlife Service (USFWS) Alaska Maritime National Wildlife Refuge (AMNWR) and NOAA. In addition it is adjacent to waters that have received extensive oceanographic monitoring dating back to 1970 (Royer 1996) and abuts focal regions for global-scale, long-term oceanographic monitoring conducted by the Institute of Marine Science at the University of Alaska, Fairbanks.

Other investigations conducted by the ASLC complement the video monitoring project and are being used to link changes in relatively simple tidewater glacial fjord environments with the behavior, distribution and population trends of tractable marine organisms. Ongoing projects include: (1) regional aerial surveys of seasonal distribution and numbers of seals and other coastal features within a broader geographic range including fjords with and without tidewater glaciers, (2) weather conditions recorded at Squab Island at the head of Aialik Bay and at Chiswell Island (10 km south of Aialik Bay), (3) oceanographic

measurements of conductivity, temperature, dissolved oxygen, chlorophyll, and zooplankton sampling conducted during summer months within Aialik Bay and (4) Steller sea lion investigations on Chiswell Island using similar remote video technology (Maniscalco et al. 2002, 2006, 2007).

The remotely-controlled video project provides temporally rich records of tidewater glacial habitats in fjord and lake environments and of harbor seals that use the ice for pupping, molting and resting. The technology provides access to a natural lab and generates images and media that facilitate live and retrospective analysis of glacier activity and harbor seal population dynamics, activities, behaviors, and responses to natural and anthropogenic change.

Research Questions and Objectives:

Research questions and objectives are grouped under three topics: (1) glacial fjord habitats, (2) harbor seal population dynamics, and (3) effects of human interactions with harbor seals.

Glacial Fjord Habitats: Ongoing research is documenting changes in characteristics and dynamics of two distinct glacier habitats used by seals: a relatively stable glacier that calves directly into a fjord and a retreating glacier that calves into a tidally influenced lake. Questions pertaining to glacial habitats include: (1) How are glaciers in Aialik Bay responding to short and long-term changes in summer and winter temperatures and precipitation? (2) Can environmental conditions including air and water temperatures, precipitation, and/or tidal cycles be used to predict periods of increased calving? (3) How does glacial activity and ice differ between lake and fjord environments? (4) What physical factors (including tides, winds, precipitation, water temperature) affect ice longevity and availability in fjord and lake habitats? (5) Has ice availability changed since the early 1980s? (6) How does use of haulout habitats differ between fjords with and without glacial ice?

Harbor Seal Population Dynamics: Attendance at haulouts varies seasonally and inter-annually, providing a tractable indicator of local ecological change (Hoover-Miller 1994; Frost et al. 1994; Pitcher 1980; Thompson et al. 1989, Jemison and Kelly 2001, Bowen et al. 2003). This study uses harbor seals as bioindicators of ecosystem change associated with tidewater glacier habitats. Response is being measured by both haulout attendance and reproductive success (numbers of pups counted). Questions currently under investigation include: (1) Does timing of haulout during pupping and molting periods vary with atmospheric, oceanographic and glacial ice conditions? (2) Are population trends of harbor seals in Aialik Bay similar to trends observed at terrestrial haulouts in the northern Gulf of Alaska that are not influenced by glacier ice? (3) Are population trends indicated by counts taken during pupping and molting equivalent? (4) Does monitoring changes in pupping phenology provide predictive measures of population trends? (5) To what extent do population trends of harbor seals in Aialik Bay reflect changes in glacial habitats? (6) If glaciers retreat on shore during the study, do seals adapt to terrestrial haulouts or do they relocate?

Human Interactions: Rapid growth in human visitation of the Kenai Fjords National Park is causing more frequent interactions between humans and seals. This research is investigating: (1) What types of interactions are affecting seals in Aialik Bay? (2) How frequently are seals being impacted by human activities? (3) What steps can be taken to mitigate adverse interactions? (4) Are those steps effective?

Remote Video Monitoring System.

Methods. Remotely controlled video monitoring equipment (Figure 4), developed and maintained by SeeMore Wildlife Inc., has been operated by personnel at the ASLC since 2002. The first phase of the installation was completed in June 2002 on Squab Island, the location where field counts of seals at the head of Aialik Bay have historically been taken, and on the south side of Pedersen Lake, near Pedersen Glacier (Figure 2). In 2003 a higher altitude camera site (approximately 230 m) was established on the north side of Aialik Glacier and in 2005 cameras were installed on the south side of Pedersen Glacier (approximately 180 m altitude). Although multiple cameras are present in the field, data is received from only one camera at a time.

Cameras are operated from mid-May until September or October, when light availability and weather inhibits reliable operation. Video equipment includes visible-light, commercially available block video cameras with 25X optical and up to 300X digital zoom lens. The cameras are mounted in weatherproof housings that include remote-controlled pan, tilt, zoom, and windshield wiper/washer assemblies. Cameras are controlled via computers located at the Alaska SeaLife Center. User-selected control signals are transmitted more than 90 km to the desired camera via UHF frequencies, and video signals are transmitted along the reciprocal path to the ASLC via a series of microwave repeaters (Figure 2). Video signals from the camera site are received by a microwave receiver and are forwarded to a video transmitter. Both the receiver and transmitter are powered through the processor board, and both may be turned off remotely. The processor board at the repeater provides similar tasks as the processor at the imaging site. The microprocessor on the board decodes data from the data transceiver, and depending on whether the commands are intended for it the processor will either forward the data to the camera site or execute the command itself. The microwave modulates video and sends a microwave signal from the repeater site to the receive site. At the ASLC, the receiver outputs standard analog video, which is ready for display on a television monitor. A video splitter is used to split the video signals from the microwave receiver which are distributed via wire to multiple television monitors, VCRs, and computers at the ASLC.

Camera control software (Figure 3) provides the ability to select and control cameras, view camera images, and adjust features throughout the system. Cameras can be positioned using direction buttons or by pointing the mouse on the desired location on-screen. Zoom levels can be selected by user defined



Figure 3. Computer Video Control for selecting and controlling video cameras

buttons or by dragging a box on the screen. Buttons provide the ability to take snapshot images and obtain short digital video recordings (<1 min) going forward or backwards in time. Power controls provide the ability to turn on and off equipment at each camera and repeater site.

Camera operators immediately record data from live images. Time-lapse recordings are concurrently taken to provide a record of environmental conditions, seal distribution, interactions between humans and seals, and, when viewing opportunities are favorable, the behavior of seals.

Surveys are scheduled to be conducted at 9:00, 11:00, 13:00, 15:00, and 17:00, although the schedule may be adjusted for weather, data collection pertaining to concurrent events (e.g. vessel activities), and camera performance problems. Table 1 summarizes observation effort in specific tasks based on log records.

Table 1. Number of camera hours (HH:MM) spent with active and non-active monitoring of seals near Aialik and Pedersen Glaciers during 2008. (FP=Fixed Camera Position; SU=Survey; PP=Preset Photos; KI=Kayak Interaction; KS=Kayak Sighting; VI=Vessel Interaction; VS=Vessel Sighting)

	Non-active (hh:mm)	Active (hh:mm)				
	FP	SUM Active	SU/PP	KI/KS	VI/VS	Total
2009						
Aialik	369:11	448:01	302:20	2:38	15:31	320:29
Pederson	136:38		126:25	1:52	0:00	128:17
All	499:49		428:45	4:30	15:31	

Censuses are initiated with the Squab Island camera. During ice scans, snapshot images are taken from predefined positions that capture a panorama of images covering a 360 degree view. These images show the ice distribution and general survey conditions (cloud cover, precipitation, and sea state). The ice then is methodically scanned for the presence of harbor seals. Seals present on ice are immediately recorded on data forms with the date and time. Swimming seals are distinguished from seals on ice but are not included in the count. Weather conditions including percent cloud cover, wind direction, wind velocity (based on a modified Beaufort scale reflecting the reduced fetch of the upper bay), precipitation, composite weather (1= full sun, 2=partial clouds to overcast, 3=precipitation and wind >20kts), and general direction of ice movement are recorded.

Prior to analysis, counts were screened to include only complete, good quality, counts. Counts were removed from analysis if any of the following occurred: (1) sustained winds speeds exceeded 7.72 m/s (15 kts) due to effects on ice availability; (2) fog or moderate to heavy rain, conditions when seals may leave the ice and visibility is obscured; (3) camera malfunctions that resulted in compromised viewing; or (4) when observers, for any reason, ranked the overall quality of the surveys as less than 2 (good) on a scale of 1 (excellent) to 4 (poor).

Results

Numbers of seals counted in Aialik Bay varied seasonally with peak haulout attendance during molting and pupping periods.

Molting: In Alaska, counts taken during the molt are used for monitoring population change in Alaska. Figure 4 shows all counts of harbor seals taken from 1979-2009. Data suggest rapid recovery from 2002-2007, then a leveling off, or possible decline, through 2009. Table 3 summarizes numbers of seals counted during the molt from 1979-2009. During 1979 and 1980 numbers of seals were lower than expected which was attributed to fewer than expected numbers of adults present in Aialik Bay (Hoover 1983). Between 1980 and 2002, mean numbers of seals counted from 5-13 August, within 4 hours of Solar Noon, diminished 82%; maximum numbers counted diminished 78%. From 2002-2007 mean numbers of seals steadily increased an average of 34% annually, at a rate greatly exceeding maximum annual reproductive rates estimated at about 12% (Angliss and Outlaw 2007). From 2003-2007, mean numbers of seals counted during the index window (5-13

August) increased an average of 12% annually while maximum numbers increased 8% annually. Mean numbers also showed more variation from year to year than maximum numbers, which could reflect differing amounts of time hauled out on the ice between years. A graphic comparison of trends in molt counts taken from 2002-2009 (Figure 5) also indicates diminishing numbers in recent years in mean and maximum counts. In 2008 and 2009, numbers of seals were lower than in 2007 indicating potential effects from changes in habitat associated with the recession of Pedersen Glacier (see below) that affected ice distribution, haul out schedules, or possible changes in survivorship or reproduction. As in 2008, numbers counted in 2009 during the molt were similar to those counted during pupping (Figure 6). From 2003-2007, more seals were counted during the molt than during pupping unlike many locations where molt counts are higher than counts obtained during pupping (Pitcher and Calkins 1979). The return of seals for the molt was unlike patterns seen in previous years. Numbers did not increase gradually in July, when yearlings and other young seals molt. Rather, numbers of seals abruptly increased in early August, suggesting coordination of movements in response to environmental change.

Table 3. Total numbers of harbor seals in Aialik Bay counted during the molt from 1979-2008

Total Seals: 25 July-25 Aug (Molt)			Total Seals: 5-13 August, <4hr Solar Noon			
YEAR	N	Max	N	Max	Mean	SD
1979	27	923				
1980	30	1029	10	1029	786	81
2002	27	219	6	219	141	61
2003	108	401	28	359	207	68
2004	111	415	26	415	198	92
2005	160	565	35	444	257	81
2006	118	536	32	483	313	117
2007	101	660	31	549	383	101
2008	146	494	8	494	376	90
2009	99	479	20	479	229	127



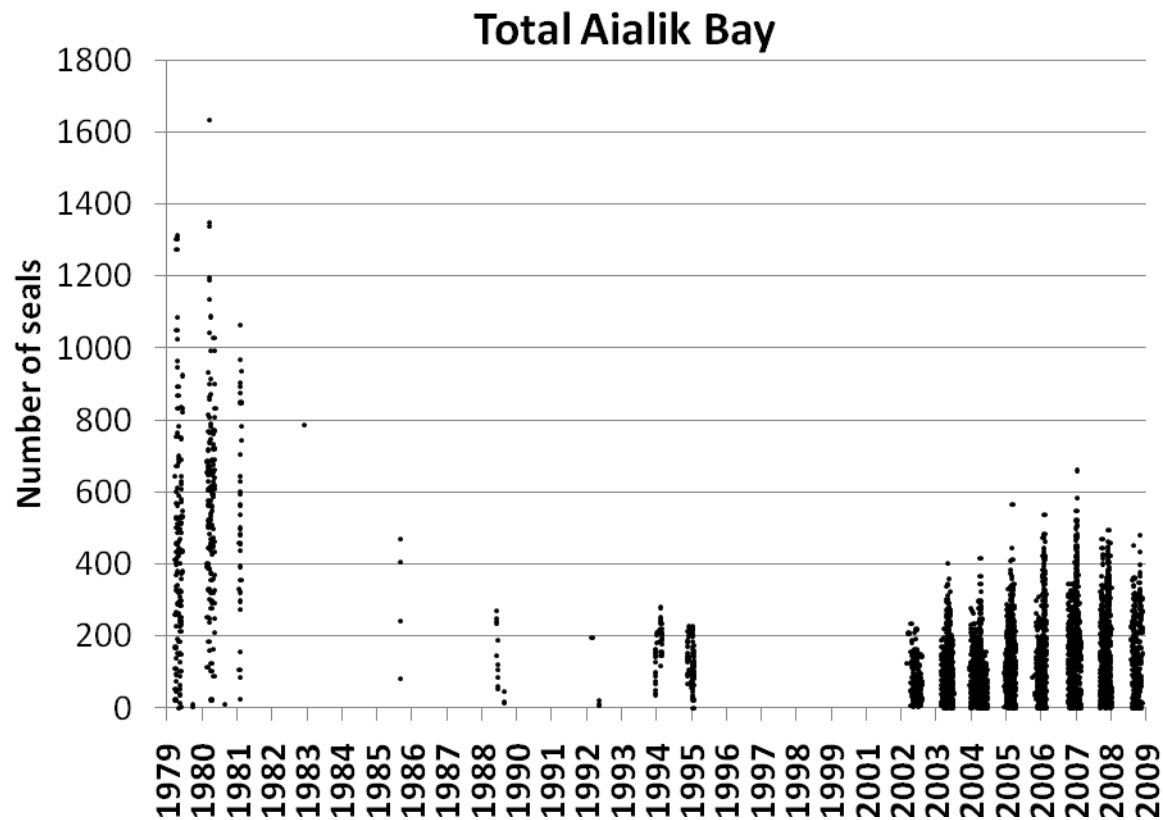


Figure 4. Total number of seals counted near Aialik (1979-2009) and Pedersen (2002-2009) glaciers.

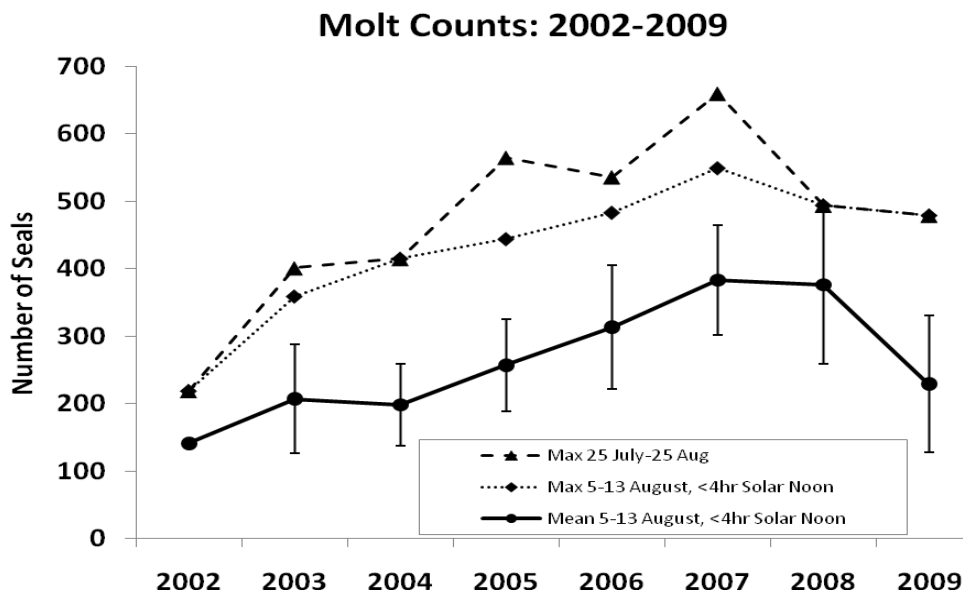


Figure 5. Interannual variation in harbor seal haulout during the molt in Aialik Bay. Three indicies are presented. Maximum counts from 25 July-25 August. Maximum and mean attendance from 5-13 August, within 4 hours of solar noon. Vertical bars represent 1SD above and below the mean.

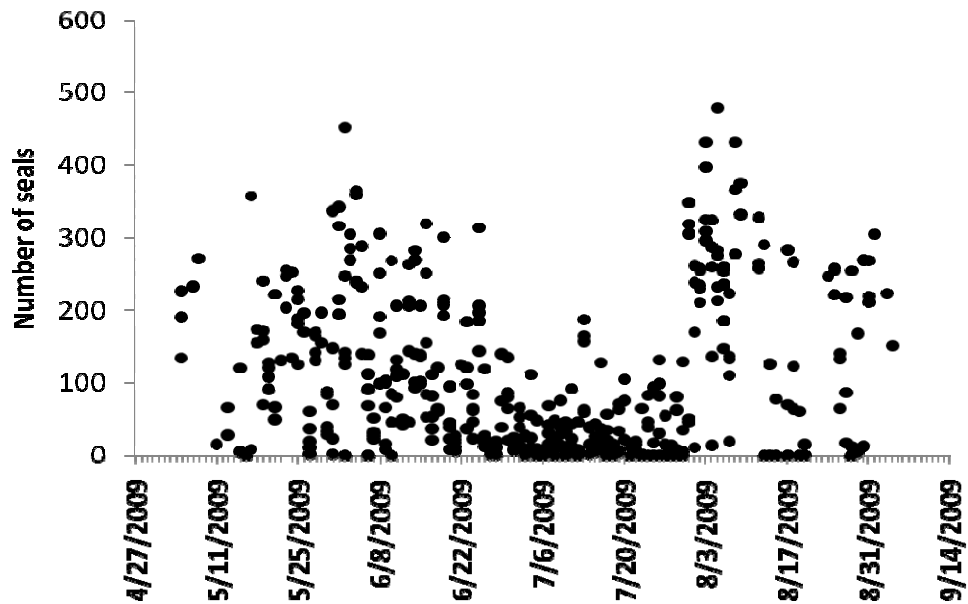


Figure 6. Seasonal variation in numbers of seals counted in Aialik Bay (including Pedersen Lake) during 2009.

Pupping:

Numbers of pups counted each year provide a measure of reproductive success. In addition, pups are dependent on haulouts and show less variation in haulout with respect to environmental conditions than older seals (Frost 1994). Figure 7 shows attendance of all seals and pups counted using the video cameras. Numbers of pups peaked around the 14th of June. Similar numbers of pups were seen relative to previous years (Figure 8), suggesting that productivity has not increased, as might be expected with a recovering population. Using observations from KFT vessels (see Appendix A) we contrasted numbers of pups observed from the vessels in Northwestern Fjord and using the video cameras in Aialik Bay (Figure 9). Although differences were observed, the general magnitude of numbers of pups were similar, suggesting that seals were not shifting to Northwestern Fjord for pupping. Analysis is ongoing to contrast these counts with those obtained during aerial surveys and surveys conducted in previous years.

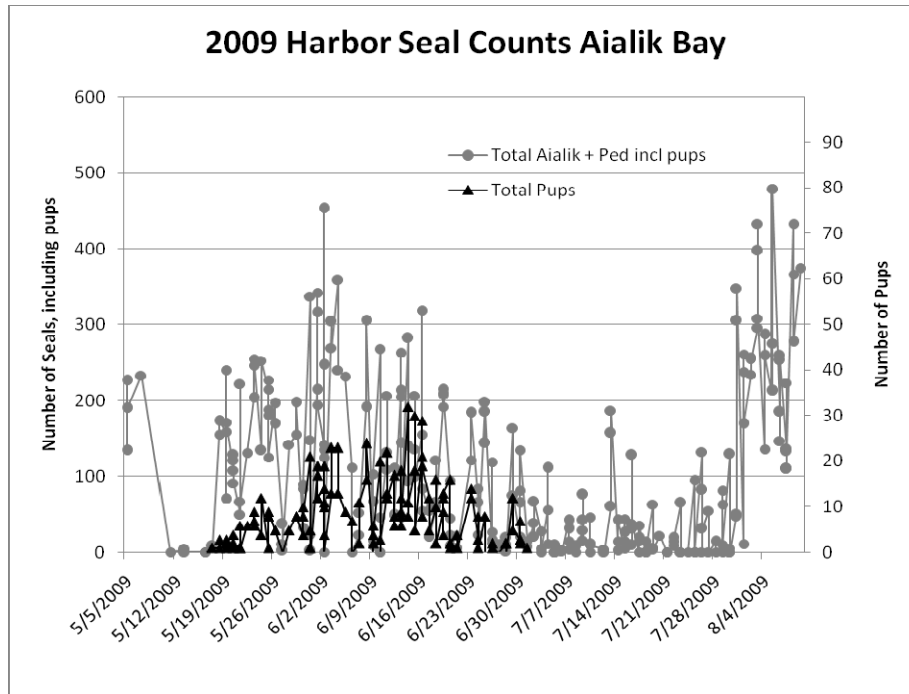


Figure 7. Counts of total number of total numbers of harbor seals (grey) and pups (black) observed at Aialik and Pedersen Glaciers during 2009.

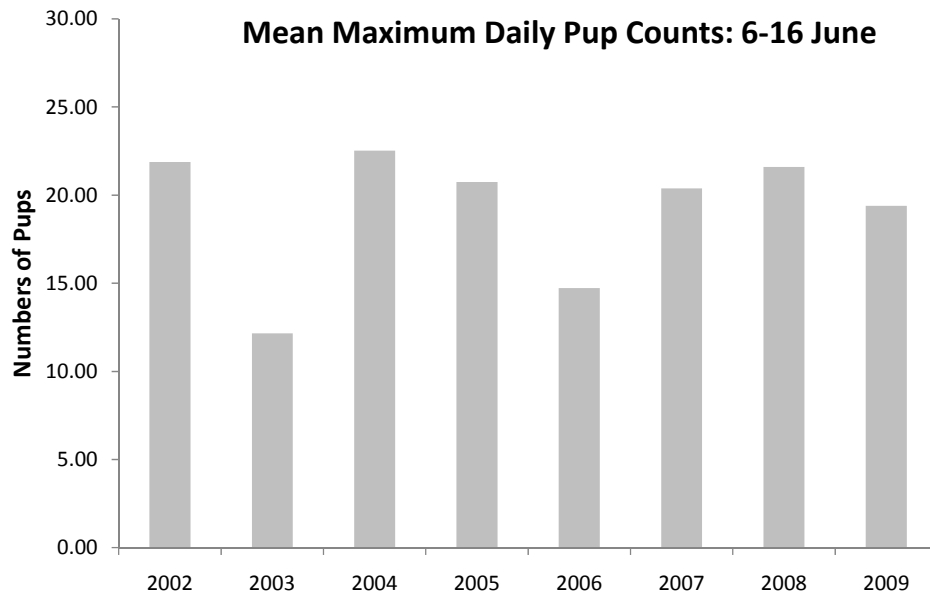


Figure 8. Mean maximum daily count of harbor seal pups counted in Aialik Bay from 6-16 June

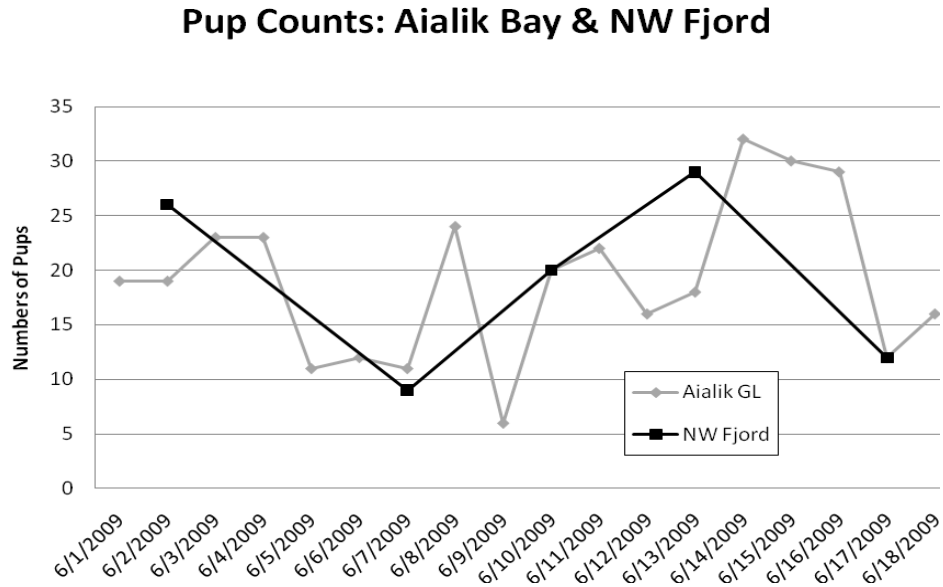


Figure 9. Comparison of number of pups counted in Aialik Bay (grey) using video monitoring system and Northwestern Fjord (black) from KFT vessels from 1-18 June, 2009 as described in Appendix A.

Aialik and Pedersen Glacier Ice Use. Use of ice at Aialik and Pedersen glaciers varies by year. During 2009 all pupping occurred at Aialik Glacier. Despite the abundant ice in Pedersen Lake, seals infrequently hauled out in the lake until mid July, when seals appeared in moderate numbers. Large numbers of seals were not observed until they abruptly appeared August 1st (Figure 10, red dots).

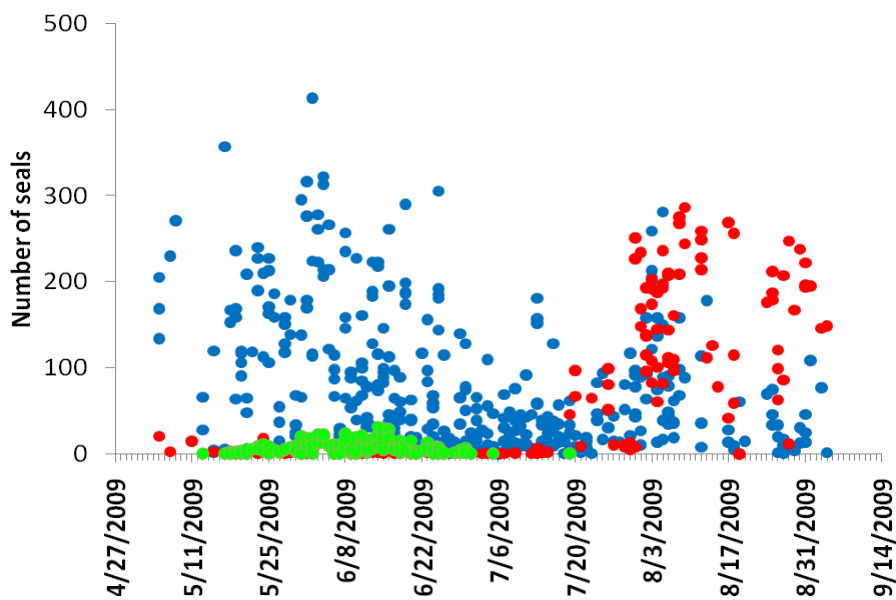


Figure 10. Numbers of seals (excluding pups) counted at Aialik (blue) and Pedersen (red) glaciers. Pups (green) were counted only at Aialik Glacier.

Glacial Monitoring

In conjunction with standard surveys, snapshot images of the glacier face and distribution of ice are taken at Aialik and Pedersen glaciers to illustrate seasonal and interannual changes over time. Figure 11 shows seasonal and multi-year changes of receding Pedersen glacier between 2006 and 2009 while Figure 12 shows seasonal and interannual changes in the face of Aialik Glacier from 2003-2009, a period of time that has shown both glacial recession and advance.

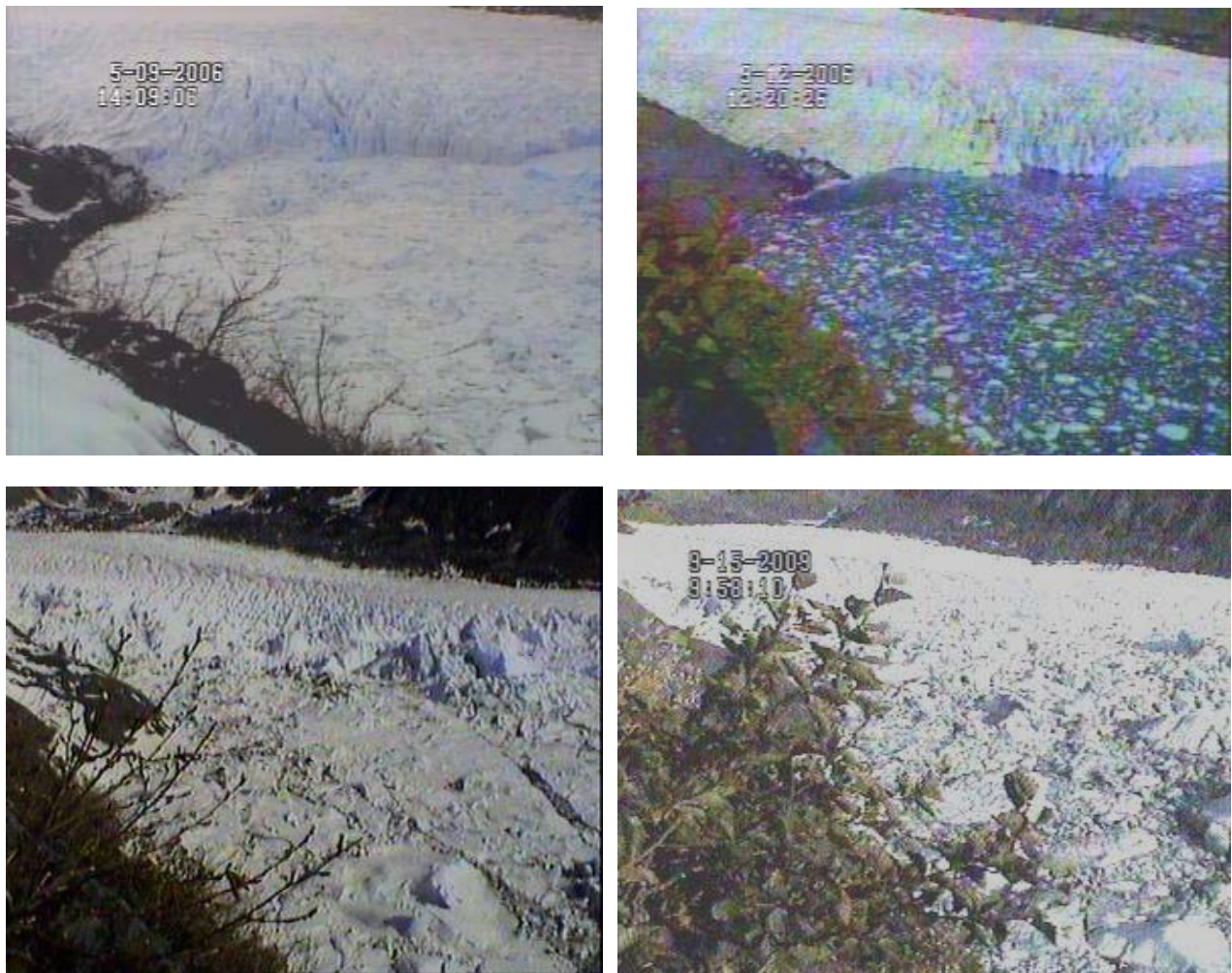
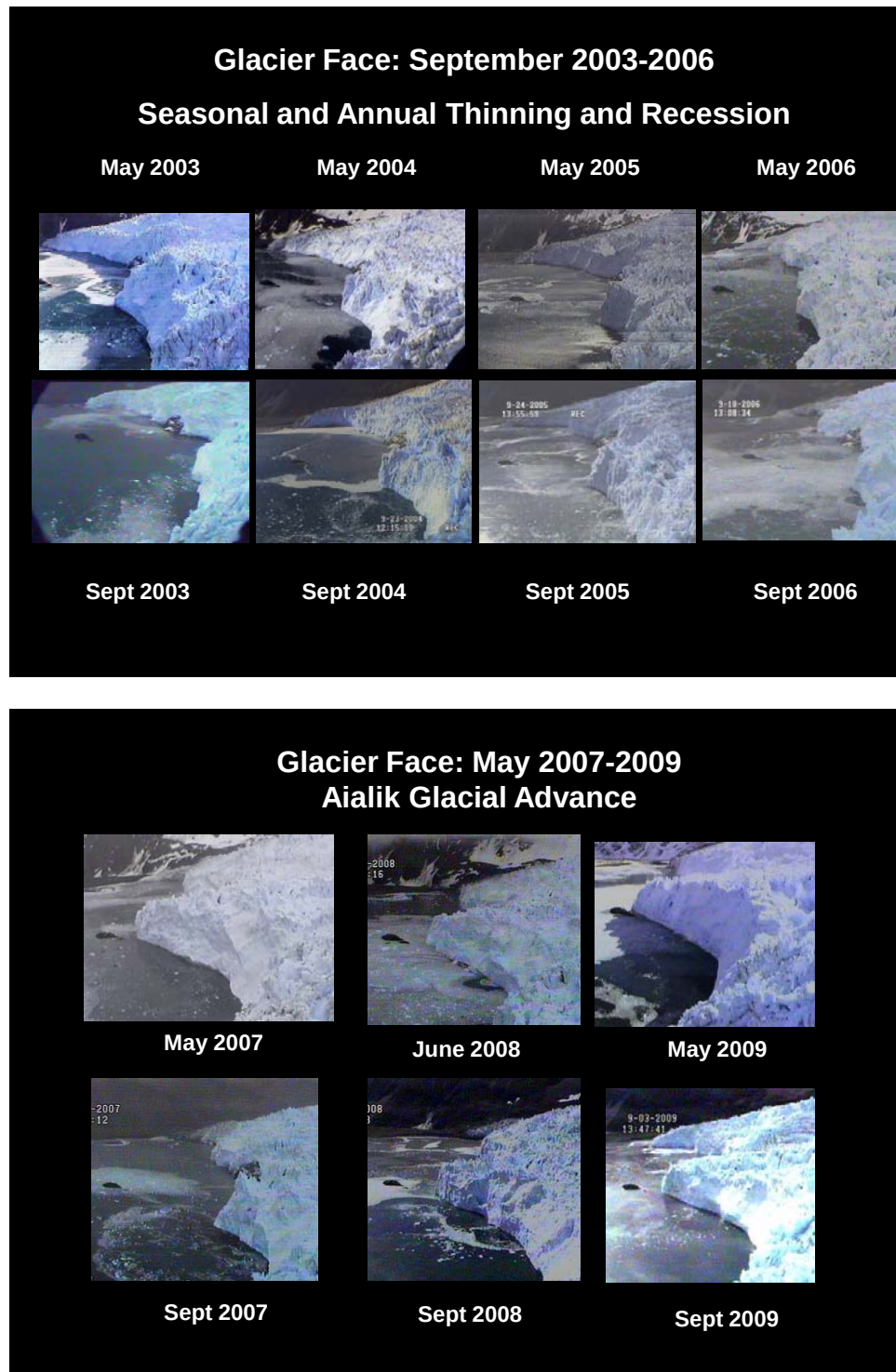


Figure 11. Comparison of the southern face of Pedersen Glacier showing thinning and differences in the glacial face and ice characteristics once Pedersen glacier receded off of its terminal moraine into deeper water. The top pictures were taken in 2006 (left in May and right in September) when terminating on a moraine; the lower pictures were taken in 2009 (left in May and right in September) after the glacier receded from the moraine and began to float.

Figure 12. Comparative images of seasonal and interannual changes in face of Aialik Glacier from 2003-2009. From 2003 through summer 2006, Aialik Glacier was relatively thin and showed signs of recession. Beginning the winter of 2006, in conjunction with cold winter temperatures, the central portion of Aialik Glacier began advancing forward and the glacier face increased in height.



Human Interactions

Tourism is among the fastest growing industries in Alaska and worldwide. Marine and ecotourism are expanding at the highest rates and assessments of the impacts of tourist activities on wildlife and the ecosystems. Kenai Fjords National Park was established in 1980 and has increased in popularity for both large vessel tours and kayakers. Since 2002 the remote cameras have been used to monitor the response of seals to vessels. During 2009, with the economic downturn, we noticed fewer vessels visiting Aialik Glacier. Congested ice conditions in Pedersen lake also reduced numbers of kayakers that visited that location. Tables 4 and 5 summarize vessels observed and interactions between seals and vessels. Of 126 interactions observed, 12 (10%) likely caused seals to enter the water.

Table 4. Preliminary summary numbers of vessels and kayaks seen during active monitoring near Aialik and Pedersen Glaciers during 2009.

2009	Vessels			Kayaks	Kayaks + Vessels	Aircraft
	Total	<80ft	>80ft			
Aialik	79	43	37	26	106	0
Pederson	0	0	0	19	19	1
Total	79	43	37	45	125	1

Table 5. Preliminary summary of vessel/aircraft and seal interactions near Aialik and Pedersen glaciers during 2009.

2009	Seal Disturbances			
Area	Total	Unlikely	Unknown	Likely/ Confirmed
Aialik	106	63	37	7
Pederson	20	9	5	6
Total	126	72	42	12

Although heavy ice during June protected most young pups from interactions with tour vessels, young pups are particularly vulnerable to adverse effects of disturbance to swimming, nursing, and resting patterns that could potentially influence their energy balance and ability to maximize their blubber growth. For that reason we began a campaign to make vessel operators more aware of their potential impact on seals, particularly young pups.

“Give Pups A Break” In June 2009 a poster (Figure 13) was developed, in collaboration with the Ocean Alaska Science and Learning Center, to encourage vessel operators to take extra care when operating near seals when pups are around. The poster reminds vessel operators to be particularly aware of pups when 500 yards away and not approach pups within 100 yards. Numbers of pups are not increasing in Aialik Bay. Although vessels have not been identified as a cause for failure recovery, their assistance is requested to minimize potential adverse impacts of disturbance on pups, including increased energy loss from excess exposure to cold water and disruption of nursing and resting cycles, particularly when pups are very young. The poster was distributed to tour vessel operators in June 2009. In spring 2010, revisions will be made based on vessel operator review and suggestions, and then redistributed.

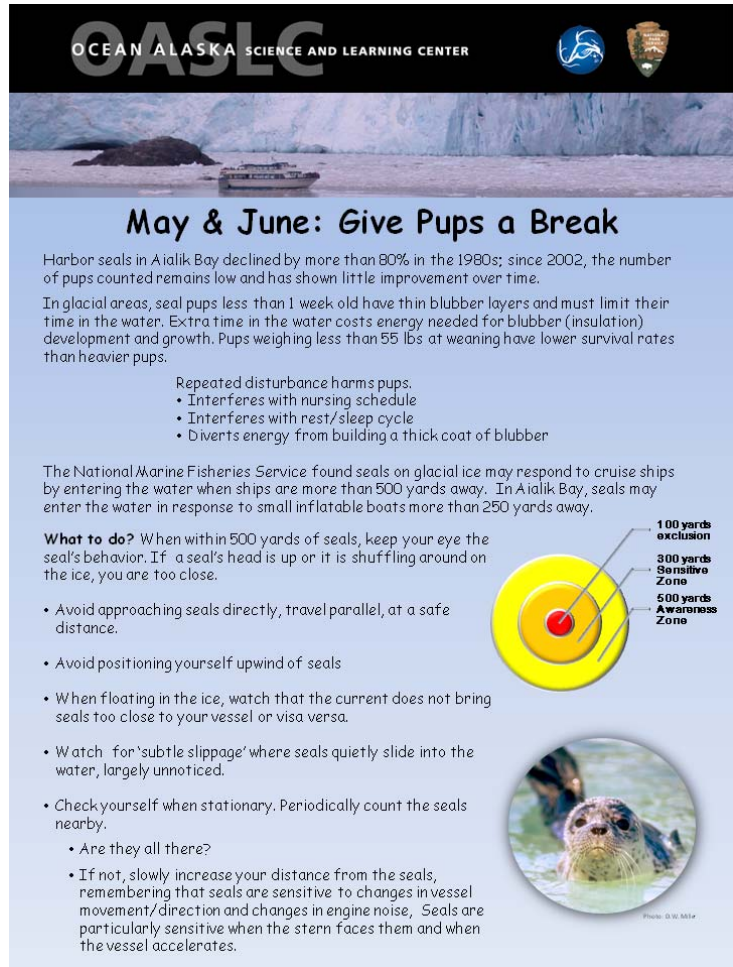


Figure 13. “Give Pups A Break” Poster distributed to tour vessel operators

Other Activities. Besides using the video system to monitor seals and glacial habitats, we undertook several other activities, summarized below.

Aerial Surveys. The Kenai Fjords comprise an intricate fjord coastline. Habitats are diverse ranging from estuarine lakes with and without tidewater glaciers, to precipitous capes eroded by the North Pacific. The distribution, abundance, reproductive success, and survival of marine mammals and birds depends on predictable food resources. This study uses aerial surveys to map the distribution and abundance of harbor seals in land and ice habitats relative to other tractable marine organisms and events, such as foraging seabirds. This study is designed to augment and complement information obtained using the remotely controlled video cameras. Detailed observations focused on a single species, harbor seals, in a single area, such as upper Aialik Bay, lacks context regarding how well finding from Aialik Bay can be applied to other regional ice or land haulouts. Ecological events occurring outside the camera's field of view can have profound effects on seal haulout attendance. Since 2004, aerial surveys have been used to assess the distribution and relative abundance of harbor seals and other marine organisms along a standardized route from Johnstone Bay to McCarty Fjord on the southern Kenai Peninsula. These surveys are being used to

monitor seasonal and interannual changes in the distribution and relative abundance of harbor seals and other organisms along the coast during the summer from May-September.

Objectives: Surveys are being conducted to meet the following objectives:

Contrast findings of harbor seals at Aialik Bay with other locations in the Kenai Fjords:

- Map harbor seal haulout sites along the outer Kenai Peninsula
- Monitor seasonal and interannual relative abundance of seals at haulouts
- Contrast haulout patterns and attendance in upper Aialik Bay with other routinely used haulouts

Methods. Surveys are conducted using a Cessna 172 aircraft with an observer on the right front seat and a photographer in the rear seat. Direct counts are made by the observer while the photographer takes concurrent photographs using digital cameras or a Nikon D1 with a 200mm Nikkor lens (2004) or a Nikon D70 camera with a AF-S-VR-Nikkor 70-200 lens (2005-2008). Additional images were taken by the observer using Nikon Coolpix 5400, 8700, 8800 or Fuji S7000 cameras. From 2004-2006, surveys were attempted twice each month from May-September; from 2007-2009, surveys focused primarily on the pupping period. Surveys are conducted within windows during which low tides occur during midday. Within those windows, surveys are only flown during periods of fair weather, when strong winds and heavy rain are absent. These criteria are used to optimize haulout conditions among both land and ice haulout areas. Records denote when ice availability and human activities potentially affected numbers of seals counted. Surveys are flown at 150-305 m depending on behavior of seals, weather, and shoreline topography. GPS is used to record survey tracks. Since 2005, images have been linked with survey tracks using RoboGeo software.

2009 Accomplishments. Aerial surveys focused on obtaining replicate counts during the pupping period. During 2009, aerial surveys were flown on May 29th, June 5th and June 13th.

One component of our analysis assesses observational bias in determining numbers of pups using the video cameras. As an example, Figure 14 indicates numbers of seals and pups observed on June 13th counted using the video system and by photographs taken shortly afterwards. Numbers of seals were underestimated by 8.6% while numbers of pups were underestimated by 28% using the video cameras. Further analysis is ongoing.

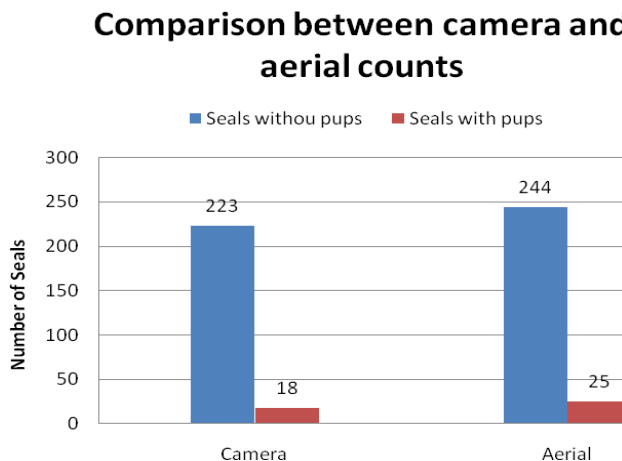


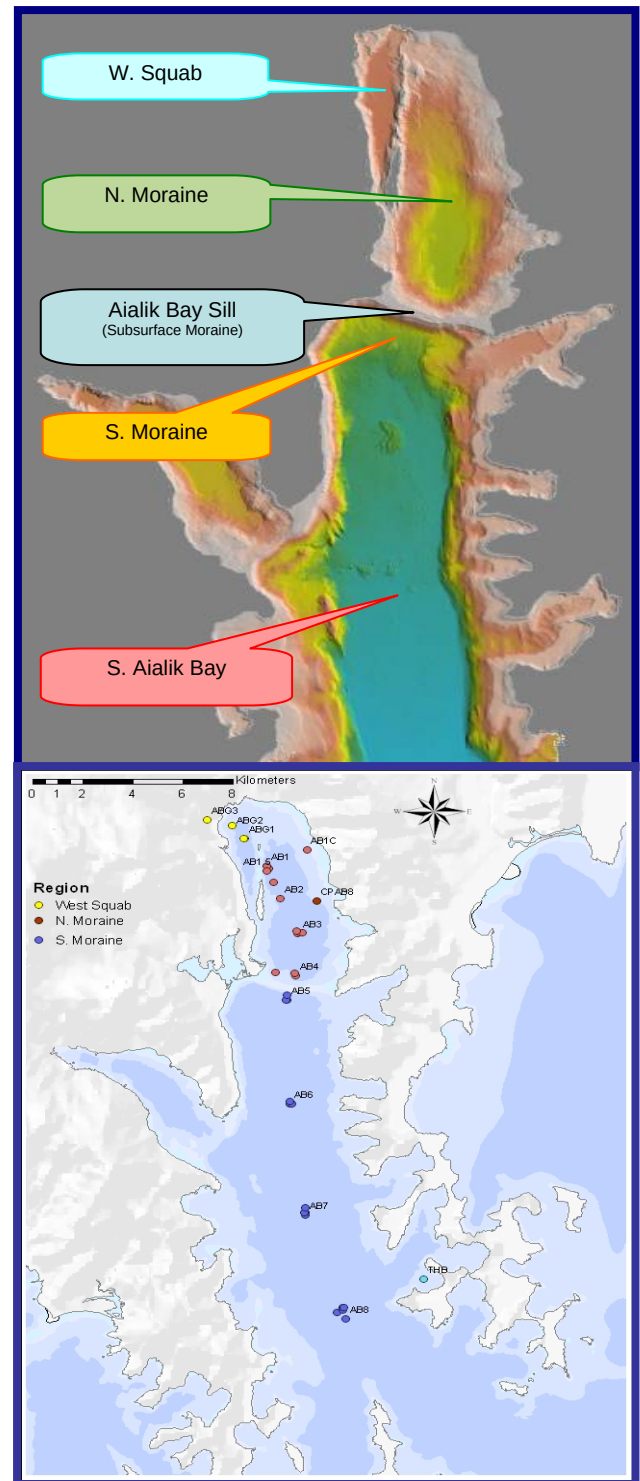
Figure 14. Comparison between numbers of seals and pups counted by remote video cameras and aerial surveys in upper Aialik Bay

Marine Conditions in Aialik Bay. Aialik Bay is a 30 km tidewater glacier fjord. Tidewater glaciers exist on the northwest shore at the head of the bay, at Pedersen Lake, a tidally influenced lake east of the Aialik Bay sill, and at the head of Holgate Arm on the western side of the fjord. Sills, subsurface moraines, restrict circulation to Holgate Arm and the northern basin of Aialik Bay, between Coleman Bay and Pedersen Lagoon. Another sill extends from the northern shore of the Pedersen Spit through Slate and Squab Islands to the northern shore of Aialik Bay. South of the Aialik Bay sill, circulation is unobstructed. The Aialik Bay sill is relatively shallow (approximately 12 m). The fjord south of the sill reaches depths of 294 m while the basin north of the sill reaches 192 m. The small basin that abuts Aialik Bay reaches only 106 m deep and is heavily influenced by sedimentation from the glacial outwash.

Oceanographic surveys were initiated in 2006 to contrast temporal and spatial conditions between lower Aialik Bay, the basin north of the Aialik Bay Sill (N. Moraine) and the basin west of Squab Island that abuts the glacier (W. Squab).

Methods. Hydrography samples were collected using a SeaBird Electronics (SBE) 19 plus profiler fitted with a SBE 43 dissolved oxygen sensor and a WetLabs fluorometer. Stations were selected to include sites sampled by Gay and Armato (1998). North of the Aialik Bay Sill, sites were selected to provide spatial diversity in addition to replication of sites sampled by Gay and Armato (1998) and Carpenter (1983). Sampling north of the moraine often was constrained by the distribution of ice. Vertical zooplankton net tows were made to 100 m using a 25 cm diameter, 150 micron mesh bongo net with General Oceanics R2030 flow meters in each net. Plankton sampling nearest the glacier generally was limited in depth due to water depths less than 100m. Shipboard processing included: formalizing zooplankton samples in 5% formalin and downloading CTD data to review and duplicate data.

2009 Accomplishments. A Seabird SBE18 pH sensor was added to the CTD array and additional personnel were trained for deployment. Zooplankton samples and CTD measurements were taken on the ASLC vessel *Sea Searcher* on June 4, June 26, and Aug 21, 2009. An example of spatial variation in marine water chemistries are shown in Figure 15 based on measurements take on June 4th.



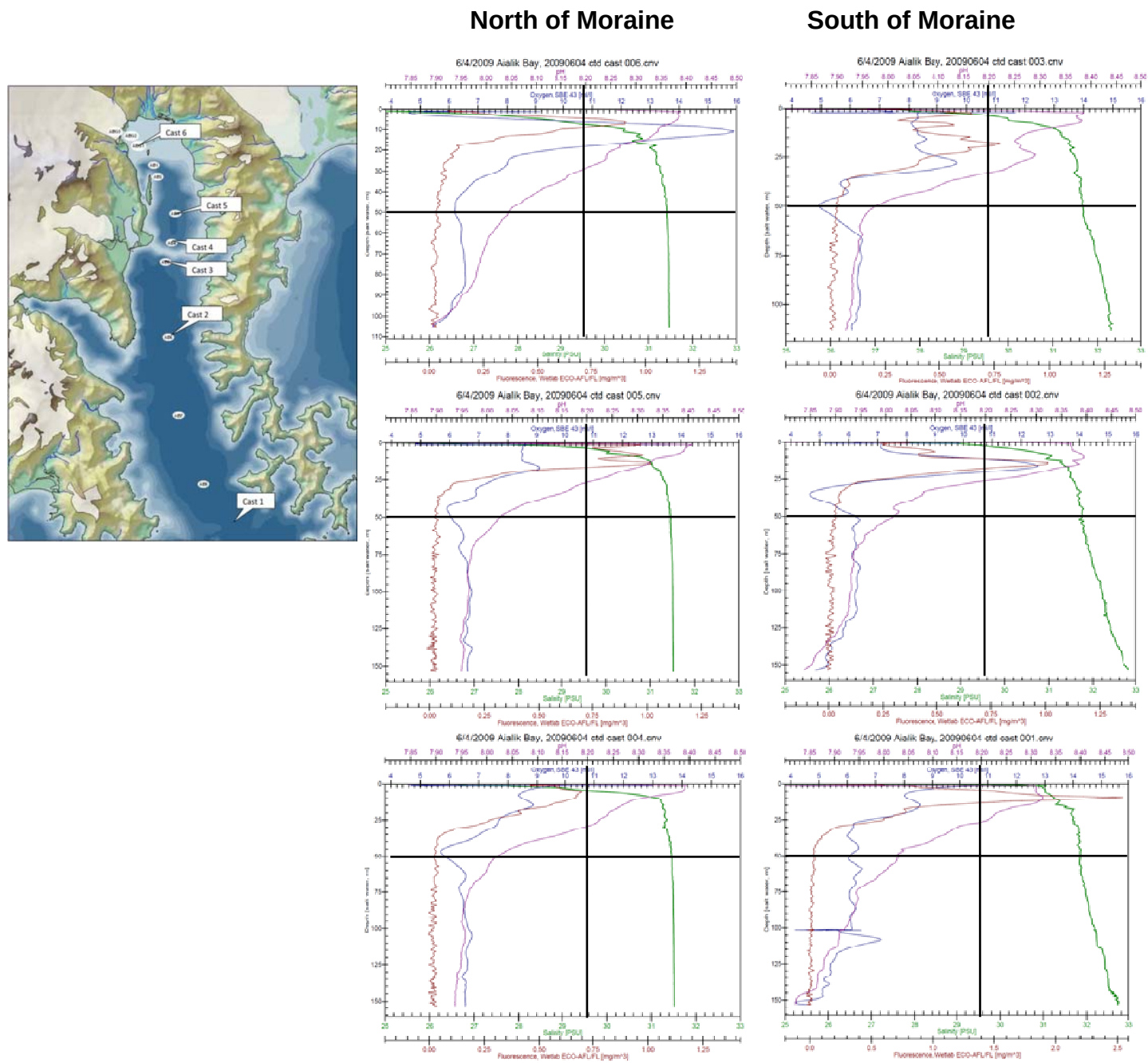


Figure 15. Spatial variability and effects of Aialik Bay moraine on marine water chemistries including salinity (green), dissolved oxygen (blue), fluorescence (brown) and pH (purple) measured on 4 June, 2009. Cast 6 represents waters most strongly influenced by the glacier with infusion of fresh water with high dissolved oxygen; cast 1 represents waters most strongly influenced by nearshore waters of the Alaska coastal current. The shallow, 10 m deep, moraine retains effects of glacial input within the northern basin. Horizontal black bars mark 50 m depth for reference. Vertical black bar represents average global ocean pH of 8.2 in the upper 50m surface waters.

Time-Lapse Video Tape Conversion. To make video clips more available to collaborators and other potential users, we have begun to convert time-lapse tapes to MPG4 digital recordings. Conversion of time-lapse video tapes to MPG4 format has been completed for the year 2007. This has been a very time consuming project as it takes a full summer to process tapes from a single year. This process has been successful for broadening portability and access to video material and preserving video images in a non-proprietary format. This process will be continued in 2010 for the 2008 tapes.

Kenai Fjords Tours (KFT) Surveys. During 2009, in collaboration with Kenai Fjords Tours, a new series of surveys was initiated to provide more detailed information about harbor seal haulout attendance and pupping in Northwestern Fjord. A summary of the 2009 pilot project is provided in Appendix A. Surveys into Aialik Bay were compromised by variability in vessel destination and viewing distances to seals on the ice. KFT vessels, however, provided a valuable platform for expanding research into Northwestern Fjord. In addition to targeted research on harbor seals, surveys conducted while the vessel was in transit, provided data on distribution and habitat preferences of other marine mammals, Steller sea lion brand resightings, photographs documenting seabirds densities at rookeries, and cetacean identification photographs.

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**Vessel Based Surveys of Harbor Seals (*Phoca vitulina*)
in Kenai Fjords National Park.**

Anne Hoover-Miller, Jill Prewitt, Amy Bishop, Laura Marcella

INTRODUCTION

Harbor seals (*Phoca vitulina*), can be found almost continuously along the Northwest Pacific coast, from southern California in the east to Japan in the west, and as far north as the Bering Sea (Hoover-Miller 1994). Harbor seals spend a large proportion of their lives in the water but also haul out on rocks, beaches, ice floes and manmade structures; these non-marine habitats are particularly essential to the seals during the months of June and August when the seals give birth and molt. In Alaska, the harbor seal population are unique in that approximately 10% of the population utilizes glacial ice, calved from tidewater glaciers, to haul out on. Such habitats form estuarine environments—an interface between ocean salt-water and melting glacial ice. Glacial ice habitats also are dynamic as the availability of ice is dependent on the rate of glacial calving, winds, currents and temperatures, rather than tides and surf that affect terrestrial environments. Unlike terrestrial haul-outs, glacial ice haul outs are not dependent on tidal fluctuations, thus seals have options for spending longer times hauled out and can haulout at any time of day or night.

This study is focused on the population of harbor seals occupying the waters adjacent to the Kenai Fjords National Park, in southcentral Alaska. Since the decline in the harbor seal population in the mid 1970s, population estimates have been conducted and monitored closely for further fluctuations. Numbers of harbor seal pups in Aialik Bay have remained low and have not been shown signs of increase since 2003.

Since 2002, the Alaska Sea Life Center has been monitoring the seal populations at Aialik Glacier and Pederson Glacier through the use of remote video monitoring but the only data source for Northwestern Fjord has been collected using aerial surveys on an infrequent basis.

Numbers of seals hauling out in Aialik Bay fluctuate on multiple times scales. Interannually, haulout attendance has shown high variability outside the pupping and molting periods which may be influenced by the availability and distribution of forage fish. Counts used for population monitoring are during pupping and molting, when haulout attendance of specific age groups is more consistent. A fundamental questions are whether seals in Aialik Bay primarily use haulouts in Aialik Bay for haulout or there is frequent exchange of seals with those in Northwestern Fjord. If exchange between Aialik Bay and Northwestern Fjord is occurring, under what conditions are shifts in attendance evident. We are also interested in evaluating whether seals or pups, in general, are more abundant in Northwestern Fjord than Aialik Bay.

Objectives: Objectives of this project are to 1) evaluate viability of using Kenai Fjords Tour vessels as a platform for obtaining data on harbor seal usage of Northwestern Glacier and Aialik Bay during the pupping and molting seasons, 2) compare harbor seal attendance in Aialik Bay and Northwestern Fjord and 3) collect opportunistic data on other marine mammals observed in the waters surrounding these two locations.

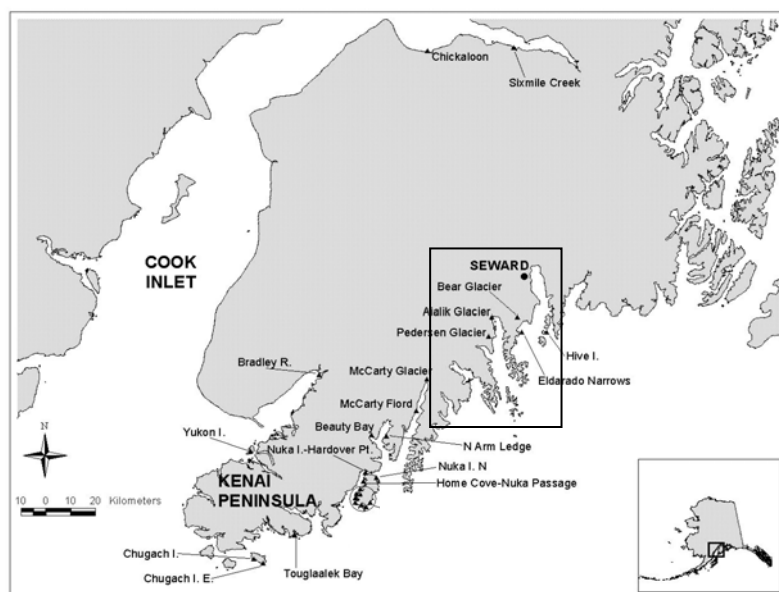


Figure 1. Map of Kenai Peninsula showing the survey area including Resurrection Bay, and the tidewater glacial fjords, Aialik and Northwestern, where seals congregate on ice and terrestrial haul-outs. This is also the extent of the region the tour vessel fleet travels through during the summer (May-Sept).

Methods

The survey area of Aialik and Northwestern Fjords is located on the southeast side of the Kenai Peninsula in Alaska, adjacent to the Kenai Fjords National Park (Fig 1). In conjunction with Kenai Fjord Tours (KFT), we conducted vessel based surveys of those locations, specifically focusing on harbor seal haul-out locations, but also took opportunistic observations of other marine mammals throughout the trip.

Surveys were conducted at Northwestern Glacier twice a week and Aialik Glacier once a week. The lesser emphasis on Aialik Glacier was decided due to the continuous observation of that area via remote video cameras, whereas the only census data for Northwestern Glacier was gathered through aerial surveys.

Our surveys were opportunistic and passive, and did not interfere with the normal operating of the boat. Routes were variable due to weather conditions, discussion of wildlife sightings between ships and other external factors but generally followed a set path (Fig 2).

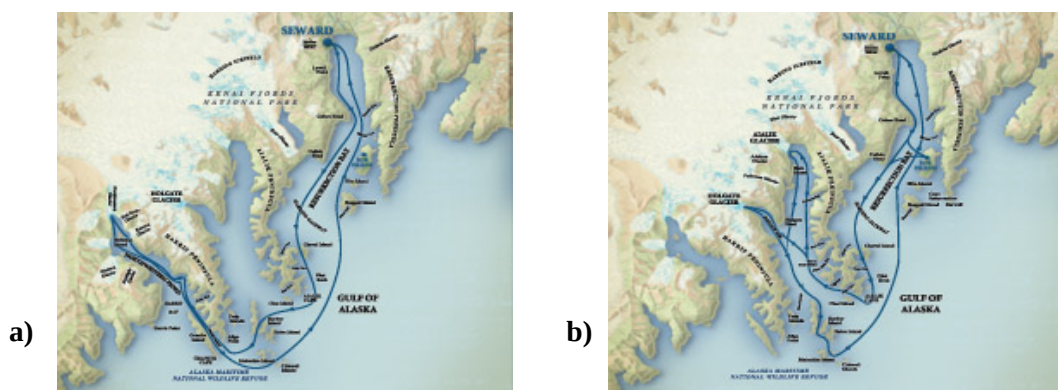


Figure 2. General route taken by KFT tour boats to a) Northwestern Glacier, and b) Aialik Glacier (Graphics from: Kenai Fjords Tours)

Surveys were conducted from late May through early September 2009 and each survey lasted 6 or 9 hours (Aialik or Northwestern respectively), totaling 291hrs of sighting efforts. (Table 1).

All trips set out from the Seward harbor, located at the northernmost part of Resurrection Bay. At the beginning of a survey, a Garmin GPS track log was started and kept activated throughout the trip. We recorded weather conditions (percent cloud cover %, precipitation and sea state) as well as time of departure.

In transit to and from the glacier, all marine mammal sightings were recorded with time of observation, activity, number of animals and the location was mapped (geographic coordinates of location were assigned post-survey from GPS track logs.) Pictures of each encounter were taken using a Nikon Coolpix 8800 digital camera with emphasis on dorsal fins, flukes, brands, and representation of as many members of the group of animals as possible. For some animals such as Dall's porpoise or sea otters, pictures were not possible at all sightings but observations were still recorded.

Once at the glacier, harbor seal censuses (total counts) within predetermined zones were conducted through 8X35 range finder binoculars. Seals on ice were distinguished from seals in the water. In addition, seals on ice were distinguished from mom/pup pairs which were counted as a single entity. Weather conditions, (cloud cover %, precipitation, modified Beaufort scale) and ice cover were also recorded for each predetermined zone. Ice cover was defined as percent of total area over percentage of large, medium and small ice (e.g. 80/ 20-20-40). After an initial census, we took pictures of the different zones, ice coverage, and seal distribution. Ice coverage and seal distribution on ice were sketched on maps of the area and distance to closest seals were estimated or quantified using the rangefinder binoculars.

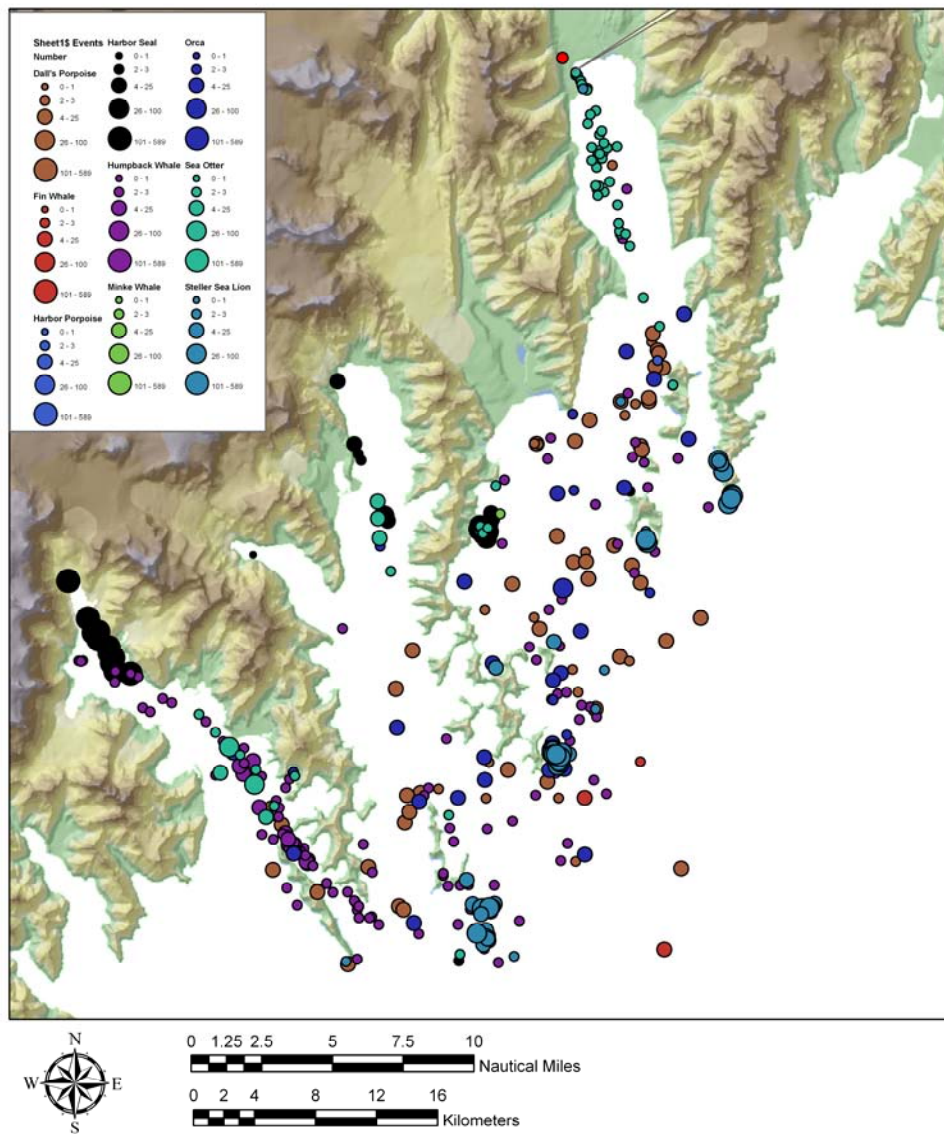
Classification of seals by age group was initially an objective of the project, with age class determined by relativity to largest seals in area. Although on approach the distance to seals being surveyed was often within 300 m, the final stopped location at the face of the glacier was often >500 m. Identification of age class at those distances was difficult not possible, even with binoculars.

After each survey, the GPS tracklog and pictures were downloaded to a hard- drive. Specific latitude and longitude coordinates for opportunistic sighting locations were determined with RoboGeo geocoding software and Google Earth. All observation notes, weather parameters, and harbor seal census data were entered into a Microsoft Excel database while the original hard copies were scanned and saved along with the electronic files.

Table 1. Marine Mammal Search and Encounter Time Summer 2009

Month	Days of Effort	Hours of Effort
May	2	12
June	11	90
July	12	93
Aug	10	87
Sept	1	9

2009 Marine Mammal Sightings KFT Vessel Surveys



Results and Discussion

Figure 3. Distribution of incidentally sighted marine mammals observed during surveys, suggestive of ecological segregation. Observations in upper Aialik Bay were infrequent and were compromised by distance and terrain. Observations in upper Aialik Bay therefore disproportionately under-represent harbor seals and sea otters near glacial ice calved from Aialik and Pedersen glaciers.

Appendix A summarizes numbers of marine mammals observed in seven regions surveyed in this study: Upper Resurrection Bay, Lower Resurrection Bay, Upper Aialik Bay, Lower Aialik Bay, Harris Bay, Northwestern Fjord, and Chiswell/Harbor islands. High concentrations of marine mammals recurred at predictable locations (Figure 3) and tended to segregate into generalized regions.

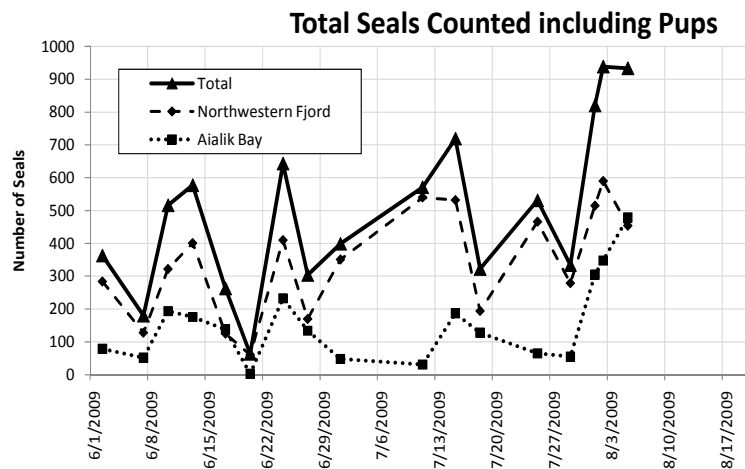


Figure 4. Total Numbers seals counted in Aialik Bay using the video monitoring system and in Northwestern Fjord, from KFT vessels from June to August, 2009. The solid dark line represents totals for both locations.

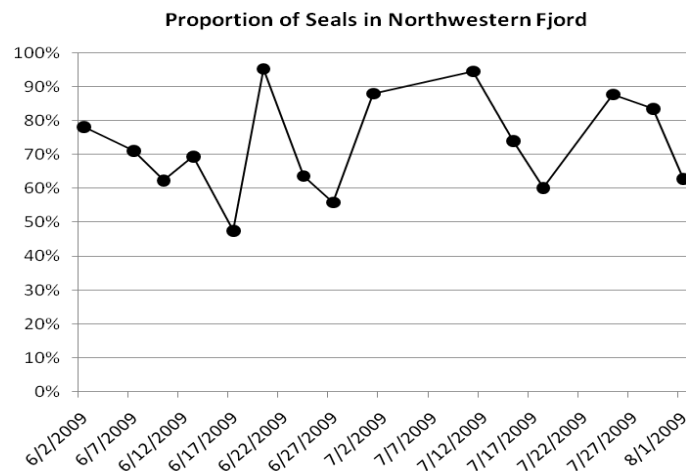


Figure 5. Proportion of seals counted in Aialik Bay using the video monitoring system and in Northwestern Fjord, from KFT vessels that were located in Northwestern Fjord from June to August, 2009.

Comparisons of numbers of seals counted in Northwestern Fjord from KFT vessels and counts taken in Aialik Bay using the video monitoring system (Figures 4 and 5) suggest that about 70% of the seals were typically counted in Northwestern Fjord and that, in 2009, Northwestern Fjord appeared to be a more reliable haulout than Aialik Bay.

Pup Counts: Aialik Bay & NW Fjord

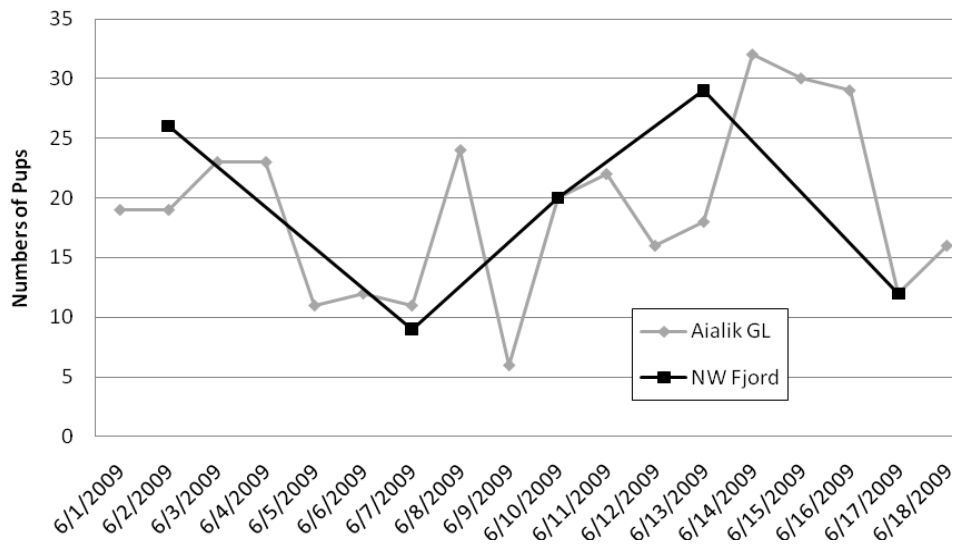


Figure 6. Comparison of number of pups counted in Aialik Bay (grey) using video monitoring system and Northwestern Fjord (black) from KFT vessels from 1-18 June, 2009.

Proportion Pups in Northwestern Fjord

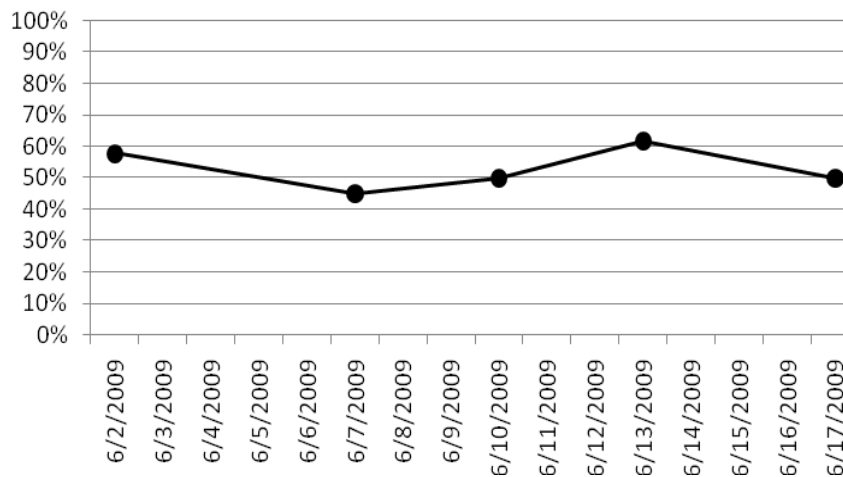


Figure 7. Proportion of Pups counted in Aialik Bay, using the video monitoring system, and at Northwestern Fjord, from KFT vessels, that were located in Northwestern Fjord during June 2009.

Figures 6 and 7 indicate that similar numbers of pups were in Northwestern Fjord and Aialik Bay during 2009. These data also suggest that a disproportionate number of seals without pups were located in Northwestern Fjord during 2009, suggestive that more favorable conditions for non-pupping seals were

present in Northwestern Fjord in 2009. Further studies are needed to determine whether these patterns are consistent across years.

Results from these preliminary assessments indicate that the KFT vessels are a valuable platform for obtaining information on harbor seals and other marine mammals, particularly in route to Northwestern Fjord. Surveys into Aialik Bay were less productive and counts taken from the video camera system were superior to those from vessels. We do not anticipate repeating surveys into Aialik Bay in future studies.

Appendix 1: Survey Summary

Summary of numbers of marine mammals sighted in seven coastal regions during KFT vessel surveys conducted from May 22nd through Sept 1st, 2009.

Date	Region	Humpback Whales	Fin Whales	Minke Whale	Dall's Porpoise	Harbor Porpoise	Orcas	Steller Sea Lions	Harbor Seals	Sea Otters
5/22/2009	Upper Res Bay				2					2
	Lower Res Bay	1					8	60	25	2
	Upper Aialik									
	Lower Aialik				20				2	
	Northwestern									
	Harris Bay									
	Chiswell/Harbor Island									
5/26/2009	Upper Res Bay							1		
	Lower Res Bay									
	Upper Aialik	NS								
	Lower Aialik	3	6		5					
	Northwestern	NS								
	Harris Bay	NS								
	Chiswell/Harbor Island	1						4		
6/2/2009	Upper Res Bay				2					7
	Lower Res Bay	3			2			138	28	
	Upper Aialik	NS								
	Lower Aialik				6		6			
	Northwestern								232	
	Harris Bay	4								46
	Chiswell/Harbor Island	2						4		
6/7/2009	Upper Res Bay									3
	Lower Res Bay	2			2		3	62		
	Upper Aialik	NS								
	Lower Aialik									
	Northwestern								110	2
	Harris Bay	3								42
	Chiswell/Harbor Island				3			8		
6/10/2009	Upper Res Bay				2					2
	Lower Res Bay				16		9	34		
	Upper Aialik	NS								
	Lower Aialik				3		10			
	Northwestern								282	
	Harris Bay	5			4					
	Chiswell/Harbor Island	3			2			11		
6/13/2009	Upper Res Bay							1		2
	Lower Res Bay	2					14	22	68	
	Upper Aialik	NS								
	Lower Aialik				7					

	Northwestern						343	2
	Harris Bay	14						
	Chiswell/Harbor							
	Island			7		24		
6/14/2009	Upper Res Bay							2
	Lower Res Bay	1	12			11	20	
	Upper Aialik	NS						
	Lower Aialik			8				
	Northwestern							
	Harris Bay							
	Chiswell/Harbor							
	Island	1				10		
6/17/2009	Upper Res Bay			14				
	Lower Res Bay	1				5	49	
	Upper Aialik	NS						
	Lower Aialik							
	Northwestern	1					101	
	Harris Bay	6						2
	Chiswell/Harbor							
	Island	5					15	
6/20/2009	Upper Res Bay	1		8				
	Lower Res Bay	4		11			128	6
	Upper Aialik	NS						1
	Lower Aialik							
	Northwestern						45	
	Harris Bay	11						1
	Chiswell/Harbor							
	Island	4		1			17	
6/21/2009	Upper Res Bay			4		6		3
	Lower Res Bay	4					40	
	Upper Aialik	NS						
	Lower Aialik							
	Northwestern	NS						
	Harris Bay	NS						
	Chiswell/Harbor							
	Island	NS						
6/24/2009	Upper Res Bay	4		12	2			2
	Lower Res Bay	4	1			7	103	
	Upper Aialik	NS						
	Lower Aialik	1						
	Northwestern						274	
	Harris Bay	11		6				
	Chiswell/Harbor							
	Island			6		5	10	
6/27/2009	Upper Res Bay							2
	Lower Res Bay			5			73	85
	Upper Aialik	NS						1
	Lower Aialik							1
	Northwestern	1					138	
	Harris Bay	14		1				6
	Chiswell/Harbor						20	

Island								
6/28/2009	Upper Res Bay	1	17					
	Lower Res Bay	1	10		42			
	Upper Aialik					4		7
	Lower Aialik	1						1
	Northwestern	NS						
	Harris Bay	NS						
	Chiswell/Harbor							
	Island	NS						
7/1/2009	Upper Res Bay		12	2				2
	Lower Res Bay				71	42		1
	Upper Aialik	NS						
	Lower Aialik							
	Northwestern	1				351		
	Harris Bay	24			4			
	Chiswell/Harbor							
	Island				17			
7/5/2009	Upper Res Bay							1
	Lower Res Bay				4	57	24	1
	Upper Aialik				1		2	19
	Lower Aialik	4	2					1
	Northwestern	NS						
	Harris Bay	NS						
	Chiswell/Harbor							
	Island	NS						
7/8/2009	Upper Res Bay	1	7					
	Lower Res Bay	1	4					
	Upper Aialik	NS						
	Lower Aialik		5					
	Northwestern						364	
	Harris Bay	21						
	Chiswell/Harbor							
	Island	2						
7/11/2009	Upper Res Bay							1
	Lower Res Bay	2	17		70	95		1
	Upper Aialik	NS						
	Lower Aialik							
	Northwestern	1				536		
	Harris Bay	11	4					
	Chiswell/Harbor							
	Island				31			
7/12/2009	Upper Res Bay							1
	Lower Res Bay	6				93		
	Upper Aialik					8		
	Lower Aialik							
	Northwestern	NS						
	Harris Bay	NS						
	Chiswell/Harbor							
	Island				28			
7/15/2009	Upper Res Bay				6			2
	Lower Res Bay		15			40		

	Upper Aialik	NS					
	Lower Aialik						
	Northwestern	2				524	
	Harris Bay	6		3			
	Chiswell/Harbor Island	3	7		14		
7/18/2009	Upper Res Bay						1
	Lower Res Bay	3	2	9	79	66	
	Upper Aialik	NS					
	Lower Aialik						
	Northwestern	2				194	
	Harris Bay	10	10				
	Chiswell/Harbor Island		4				
7/19/2009	Upper Res Bay						1
	Lower Res Bay		6		1		1
	Upper Aialik					1	
	Lower Aialik						
	Northwestern	NS					
	Harris Bay	NS					
	Chiswell/Harbor Island	NS					
7/25/2009	Upper Res Bay						1
	Lower Res Bay		3		76	93	
	Upper Aialik						
	Lower Aialik						
	Northwestern					465	
	Harris Bay	2					
	Chiswell/Harbor Island			4			
7/26/2009	Upper Res Bay						2
	Lower Res Bay				50	1	
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern	NS					
	Harris Bay	NS					
	Chiswell/Harbor Island	NS					
7/28/2009	Upper Res Bay		2	5			2
	Lower Res Bay	1			28		
	Upper Aialik					21	
	Lower Aialik						
	Northwestern	NS					
	Harris Bay	NS					
	Chiswell/Harbor Island	2			18		
7/29/2009	Upper Res Bay			5			2
	Lower Res Bay				26		
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern					279	

	Harris Bay	3	2		1		
	Chiswell/Harbor						
	Island			18		2	
8/1/2009	Upper Res Bay						
	Lower Res Bay	2		11	24	64	
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern					515	
	Harris Bay	2	3				7
	Chiswell/Harbor						
	Island	2		44			
8/2/2009	Upper Res Bay	3					3
	Lower Res Bay	3	4		57		
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern					589	
	Harris Bay	1				1	1
	Chiswell/Harbor						
	Island	2		44			
8/5/2009	Upper Res Bay		3				4
	Lower Res Bay				20	62	1
	Upper Aialik	NS					
	Lower Aialik	NS	1				
	Northwestern					454	
	Harris Bay	3	3	4			
	Chiswell/Harbor						
	Island	2		4			
8/8/2009	Upper Res Bay		5				1
	Lower Res Bay	5			33	73	
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern					490	
	Harris Bay	4	5				2
	Chiswell/Harbor						
	Island		4			1	1
8/9/2009	Upper Res Bay						
	Lower Res Bay	1	1	12	33	33	3
	Upper Aialik					26	
	Lower Aialik			7			
	Northwestern	NS					
	Harris Bay	NS					
	Chiswell/Harbor						
	Island	NS					
8/14/2009	Upper Res Bay						3
	Lower Res Bay		4	30	44		
	Upper Aialik	NS					
	Lower Aialik	NS					
	Northwestern					66	
	Harris Bay						
	Chiswell/Harbor						
	Island	2				10	

8/19/2009	Upper Res Bay								1
	Lower Res Bay	3		8		3	111	19	1
	Upper Aialik	NS							
	Lower Aialik	1							
	Northwestern							225	
	Harris Bay			4					
	Chiswell/Harbor								
	Island			4					
8/22/2009	Upper Res Bay								1
	Lower Res Bay	1	3	4			78	24	3
	Upper Aialik	NS							
	Lower Aialik	NS							
	Northwestern							163	
	Harris Bay								
	Chiswell/Harbor								
	Island			12					
8/30/2009	Upper Res Bay								
	Lower Res Bay	1						1	
	Upper Aialik	NS							
	Lower Aialik					4			
	Northwestern							284	
	Harris Bay								
	Chiswell/Harbor								
	Island	1							
9/1/2009	Upper Res Bay								1
	Lower Res Bay	2		4					
	Upper Aialik	NS							
	Lower Aialik			12					
	Northwestern							252	
	Harris Bay								11
	Chiswell/Harbor								
	Island	2							